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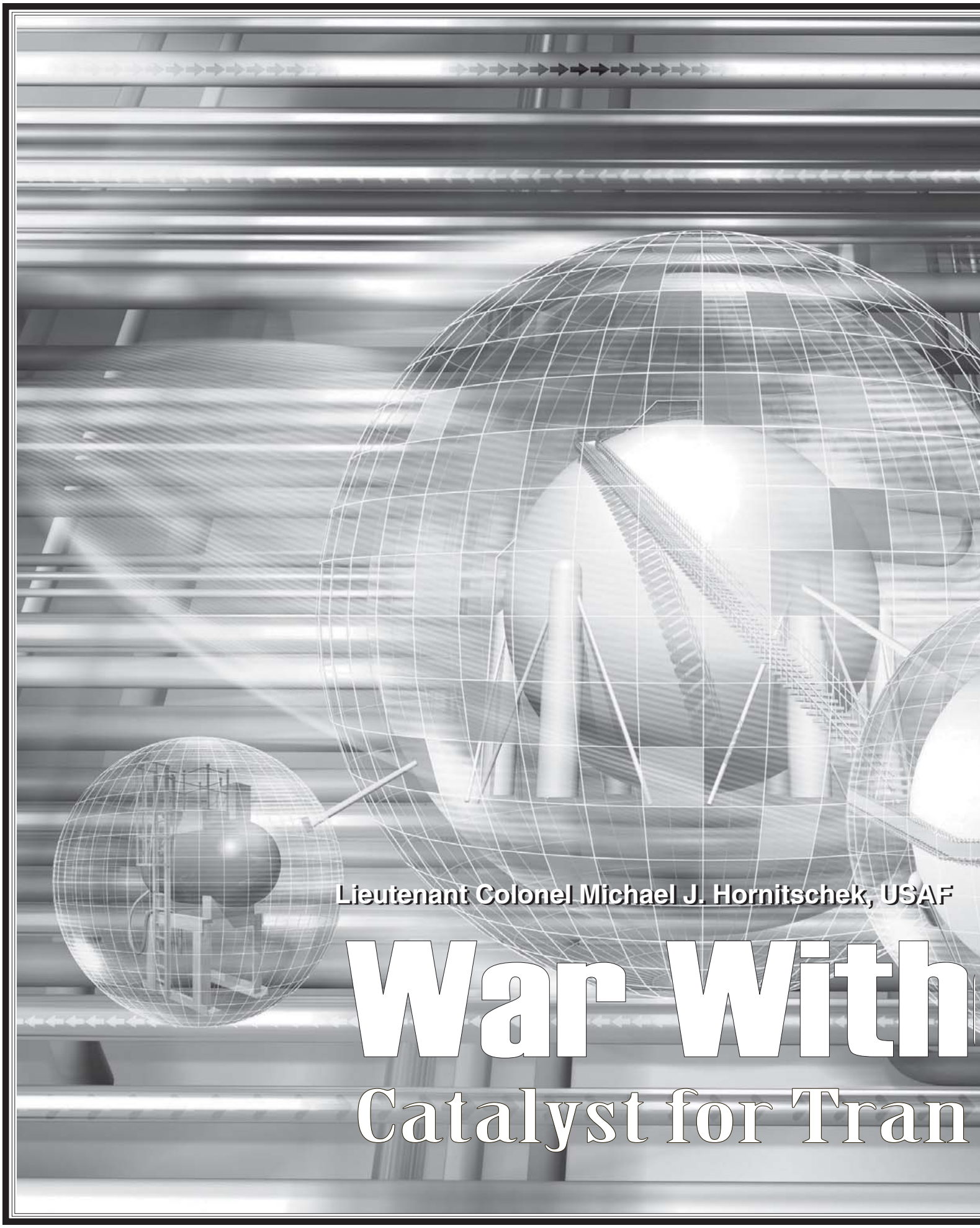

Lieutenant Colonel Michael J. Hornitschek, USAF

War With

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Introduction

Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world. The best way to break this addiction is through technology.

—President George W. Bush, State of the Union Address, 31 Jan 2006[1]

Special Feature

On 31 January 2006, President Bush pronounced in his annual State of the Union Address, that "America is addicted to oil," and that the key to eliminating US dependence on foreign energy was through the application of breakthrough technologies as part of his Advanced Energy Initiative (AEI).[2] Focused on revolutionizing energy sources and uses for facilities and automotive applications, the President proposed increasing Department of Energy (DoE) research and development (R&D) funding by 22 percent to accelerate technologies in clean coal consumption, nuclear energy, solar, wind, biofuel renewables, hybrids, and fuel-cells in order to move beyond a petroleum-based economy.[3] The President's AEI represents one of the numerous energy independence proposals to surface on the nation's agenda since the Arab oil embargo of 1973. Despite decades of effort by government institutions, industry, and academia to free America of its petroleum *addiction*, the simple fact is that over the last 30 years American oil consumption has increased by one-third and imports have more than doubled. By 2025 the Energy Information Agency predicts that Americans will be importing 68 percent of their petroleum needs.[4]

Although the DoD uses only approximately 1.8 percent of the 20 million barrels of oil consumed each day in the US, it is the largest single institutional energy customer in the United States and likely the world.[5] Subscribing to a National Defense Strategy that values effectiveness over efficiency, the DoD relies upon petroleum to deliver the energy-intense global power projection, agile logistics, and operational maneuver capabilities essential to waging a dominant and uniquely high-technology *American way of war*. As the nation's primary security provider, the DoD has a vested interest in ensuring that it possesses the uninterrupted energy resources needed to deter all would-be aggressors and decisively engage in the full spectrum of conflict, particularly as it engages in a decades-long global war on terrorism. The question then becomes, how can the DoD contribute toward the President's goal of creating a society which is not addicted to oil while simultaneously ensuring it has the energy and capabilities to complete its mission?

Mankind's long-term supply of petroleum fuel is threatened by a phenomenon known as Hubbert's Peak—that point in time when the production of oil reaches a maximum, and then declines steadily thereafter. The debate about when the world will reach its Hubbert's Peak has raged for decades, with many credible

Article Highlights

An uncertain world energy prospect, a vital national defense mission, and the unique organizational capacity and situation of the DoD invites one to ask if an opportunity exists for the DoD to serve as an example for a national transformation toward a new energy future.

"War Without Oil: Catalyst for Transformation" via the application of the first three steps of Dr John P. Kotter's eight-step process for leading organizational change, proposes a method by which the Department of Defense (DoD) can lead an immediate, coherent, and viable long-term strategy toward a vision of replacing petroleum as its primary energy source in order to maintain all necessary strategic and operational capability for US security to 2050 and beyond. According to the author, the first step is to create a sense of urgency within the DoD that its long-term existence is threatened by rising energy costs and the prospect of declining energy supplies. The second step is to create a guiding coalition in the form of an Office for the Undersecretary of Defense for Assured Energy that possesses both the internal and interagency authority and the singular purpose necessary to lead a 45-plus year energy transformation process. Consisting of permanent representatives from OSD, the Services and interagencies, as well as representatives of industry and academia, this group must develop and communicate the vision of a desired energy future it wishes to create. Finally, by working backwards from that desired end state, the team must then build, communicate, and execute an overarching strategy that subdivides this grand challenge into a continuum of manageable short-term goals.

Using the hypothetical vision of a 2050 US military unconstrained by conventional paradigms, this article proposes a three-stage transformation strategy to

sources predicting dates which have already passed, others predicting dates within the next decade, and others proclaiming there will never be a peak. This discussion recently intensified when ExxonMobil, the world's largest oil company, achieved record profits of $36B in 2005[6] on all-time-high oil prices, but also quietly predicted in that same year that world oil production in non-Organization of Petroleum Exporting Countries (OPEC) would peak within 5 years.[7] If this prediction is, in fact, true, the potential global geopolitical and economic consequences could be profound. Consider the effects Hurricane Katrina and Iranian *nuclear brinksmanship* have demonstrated on an 84 million barrel-per-day world oil market,[8] in which two-thirds of all reserves reside in the Middle East.[9] In addition, the growth of emerging economies will push global demand to within 98 percent of available production capacity.[10]

If the US were ever forced to rely upon domestic petroleum supplies exclusively, it only possesses enough indigenous reserves to meet 2005-level demand for 4 to 5 years (equal to 2 percent of global reserves which includes Alaska National Wildlife Refuge supplies).[11] The President is correct in proclaiming that technology will be necessary to break America's addiction to oil. Another strong proponent of technology is the DoD, which has embraced its benefits as a key enabler for strategic, operational, and tactical success—a concept validated by the swift combat victories in Kuwait, Afghanistan, Iraq, and Bosnia over the last 15 years. However, the demand for increasingly more complex high-technology systems has placed the DoD at the end of increasingly long acquisition cycles, of which the 20-plus year development of the F-22A Raptor is a perfect example. It is precisely the long acquisition lead times of these petroleum-fueled weapon systems, in conjunction with their decades-long life cycles (for example, the 45-year-old B-52 fleet), that will uniquely force the DoD to be the first government agency to address an approaching global oil peak.

The Department has already felt the impacts of a tight oil supply over the past 2 years. Increased global demand and Hurricane Katrina-induced shortages doubled the price of a barrel of oil from $36 in 2003 to $73 by 2005, forcing the DoD to redirect nearly $3B of its fiscal year (FY) 2005 budget to cover the cost of fuel to the detriment of other programs.[12] This budgetary *pain* has caused every Service to form senior-level focus groups aimed at exploring and implementing various approaches to reduce the Department's fuel burden. Proposals range from promoting conservation efforts, expanding the use of renewable energy for base support, intensifying turbine engine efficiency research, and even establishing an independent DoD oil shale-to-synthetic fuel industry. While actionable, these various strategies appear to be occurring relatively independently within the DoD, absent an official grand vision or long-term, overarching strategy to move the DoD beyond petroleum as the President has asked America to do. This condition also appears representative of the competition among future energy strategies vying for dominance in American society at large.

An uncertain world energy prospect, a vital national defense mission, and the unique organizational capacity and situation of the DoD invites one to ask if an opportunity exists for the DoD to serve as an example for a national transformation toward a new energy future. Based upon the first three elements of Dr John P. Kotter's popular eight-step model for organizational

transformation, this article presents a methodology for determining if the DoD can lead an immediate, coherent, and viable long-term strategy toward a vision of replacing petroleum as its primary energy source in order to maintain all necessary strategic and operational capability for US security to 2050 and beyond.

The three-part approach begins in the first section by scoping the dimensions of the American energy security problem to create a sense of urgency. It continues in second section by examining the method in which an assured energy-guiding coalition and a DoD grand energy vision can be formulated within the context of the specific security responsibilities and desired capabilities of the DoD, as well as responsibilities of the DoE. The methodology finishes in the third section by highlighting the process by which a grand strategy can be developed that supports a new DoD energy vision. While there are a multitude of possible and competing DoD energy visions suitable for separate debate, the analysis in this article is accomplished under the structure of a conceptual three-phase hydrogen- and electric-based military transformation strategy that supports a 2050 post-petroleum vision aligned with President Bush's State of the Union goals.

If the above methodology demonstrates a feasible approach for guiding the DoD energy transformation to serve the Department's own requirements, it can then be argued that the lessons learned and knowledge gained from such an endeavor could be applied toward a larger national energy transformation. The DoD-to-civilian transition model has been successfully applied in other major societal changes to include racial integration, sexual equality, and the benefits of networked-based information sharing (Arpanet/Internet) to highlight a few. The creation of a broadly supported post-petroleum DoD vision and transformation strategy could not only preserve a relevant military force, but also lead a positive, bipartisan, interagency, and economic demonstration for preserving American security overall.

Creating a Sense of Urgency

The world is fast approaching the inevitable peaking of conventional oil production…(a problem) unlike any yet faced by the modern industrialized society.

—Feb 2005 DoE Report, Washington, DC[13]

The Big Picture

Two hundred million years ago the foundations of modern civilization were laid. Not only was it the evolution of man that gave us our world as we know it today, but also the life, death, and decay of nondescript vegetation, creatures, and microbes that would eventually become the 2 trillion barrels of crude oil man discovered and harnessed to write his modern history.[15] How does one visualize 2 trillion barrels? Simple—the 76 cubic miles of oil man has ever discovered would fill a single tank just 5 miles across and less than 4 miles high—hardly the *Great Lakes* worth of oil that many may have imagined the Earth's petroleum reserves to be. That 5-mile tank would fit nicely inside the 10-mile boundaries of Washington, DC and rise to an altitude of just 20,500 feet—an elevation equal to half of a typical passenger jet's cruising altitude, or no more than 37 Washington Monuments (555 feet each) stacked one atop another (see Figure 1). Now consider the most dramatic visualization: based upon a widely accepted model of peak oil

Article Highlights

illustrate the incremental issues that will likely present themselves in a wholesale energy transformation. Stage I (2006–2020) includes undertaking conservation, efficiency, acquisition, and organizational reforms; the development of bridging energies; massive research and development (R&D) efforts; the establishment of *new energy* standards; and identification of a primary alternate energy source most likely to be some combination of electricity and hydrogen produced from a variety of sources. Stage II (2020–2035) focuses on adjusting force structure, adjusting operational and training procedures, and creating a distributed energy infrastructure and technology transition in a modular fashion. Stage III (2035–2050) involves finishing infrastructure conversion; ensuring adequate, distributed, and ubiquitous energy production; and a continuation of R&D energy efforts.

Article Acronyms

AEI - Advanced Energy Initiative
ARPA-E - Advanced Research Project Agency-Energy
DARPA - Defense Advanced Research Projects Agency
DESC - Defense Energy Support Center
DoD - Department of Defense
DoE - Department of Energy
DSB - Defense Science Board
EIA - Energy Information Agency
EPFO - Energy Power and Fuels Office
EPTI - Energy and Power Technologies Initiative
FT - Fischer-Trophsch
ISR - Imagery, Surveillance, and Reconnaissance
LED - Light-Emitting Diode
KPP - Key Performance Parameters
NAS - National Academy of Sciences
NDS - National Defense Strategy
NRAC - Naval Research Advisory Committee
NSS - National Security Strategy
O&M - Operations and Maintenance
OPEC - Organization of Petroleum Exporting Countries
OSD - Office of the Secretary of Defense
PPBS - Planning, Programming, and Budgeting System
QDR - Quadrennial Defense Review
R&D - Research and Development
USD - Under Secretary of Defense

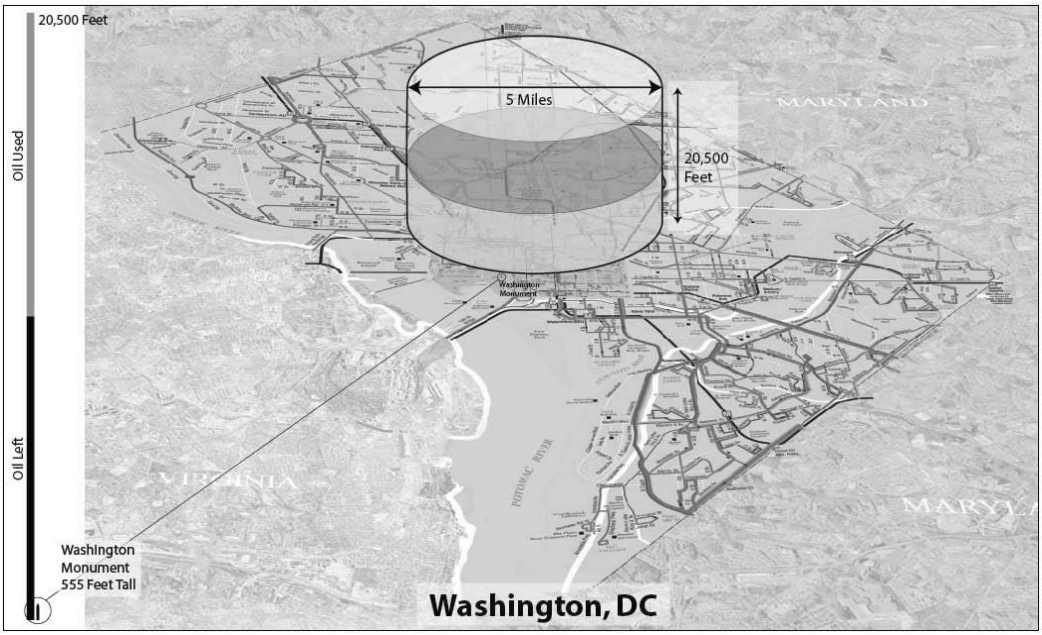

Figure 1. The *Big Picture*[14]

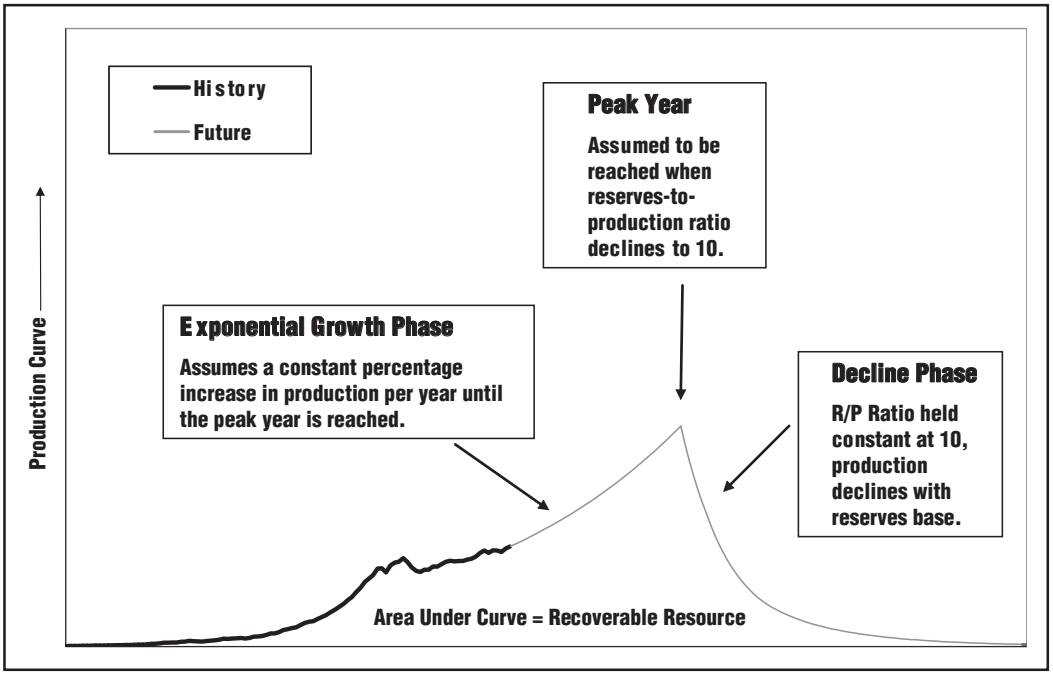

Figure 2. EIA's Model for Conventional Oil Resources [17]

Top 10 Petroleum Producers				
Rank	Country	M bbl/Day Produce	M bbl/Day Export	% World
1	Saudi Arabia	10.4	8.7	12
2	Russia	9.3	6.7	11
3	United States	8.7	-	10
4	Iran	3.8	2.6	5
5	Mexico	3.6	1.8	4
6	China	3.2	-	4
7	Norway	3.2	2.9	4
8	Canada	3.1	<1.0	4
9	Venezuela	3.1	2.4	4
10	UAE	2.8	2.3	3

Table 1A. 2004 Top 10 Petroleum Producers[22]

production known as Hubbert's Peak, many world petroleum geologists believe that by 2020 traditional global oil production will reach a maximum,[16] followed by a predictable and potentially very rapid decline as depicted by the Department of Energy's Energy Information Agency (EIA) in Figure 2.

Complicating the matter is a lack of professional consensus on the actual expected date of global peak oil production, with credible organizations such as ExxonMobil predicting that the non-OPEC (Organization of Petroleum Exporting Countries) Hubbert's Peak will arrive within 5 years,[18] and the US government claiming the planet's absolute peak will occur somewhere around 2037, the midpoint of an officially estimated 45-year window (see Figure 3).

What cannot be disputed is that since the first drop of oil was discovered in 1859, 920 billion[20] of the Earth's 2.001 trillion barrels[21] in proven conventional petroleum have been consumed with activities such as building homes, growing food, producing plastic packaging, creating industries, running to the corner video rental store, and waging wars. There is now only one question left to answer—with a depth of only 20 Washington Monument-equivalents left, is the tank that remains half full, or is it half empty?

Global Oil Supply and Demand

Each day mankind consumes approximately 84 million barrels of oil exchanged through a global commodities market that maintains a supply and demand equilibrium through the fluctuations of a single trade price.[23] An immediate observation from Tables 1A and 1B is that Saudi Arabia and Russia occupy the number 1 and number 2 producer positions ahead of the United States, and that of the top 10 producer countries listed, only Mexico, Norway, and Canada can be considered strategically reliable sources for the US. Furthermore, among the major consumers, only Russia, Canada, and Brazil are petroleum self-sufficient. This imbalance highlights the fact that the majority of nations rely upon some form of petroleum imports to

Top 10 Petroleum Consumers				
Rank	Country	M bbl/d	M bbl/Day Import	% World
1	United States	20.7	12.1	24
2	China	6.5	2.9	8
3	Japan	5.4	5.3	6
4	Germany	2.6	2.4	3
5	Russia	2.6	-	3
6	India	2.3	1.5	3
7	Canada	2.3	-	3
8	Brazil	2.2	-	3
9	South Korea	2.1	2.1	3
10	France	2.0	1.9	2

Table 1B. Top 10 Petroleum Consumers[22]

Rank	Country	Crude Oil	Products	Total
1	Canada	1,616	522	2,138
2	Mexico	1,598	66	1,665
3	Saudi Arabia	1,495	63	1,558
4	Venezuela	1,297	258	1,554
5	Nigeria	1,078	62	1,140
6	Iraq	655	1	656
7	Algeria	215	237	452
8	United Kingdom	238	142	380
9	Virgin Islands	0	330	330
10	Angola	306	10	316
11	Russia	158	140	298
12	Kuwait	241	9	250
13	Ecuador	232	13	245
14	Norway	143	101	244
15	Colombia	142	34	176
	Total	**10,088**	**3,057**	**13,145**
	Persian Gulf	2,400	93	2,493

Table 2. Top Suppliers of US Crude Oil and Petroleum, 2004 (Thousand Barrels per Day)[25]

satisfy domestic energy needs; for example, the US imports 53 percent of daily demand (25 percent of which comes from OPEC, with 60 percent of that amount imported from Saudi Arabia), China 44 percent, Germany 93 percent, and Japan, South Korea, and France import virtually all of their oil.[24] The top 15 US oil suppliers are shown in Table 2.

While the US is the third leading oil producer, it does not enjoy a podium position when it comes to known oil reserves—a much greater measure of long-term energy vulnerability. Figure 4 depicts global oil reserve distribution. Canada's 178 billion barrels include 4.3 billion barrels of conventional crude and 174 billion barrels of synthetic oil to be potentially derived from tar sands.[26]

Saudi Arabia's 262 billion barrels, together with OPEC's additional 449-plus billion barrels, represent 68-plus percent of known oil reserves.[28] Russia, Venezuela, and Nigeria together control the next major share, at 14 percent.[29] What this means for the US, which possesses only 2 percent of the world's reserves (including Alaska National Wildlife Reserves), is that if it were forced to consume only domestic oil starting tomorrow, pumping the additional 4 billion barrels a year over current levels would deplete the country's supplies within 4 to 5 years.[30] Most of America's declared allies would last only months on internal reserves. The simple consequence is that because Western economies depend on foreign oil, today the US and its

Published	By	Peak Year/Range	Published	By	Peak Year/Range
1972	ESSO	About 2000	1999	Parker	2040
1972	UN	By 2000	2000	Bartlett	2004 or 2019
1974	Hubbert	1991-2000	2000	Duncan	2006
1976	UKDOE	About 2000	2000	US DoE/EIA	2021-2167; 2037 most likely
1977	Hubbert	1996	2000	IEA (WEO)	Beyond 2020
1977	Ehrlich, et al.	2000	2001	Deffeyes	2003-2008
1979	Shell	Plateau by 2004	2001	Goodstein	2007
1981	World Bank	Plateau by 2004	2001	Smith	2010
1985	Bookout	2020	2002	Campbell	2010
1989	Campbell	1989	2002	Cavallo	2025-2028
1994	Ivanhoe	OPEC Plateau 2000-2050	2003	Greene, et al.	2020-2050
1995	Petroconsultants	2005	2003	Laherrere	2010-2020
1997	Ivanhoe	2010	2003	Lynch	No visible peak
1997	Edwards	2020	2003	Shell	After 20205
1998	IEA (WEO)	2014	2003	Simmons	2007-2009
1998	Campbell Leherrere	2004	2004	Bakhitari	2006-2007
1999	Campbell	2010	2004	CERA	After 2020
1999	Odell	2060	2004	PFC Energy	2015-2020

Figure 3. Thirty-Six Estimates of the Time of Peak World Oil Production[19]

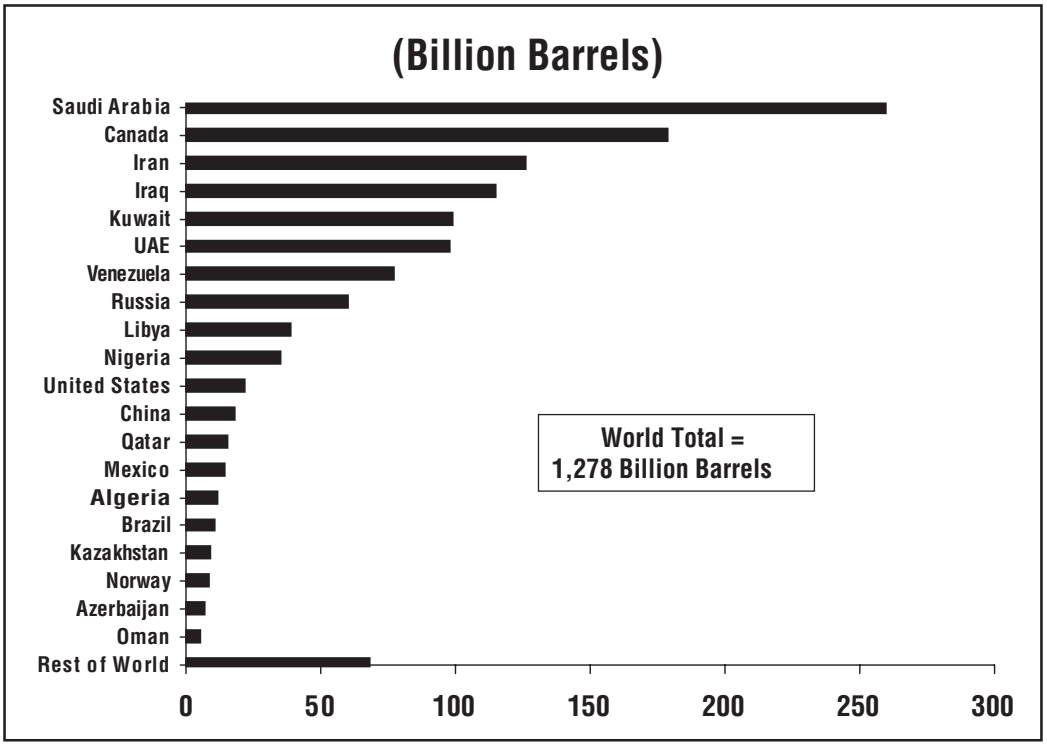

Figure 4. Proven World Oil Reserves[27]

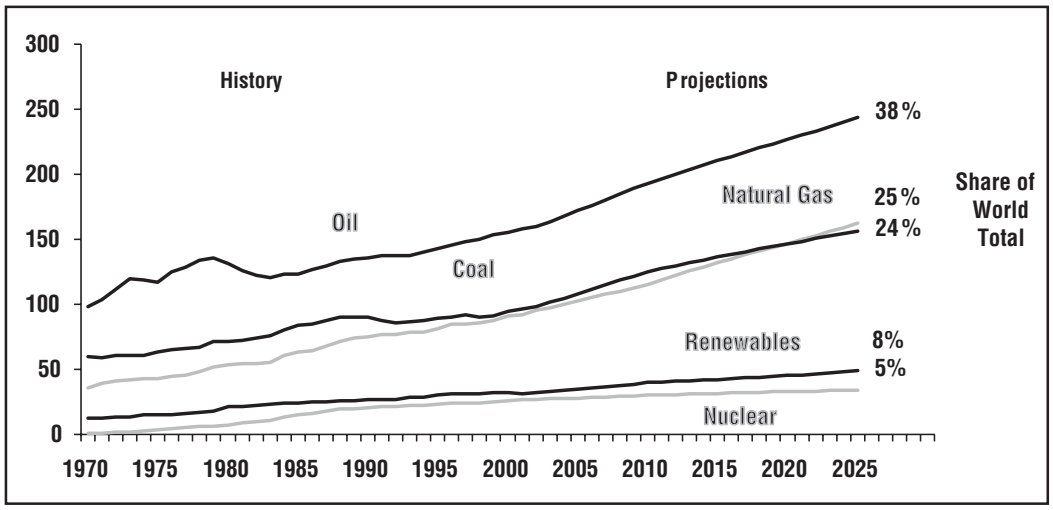

Figure 5. Worldwide Energy Consumption by Fuel Type[36]

allies cannot unilaterally control their own economic and physical securities.

Global reserve figures fluctuate with the discovery of new oil fields and extraction technologies—an activity directly related to the profitability of each barrel of oil. Easily discovered and recovered oil is produced first, while more difficult sites are only identified or developed when technically and financially feasible. This basic condition leads to a reduction in discoveries over time. The fact that 80 percent of today's oil reserves were discovered before 1973 supports this simple model.[31] Additionally, reserves are being depleted at three times the discovery rate,[32] and since 2000 the cost of finding and developing new oil sources has risen about 15 percent annually.[33]

Possessing accurate international reserve data is extremely important in the development of national security strategy—it defines acceptable near- and long-term energy dependence risks, international relationships, and economic and military structures for each nation on Earth. Herein lies great uncertainty, in that many countries withhold reserve information or may actually inflate values to obtain economic or diplomatic leverage. The obvious conclusion is that public world oil reserve prediction is both an imprecise art and a science, encouraging prudence when it comes to performing national security calculations.

Reserve data itself only becomes meaningful when applied against projected consumption rates (see Figure 5). DoE's EIA tracks, analyzes, and predicts global energy supply and demand. EIA administrator Guy Caruso predicted that,

> Worldwide energy consumption will grow by 57 percent between 2002 and 2025, at an average annual growth rate of 2 percent, with the strongest growth in the emerging economies, particularly in Asia.[34] World oil demand will grow from 78 to 119 million barrels per day, with the United States and emerging Asia, including China and India, accounting for 64 percent of the growth.[35]

As a result of globalization, the ability of individuals in emerging economies (such as China) to rapidly improve their quality of life has exploded in the last 10 years. This trend, when combined with projected population growth patterns, reveals a first-of-its-kind event in human history. Emerging economies will overtake the energy needs of economically mature and transitional economies (such as former Communist countries) by 2020, with potentially profound sociopolitical consequences for the world (see Figure 6).

Energy Implications for America

This type of mushrooming, emerging-economy demand elevates prices and precisely collides with a growing US demand for imported oil. US demand is expected to grow by 37 percent (1.5 percent per year) in the next 20 years to a total of 27.9 million barrels per day in 2025, at which point the nation will be importing 68 percent of its oil.[38] The EIA chart in Figure 7 most clearly illustrates America's expected oil future.

What are the consequences of this situation for the US military? First, as the world's largest single oil consumer, the

DoD will pay significantly more to sustain its daily operations. Whereas the temporary 1973 and 1980 energy crises were politically motivated, OPEC-engineered supply shortages that self-corrected after world demand constricted and non-OPEC suppliers expanded production, the 2005 energy situation appears semipermanent, with global demand essentially equaling available global production capacity. EIA reported that, in 2005, surplus global oil production capacity was only 1.5 million barrels per day, less than 2 percent above the daily 84 million barrels/day demand.[40] Consequently, Goldman Sachs expects oil to remain at $60-plus a barrel for at least the next 5 years—indicating that a new oil equilibrium in world oil prices has been reached.[41] Acute regional crises such as another Gulf Coast Katrina-style weather event, a terrorist destruction of the 5 million barrels per day Saudi Ras Tanura petroleum processing facility,[42] or a UN-sponsored embargo of Iran could also temporarily drive the price of oil to as high as $131 per barrel, according to Mr. Zarocostas.[43] The second and greater significance of a permanently tightening global energy market is that, precisely when the energy cost of national security is rising, by 2025 the DoD's activities and America's foreign policy could be ever more dictated by the requirement to secure the 68-plus percent share of oil it needs to acquire internationally.

The simple fact is that America's (and the world's) economic and physical health are dependent upon a fragile oil lifeline. While this system is so distributed that it would be virtually impossible to ever destroy it in its entirety, the evaporation of excess global production capacity in the past decade ensures that any major disruption (2 million barrels per day or more) in one area, cannot be compensated for by increasing production in another. It is important to understand how the US economy and military depend upon oil so that when shortages do occur, military leaders are knowledgeable about the challenges they will face.

The major end use for oil in the US should be a surprise for no one—transportation. Figure 8 from *Winning the Oil Endgame* best describes this situation. In 2000, America consumed approximately two-thirds of its 19.7 million barrels of oil per day for all forms of transportation—by 2025 this percentage is expected rise to 73 percent of a total 28.3 million barrels per day consumption rate (see Figure 9).[44]

These statistics reinforce the observation that it is difficult to replace petroleum-based fuels as a source of mobility for American society—the combination of relatively low production cost and high energy density make it very attractive for this purpose. Mobility allowed America to take advantage of its natural resources, entrepreneurial spirit, and intellectual capacity to become the world's economic and military leader. In addition to transportation uses, the remaining one-third of petroleum powers America's industrial engine, heats and electrifies its buildings, and most importantly, forms the industrial feedstock to produce a wide variety of organic compounds, the most significant of which is the family of plastics and fertilizers.

DoD Energy Dependencies

In addition to the direct consumption of petroleum to power combat systems, there are four under-recognized DoD petroleum dependencies.

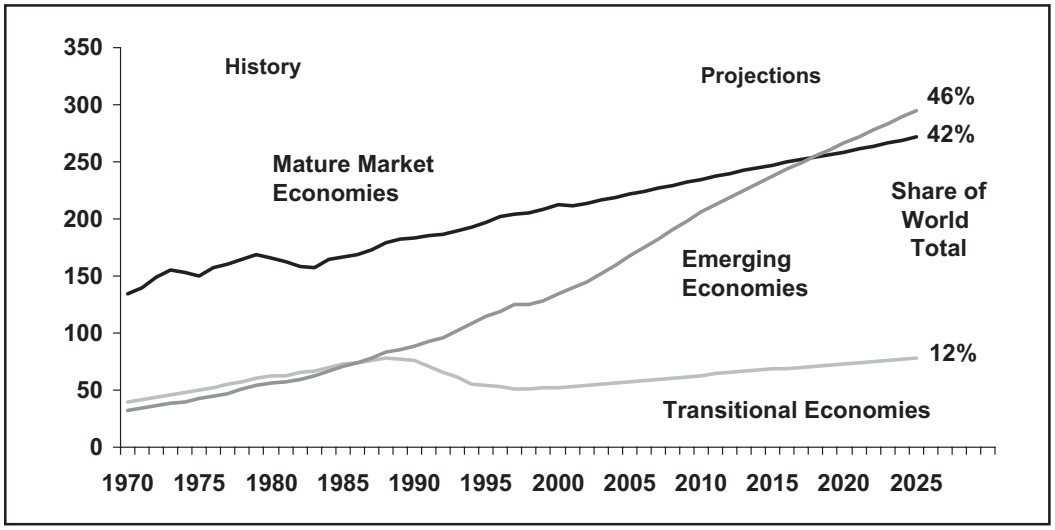

Figure 6. World Energy Consumption by Region[37]

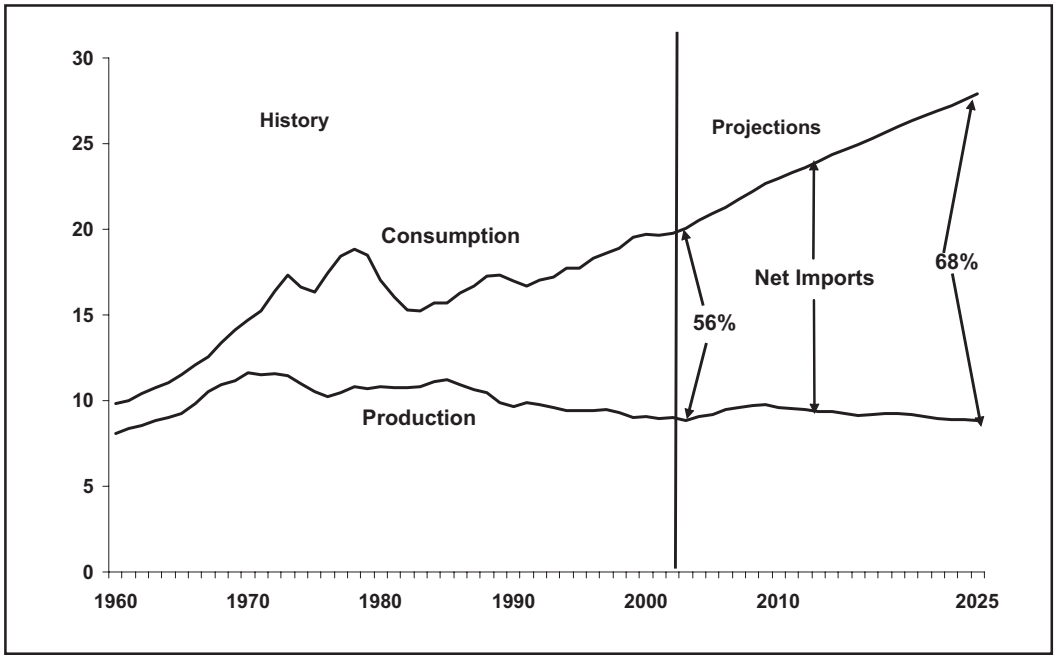

Figure 7. US Petroleum Supply, Consumption, and Imports[39]

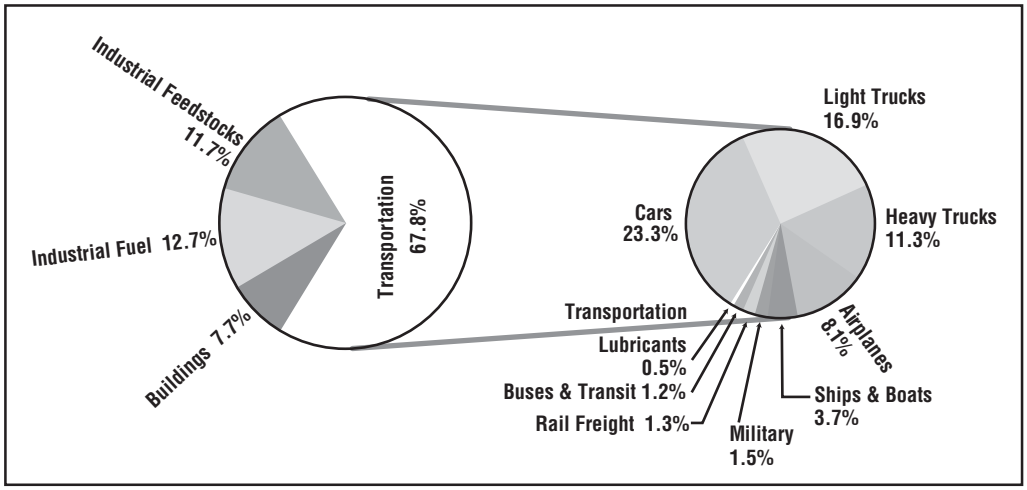

Figure 8. 2000 US Oil End Use [45]

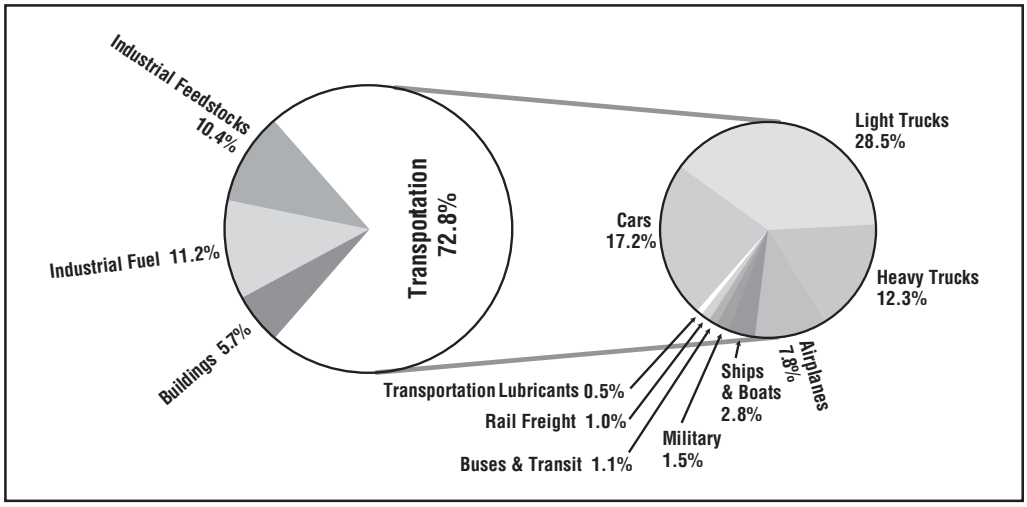

Figure 9. 2025 US Oil End Use[46]

- Military industrial supply
- Contractor support
- Commercial logistics
- Installation requirements

While studying DoD petroleum dependencies, most policymakers and analysts will focus on the 1.8 percent of national petroleum consumption directly used by the DoD (94 percent of which is for mobility and transportation).[47] This approach ignores the indirect dependencies of a highly intertwined military-industrial complex necessary for modern high-technology warfare. While it may be virtually impossible to quantify and categorize the amount of petroleum specifically required to create and support every activity or procured end item within the DoD, the fact that the DoD relies upon an industrial base for medical syringes, M-16s, and C-17 parts serves to illustrate that the DoD is just as reliant upon petroleum-fueled civilian and governmental institutions as the rest of American society. Recognizing the fact that fueling national defense goes beyond just the direct use of petroleum by armed forces and into a much deeper supply chain dependency is fundamental to understanding the vulnerability of America's security to strategic petroleum supply disruptions or declines. This military/industrial dependency necessarily links civilian and military future energy solutions.

The second under-recognized DoD petroleum dependency exists in the realm of increasingly ubiquitous contractor support. The DoD relies upon service contractors to fulfill a broad spectrum of requirements ranging from base maintenance to military interrogations. With the exception of DoD-provided combat zone fuel, the vast majority of DoD service contracts expect the contractor to independently acquire all fuels necessary to fulfill his obligations. These requirements are not represented on DoD total fuel tally sheets, and represent a potential problem for military leaders should their contractors ever be unable to purchase fuel during a strategic or even operational energy shortage or crisis.

The third under-recognized DoD petroleum dependency is in commercial logistics. The DoD possesses one of the greatest organic mobility fleets in the world, for which the Defense Energy Support Center (DESC) and Service fuel managers diligently supply and track fuel usage. What is often ignored in determining total national security energy requirements, however, is the fuel required to transport military supply chain materials within the industrial production cycle and then from the factory to the point of military possession. Similarly, fuel used by contract commercial air carriers, Civil Reserve Air Fleet participants, and oceanic shippers to shuttle DoD personnel and material to and from deployments or on routine business does not receive an entry on military fuel balance sheets. While it is virtually impossible to precisely tabulate the amount of transportation fuel used by the civilian sector to support the DoD, it is accurate to say that some non-negligible civilian portion of the 67.8 percent of US oil used for transportation in Figures 8 and 9 is used to directly or indirectly support DoD operations.

The final under-recognized defense petroleum dependency is in installation requirements. While most permanent US military installations rely upon commercially purchased coal- or natural gas-fueled electricity or heat, expeditionary bases rely upon petroleum-fueled organic power production because of their temporary nature and high security requirements. Today's increasingly electrified forces demand large quantities of uninterruptible power to support critical garrison, command and control, and expeditionary functions. Even where reliably safe commercial electrical power is available in the US, mission-

critical functions utilize diesel back-up generators to guarantee uninterrupted power. The implication then is that any DoD future energy strategy must also address how to provide installation power in a petroleum-constrained environment, whether it is in an austere forward deployed location, or in the US after a natural gas *Hubbert's Peak* (EIA expects US domestic natural gas production to peak in 2015).[48] As will be discussed later in this article, the similarities between permanent base energy requirements and their civilian institutional counterparts provide the DoD with a double opportunity to immediately leverage commercial advances against installation energy vulnerabilities and then to apply this same process toward solving more demanding expeditionary base energy vulnerabilities.

Having explored the four under-recognized forms of DoD petroleum dependence and vulnerability, the more obvious question can now be asked, "how much and in what way does DoD depend upon petroleum to directly complete its combat mission?" Few would disagree that combat is one of the most energy intense activities known to man. The military depends on oil to provide agility, global power projection, and focused logistics.[49] It must also be able to rapidly produce and sustain these effects in maximum performance scenarios, under broad climate extremes, and in hostile fire situations—criteria for which petroleum fuels are typically well suited. The two most recent US military operations serve as perfect examples of the fuel required to sustain decisive combat activities. In its Fiscal Year 2004 Fact Book, the Defense Energy Support Center (DESC) reports that between October 2001 and September 2003, Operation Enduring Freedom required 2.6 million gallons (61,500 barrels) of fuel a day. Between March 2003 and September 2004, Operation Iraqi Freedom consumed 1.06 million gallons (25,300 barrels) per day.[50]

Reviews of American military doctrine over the last 60 years reveal a heavy emphasis on airpower as either a stand-alone strategic instrument, or as a complement to ground forces that can gain, achieve, and then exploit air superiority to maximize terrestrial opportunities. Airpower leverages inherent surprise, maneuverability, mobility, and the ability to amass firepower to overwhelm an enemy, and reduce the risk to one's own forces. This American-perfected and synergistic air-land dominance comes at a great energy cost. By studying the DESC *FY04 Fact Book*, one can identify some force structure vulnerabilities that would quickly manifest themselves, should the US military ever find itself in a strategically or operationally constrained petroleum environment. The first clue can be found in the breakdown of total fuels used in DoD. Accounting for $5B of the Department's $437B FY04 budget, DESC procured 134 million barrels of liquid fuel (370,000 barrels per day), of which 75 percent (101 million barrels) were some form of aviation fuel (JP-4, JP-5, JP-8, or Jet A).[51]

By combining the Air Force's $2,841M bill with the $722M JP-5 portion of the Navy's $1,627M bill,[53] and other smaller Army and Marine Corps amounts, Table 3 reveals that in fact 75 percent of the DoD's petroleum purchases went to fuel aircraft and some ships, with the Air Force accounting for 57 percent of the total DoD bill in FY04.[54] Deeper analysis reveals that of the Air Force's $2.8B aviation fuel bill, 54 percent went to mobility air forces, 38 percent went to combat air forces, and the remaining 8 percent was consumed by aircrew training and other aviation operations.[55] The fact that 8 of 10 entries on DESC's list of Top Ten Customers for FY04 are air mobility bases[56] seemingly confirms that air mobility (airlift and air refueling) is the single most petroleum-intense activity within the DoD, making focused logistics and dominant maneuver the most energy-vulnerable dimensions within the DoD's vision of full spectrum dominance for *Joint Vision 2025*.

It is at this point that operational commanders and future force planners should take note of the petroleum dependencies of their systems and contemplate the loss of combat power or force multipliers during hypothetical conditions of extreme fuel constraint (conceivably created by asymmetrical attack, large-scale fuel contamination, or limited future global availability). Taking a quick scroll through today's weapon systems inventory, it is not unreasonable to visualize that in the hypothetically extreme case of 100 percent expeditionary fuel nonavailability, only nuclear submarines (nuclear aircraft carriers are relatively useless without jet fuel), missile forces, space forces, cyber forces, and certain self-sufficient special operations forces could likely operate in a petroleum-free environment. In the case of a 75 percent severely constrained petroleum environment, perhaps only light infantry that could *live off the land* would be persistent. In a 50 percent, medium-fuel-constrained environment, sea shipping, light-medium ground forces, and some limited range combat air support might be available. In a 25 percent, mildly constrained-fuel environment, the greatest shortfall would likely be in air mobility, followed by combat air support (a potential issue for a US Army that has committed to reducing field artillery in exchange for reliance on air power to provide indirect fire effects). The only way to be scientifically confident of the impact that various levels of fuel constraint would place upon US operational forces would be to conduct a purpose-built modeling simulation that specifically asks this question—an endeavor that sources, polled by this author, indicate has not yet occurred[57]. This capabilities drill demonstrates that the effectiveness of necessary *JV2025* dominant maneuver, focused logistics, precision engagement, full dimension protection, and information security concepts will be dependent upon the force structure and energy security decisions DoD policymakers elect to make today.

The National Security Strategy

Before setting out to create a future energy vision and strategy for the DoD, it is important to understand America's vision for its future security and credible threats to it, develop the best grand strategy to counter those threats, and then analyze how dependent that strategy is upon known and projected energy supplies so that adjustments can be made if necessary. The National Security Strategy (NSS) is the President's cornerstone document for articulating America's perceived threats and how he expects to protect the nation's interests. The NSS provides broad strategy for both near- and long-term threats, while

Service	Air Force	US Navy	US Army	US Marine Corps
Fuel Purchased ($ millions)	$2,841	$1,627	$440	$23

Table 3. FY04 DoD Fuel Purchases by Service[52]

enabling subordinate documents such as the DoD's *National Defense Strategy* (NDS) and the Chairman of the Joint Chiefs of Staff's National Military Strategy to identify ever more detailed approaches for converting strategy into actionable security. Examining these documents provides a framework within which to study America's future defense requirements and how they relate to the subject of assured energy.

In his NSS President Bush acknowledges that, [58]

> Defending our Nation against its enemies is the first and fundamental commitment of the Federal Government. Today, that task has changed dramatically. Enemies in the past needed great armies and great industrial capabilities to endanger America. Now, shadowy networks of individuals can bring great chaos and suffering to our shores for less than it costs to purchase a single tank. Terrorists are organized to penetrate open societies and to turn the power of modern technologies against us.[59]

> America is now threatened less by conquering states than we are by failing ones. We are menaced less by fleets and armies than by catastrophic technologies in the hands of the embittered few. We must defeat these threats to our Nation, allies, and friends.[60]

> We are guided by the conviction that no nation can build a safer, better world alone. The United States is committed to lasting institutions like the United Nations, the World Trade Organization, the Organization of American States, and the North Atlantic Treaty Organization, as well as other long-standing alliances.

To achieve the goals of political and economic freedom, peaceful relations with other states, and respect for human dignity, the strategy of the United States is to: [61]

- Champion aspirations for human dignity
- Strengthen alliances to defeat global terrorism and work to prevent attacks against us and our friends
- Work with others to defuse regional conflicts
- Prevent our enemies from threatening us, our allies, and our friends, with weapons of mass destruction
- Ignite a new era of global economic growth through free markets and free trade
- Expand the circle of development by opening societies and building the infrastructure of democracy
- Develop agendas for cooperative action with other main centers of global power
- Transform America's national security institutions to meet the challenges and opportunities of the twenty-first century

These NSS excerpts imply the following tasks for the DoD:

- Be prepared to cooperate with friends and allies to prevent weapons of mass destruction or other attacks
- Be prepared to help diffuse regional conflicts
- Protect the foundations of free markets and trade
- Be prepared to transform to meet the challenges and opportunities of the 21st century

In essence, these strategic defense responsibilities become the DoD's mission—how well these tasks are accomplished becomes the standard of performance against which any present or future force will be measured, regardless of whether it is petroleum or alternatively fueled. It is an ongoing responsibility of force structure planners to create a capable and relevant force not only for today, but to 2050 and beyond.

Before creating a defense energy strategy from the NSS, it would also be prudent to incorporate the President's guidance with regard to strategic energy security. On this matter the NSS states:[62]

> We will strengthen our own energy security and the shared prosperity of the global economy by working with our allies, trading partners, and energy producers to expand the sources and types of global energy supplied, especially in the Western Hemisphere, Africa, Central Asia, and the Caspian region. We will also continue to work with our partners to develop cleaner and more energy-efficient technologies.

And under the strategy for reducing carbon dioxide emissions to slow global warming, the NSS promotes: [63]

- Renewable energy production and clean coal technology, as well as nuclear power—which produces no greenhouse gas emissions, while also improving fuel economy for US cars and trucks
- Increasing spending on research and new conservation technologies, to a total of $4.5B—the largest sum being spent on climate change by any country in the world and a $700M increase over last year's budget

While the NSS does not appear to directly discuss the risk of a growing reliance on increasingly scarce foreign energy, the President's 2006 State of the Union Address updates this concept by elevating the security imperative of eliminating foreign energy dependence.[64]

The National Defense Strategy

The DoD is the primary organization charged with ensuring America's external physical security. The Secretary of Defense translates the President's NSS into a National Defense Strategy that guides DoD thought and action. The DoD's specific strategic objectives, as outlined in the NDS, are as follows.

- Secure the US from direct attack
- Secure strategic access and retain global freedom of action
- Strengthen alliances and partnerships
- Establish favorable security conditions[65]

Force structure builders recognize that securing the US from direct attack requires possessing the means to do the following.

- Gather superior intelligence
- Deter and defend against identified threats
- Ensure uncontested movement on the seas, in the air, in space, and cyberspace
- Provide material assistance
- Directly aid a threatened friend while simultaneously satisfying the first two requirements
- Respond rapidly to world developments

To accomplish the objectives of assuring allies and friends, dissuading potential adversaries, deterring aggression and countering coercion, and defeating adversaries when necessary, the NDS implementation guidelines advocate the use of an active and layered defense, continuous transformation, a capabilities approach, and risk management to guarantee success.[66] This strategy is built upon several important assumptions.[67]

- The US will retain a resilient network of alliances and partnerships.
- The US will have no global peer competitor and will remain unmatched in traditional military capability.
- The US will maintain important advantages in other elements of national power, such as political, economic, technological, and cultural.
- The US's capacity to address global security concerns alone will be insufficient.
- Natural forces of inertia and resistance to change will constrain military transformation.

The NDS unequivocally states that the US cannot achieve its defense objectives alone—the concept of active, layered defense includes international partners.[68] This admission and the assumption that the US will work through a network of alliances and partnerships necessarily dictates that any national defense and energy analysis must include the energy limitations or strengths of those aligned nations, many of which are significantly worse off than the US.

The US also assumes no current global peer competitor or traditional military equal. This is certainly the case in 2006, but it would be foolish to assume the same for 2050 since the US cannot unilaterally control the power rise of every nation on Earth—it can only control the level of effort it will expend to maintain its sole superpower position. Since superpowers typically seek to maintain their strength through various forms of innovation,[69] it is not unreasonable to assume the presence of technological advantages for the US—however, it is an assumption that can only be made if one also expects the rate of American innovation to exceed that of security competitors—another security concern raised by President Bush in his 2006 State of the Union Address.[70] Finally, the NDS strategy correctly recognizes that institutional inertia will act to resist the NSS's guidance to transform ahead of emerging threats.

Based on these assumptions, the NDS strategy for achieving an active, layered defense is to possess several key operational capabilities.[71]

- Protect critical bases of operation
- Operate from the global commons
- Project and sustain forces in distant, anti-access environments
- Improve proficiency against irregular challenges
- Increase capabilities of partners, international and domestic

These capabilities must exist so that when deterrence fails or efforts short of military action do not forestall gathering threats, the US can employ military power with other instruments of national power to *swiftly defeat* adversaries and achieve decisive, enduring results.[72] In all cases the DoD plans to *seize the initiative and dictate the tempo, timing, and direction* of military operations.[73] Operational experience since 1990 also indicates that the DoD should no longer expect to fight in place, but rather it should *plan to surge from a global posture* to respond to crises.[74] The DoD's goal is to develop greater flexibility to contend with uncertainty by emphasizing agility and by not concentrating military forces in a few locations.[75] The US sees itself operating with *increasingly rotational forces* in four forward regions: Europe, Northeast Asia, East Asian Littoral, and Middle East-Southwest Asia.[76]

Using words such as *swiftly defeat*, *seize the initiative*, *surge from a global posture*, *emphasizing agility*, and *increasingly rotational forces* indicates that the US defense strategy relies heavily upon high-energy strategic mobility and operational and tactical maneuverability. The conclusion that can be drawn from this NSS and NDS review is that, to remain secure, the US will need to be both proactively engaged and ready to respond globally on a moment's notice against the full spectrum of threats—including nonwarfare events such as humanitarian crises and natural disasters. In 2006 the military capabilities providing this security are powered predominantly by liquid petroleum fuels. Acknowledging an uncertain global petroleum future and the uniquely energy-intense nature of modern warfare, the question then becomes, "How does the US envision the military force of 2050 to be reliably fueled and configured to provide the security America requires?"

Developing a Guiding Coalition and an Assured Energy Vision

By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy, and make our dependence on Middle Eastern oil a thing of the past.

—President George W. Bush,
2006 State of the Union Address[77]

Leading Change

In his popular book, *Leading Change*, renowned Harvard Business School professor John P. Kotter advocates an eight-step process for leading institutional change:[78]

- Establish a sense of urgency
- Create a guiding coalition
- Develop a vision and strategy
- Communicate the change vision
- Empower employees for broad-based action
- Generate short-term wins
- Consolidate gains and produce more change
- Anchor new approaches in the culture

Dr Kotter's approach would seem to indicate that a structure exists to guide successful organizational transformation. While all eight steps are fundamental for creating lasting change, this article seeks to consider only the first three—establishing a sense of urgency, creating a guiding coalition, and developing a vision and strategy—as a basis for answering the question of whether the DoD can lead a long-term energy conversion vision and strategy in order to remain relevant to 2050 and beyond.

The first section of this article was intended to highlight the type of data necessary for generating a sense of urgency within the minds of policy decisionmakers. Acquiring a sense of urgency regarding any problem is a personal event, something strategic leaders must individually develop based on their perception of how facts and trends within a particular context might combine to negatively affect an organization's goals. Without a basic belief by senior leadership that an organization's

fundamental mission is at risk, it is likely that little, if any, transformation will result, regardless of the organization.

Once a senior leader believes that his organization's mission is threatened and that corrective action is warranted, Kotter suggests that the next step is to form a guiding coalition that will develop a vision and a strategy toward a better future.[79] Building upon the previous chapter's presentation of energy data, NDS assumptions, and required key operational capabilities, this section examines a methodology in which senior defense leaders could conceptually assemble an effective guiding coalition responsible for creating the vision of defense energy transformation. According to Dr Kotter, the strong coalition is necessary:

> Because major change is so difficult to accomplish, a powerful force is required to sustain the process. No one individual, even a monarch-like leader, is ever able to develop the right vision, communicate it to large numbers of people, eliminate all of the obstacles, generate short-term wins, lead and manage dozens of change projects, and anchor new approaches deep in the organization's culture. A strong guiding coalition is always needed—one with the right composition, level of trust, and shared objective.[80]

Furthermore, building a coalition that can make change happen requires finding the right people, creating trust among them, and then allowing them to develop a common goal.[81] Bottom line: a guiding coalition must function as a championship team.

The first step in forming a winning assured energy team is to include representatives of the major elements inside and out of the DoD who would play a fundamental role or be fundamentally affected by an energy transformation. The list would include such easy choices as highly motivated strategic leaders in the operations, plans, and logistics communities, the science and technology research and development community, the acquisition community, and leaders of individual Service energy senior focus groups. Less obvious might be the public affairs community needed to effectively market an energy vision and transition strategy, the budget and programming community to advise and execute programming decisions, and representatives of key agencies such as the Department of Energy, the National Science Foundation, or the Environmental Protection Agency to provide specific expertise. These members would all serve in full-time positions, while additional expertise could be provided through outside consultations or partnerships with industry and academia.

Because of the potentially profound department-wide scope that an energy transformation could entail, and the typical institutional resistance to transformational change acknowledged in the first section's review of NDS assumptions, the guiding coalition would need to occupy a position of significant authority within the organization such that coalition decisions could be sufficiently respected and executed within all elements of the Department. Such authority is best exercised in close proximity to the strategic leader forming the guiding coalition, which in this case would mean an office no less than that of an undersecretary.

Creating the Office of Assured Energy

Proposing a high-level agency to lead energy transformation is not without precedence. In a December 2005 predecision proposal to Dr Theodore Barna, Assistant Deputy Undersecretary Defense/Advanced Systems and Concepts recommended that the DoD establish an Energy, Power, and Fuels Office (EPFO), composed of Service, OSD, and interagency representatives to lead a multifaceted approach (called the Assured Fuels Initiative) for military energy security focused primarily on synthetic fuels production.[82] This EPFO represents the type of *guiding coalition* that Dr Kotter recommends. However, by broadening the scope of Dr Barna's proposal beyond synthetic fuels to include all forms of military energy, it may be advantageous to elevate the EPFO synthetic fuels office that Dr Barna recommends into an all-encompassing DoD future energy guiding coalition, designated as the OSD *Office of Assured Energy*, or USD(AE). This permanent office, in cooperation with force structure developers, would possess the overarching mission and authority to lead a comprehensive 40-plus year DoD energy transformation strategy toward the vision of a petroleum-free combat force that is relevant to 2050 and beyond. With the full support of the Secretary, the President, and Congress, this new office would be the driving force for DoD cultural and physical change vertically down to the lowest level of the organization, while simultaneously ensuring that the DoD both provides and receives maximum horizontal interagency support to meet DoD objectives as part of a larger and more aggressive national energy independence agenda.

Expecting to create additional bureaucracy or another undersecretary position without institutional skepticism would be unrealistic. One of the loudest arguments would be that government energy leadership belongs in the hands of the $24B-a-year[83] DoE whose mission is "to advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission, and to ensure the environmental cleanup of the national nuclear weapons complex."[84] The energy security and scientific research strategic goals within the DoE's 2003 Strategic Plan include:

> **Goal 4. ENERGY SECURITY:** Improve energy security by developing technologies that foster a diverse supply of reliable, affordable, and environmentally sound energy by providing for reliable delivery of energy, guarding against energy emergencies, exploring advanced technologies that make a fundamental improvement in our mix of energy options, and improving energy efficiency.

> **Goal 5. WORLD-CLASS SCIENTIFIC RESEARCH CAPACITY:** Provide world-class scientific research capacity needed to: ensure the success of Department missions in national and energy security; advance the frontiers of knowledge in physical sciences and areas of biological, medical, environmental, and computational sciences; or provide world-class research facilities for the Nation's science enterprise.

Examination of these goals reveals that when it comes to energy, the DoE is an institution that focuses primarily on science and technology research and development (R&D). The department's affirmation that its principal tool for implementing policy is conducting high-risk, high-value energy R&D at 24 world-renowned national research laboratories and facilities that the private sector alone would not or could not develop in a market-driven economy confirms this observation.[85] For the DoD assured-energy strategists, it is important to realize that the DoE performs its mission for a broad national clientele, not just the DoD. In this context, DoE's natural focus and obligation is to

perform basic research with the broadest potential impact (further reinforced in the Energy Policy Act of 2005). It is then up to individuals, corporations, institutions, and governments to apply this newly acquired knowledge for the greatest national benefit in a free-market system. DoE makes this relationship very clear in its strategic plan:[86]

> It is the role of the federal government to promote competitive energy markets, not to choose the energy sources for the country, now or in the future. *The Department's aim is to assist the private sector where appropriate to develop technologies capable of providing a diverse supply of reliable, affordable energy, and environmentally sound energy, while protecting the environment* (emphasis added). Market forces, *influenced by these Federal investments and other policies such as tax incentives and environmental regulation* (emphasis added), will determine the supply mix that consumers choose.

The tremendous lead times needed to uniquely adjust military force structure, systems, and doctrine may prevent the DoD from waiting for market forces to shape an energy future. This obligates the DoD energy strategists to be keenly aware not only of the DoE's ongoing efforts, but also of expected energy advances so that institutional changes can be made early enough to guarantee required combat capabilities are protected before petroleum scarcity becomes an issue. Understanding this situation is key to understanding why the DoD must actively lead its own energy transformation. DoE can and will accelerate transformation technology development as rapidly as the President, Congress, and DoD resource, but in the end it will still be up to the DoD to acquire, deploy, and absorb the risk of not having the technologies necessary to complete an energy transformation before petroleum supplies become a critical concern. Considering this relationship between DoD and DoE, it can then be argued that establishing an Undersecretary of Defense for Assured Energy office would not only provide the appropriate organizational level to synergize transformation activities within the DoD, but would also be perfectly suited to facilitate the necessary interagency cooperation with DoE's Undersecretary of Science office, as created by the Energy Policy Act of 2005, to accelerate energy technology development.[87]

Assembling the right people is only the first part of creating a guiding coalition. The next two steps are to create trust and develop a common goal. Creating trust in a newly formed organization can be accomplished by dedicating the first several months, and up to the first year of the coalition's existence, to collectively gather information about DoD's multiple threats, required capabilities, energy vulnerabilities, and future concepts, while also gaining familiarity with international energy systems, alternate energy options, and anticipated problems to ensure that maximum knowledge is possessed prior to developing a post-petroleum vision and strategy. The daily immersion and interaction between members during this period can also be used to gradually reinforce the common goal of developing and executing the best energy strategy to ensure the US military remains effective and relevant to 2050 and beyond.

Create an Assured Energy Vision

Once formed into an effective guiding coalition, the Office of Assured Energy's first deliverable is to write the vision of an alternate energy future. The vision should refer to a picture of the future with commentary on why people should strive to create that future.[88] Good vision is imaginable, desirable, feasible, focused, flexible, and communicable, and serves three important purposes.

- By clarifying the general direction for change, it simplifies hundreds or thousands of more detailed decisions.
- It motivates people to take action in the right direction, even if the initial steps are personally painful.
- It helps coordinate the actions of different people, even thousands and thousands of individuals, in a remarkably fast and efficient way.[89]

By progressively moving backward in time from an effective vision of the future to the present day, the guiding coalition can then identify the milestones, tasks, and resources—the strategy—that will be necessary to create a petroleum-free military.

To frame the creation of an effective vision, the guiding coalition must possess a deep understanding of the threat it is trying to mitigate (loss of military effectiveness following Hubbert's Peak), the task for which the vision is being created (operationally executing America's NSS and NDS), and the options and resources (the means) that are reasonably available to construct the desired end state. The Office of Assured Energy's trust-building first year is designed to gather that knowledge. With recent advances in materials, biotechnical, and computational sciences, the technological solution set is building rapidly. Understanding the true pros and cons of each option may require significant objective learning on the part of each coalition member.

Today, the list of proven and most promising energy and technology options includes coal, natural gas, synthetic fuels, biofuels, nuclear power, hydroelectric power, wind power, solar power, oceanic power, hydrogen science, methane hydrates, material science and nanotechnology, fuel cell science, six-sigma concepts, and even enhanced use of petroleum. The scope of this article does not permit detailed descriptions of the identified emerging energy options. Only after understanding these energy sources and technologies, as well as the nation's defense and energy objectives, strategies, capabilities, and limitations, will the members of the Office of Assured Energy be ready to create an assured energy vision.

The visioning process can be lengthy and produce any number of possible outcomes, but for illustrative purposes, consider the following hypothetical proposal that is not only imaginable, desirable, feasible, focused, flexible, and communicable, but also aligns with the President's statements regarding a long-term national energy vision he sees for the United States:

The Vision – DoD Petroleum Independence by 2050

> In 2050 the Department of Defense is a highly effective, networked, interdependent, and dominant military force, protecting all required American and allied interests, powered almost exclusively by an electrical and hydrogen energy standard that is reliably, efficiently, securely, and environmentally produced in a distributed manner without the need for foreign sources of energy.

The above vision statement represents the potential for a tremendous paradigm shift in the way modern forces wage war. Food, fuel, and ammunition logistics constraints have vexed commanders as long as war has existed. Envision the logistically

unconstrained maneuver capabilities of a force that is purposely designed to be 50 percent more efficient than today's force and requires no physical ammunition resupply and only a fraction of the liquid fuels consumed by today's forces. A directed-energy-based, highly automated force, capable of generating a majority of its own power in a distributed fashion from local and environmental sources, could theoretically provide that future. The potential efficiency, environmental ubiquity, universality and convertibility from one form to another of this configuration, make strong arguments that the force of 2050 can be powered almost exclusively by electricity and hydrogen.

Setting aside conventional paradigms allows one to imagine a conceptual 2050 force. All Navy ships might employ nuclear-powered, direct-electric drives, lightweight nano-engineered hulls, and directed-energy armament. All Army and Marine Corps future combat system land vehicles (many of which are unmanned) are designed for modular upgrades with plug-in electric hybrid or fuel-cell power, lightweight carbon nanotube-based armor, and directed energy weaponry. Today's vulnerable tanker fuel trucks are replaced with smaller hybrid or fuel-cell powered trucks carrying stable, solid hydrate-based hydrogen batteries or combat safety-engineered liquid hydrogen containers. Individual soldiers are outfitted with pocket hydrogen fuel cells to power 10 to 15 onboard electric systems. Virtually all combat fighter aircraft are small, unmanned or single-seat, and powered by liquid or even nano-engineered, solid hydrogen-based fuels. Ultra-efficient aircraft designs eliminate the need for tanker aircraft. All imagery, surveillance, and reconnaissance (ISR) platforms are either space-based or unmanned vehicles, orbiting for weeks at a time exclusively on solar-generated power while peering through weather from above. Similar platforms, orbiting alongside ISR brethren, reflect friendly, ground-based, directed-energy fires on rapidly moving enemy forces or weapons. Expeditionary bases would generate most base-support power autonomously through a flexible menu of options best suited for the particular mission or environment. Choices could include truck-portable nuclear electric generation (for secure environments); waste-stream and local biomass biofuel production; portable wind generation; extensive solar energy systems; ocean thermal; solar photolysis or hydrocarbon-based hydrogen production; high-efficiency, thermoelectric waste-heat recovery; fuel cells; or quite simply, local electrical grid connection—whatever best suits the situation.

Every networked physical component within the 2050 force structure would possess low-power optical computing; very low-power LED lighting; nano-engineered, superconducting power transmission; whole-surface, thin-film solar panels; a modular construct to enable component upgradeability, and most importantly, all systems would use the same universal electrical standards to ensure interconnectivity. Most systems could recharge from an expeditionary base local power grid during nonactivity periods, but would also be capable of enhancing unit survivability and flexibility by using excess onboard power production to energize the unit grid or any other single force component if its primary means were rendered ineffective. Operational-level energy could be delivered from sea-based, nuclear powered, hydrogen production ships. Strategic energy augmentation from orbiting solar-generation satellites or space-based relay satellites linked to terrestrial continental United States generators could even be delivered via microwave to a suitably configured tactical receiver anywhere in the hemisphere.

While the envisioned force of 2050 may sound as if it is a Star Wars fantasy to some, imagine how the following vision statement may have sounded to the War Department in 1906:

> In 1950 the US military is a highly effective, mobile, and mutually supporting force, protecting all required American interests through dominant air, land, and sea operations powered by a petroleum energy standard that is reliably and economically produced from domestic sources.

Most of the horse-riding officers at the time would likely not have even imagined the aircraft carrier-, jet fighter-, and tank-based force America went to war with against North Korea 45 years later. The vision of a petroleum-independent military in 2050 is certainly imaginable, and virtually each of the systems concepts discussed has already been proven physically feasible, or at least theoretically so. Proposing a hydrogen-electric standard focuses all subsequent development activity into the framework of a purpose-designed force, while sufficient flexibility remains in the vision so as to not force specific solutions. Finally, the vision communicates a desirable future in which military effectiveness is preserved, but where security, efficiency, environmental consciousness, and energy independence are also achieved. It is clear that by eliminating the constraints of conventional paradigms in any problem-solving exercise, a potentially better, revolutionary future can be envisioned. Converting what exists today into the future of tomorrow is the realm of strategy. The following section examines how to develop the best strategy to create the vision of a petroleum-free Department of Defense.

Developing an Assured Energy Strategy

The magnitude of the DoD's fuel consumption indicates substantial changes must be made in the performance DoD requires of its future systems in order to achieve the goals of JV2010 and JV2020.

—Defense Science Board Task Force on Improving Fuel Efficiency in Weapons Platforms, OSD (AT&L), January 2001[90]

Building Strategy from a Vision

Forty-five years ago, on 25 May 1961, under the very real security threat of losing a space race with the Soviet Union, President Kennedy issued to the nation an urgent challenge of placing a man on the moon by the end of the decade.[91] Given the state of rocket technology in 1961, President Kennedy knew that, to many, the goal of landing on the Moon 230,000 miles above the Earth seemed impossible . With great foresight he stated:[92]

> I believe we possess all the resources and talents necessary. But the simple facts of the matter are that we have never made the national decisions or marshaled the national resources required for such [international] leadership. We have never specified long-range goals on an urgent time schedule, or managed our resources and our time so as to ensure their fulfillment.
>
> Let me make it clear that I am asking the Congress and the country to accept a firm commitment to a new course of action, a course which will last many years and carry very heavy costs…. This

decision demands a major national commitment to scientific and technical manpower, material and facilities, and the possibility of their diversion from other important activities where they are already thinly spread. It means a degree of dedication, organization, and discipline, which have not always characterized our research and development efforts.

What President Kennedy gave America was a vision, a vision of *a future it could create*, a vision each American could personally imagine by simply gazing upward on any cloudless night. Working *backward* from the President's clearly stated goal, thousands of Americans from government, industry, and academia teamed together to correctly dissect one seemingly *insurmountable* problem into thousands of smaller solvable ones. Only 8 years later, through courageous leadership, teamwork, and pure determination, a Saturn V rocket lifted the Apollo 11 astronauts to the moon. While the energy-Apollo problem scope cited here is not an original analogy, the similarities in trying to solve a grand challenge are compelling and can serve as an example of how the DoD can focus government, science, and industry to ensure the US military has the energy to guarantee America's security to 2050 and beyond.

The methodology for forming a strategy requires starting at the desired end state and stepping backward in time toward the present to identify the hierarchy of goals that must be met to support follow-on achievements. For example, in order to deploy an envisioned hydrogen-powered force, the capability to effectively and efficiently produce hydrogen fuel must first exist. Before the capability to produce hydrogen fuel exists, certain technical challenges must be solved, and before that, certain research institutions must be formed and resourced. This deductive process can be repeated hundreds of times over to design a complex system or system of systems. In this manner, a series of milestones is identified to serve as short-term wins that Kotter states are essential for sustaining the transformation process.[93]

In the case of creating a future hydrogen- and electric-powered force, there are two primary strategies.

- Allow market forces and timing to create and deliver necessary transformational capabilities (the DoE model).
- Allow the DoD to lead an energy transformation much as it did the race into space (with NASA), the adoption of computational problem solving, or creating ubiquitous modern high-speed commercial air travel through development of the high-bypass turbofan jet engine.

The fundamental difference between the two is acknowledging who must bear the risk of stranded development in an environment with an as-of-yet unclear future—should it be the commercial sector or government to bear that responsibility? As previously argued in the second section, the unique acquisition lead times and vital responsibilities of the DoD may force it to address this problem long before market forces have identified winning solutions. This fact is therefore the basis for selecting the latter option for examination in this article. A strategy of waiting for market forces to deliver options is not without merit.

Working backwards from the vision, the overarching strategy can be imagined to address the following tasks:

- Acquire alternate-fueled systems
- Create an alternate fuel delivery infrastructure
- Develop new energy standards
- Determine a new energy force structure
- Conduct R&D to acquire transformational technologies
- Throughout the process, protect against negative oil peaking effects to allow sufficient transformation time
- Minimize transformation costs
- Preserve military capability during the transition

This type of temporal task ordering is not new but demonstrates that a logical flow exists from the present condition to the desired end state, which in this case is complicated by the need to preserve defense capability while transitioning away from significant legacy investments in a resource-constrained environment. The strategy for accomplishing these tasks will take several decades and can be subdivided into three separate phases: 2006-2020, Near Term; 2020-2035 Mid-Term; and 2035-2050, Long Term.

A Three-Stage Approach

The DoD would be best served to lead three stages to military petroleum independence:

- A near-term (2006-2020), DoD-wide focus on establishing proper strategic leadership, energy efficiency, conservation, acquisition reform, bridge energy sources, and research and development (R&D)
- A mid-term (2020-2035) focus on infrastructure and technology transition
- A far-term (2035-2050) focus on employing the new energy

Quite simply, the concept is to use the DoD's enabling hierarchy and economic leverage of a $400-plus billion annual budget to reduce or reverse the annual rise in energy consumption while simultaneously developing bridge energies that will buy the necessary time for an intensive DoD and DoE-facilitated R&D effort designed to discover and deploy distributed, clean, diverse, affordable, and self-sustaining energy sources before petroleum scarcity or high prices impact military capability even more severely. Using a process that Amory Lovins calls *creative destruction*,[94] the new energy conversion must occur in a way that maximizes the remaining return-on-investment value of legacy systems while simultaneously enabling a convincing paradigm shift for users toward the new energy. Much as DoD-funded projects like Arpanet and the global positioning system set early industry standards that gave the commercial sector the framework upon which to create exponential market developments, so too could the early establishment of new energy infrastructure standards (production, transmission, connectivity, and modularity) prove to be the DoD's greatest contribution to America's long-term energy security

Stage I – 2006-2020 Near-Term Strategy

Five up-front activities can be initiated through effective and immediate DoD policy changes.

- Establish the Office of Assured Energy
- Increase energy efficiency and conservation

- Promote acquisition reform
- Develop bridging energy sources to buy time
- Complete intensive R&D efforts for the new energy beyond petroleum

Establishing the Office of Assured Energy

After creating a DoD energy vision, the Office of Assured Energy's next most important task would be to accomplish Kotter's fourth step in leading change, which is communicating the change vision to create a common understanding of its goals and direction.[95] To prepare the entire DoD, industry, and academia for the magnitude of change they are about to help create, the Office of Assured Energy must effectively convey the urgency of the energy problem facing the DoD, the envisioned petroleum-free future, the fundamental transformations that will need to unfold over the course of several decades, the breadth of the leadership role the Office of Assured Energy will directly play in that transformation, and the commitment that will be required of leadership and each individual member of the organization in helping create a more secure envisioned energy future. The message should be simple, continuous, and ubiquitous, and those delivering it should be prepared for both positive and negative feedback as they work to overcome the resistive forces of doctrinal dogma and risk aversion.[96]

Increasing Efficiency and Conservation

The first logical physical step toward any long-term petroleum independence is reducing consumption through increased efficiency and conservation. The military has always valued capabilities and effectiveness (such as speed, mass, stealth, and so forth) over efficiency for good reason—restraint when national survival is at risk is illogical. However, this is a short-term perspective and in an energy-constrained environment, efficiency becomes its own effect, enabling the sustained application of other desired military effects. Not only does conservation through increased efficiency directly and immediately enhance and help stabilize an organization's typically tight budget from gross energy cost fluctuations (such as after Hurricane Katrina, Operation Desert Storm, or Operation Iraqi Freedom), it also lays the necessary groundwork for enabling new alternate energy futures. If, for example, some new promising energy technology still requires a 20 percent process efficiency increase in the system it would support in order to become feasible, then the argument for making the original system 20 percent more efficient is powerful not only because it saves petroleum energy costs in the short term, but it also pushes the realm of the new technology from the theoretical to the practical, and should therefore be pursued whenever possible to preserve needed military capabilities.

To date, the definitive DoD internal document advocating increased efficiency remains the 2001 Defense Science Board (DSB) Task Force on Improving Fuel Efficiency of Weapons Platforms' report entitled, *More Capable Warfighting Through Reduced Fuel Burden*. It identified five major efficiency recommendations.

- Base investment decisions on the true cost of delivered fuel, warfighting, and environmental benefits
- Strengthen warfighting and fuel logistics links in wargame modeling
- Have leadership incentivize fuel efficiency throughout the DoD
- Specifically target fuel efficiency improvements through investments in science and technology and systems designs
- Explicitly include fuel efficiency in requirements and acquisition processes

Arguably, it is the report's third suggestion, "Have leadership incentivize fuel efficiency throughout the DoD," that is the most important and transformational.[97] The authors go on to emphasize:

> For the DoD to take advantage of the large cost and performance benefits of significant improvements in weapons platform fuel efficiency, senior civilian and military leadership must set the tone and agenda within the Department. Leadership must begin promoting the message that efficiency at the tactical platform and system level is a clear strategic path to improve performance, reduce logistics burden and free resources for modernization and readiness. This needed emphasis by DoD leadership is not merely desirable; it is an essential ingredient to achieve the force improvements to execute Joint doctrine.[98]

While looking specifically at improving existing and future weapon systems, the DSB's advice applies equally well to all operating procedures and installation infrastructure as well. This is a message that all Service chiefs and combatant commanders could broadcast loudly and repeatedly through their established information outlets. Subordinate levels of command would have to internalize and demonstrate acceptance of these concepts to junior ranks until even basic recruit and contractor behavior reflects the DoD's emphasis on efficiency and conservation. Success will depend largely on providing meaningful behavior change incentives to energy users for the purpose of long-term payback. One incentive model could be to return any normalized energy savings over the previous year directly to the saving organization—a potentially powerful motivator for under-resourced units. It is important, though, that to avoid the temptation of compromising safety to earn energy efficiency rewards, commanders and leaders not be penalized for exceeding the previous year's normalized energy bill. Bottom line: properly incentivized people will make a difference.

Promoting Acquisition Reform

To date, DoD acquisition has undervalued weapons system efficiency as a critical desired system effect. In 2001 the DSB Task Force on Improving Fuel Efficiency of Weapons Platforms, remarked,

> Efficiency attributes are not addressed in the acquisition process. Military requirements documents understandably place the highest priority on performance. Energy and fuel efficiency would become a major design variable if specified as key performance parameters (KPP).[99]

The board continued,

> The PPBS does not reward efficiency or penalize inefficiency. Interest in fuel and energy efficiency is largely limited to meeting federal executive orders or legislative mandates. However, since federal mandates do not apply to military weapons systems, there are neither policy focus nor resource incentives to seek operational fuel efficiencies. Consequences of no efficiency requirement and a subsidized fuel price are that investments to improve efficiency do not compete well (or at all) in the PPBS process—the result is increased costs and degraded warfighting capability.[100]

There are several examples of the type of efficiency-related changes the DoD might consider as a matter of ongoing acquisition policy reform. First, as the DSB suggests, all future operational requirements documents could require an energy efficiency KPP for systems and infrastructure purchases. In one approach, acquisitions that would last 5 years or less, commercial-equivalent, state-of-the-art efficiency would be acceptable; for acquisitions lasting more than 5 years, the KPP should require an efficiency standard better than state of the art. If better-than-state-of-the-art is not immediately feasible, then the new system would have to adhere to the second proposed change, which is that it must start with state-of-the-art efficiency at the time of acquisition but possess modular upgradeability such that, as more efficient subsystems and components are developed, they can be interchanged with legacy components to reduce life-cycle energy costs and maximize legacy system total return (this is a critical concept—it answers the question of how to avoid discarding inefficient legacy systems and how to minimize the risk of stranded investments). A required element of the efficiency KPP would be to require each new system or facility proposal to calculate estimated operating energy costs based on the price of delivered energy at the point of use as the DSB suggests—this is similar to the familiar yellow *Energy Guide* labels found on major home appliances. The third change is to begin requiring proposed systems to adhere to the new energy standards (connectors, power and energy quality, operating limits, and so forth) as they are developed and approved by the Office of Assured Energy in conjunction with appropriate DoD partners like DoE or industry standards consortiums. Actual adoption of this third step into hardware design will be the signal of progress and will mark one of the DoD's most important contributions to the expansion of energy reform for American society at large.

Developing Bridge Energies

Conservation and efficiency can provide immediate returns, but the total impact will not be sufficient to eliminate foreign petroleum dependence. Because full-scale transition to the new energy will take at least 40 years to complete, and many professionals predict Hubbert's Peak will occur by 2020, bridge energy sources are necessary to maintain combat capability. Bridging energy sources are those energies and fuels other than petroleum which are available or can be made available in sufficient quantity in the near term to supply necessary energy needs until a revolutionary energy is deployed. Examples include natural gas; synthetic fuels from oil shale, tar sand, or coal liquefaction; nuclear power; possibly methane hydrates; and renewables like biofuels, solar, wind, and geothermal power.

Catalyzed by the 2002 Clean Fuels Initiative, the DoD began exploring the mechanics of liquid fuel production from Western US oil shale and Canadian tar sands through the German-developed Fischer-Tropsch process used in World War II.[101] The Clean Fuels Initiative segregated development into two parallel foci:

- Total energy development for overcoming the economic and technical obstacles necessary to enable large-scale industrial fuel production
- Certifying a Joint battlespace use fuel for the future as a single nonpetroleum-derived fuel suitable for use in all current, legacy, and emerging systems.[102]

In its Energy Policy Act of 2005, Congress formally authorized the DoD to pursue development of coal/shale/sands fuel extraction technologies with the statement,

> The Secretary of Defense shall develop a strategy to use fuel produced, in whole or in part, from coal, oil shale, and tar sands (or other resources) that are extracted by either mining or in-situ methods and refined or otherwise processed in the US in order to assist in meeting the fuel requirements of the DoD *when the Secretary determines that it is of national interest.*[103]

It appears that time has come through the advocacy of Mr. John Young, representing the Naval Research Advisory Committee (NRAC). His October 2005 post-Hurricane Katrina memo to USD (AT&L) (and subsequently endorsed by the Air Force), stated,[104]

> I believe that DoD can complete the necessary due diligence and have a program well underway within 3 years. With sufficient priority we can achieve initial operational capability by 2011 and full energy independence for DoD by 2020." He continues, "We can do this by making a long term commitment to shift from petroleum products to manufactured fuels produced by assured domestic sources of supply. Such a DoD commitment now could also generate economic benefits for the Department and the nation in 5-10 years. In light of the current painful reality of DoD fuel price adjustments, and the risks to our fuel sources posed by natural disasters and terrorists threats, I believe we need to act on this recommendation *with a sense of urgency* (emphasis added).[105]

At the time of this writing, it appears that OSD is poised to commit toward leading development of synthetic fuels from oil shale, tar sands, and coal. The promise of 2 trillion barrels of oil equivalence, the need to supply the DoD with approximately 400,000 barrels of oil per day by 2020, the fact that Canada already produces 1 million barrels of oil per day using these techniques from Albertan tar sands (of which 95 percent is already sold to the US),[106] and the existence of Congressional preapproval makes this low-risk decision virtually inevitable. Many would claim this event marks the end of US petroleum worries; there is no need to be concerned about alternate energies if the DoD can catalyze industrial production by 2020—Hubbert's Peak becomes a nonevent. This program, however, may not provide a permanent panacea.

The primary benefit of using synthetic liquid fuels is that virtually no infrastructure modification is necessary—simply certify all current engines for use and start pumping shale oil into the existing fuel distribution system and America's air, sea, and land power is preserved. However, four problem areas arise from military reliance on synthetic fuels as a potential long-term energy solution:

- Increased lines-of-communication (LOC) demands
- Potential environmental harm (strip mining, high-water consumption, CO_2 emissions)
- Increased public-sector synthetic fuel consumption
- Neglected allies

According to Defense Energy Supply Center standard procedures, the DoD globally purchases fuel from regional and local suppliers at a DoD-wide contract price. Oil corporations ensure that adequate regional supplies exist through an established global shipping and distribution system, while organic military systems provide final fuel delivery into combat

zones or to end users. The DoD's universal adoption of oil-shale fuels by 2020 will create a unique distribution situation not seen since the US last exported fuel: the flow of full tankers *leaving* US seaports! It is unclear from available literature what type of cargo these ships will carry—will it be finished fuels or unrefined crude requiring dependence on potentially vulnerable host nation refining before it is ready for use? Project sponsors must specify this information in their proposals. Additionally, is the US Navy prepared to protect these shipments that an asymmetric enemy could clearly identify and target on the open seas? Because it would flow through the existing petroleum distribution infrastructure, the post-2020 synthetic-fuel military might end up relying on a reversed supply system as fragile and vulnerable as today's.

Virtually every industrial process comes at an environmental cost—coal/shale/tar sand oil is no exception. While it is widely known that the Fischer-Tropsch (FT) process produces liquid fuels that burn cleaner than their petroleum-derived counterparts, the environmental advantage ends there. Oil shale/tar sand/coal extraction requires intensive mining operations—subterranean and strip processes in the Appalachians and strip mining in Wyoming and Colorado, where the largest deposits are found. Strip mining would tear open vast tracks of pristine wilderness and destroy natural habitats. The alternative is to liquefy underground solids with electrical heaters—a process that requires substantial energy of its own. Combine that with the one to four barrels of water and 400–1,000 cubic feet of natural gas needed to refine each barrel of shale oil[107] in a historically water-scarce region of the country, and the millions who live downstream of the Colorado River will certainly raise loud voices. Finally, shale oil products release a significant amount of CO_2, the primary cause cited in the theory for global warming. The significant amounts released during the FT extraction process can be sequestered below ground, but wide scale adoption of synthetic fuel does not prevent release of CO_2 at the point of end use combustion. Consuming approximately 400,000 of the world's estimated 120 million barrels a day by 2020,[108] one could successfully argue that the DoD's contribution to global environmental harm would be relatively negligible, but taking a minimalist approach would not excuse the program from addressing the third looming issue with the DoD conversion to shale-oil: purchasing competition from a growing public sector demand for synthetic fuel.

Preliminary studies have shown that coal/shale/sands oil production becomes economically feasible at approximately $45 a barrel.[109] Considering oil's recent $70-a-barrel peak, and the fact that each $1 per barrel price increase costs the DoD $135M annually,[110] synthetic fuels become very attractive financially. It would only be realistic to assume that the same attraction drawing the DoD to shale-oil conversion would also generate a surge of public-sector consumption for the fields of Wyoming. On one hand, increased economies of scale should help drive down production costs for the DoD, but since oil is a commodity, one must expect synthetic oil to sell for the same volatile price as petroleum oil. Philip Deutch, in his 2005 *Foreign Policy* article "Energy Independence," correctly observes that, "No private oil company will sell oil on its domestic market for one penny less than it could realize on foreign markets, and the price that a barrel of oil commands will be based upon pressures beyond any one government's control."[111]

Unless the US government enters long-term contracts or cooperatives with producers to provide federal fuel at a fixed price in exchange for Department of the Interior mining rights on federal lands, free-market forces will negate the last portion of the NRAC's justification for oil-shale development: "Setting a 2020 goal of complete conversion to assured domestic sources of manufactured fuels will enhance national security and potentially save money compared to riding the curve of rising global petroleum prices."[112]

The final concern with the DoD reliance on shale-oil regards America's strategic allies and friends. Today, and to 2020, allies such as Canada and the United Kingdom can approximately meet or exceed domestic and security needs. However, nations such as Germany, France, or Japan already rely upon imported oil for over 90 percent of their requirements. None of these allies have sufficiently vast solid hydrocarbon reserves to accomplish their own internal shale, coal, or tar sands conversion. For these countries, military foreign energy independence will be a virtual impossibility by 2020, severely shaping the foreign policy objectives and freedom of these nations reliant on petroleum imports. Unless the United States is willing to develop its synthetic fuels resources beyond the levels needed to power only the DoD, many of America's international military partners may simply be unavailable for the coalitions the US has acknowledged it will need to favorably shape tomorrow's world.

Synthetic liquid fuels are only one bridging energy alternative. At present, they provide the only real option for mobile systems which rely on high-energy-density liquid hydrocarbon fuels to provide the maneuver and logistics capability that allows the US military to dominate all others. They would be intended to serve as the main mobility bridge to the 20-40 year hydrogen energy future America has placed great faith in, as evidenced by the 2005 Energy Policy Act allocating $2.1B for hydrogen research over the next 5 years.[113] In the meantime, other bridging options exist for nonmobility energy requirements such as base facilities at home, overseas, and in expedition. If fully developed, many of these emerging installation bridge energies can become permanent infrastructure energy solutions.

There is positive news to report in the area of installation bridge energy development. Here the DoD is accomplishing true energy leadership by leading the federal government in the purchase of Green Energy. This effort was in response to a 2 November 2004, DoD-wide memorandum from the Honorable Phillip W. Grone regarding installation energy policy goals. Mr. Grone stated that,

> The DoD 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.[114]

In addition to directing a reduction of installation petroleum use, Mr. Grone also directed that,

> 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 energy sources.[115]

The Air Force began adopting this practice long before 2004, resulting in the Environmental Protection Agency announcing that the Air Force was the largest single buyer of renewable energy, responsible for 40 percent of all purchased by the federal government in 2004.[116] Edwards AFB was able to meet 60 percent

of its annual energy needs by securing a 5-year contract that saved $42M over fluctuating conventional electrical prices. Fairchild AFB is nearly 100 percent Green Energy from supporting local wind farms. Dyess AFB became the 2003 Green Power Partner of the Year as the nation's largest, single-point Green Energy consumer, meeting 100 percent of its electrical needs.[117]

Other Services are following suit, which allowed OSD to provide a positive report to Congress on 14 Mar 2005 that, "…at the end of 2004, 2.5 percent of energy used by US military installations came from renewable sources."[118] In addition, the report stated that, "While the current level of the DoD's renewable energy use meets the federal goal set by DoE, it only represents a small fraction of the possibilities."[119] The Air Force has already demonstrated the ability to operate one base on 100 percent renewable power. Therefore, if all installations adopted some form of this goal, commercial renewable energy suppliers would be incentivized to develop more capacity. In fact, demand for wind power has been rising so rapidly that 2005 was a record year for the US, with 2,500 mega watts of new capacity installed, resulting in a 35 percent increase in national production capacity and the US being at the top of all countries for new installations.[120]

The wind power explosion is not a solo actor in the race to develop bridging energies. Solar power has seen dramatic price drops in recent years with the emergence of exciting new technologies such as solar-electric shingles, thin-film solar, and solar day lighting offering opportunities for bases to pay a onetime energy installation cost and then reap free energy for the life of the system. Many of the technologies can also be used in expeditionary environments. These types of exciting advances have led OSD to make such commitments to Congress as, "Where economical, DoD should pursue on-installation production of renewable energy because it provides energy savings, reduces our dependence on foreign energy, and saves money, while increasing energy security."[121] OSD further states,

> DoD is continuing its historic role as a catalyst for the development of other emerging renewable technologies. The DoD's renewable energy vision is to maintain a commitment to renewable energy supported by a DoD-wide appreciation for the economic, environmental, and security benefits of renewable energy technologies.[122]

Quite simply, the DoD's installation renewable energy program demonstrates the positive effects of a coherent DoD energy strategy fully supported by leadership. This warm-up event can provide valuable lessons and the short-term gains Kotter claims are mandatory to sustain motivation[123] for the much larger and anticipated upcoming fuels transformation event.

Energy Research and Development

The final required element in the DoD's quest for foreign oil independence is the re-creation of R&D accomplishments on the scale that allowed America's aerospace engineers to send Neil Armstrong to the moon. After decades of successful innovation since Apollo, President Bush and others have stated that today America's global innovation leadership position is under attack by the effects of globalization. On the positive side, US companies can significantly reduce costs by outsourcing both menial and intellectual work for pennies on the dollar in a globalized world. On the negative side, the growing lack of interest (and ability) on the part of American students to pursue engineering and science degrees, coupled with a reverse brain-drain of R&D talent back to new renaissance countries like India and China, has left the US with a quickly aging science and engineering community and the prospect of losing its position of science and technology leadership in the world. To illustrate, last year in Germany 36 percent of undergraduate students earned degrees in math and science, in China 59 percent, and in Japan 66 percent–in the US the figure was only 32 percent.[124] In 2004, China graduated over 600,000 engineers, India 350,000, and America only about 70,000.[125] Underscoring the President's acknowledgment of this problem in his 2006 State of the Union Address,[126] the National Academy of Sciences (NAS) Committee on Prospering in the Global Economy of the 21st Century best articulates the alarm in their 2005 report, *Rising Above the Gathering Storm*, in which they state,

> It is easy to be complacent about the US competitiveness and preeminence in science and technology. We have led the world for decades, and we continue to do so in many research fields today. But the world is changing rapidly, and our advantages are no longer unique. Without a renewed effort to bolster the foundations of our competitiveness, we can expect to lose our privileged position. For the first time in generations, the nation's children could face poorer prospects than their parents and grandparents did….The US faces enormous challenges because of the disadvantage it faces in labor costs. Science and technology provides the opportunity to overcome this disadvantage by creating scientists and engineers with the ability to create entirely new industries (emphasis added)—much as has been done in the past.[127]

In response to their alarm, the committee identified two challenges tightly coupled to scientific and engineering prowess: creating high-quality jobs for Americans and responding to the nation's need for clean, affordable, and reliable energy.[128] The NAS identifies a nexus of opportunity that simultaneously strengthens the economy and national security while simultaneously solving America's looming energy crisis—the intense application of an R&D commitment that promises intellectual and financial reward for those Americans already inspired, and those yet to be inspired in the sciences. With a DoD commitment to lead its own energy revolution, the US could create an entirely new, leading-edge commercial sector for the global market; a sector that could propel the US economy for decades and turn this nation into a new energy or energy technology exporter, much like the US achieved in the 1940s and 1950s when it dominated the export of petroleum development technology.

Solving future energy problems for the DoD and the US will take 20 to 40 years—an inspiring and exciting potential lifetime career for a new engineering graduate. Could the DoD possibly partner with the Department of Energy to create a world-renowned New Energy Research Center of Excellence? To generate the necessary intellectual enthusiasm and capability for this endeavor, the NAS proposes four recommendations listed below (including some selected subpoints), with implementation responsibility falling to Congress; the Departments of Energy, Education, and Defense; and the National Science Foundation:[129]

- **Recommendation A:** Increase America's talent pool by vastly improving K-12 science and math education.
- **Recommendation B:** Sustain and strengthen the nation's traditional commitment to long-term basic research that has

the potential to be transformational to maintain the flow of new ideas that fuel the economy, provide security, and enhance the quality of life.

- Increase the federal investment in long-term basic research by 10 percent a year over the next 7 years. Special attention should go to the physical sciences, engineering, mathematics, and information sciences, and to DoD basic research funding.
- Allocate at least 8 percent of the budgets of federal research agencies to discretionary funding
- Create in DoE an organization like the DARPA called the Advanced Research Projects Agency-Energy (ARPA-E). The agency would be charged with sponsoring specific research and development programs to meet the nation's long-term energy challenges. ARPA-E would be based on the successful DARPA model and be designed as a lean and agile organization with a great deal of programs that can start and stop programs based on performance. The agency would perform no research or transitional effort but would fund such work conducted by universities, start-ups, established firms, and others.

- **Recommendation C:** Make the United States the most attractive setting in which to study and perform research so that we can develop, recruit, and retain the best and brightest students, scientists, and engineers from within the United States and throughout the world.
  - Increase the number and proportion of US citizens who earn physical sciences, life sciences, engineering, and mathematics bachelor's degrees by providing 25,000 new 4-year competitive undergraduate scholarships each year to US citizens attending US institutions.
  - Increase the number of US citizens pursuing graduate study in *areas of national need* by funding 5,000 new graduate fellowships each year.
- **Recommendation D:** Ensure the US is the premier place in the world to innovate; invest in downstream activities such as manufacturing and marketing; and create high-paying jobs that are based on innovation by modernizing the patent system, realigning tax policies to encourage innovation, and ensuring affordable broadband access.

The aviation and computer industries exploded shortly after they were created because hundreds of thousands of innovators were interested in the fascinating subject matter and expended tremendous personal energy expanding these fields. The potentially dark future of conventional energy supply is sufficient to generate the same type of broad interest that aircraft and computers still enjoy today. Scientists and engineers live for the excitement of new discovery and associated peer recognition—it may be as simple as DoD and DoE creating the R&D opportunities so that the inspired will come. Case in point is DARPA's recent Grand Challenge contest. By offering a $2M prize to the university, industry, or government team that could build an autonomous vehicle capable of auto-navigating 131 miles of Mohave Desert, DARPA received some 20-plus approaches to solving the problem with a clear demonstration of what works and what does not.[130] Much as the Gossamer Albatross and Spaceship One were inspired by standing prizes, the DoD may find its energy answers in a team of bright college students competing to win a million dollars of government prize money. Could innovation prizes be the DoD's low-budget R&D model of the future? It certainly appears to be one attractive low-cost option for the government.

Where can the DoD best focus R&D efforts to maximize energy solutions? Fortunately, work has begun in all necessary fields, but the energy research percentage in the Department's $75B FY05 R&D budget would likely still need to be increased substantially to help create the new energy before Hubbert's Peak arrives.[131] The President has proposed a 22 percent increase in certain areas of federal government alternate energy research even though the Energy Policy Act of 2005 already allocates $7.5B of R&D funds over the next 5 years.[132] Four areas of possible focus spring to the forefront.

- Efficiency technologies
- Nanoscience
- Energy and power technology initiatives
- Infrastructure technologies

The 2001 Defense Science Board Task Force for Improving Fuel Efficiency of Weapons Systems recommended that the DoD,

> Specifically target fuel-efficiency improvements through investments in science, technology, and systems designs. DoD labs could produce a large number of technologies in their portfolios that could improve the efficiency of their platforms and systems; a consistent message was that their customers, the operators, were generally not asking for efficiency. The science and technology community should make platform efficiency a primary focus to identify, track, and package technologies that improve efficiencies. It is fundamental that the DoD support (Category 6.1 and 6.2) investments that can lead to revolutionary improvements in the fuel efficiency of tomorrow's weapons platforms.[133]

For instance, with thousands of gas turbine engines in the inventory consuming billions of gallons of fuel annually, every percentage increase matters—programs such as the Versatile Advanced Affordable Turbine Engine are critical. Agencies such as the Air Force Research Laboratory already seek engine efficiency gains as elements of contracted research projects but need dedicated funds for the sole purpose of revolutionizing aircraft propulsion. A good example of such a project was the development of the hydrogen-fueled PW304 jet engine designed and tested in the 1940s and 1950s for the *Suntan* project.[134]

The exciting and new field of nanoscience offers great hope for a DoD energy vision. As part of the National Nanotechnology Initiative, the National Science and Technology Council's Nanoscale Science, Engineering, and Technology Subcommittee concluded that,

> At the root of the opportunities provided by nanoscience to enhance our energy security is the fact that all of the elementary steps of energy conversion (charge transfer, molecular rearrangement, chemical reactions, and so forth) take place on the nanoscale.[135]

DoE's Basic Energy Sciences Advisory Committee's "Basic Research Needs to Assure a Secure Energy Future" and their Office of Basic Energy Science's "Basic Research Needs for the Hydrogen Economy" have recognized that solutions will require scientific breakthroughs and truly revolutionary developments. Within this context, nanoscience and nanotechnology present exciting and requisite approaches to addressing these challenges.[136] Participants of the March 2004 National

Nanotechnology Grand Challenge Workshop identified nine research targets in energy-related science and technology in which nanoscience is expected to have the greatest impact.[137]

- Scalable methods to split water with sunlight for hydrogen production
- Highly selective catalysts for clean and energy-efficient manufacturing
- Harvesting solar energy with 20 percent power efficiency and 100 times lower cost
- Solid state lighting at 50 percent of the present power consumption
- Superstrong and lightweight materials to improve the efficiency of cars, planes and the like
- Reversible hydrogen storage materials operating at ambient temperatures
- Power transmission lines capable of 1 gigawatt transmission
- Low-cost fuel cells, batteries, thermoelectrics, and ultra-capacitors built from nano-structured materials
- Materials synthesis and energy harvesting based on the efficient and selective mechanisms of biology

Involving the basic building blocks of all matter, the nine material science areas above indicate that the foundation of the world's energy future lies within nanoscience research.

The third area of impact involves enhancing the DoD's 2001 Energy and Power Technologies Initiative (EPTI). Expanding across all military Services in only 5 years, EPTI's objective is to revolutionize the energy and power components of military systems to enable an envisioned *all-electric* force. Divided into power generation, energy storage, and power control and distribution categories, EPTI will draw heavily from nanoscience discoveries and quantum physics to create the physical components (electric motors, batteries, capacitors, low-resistance wiring, electric actuators, and high-power electronics) necessary to reduce the logistics burdens and operational capabilities of future military systems.[138] Each new advance should cascade rapidly to other DoD systems, which in turn will inspire other new applications discoveries. Most importantly, EPTI technologies have the potential to gain rapid public sector use propelling mass-production cost reductions and even greater innovations. Already funded at over $250M for research this year,[139] this funding level could easily again be tripled or quadrupled to accelerate innovation returns with the strategic blessing of a hypothetical *Office of Assured Energy*.

Although energy infrastructure is perhaps the least glamorous of all the research areas, it is as fundamental to the total solution as discovering the *Holy Grail Fuel of the Future* itself. In lockstep with the most promising of any new fuels or energy research must be the development of the systems that will produce and distribute the new energy. By objectively examining the most promising alternatives early, the DoD can be the first to establish new industry standards for energy quality, format, interconnectability, transportability, and so forth, to maximize universality and modularity. The consumer electronics industry demonstrates time and again how a particular technology will not flourish until an industry standard is established (for example, Betamax versus VHS, CD, and DVD formats). The computer industry did not expand rapidly until adoption of universality and modularity allowed users to custom configure and continually upgrade their systems, preserving their legacy investments. This model can be seized upon and articulated early by the DoD—until this is accomplished, neither military nor commercial developers have frameworks to build upon. Creating these frameworks through future acquisition requirements would serve as a catalyst for industrial activity and could become the DoD's greatest contribution to energy security.

Stage II – 2020-2035 Mid-Term Strategy

If the seeds of change are to be sown in Stage I of an energy transformation strategy, then the concept and idea seedlings must be cultivated in Stage II before the benefits can be harvested in Stage III. By the end of Stage I, the DoD should have internalized the commitment of energy transformation across the entire department, selected its primary and supporting long-term future energy sources, deployed necessary bridging energies, and created the necessary R&D momentum and energy standards to support the transition to Stage II. In Stage II the DoD would need to focus on:

- Adjusting force structure for the new energy future
- Adjusting operational training and procedures
- Investing in new energy infrastructure and transition technologies while continuing intense R&D efforts to meet the Stage III goal of remaining militarily relevant in 2050 and beyond

Adjusting Force Structure

The world's looming energy situation has the potential to dictate historic force structure decisions. The DoD's primary mechanism to assess force composition relative to threats and *Joint Vision 2025* goals is the *Quadrennial Defense Review* (QDR). This comprehensive approach produces force structure decisions that the Services are subsequently expected to execute. In the February 2006 *QDR*, no force structure decisions were made based on fuels or energy limitations. The next opportunity to formally adjust force structure will occur in 2009.[140] Four years from now, the state of world and DoD petroleum supplies may be much more acute, at which point the DoD would likely be required to address energy efficiency and consumption as part of its force structure decision matrix. Attention to detail and proper QDR energy-related course corrections would be one of the most effective tools available to ensure the DoD reaches its goal of long-term relevancy.

QDR 2009 force structure decisions will be reaching full effect by 2020. In the proposed 40-plus year transformation strategy, the US would need to begin retiring all inefficient systems between 2020 and 2035 and activating those new 30-year systems which support a force structure deemed most effective in an energy-constrained world. In order to minimize any capability gaps between retirement of traditional systems (at the beginning of the window) and the arrival of high-efficiency and perhaps radical replacements (at the end of the window), the grand force structure strategy must maximize multi-role capabilities of remaining systems, perform cost and risk analyses of extending inefficient system life spans, and plan to accept certain mission limitations and vulnerabilities for a period, if necessary. The sooner replacements are produced, the smaller this vulnerability window will be. The US missile defense system being deployed today is a perfect example of how the earliest-

maturing technologies of a system can be spiraled into warfighter hands long before full system capability in order to mitigate enemy threats as soon as possible.

Adjusting Operational and Training Procedures

Operations and maintenance (O&M) costs—the most energy intensive portion of the budget—consume 31 percent of today's DoD funds.[141] If the DoD is unable to deploy bridge energies before the arrival of Hubbert's Peak, the DoD will need to have adopted universal energy conservation approaches to control the volatility and size of O&M expenses. Traditional infrastructure and operating procedures will need to continue improving efficiencies, reducing footprint, and maximizing alternate energies to guarantee security and stabilize energy costs. A good example of the change is the growth in electrically powered computer training simulations that are replacing more expensive and petroleum-intense physical training events.

High energy costs may also force warfighters and national security decisionmakers to carefully select future engagements. If so, operational commanders will also be required to integrate maximum fuel efficiency and opponent energy limitations in their planning calculus. Because within 2 decades a deployed operational force may be relying upon synthetic fuels shipped from North America and shared with coalition partners, a Joint force commander may find his maneuver options limited, and in turn, driving certain, less energy-intensive courses of action. It is not unreasonable to expect the military of 2020-2035 to be forced to rely upon very lean logistics, as this dimension is typically the most energy intensive of modern warfare.

New Energy Infrastructure and Transition Technologies

Today's petroleum extraction, refinement, and distribution systems were developed and built over the course of a century. Fortunately, in today's environment, broad knowledge sharing, instant communications, rapid mass production and distribution, and large resource capital movements can enable the construction of a properly envisioned and planned new energy infrastructure in less than 100 years.

The first major infrastructure activity the DoD will have to address is incentivizing commercial development for manufactured liquid hydrocarbon fuels—this is akin to the DoD buying an energy life insurance policy and should already be executed in Stage I of the DoD's energy transformation. Without this bridge energy ensured upfront, time may run out to satisfactorily complete development of any new energy infrastructure. Because manufactured fuels can be distributed through slightly modified existing liquid fuel networks, the only area needing new investment is site extraction and refinement. The NRAC estimates that the 10 plants needed to meet the DoD's daily needs could be operational by 2020.[142]

Within its current civil engineering construct, the DoD may also need to deploy a collection of smaller infrastructures that contribute to the total energy supply for both permanent and expeditionary installations. For example, as biofuel processing technology rapidly advances, it may become practical in the 2006-2020 timeframe to actually build on-site biofuel and bioelectric generation plants that utilize a base's own waste stream and surrounding biomass as raw energy sources. In addition to helping solve environmental concerns, these bioenergy plants could be produced in standardized, modular sizes from semi-truck portable to the mega-plant, expandable to appropriately meet each base's needs. Every DoD roof and sun-facing flat surface should be covered with mass-produced, thin-film solar panels. All fluorescent and street lighting, efficient by today's standards, could be replaced by 50-plus percent more efficient LED lighting. Wind power farms subsidized by long-term DoD purchase contracts could become the norm versus the exception as they are today. Coastal bases should be able to purchase Green Energy from subsurface tidal and ocean thermal production systems facilitated by Congress and DoE with the DoD as a guaranteed buyer. If successful, this collaborative model can be repeated endlessly with any number of new concepts.

The above mentioned infrastructures (with the exception of synthetic fuels) point to a developing trend. In contrast to today's energy production at large-scale centralized facilities, distributed, on-site production has the potential to become prominent. Historically, industrial societies have produced energy at a few central locations for good reason:

- Proximity to raw energy resources
- Economies of scale
- Consolidation of limited expertise to manage the process

Unfortunately, much of the central production benefit is lost through inefficient and vulnerable distribution systems. While scientific advances are occurring with the potential to overcome these distribution inefficiencies, today's technology has also balanced the playing field, increasing the efficiencies of smaller producers, automating control and maintenance functions through computers and better design, and enabling the extraction of energy from proximate sources—much in the same manner that nature does. By "unleashing us from the tether of fuel"[143] as Lieutenant General James Mattis, USMC, has desired, DoD's forces can use the maneuver-enhancing logistical and security freedom of distributed production to offset the high mobility benefit, but precarious security, of delivered liquid fuels.

Up to this point, the subject of hydrogen infrastructure development has not been mentioned. As evidenced in the 2005 Energy Policy Act, DoE, Congress, and the President place great faith in the potential of hydrogen as the only viable large-scale, long-term replacement to hydrocarbon liquid fuels. This optimism is no doubt inspired by such recent exciting nanotech discoveries as the ability to create hydrogen from direct sunlight, enhanced electrolysis, or biological mimicry, as well as new discoveries for safer and more efficient hydrogen storage. Sufficiently researched during Stage I and later developed in Stage II, these capabilities could theoretically be used to locally produce and directly power hydrogen-fueled maneuver and mobility forces. Early and active research involvement would enable the DoD to make the earliest possible commitment toward a hydrogen-based military as a permanent replacement to temporary manufactured bridging fuels (interestingly, the technology already exists to extract hydrogen from hydrocarbons, meaning that local hydrogen production is already possible today from traditional feedstocks). To facilitate the entire three-phase strategy for energy transformation, the DoD will likely have to commit to building the necessary field infrastructure to support a hydrogen conversion by the end of Stage I, while simultaneously supporting the legacy liquid fuel system for unconverted systems This has the potential to be the

most difficult phase of an energy transition. Fortunately, if the 2005 EPA's hydrogen technology goals are met, the commercial and private sectors will be involved in a similar pursuit, lending their accomplishments and interests to the DoD success.

The last Stage II activity would be converting selected legacy systems and early acquired modular systems to the new energy standard. This can be as simple as replacing individual components, such as lighter and more reliable linear electric actuators versus hydraulic components, or incorporating major replacements of power-generation and energy storage systems during depot overhauls. Each system would need to be assessed on a case-by-case cost-activity analysis to determine if and when such a conversion is possible—for example, conversion of hybrid HUMVEEs from a standard JP-8 fueled engine-generator configuration to hydrogen fuel cells. Unless this activity is initiated by 2020, it is unlikely that sufficient time will exist to create a fully converted and viable force for Stage III.

Stage III – 2035-2050: *The New Energy* Force

The DoD will see the culmination of three decades of work as it enters Stage III—The New Energy Force. To capitalize on the transformation momentum already in place in Stage II, the DoD will need to focus on:

- Completing a full conversion of all infrastructure and systems to the new energy standard.
- Ensuring distributed, ubiquitous, and adequate energy production exists to provide greater agility and survivability.
- Continuing R&D to develop even more superior forms of energy production and use. By envisioning and creating its own energy future, the DoD will be able to maintain the freedom of action and operational capability it needs to defend America's interests.

Mindful of the fact that DoE has predicted Hubbert's Peak will occur around 2037, by 2035 both the DoD and the private sector will likely be deeply involved in a large-scale conversion to the new energy. The real and environmental costs of maintaining old systems will likely rise exponentially, building the case for rapid elimination. Because of Stage I and II efforts, state-of-the-art facilities, systems, and even soldiers should by this time operate on a standard energy *bus*, relying heavily on computer optimization and networking for maximum communication and situational awareness.

As the vision for 2050 draws near, energy can be expected to be produced in a variety of ways as part of a highly distributed network (not to be confused with a centralized distribution network) and almost exclusively take one of two forms: electricity or hydrogen. It is not inconceivable that electricity will be produced by state-of-the-art coal and natural gas facilities; ubiquitous solar, wind, geothermal, thermoelectric, and ocean tide and thermal sources; various-sized nuclear plants, hydrogen fuel cells, and even on-vehicle generators. Hydrogen will be derived from water electrolysis, large scale photolysis, reformation of remaining hydrocarbon fuels, and other chemical processes. It will be either safely shipped from domestic sources, or more likely produced locally. Only in the rarest of cases will it rely on foreign fuel stocks, and then only if the risk and benefit analysis demonstrates that it is situationally more advantageous to do so. Unfortunately, aircraft systems will likely be the last to undergo the new energy conversion, operationally restricted by power, weight, and volume constraints until technologies are most mature (remember that the DoD actually produced a hydrogen-powered jet engine as early as 1957, indicating that once hydrogen storage issues are resolved, the hydrogen aircraft may become a reality).[144]

In the end, as the DoD and the nation grow comfortable with the new energy paradigm, and the threat of petroleum energy insecurity fades, the transition of remaining activities to the new energy standard will be self-sustaining. A new-found post-petroleum energy security and the experiences of a somewhat long and painful, but otherwise successful energy transformation, will likely enable the DoD and the nation to eventually continue pursuit of even more advanced energy concepts such as nuclear propulsion, nuclear fusion, space solar generation, moon energy exploration, and matter-anti-matter propulsion, to name a few.

As demonstrated, the journey to the DoD's energy future will be both monumental and complex, requiring enormous strategic leadership to accomplish the desired results. By using a proven transformation methodology such as Dr Kotter's eight-step process to develop a sense of urgency and the vision of the energy future it wishes to create, the DoD can then begin to dissect the scope of the problem and identify and execute the best strategy for creating the energy future it desires. To quote EIA's director, Dr Caruso, oil peaking is a problem that will occur "…within the present century."[145]

Conclusion

From bottom to top, the military meritocracy is full of talented, dedicated and courageous people who can move out smartly to implement changes, even radical changes if they make sense and save money.

—Amory Lovins, *Winning the Oil Endgame*[146]

The United States is the world's only superpower today because its 5 percent of the global population has transformed its personal energy and 25 percent of the world's energy resources into the economic and military might necessary to earn such a position.[147] By 2025, when the United States is expected to be importing 68 percent of its petroleum needs, a majority of scientists predict that world petroleum production will have already peaked or be within a decade of doing so. The global security situation associated with the arrival of Hubbert's Peak has the potential to be of a complexity and magnitude likely never before seen in the history of man. The question then becomes, how can America ensure its security in this type of scenario?

President Bush and the Congress have offered the Assured Energy Initiative and the Energy Policy Act of 2005 as starting points on the journey of eliminating American dependence on foreign oil and creating a post-petroleum economy. While mainstream attention is being focused on the Department of Energy as the logical leader in this endeavor, closer inspection reveals that DoE's charter is to specifically produce the technologies and knowledge that in turn enable a free market economy to decide the best sources and mixture of energy to power the American way of life. While a technology-intense DoD increasingly benefits from the innovations that a free market military-industrial complex provides, it has also become

A Methodology to Achieve DoD Petroleum Independence

1. Create an Undersecretary of Defense, Office of Assured Energy to serve as a guiding coalition that leads a comprehensive military energy transformation in concert with DoE Office of Science efforts to technologically facilitate a national energy transformation.

2. Develop an agreed-upon 2050 DoD energy vision.

3. Communicate vision to lowest levels in DoD, academia, industry, and others as required.

4. Build strategy *backward* from envisioned end-state; identify all requirements, subdivide and time-order technology/policy developments into manageable tasks to create a continuing series of short-term wins.

a. Stage I – (2006 – 2020)
i. Promote conservation by directly rewarding efficient practices and technology.
ii. Reform/streamline acquisition system to reward energy efficiency, adopt new standards, and support modular upgrades of developing energy technologies.
iii. Develop bridging energies to guarantee the energy strategy end-state timeline.
iv. Create and engage best minds of the nation through broad science and engineering scholarship programs and sufficient R&D funding.
v. Commit to the best long-term practical solutions based on research and future potential, and then establish universal standards for envisioned energy end-state.

b. Stage II – (2020 – 2035)
vi. Develop energy delivery infrastructure.
vii. Begin transition of systems and operating procedures to new energy technology.
viii. Press for rapid commercialization of new technologies to quickly drive down costs and inject maximum benefit into civilian society.

c. Stage III – (2035 - 2050)
ix. Complete employment of the *new energy* force.

Figure 10. A Methodology to Achieve DoD Petroleum Independence

dependent upon its technological tools for success. Some of these combat systems now take over 2 decades to acquire and have 40-plus year life cycles.

As America's (and likely the world's) largest single institutional petroleum consumer, the DoD has also become dependent upon liquid hydrocarbon fuels to power a unique and dominant *American way of war*, in which effectiveness is valued over efficiency to execute the National Defense Strategy. The combination of long systems acquisition lead times, an overwhelming petroleum dependence, and a nontransferable national security mission may drive the DoD into the position of being the first government agency forced to practically address the problem of Hubbert's Peak. This condition begs the question of whether an opportunity exists for the DoD to contribute toward the President's goal of creating a petroleum-free society while also ensuring it has the energy and capabilities to complete its own national defense mission to 2050 and beyond.

By applying the first three steps of Dr John P. Kotter's eight-step process for leading organizational change, this article has proposed a method in which the DoD can lead an immediate, coherent, and viable long-term strategy toward a vision of replacing petroleum as its primary energy source in order to maintain all necessary strategic and operational capability for US security to 2050 and beyond. The first step is to create a sense of urgency within the DoD that its long-term existence is threatened by rising energy costs and the prospect of declining energy supplies. The second step is to create a guiding coalition in the form of an Office for the Undersecretary of Defense for Assured Energy that possesses both the internal and interagency authority and the singular purpose necessary to lead a 45-plus year energy transformation process. Consisting of permanent representatives from OSD, the Services, and interagencies, as well as representatives of industry and academia, this group must develop and communicate the vision of a desired energy future it wishes to create. Finally, by working backward from that desired end state, the team must then build, communicate, and execute an overarching strategy that subdivides this grand challenge into a continuum of manageable short-term goals.

Using the hypothetical vision of a 2050 US military unconstrained by conventional paradigms, this article proposed a three-stage transformation strategy to illustrate the incremental issues that will likely present themselves in a wholesale energy transformation (see Figure 10). Stage I (2006–2020) includes undertaking conservation, efficiency, acquisition, and organizational reforms; the development of bridging energies; massive R&D efforts; the establishment of new energy standards; and identification of a primary alternate energy source most likely to be some combination of electricity and hydrogen produced from a variety of sources. Stage II (2020–2035) focuses on adjusting force structure, adjusting operational and training procedures, and creating a distributed energy infrastructure and technology transition in a modular fashion. Stage III (2035–2050) involves finishing infrastructure conversion; ensuring adequate, distributed, and ubiquitous energy production; and a continuation of R&D energy efforts.

The Department of Energy confirms that the production of petroleum will peak sometime this century—it is perhaps the most fundamental strategic problem the DoD, the US, and the world will all inevitably have to face in the next 100 years. The Kotter-based organizational change methodology presented in this article demonstrates just one approach for guiding DoD energy transformation to serve the Department's own requirements. The lessons learned and knowledge gained from such an endeavor could be reasonably applied toward a much larger national energy transformation. The DoD-to-civilian transition model has been successfully applied in other major societal changes; there is no reason to believe this grand challenge to be any different. The creation of a broadly supported post-petroleum DoD vision and transformation strategy could not only preserve a relevant military force, but also lead a positive, bipartisan, interagency, and economic demonstration for preserving American security overall. The DoD possesses the capacity to succeed in making war without oil the catalyst of true transformation.

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notable quotes

Logistics is the careful integration of transportation, supply, warehousing, maintenance, procurement, contracting, and automation into a coherent functional area; in a way that prevents suboptimization in any of these activities; and in a way that permits and enhances the accomplishment of a given goal, objective, or mission.

—Lt Gen William G. Pagonis, USA

Logistics sets the campaign's operational limits.

—Joint Pub 1, *Joint Warfare of the Armed Forces of the United States*

Planning is everything—plans are nothing.

—Field Marshal Helmuth von Moltke

We need to continue the transition from a threat-based Cold War garrison force, focused on containment, to a capabilities-based expeditionary force focused on responsiveness.

—Gen Michael Ryan, USAF

Teamwork allows us to be an effective fighting force—a rapid expeditionary force capable of deploying anywhere in the world in a minimum of time and in austere conditions—not operating from where we are stationed, but from where we are needed, not when we can, but when we must.

—Gen Michael Ryan, USAF

In all war situations, the actions and decisions of command, whatever the level, are based on a blend of strategical, logistical, and tactical plans.

—Adm Henry E. Eccles, USN

The plan was smooth on paper, only they forgot the ravines.

—Russian Military Proverb

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