War Without Oil: A Catalyst For True Transformation

by

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Abstract

This monograph seeks to objectively explore the strategic energy leadership role the Department of Defense (DoD) can play within the context of its national defense mission and President Bush's 2006 Advanced Energy Initiative. By examining current and projected global energy/security environments, the energy roles of various branches of the Federal Government, and the unique responsibilities and characteristics of the DoD as America's largest single energy consumer and security instrument of national power, the author analyzes whether a methodology exists 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 while maintaining all necessary strategic and operational capability to guarantee U.S. security to 2050 and beyond. By envisioning and actively creating a post-petroleum military, the DoD not only guarantees the "American way of war" and national security in an increasingly energy-insecure and complex security environment, but actually obligates the organization to undertake such an endeavor as a transformational lever, catalyzing the best of government, industry, and the private sector as a positive force for a more secure world.

Table of Contents

Tables and Figures

Tables

Figures

Introduction

Transforming to War Without Oil

> *"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]

On 31 January 2006, in his annual State of the Union Address, President Bush pronounced that "America is addicted to oil" and the key to eliminating U.S. 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 & development (R&D) funding by 22 percent to accelerate technologies in clean coal consumption; nuclear energy; solar, wind, and bio-fuel 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, such that 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 1.5 percent of the 20 million barrels of oil consumed each day in the U.S., 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

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(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

[1] President Bush, *2006 State of the Union Address*.
[2] Ibid.
[3] Ibid.
[4] Caruso, *Statement Before Energy and Air Quality Subcommittee*, Figure 8.
[5] Lovins, *Winning the Oil Endgame*, 36 & 84.

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 prepares for a decades-long global war on terrorism. The question then becomes, how can the Department of Defense contribute toward the President's goal of creating a petroleum-free society 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 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 has 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 considering the effects Hurricane Katrina and Iranian nuclear brinksmanship have already demonstrated on an 84-million barrel/day world oil market[8] in which 2/3 of all reserves reside in the Middle East[9] and the growth of emerging economies have pushed global demand to within 2 percent of available production capacity.[10]

If the U.S. were ever forced to rely upon domestic petroleum supplies exclusively, it only possesses enough indigenous reserves to meet 2005-level demand for 4-5 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,

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[6] Lynch, "ExxonMobil Amasses Record $36B 2005 Profit", 30 Jan 2006.
[7] Association for the Study of Peak Oil and Gas, Ireland, 14 Feb 2006.
[8] Energy Information Agency, "World Oil Balance (2001-2005)", Table 2.1.
[9] EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates."
[10] Caruso, Report to U.S. Senate Committee on Energy and Resources, 5.
[11] Deutch, "Think Again: Energy Independence" 20.

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+ 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 (reference 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 within the past two years. Increased global demand and Hurricane Katrina-induced shortages have 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 FY05 budget to the detriment of other programs to cover the cost of fuel.[12] This budgetary "pain" has caused every Service to sit up and take action by forming 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 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 Department of Defense 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 paper 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 U.S. security to 2050 and beyond. The three-part approach begins in Chapter 1 by scoping the dimensions of the American energy security problem to create a sense of urgency. It

[12] Hampton, E-mail to Author, 25 Nov 05.

continues in Chapter 2 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 Department of Energy (DOE). The methodology finishes in Chapter 3 by highlighting the process in which a grand strategy can be developed that supports a DoD new energy vision. While there are a multitude of possible and competing DoD energy visions suitable of separate debate, the analysis in this paper is accomplished under the structure of a conceptual three-phase hydrogen/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 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 (i.e., 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, bi-partisan, interagency, and economic demonstration for preserving American security overall.

Chapter 1

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[13]

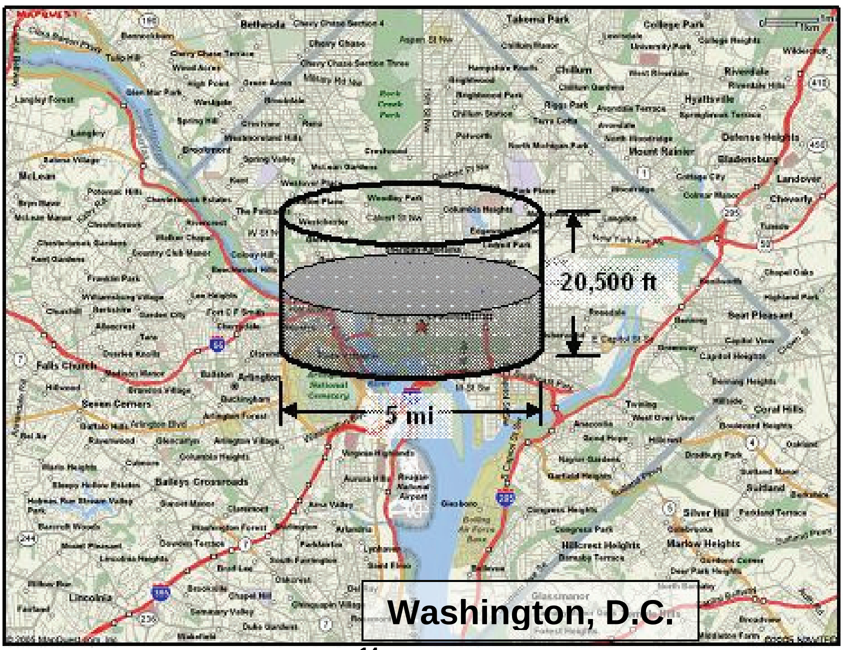

Figure 1 – "The Big Picture"[14]

"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?

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[13] Lynch, David. "Debate brews: Has oil production peaked?", 4.

[14] Map produced from Mapquest.com source; tank drawing added by author.

[15] 2 trillion barrel figure derived from EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates – 'World Oil'" estimate of 1,081T barrels remaining, plus 920B

Simple—the 76 mi^3 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, D.C. and rise to an altitude of just 20,500 ft—an elevation equal to half of a typical passenger jet's cruising altitude or no more than 37 Washington Monuments (555 ft each) stacked one atop another. Now consider the most dramatic visualization: based upon a widely accepted model of peak oil 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 (DOE) Energy Information Agency (EIA) in Figure 2 below:

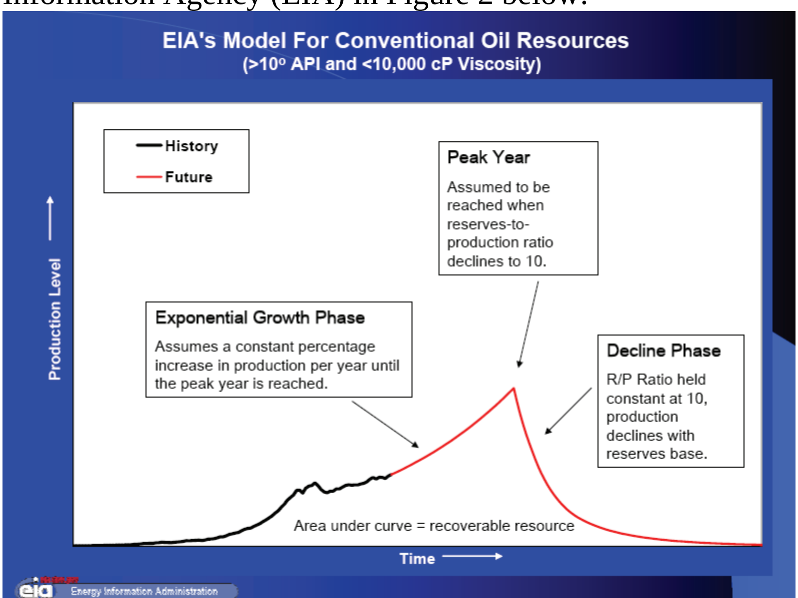

Figure 2 – EIA's Model for Conventional Oil Resources[17]

Complicating the matter is a lack of professional consensus on the actual expected date of global peak oil production, with credible organizations such a ExxonMobil predicting that the non-OPEC Hubbert's Peak will arrive within 5 years[18], and the U.S. Government claiming the planet's absolute peak will occur somewhere around 2037, the midpoint of an officially estimated 45-year window:

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of oil consumed figure from Amidon, "America's Strategic Imperative, A 'Manhattan Project' for Energy", 70.

[16] See Appendix A for a complete list

[17] Caruso, "When Will Oil Production Peak?", Slide 9.

[18] Association for the Study of Peak Oil and Gas, Ireland, 14 Feb 2006.

36 Estimates of the Time of Peak World Oil Production (There Are More)

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	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 around 2000	2002	Smith	2010-2016
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 2025
1998	IEA (WEO)	2014	2003	Simmons	2007-2009
1998	Campbell/Laherrere	2004	2004	Bakhitari	2006-2007
1999	Campbell	2010	2004	CERA	After 2020
1999	Odell	2060	2004	PFC Energy	2015-2020

Figure 3 – 36 Estimates of the Time of Peak World Oil Production[19]

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 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?

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[19] Caruso, "When Will World Oil Production Peak?", Slide 3.
[20] Amidon, "America's Strategic Imperative, A 'Manhattan Project' for Energy", 70.
[21] 2 trillion barrel figure derived from EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates – 'World Oil'" estimate of 1,081T barrels remaining, plus 920B of oil consumed figure from Amidon, "America's Strategic Imperative, A 'Manhattan Project' for Energy", 70.

Global Oil Supply/Demand

Top 10 Petroleum Producers				
Rank	Country	M bbl/d	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

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 1 – 2004 Top 10 Petroleum Producers and Consumers[22]

Each day mankind consumes approximately 84M barrels of oil exchanged through a global commodities market that maintains a supply/demand equilibrium through the fluctuations of a single trade price.[23] An immediate observation from Table 1 is that Saudi Arabia and Russia occupy the #1 and #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 U.S... Furthermore, amongst 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 satisfy domestic energy needs; for example, the U.S. 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 their oil.[24] The top fifteen U.S. oil suppliers are:

[22] EIA, “Top Oil Producers, 2004” and “Top Oil Consumers, 2004”.
[23] EIA, “World Oil Balance (2001-2005)”, Table 2.1.
[24] Deutch, “Think Again: Energy Independence” 20.

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 U.S. Crude Oil and Petroleum, 2004[25] (Thousand barrels/day)

While the U.S. 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 (note – Canada's 178B barrels includes 4.3B barrels of conventional crude and 174B barrels of synthetic oil to be potentially derived from tar sands):[26]

[25] EIA; "Imports of Crude Oil and Petroleum Products into the United States by Country, 2004.", Table 21.
[26] EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates." Table footnotes 2 – 4.

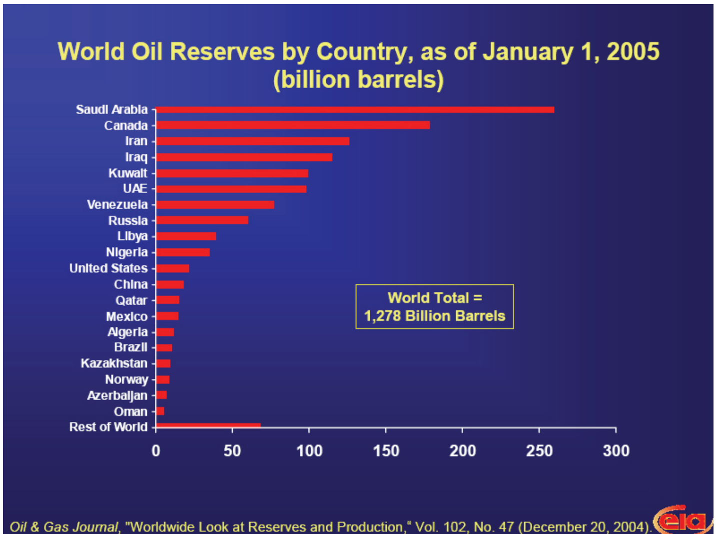

Figure 4 – Proven World Oil Reserves[27]

Saudi Arabia's 262B bbls, together with OPEC's additional 449+B bbls, represent 68+ 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 U.S., 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 4-5 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 U.S. and its 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]

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[27] Caruso, "World Energy and Economic Outlook to 2025", Slide 18.
[28] EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates."
[29] EIA, "World Proved Reserves of Oil and Gas, Most Recent Estimates."
[30] Deutch, "Think Again: Energy Independence" 20.

[31] Office of Deputy Assistant Secretary for Petroleum Reserves, *Strategic Significance of America's Oil Shale Resource; Assessment of Strategic Issues*. 7.

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/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 and 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. DOE's EIA tracks, analyzes, and predicts global energy supply and demand. EIA Administrator, Mr. 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]

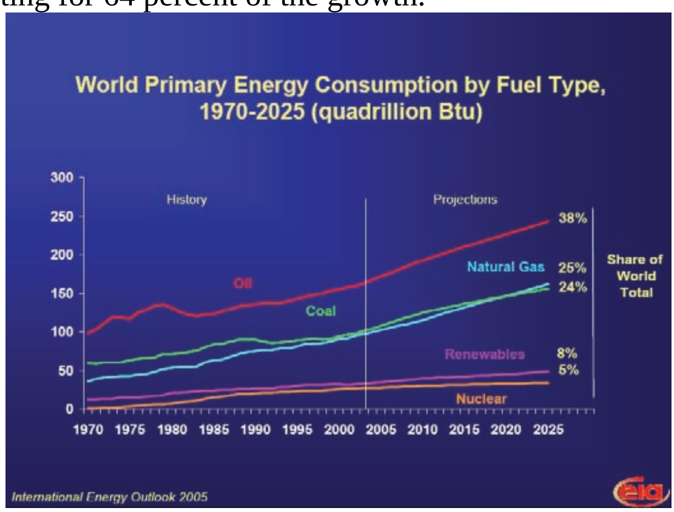

Figure 5 – Worldwide Energy Consumption by Fuel Type[36]

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[32] Ibid.
[33] Lynch, David. "Debate brews: Has oil production peaked?", 2
[34] Caruso, "World Energy and Economic Outlook to 2025", Slide 2.
[35] Caruso, "World Energy and Economic Outlook to 2025", Slide 2.
[36] Caruso, "World Energy and Economic Outlook to 2025", Slide 9.

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, which when combined with projected population growth patterns reveals a first-of-it's-kind event in human history: emerging economies will overtake the energy needs of economically mature and transitional (i.e. former Communist) economies by 2020, with potentially profound socio-political consequences for the world.

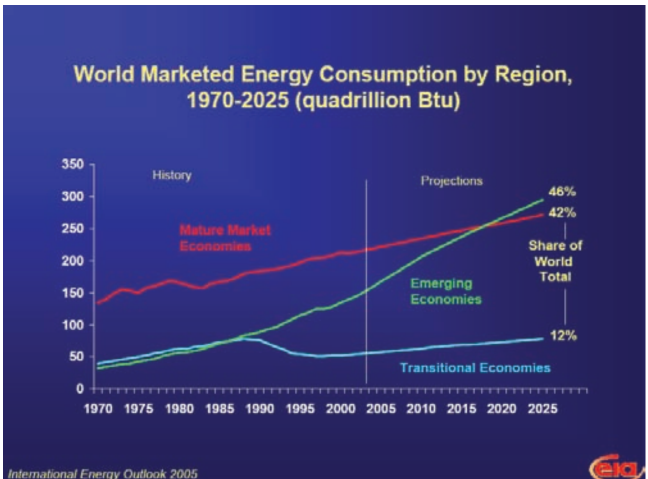

Figure 6 – World Energy Consumption by Region[37]

Energy Implications for America

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

[37] Caruso, "World Energy and Economic Outlook to 2025", Slide 6.
[38] Caruso, Statement Before Energy and Air Quality Subcommittee; and Deutch, "Think Again: Energy Independence" 20.

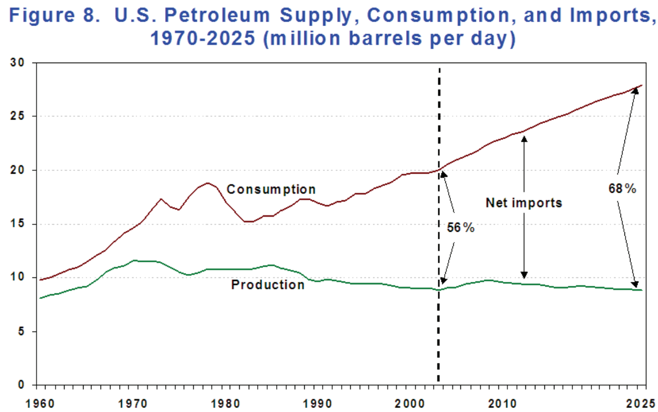

Figure 7 – U.S. Petroleum Supply, Consumption and Imports[39]

What are the U.S. military consequences of this situation? 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 semi-permanent, with global demand essentially equaling available global production capacity. EIA reported that in 2005 surplus global oil production capacity was only 1.5M bbls/day, less than 2 percent above the daily 84M bbl/day demand.[40] Consequently, Goldman Sachs expects oil to remain at $60+ a bbl 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 5M-barrel/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.[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 DoD's activities and America's foreign policy could be ever more dictated by the requirement to secure the 68+ percent share of oil it needs to acquire internationally.

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[39] Caruso, Statement Before Energy and Air Quality Subcommittee, Figure 8.
[40] Caruso, Statement to Committee on Energy and Natural Resources.
[41] "Oil and the Global Economy, Counting the Cost." *The Economist*.
[42] Amidon, "America's Strategic Imperative, A 'Manhattan Project' for Energy", 72.
[43] Zarocostas, "Skyrocketing Costs Feared in Nuke Standoff."

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 (2M bbls/day or more) in one area, cannot be compensated for by increasing production in another. It is important to understand how the U.S. 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 U.S. 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 19.7M barrels of oil per day for all forms of transportation—by 2025 this percentage is expected rise to 73 percent of a total 28.3M bbl/day consumption rate (see Figure 9)[44].

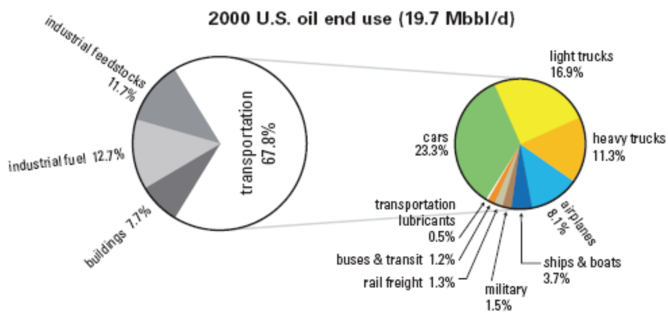

Figure 8 – 2000 U.S. Oil End Use [45]

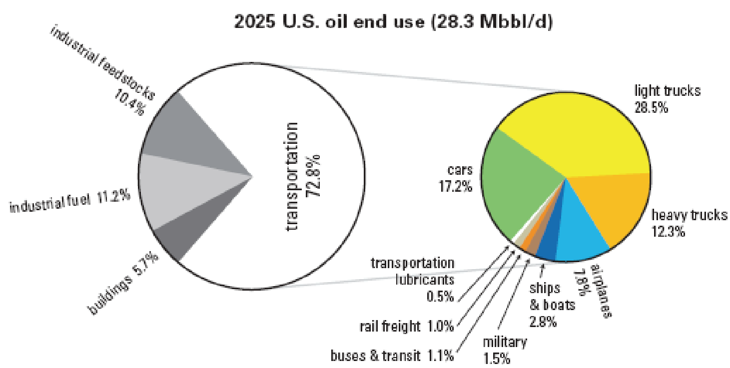

Figure 9 - 2025 U.S. Oil End Use[46]

[44] Lovins, *Winning the Oil Endgame*, 36..
[45] Ibid.
[46] Ibid.

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 allows 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: 1) military industrial supply, 2) contractor support, 3) commercial logistics, and 4) installation requirements. While most policy makers and analysts will focus on the 1.5 percent of national petroleum consumption directly used by the DoD when studying DoD petroleum dependency (94 percent of which is for mobility/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/support every activity or procured end item within DoD, the fact that 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. 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

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[47] Lovins, *Winning the Oil Endgame*, 36.

contracts expect the contractor to independently acquire all fuels necessary to fulfill his obligations. This presents another accounting category that is not represented on DoD total fuel tally sheets nor is it easily projected into the minds of military leaders as a potential Achilles' heel should their contractors ever be unable to economically or physically purchase fuel during a strategic or even operational energy shortage or crisis.

The third under-recognized DoD petroleum dependency is in commercial logistics. 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/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, suffice it to say that some non-negligible civilian portion of the 67.8 percent of U.S. oil used for transportation in Figures 8 & 9 is used to directly or indirectly support DoD operations

The final under-recognized defense petroleum dependency is in installation requirements. While most permanent U.S. 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 U.S., 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, regardless of whether it is in an austere forward deployed location, or in the U.S. after a natural gas "Hubbert's Peak" that occurs within only a few years of petroleum's peak (EIA expects U.S. domestic natural gas production to peak in 2015).[48] As will be discussed later in this paper, the similarities between permanent base energy requirements and

[48] Caruso, *Statement Before the Energy and Air Quality Subcommittee.*

their civilian institutional counterparts provides the DoD with a double opportunity to immediately leverage commercial advances against installation energy vulnerabilities and then again by applying this same progress 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 of how much and in what way does the DoD depend upon petroleum to directly complete its combat mission? Few would disagree that combat is one 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 U.S. military operations serve as perfect examples of the fuel required to sustain decisive combat activities. In its FY04 Fact Book, the Defense Energy Support Center (DESC) reports that between Oct 2001 and Sep 2003 Operation ENDURING FREEDOM required 2.6M gallons (61,500 bbls) of fuel a day and between Mar 2003 and Sep 2004 Operation IRAQI FREEDOM consumed 1.06M gallons (25,300 bbls) a day.[50]

A review of the last 60 years of American military doctrine reveals 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 mass firepower to overwhelm an enemy and reduce risk to one's own forces. This American-perfected and synergistic air-land dominance comes at great energy cost, and by studying the DESC FY04 Fact Book one can identify some force structure vulnerabilities that would quickly manifest themselves should the U.S. 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 134M barrels of liquid fuel (370,000 barrels/day), of which 75 percent or 101M barrels were some form of aviation fuel (JP-4, JP-5, JP-8, or Jet A).[51]

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[49] Lovins, *Winning the Oil Endgame*, xi.
[50] Defense Energy Support Center, *DESC FY2004 Fact Book*, 5.
[51] Ibid, 21.

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]

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 USMC amounts, Table 3 reveals that in fact 75 percent of 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 DoD, making focused logistics and dominant maneuver the most energy-vulnerable dimensions within 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 non-availability, 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

[52] Defense Energy Support Center, *DESC FY2004 Fact Book*, 18.
[53] Defense Energy Support Center, *DESC FY2004 Fact Book*,, 20.
[54] Ibid, 18.
[55] Sega, "Air Force Energy Strategy for the 21st Century", Slide 5.
[56] Defense Energy Support Center, *DESC FY2004 Fact Book*, 50.

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 U.S. 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 U.S. operational forces would be to conduct a purpose-built modeling simulation that specifically asks this question—an endeavor that sources polled by this author in OSD(AT&L), Joint Staff/J4, Joint Forces Command/J3 & J9, Sandia National Laboratory, the U.S. Army Battle Command Training Center, and Air Force Research Laboratory offices indicates has not yet occurred. This vulnerability/capabilities drill demonstrates that the effectiveness of necessary JV2025 dominant maneuver, focused logistics, precision engagement, full dimension protection, and information security concepts following a possible Hubbert's Peak will be dependent upon the force structure and energy security decisions DoD policy makers 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 basic envisioned security future and credible threats to it, 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. The NSS provides broad strategy for both near- and long-term threats, while 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 (NMS) 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 most recent NSS (2002) President Bush acknowledges that: [57]

> 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

[57] Bush, *The National Security Strategy*, Introduction.

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.[58]

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[59]

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 NATO as well as other long-standing alliances.

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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: [60]

• 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

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[58] Ibid.

[59] Ibid, 1.

[60] Ibid, 1-2.

These NSS excerpts infer the following tasks for the DoD: 1) be prepared to cooperate with friends and allies to prevent WMD or other attacks, 2) be prepared to help diffuse regional conflicts, 3) protect the foundations of free markets and trade, and 4) 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 become the standards 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 regards to strategic energy security. On this matter the NSS states: [61]

> 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: [62]

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

While the four-year-old NSS does not appear to directly discuss the risk of a growing reliance on increasingly scarce foreign energy, the President's

[61] Bush, *The National Security Strategy*, 19.
[62] Ibid, 20.

2006 State of the Union Address updates this concept by elevating the security imperative of eliminating foreign energy dependence.[63]

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. DoD's specific strategic objectives are to: 1) secure the US from direct attack, 2) secure strategic access and retain global freedom of action, 3) strengthen alliances and partnerships, and 4) establish favorable security conditions.[64] Force structure builders recognize that securing the US from direct attack requires possessing the means to 1) gather superior intelligence and 2) deter and defend against identified threats; securing strategic access and global freedom of action requires possessing the means to 3) ensure uncontested movement on the seas, in the air, in space, and cyberspace; strong alliances and partnerships requires the means to 4) provide material assistance and 5) directly aid a threatened friend while simultaneously satisfying the first two requirements; and finally, establishing a favorable security environment requires the means to 6) respond rapidly to world developments.

To accomplish the objectives of assuring allies and friends, dissuading potential adversaries, deterring aggression/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.[65] This strategy is built upon several important assumptions:[66]

1. The U.S. will retain a resilient network of alliances and partnerships
2. The U.S. will have no global peer competitor and will remain unmatched in traditional military capability
3. The U.S. will maintain important advantages in other elements of national power—e.g., political, economic, technological and cultural.
4. The U.S.'s capacity to address global security concerns alone will be insufficient

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[63] President Bush, *2006 State of the Union Address*.
[64], DoD, *The National Defense Strategy of the United States of America,* 1.
[65] DoD, *The National Defense Strategy of the United States of America*, 1.
[66] Ibid

5. Natural forces of inertia and resistance to change will constrain military transformation.

The NDS unequivocally states that the U.S. cannot achieve its defense objectives alone—the concept of active, layered defense includes international partners.[67] This admission and the assumption that the U.S. will work through a network of alliances and partnerships necessarily dictates that any national defense/energy analysis must include the energy limitations or strengths of those aligned nations, many of which are significantly worse off than the U.S.

The U.S. 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 U.S. cannot unilaterally control the power rise of every nation on Earth—the U.S. can only control the level of effort it will expend to maintain its sole super power position. Since superpowers typically seek to maintain their strength through various forms of innovation[68], it is not unreasonable to assume the presence of technological advantages for the U.S.—but, 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.[69] 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:[70]

1. Protect critical bases of operation
2. Operate from the global commons
3. Project and sustain forces in distant, anti-access environments
4. Improve proficiency against irregular challenges
5. 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 U.S. can employ military power with other instruments of national power to *swiftly defeat* adversaries and achieve decisive, enduring results.[71] In all cases the DoD

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[67] Ibid, 10
[68] Kluz, Theodore M. (USAF Air War College Professor), interviewed by author, 3 Oct 2005.
[69] Bush, *2006 State of the Union Address*.
[70] DOD, *The National Defense Strategy of the United States of America*12.
[71] Ibid, 17.

plans to *seize the initiative and dictate the tempo, timing, and direction* of military operations.[72] 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.[73] 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.[74] The U.S. sees itself operating with *increasingly rotational forces* in four forward regions: 1) Europe, 2) Northeast Asia, 3) the East Asian Littoral, and 4) the Middle East-Southwest Asia.[75]

Using words such as "swiftly defeat", "seize the initiative", "surge from a global posture", "emphasizing agility" and "increasingly rotational forces" indicates that the U.S. defense strategy relies heavily upon high-energy strategic mobility and operational/tactical maneuverability. The conclusion that can be drawn from this NSS and NDS review is that to remain secure the U.S. will need to be both proactively engaged and ready to respond globally on a moment's notice against the full spectrum of threats—including non-warfare 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 U.S. envision the military force of 2050 to be reliably fueled and configured to provide the security America requires?

[72] Ibid, 8
[73] Ibid, 18.
[74] Ibid, 18.
[75] DOD, *The National Defense Strategy of the United States of America*, 17.

Chapter 2
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[76]

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:[77]

1. Establish a sense of urgency
2. Create a guiding coalition
3. Develop a vision and strategy
4. Communicate the change vision
5. Empower employees for broad-based action
6. Generate short-term wins
7. Consolidate gains and produce more change
8. 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 paper 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 DoD can lead a long-term energy conversion vision and strategy in order to remain relevant to 2050 and beyond.

Chapter 1 of this paper was intended to highlight the type of data necessary for generating a sense of urgency within the minds of policy decision makers. 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

[76] Bush, *2006 State of the Union Address*.
[77] Kotter, *Leading Change*, Table of Contents.

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.[78] Building upon the previous chapter's presentation of energy data, NDS assumptions, and required key operational capabilities, this chapter 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 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.[79]

Furthermore, building a coalition that can make change happen requires finding the right people, creating trust between them, and then allowing them to develop a common goal.[80] 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

[78] Kotter, *Leading Change*, 52.
[79] Ibid, 51-52.
[80] Ibid, 66.

strategy, the budget and programming community to advise and execute programming decisions, and representatives of key inter-agencies such 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 that an energy transformation could entail, and the typical institutional resistance to transformational change acknowledged in Chapter 1'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 pre-decision proposal to USD(AT&L), Dr. Theodore Barna, Assistant Deputy Undersecretary of Defense/Advanced Systems and Concepts, recommended that DoD establish an Energy, Power, and Fuels Office (EPFO) of Service, OSD, and interagency representatives to lead a multi-faceted approach for military energy security focused primarily on synthetic fuels production called the Assured Fuels Initiative [81] 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+ year DoD energy transformation strategy toward the vision of a petroleum-free combat force that is relevant to 2050 and beyond. With the full

[81] Barna, Power and Energy, *A Plan for Reducing DoD's Reliance on Foreign Oil and Assuring DoD's Continued Access to Energy*, 1-6.

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[82] Department of Energy (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."[83] Examination of the energy security and scientific research strategic goals within the DOE's 2003 Strategic Plan:[84]

> **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.
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> **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.

reveals that when it comes to energy, the DOE is an institution that focuses primarily on science and technology R&D—the Department's affirmation that its principle tool for implementing

[82] DOE, *Department of Energy Budget by Appropriation*, 18.
[83] DOE, *The Department of Energy Strategic Plan*, 1,3.
[84] DOE, *The Department of Energy Strategic Plan*, 4.

policy is conducting the 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 strategist then, it is important to realize that the DOE performs its mission for a broad national cliental, 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 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 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 the DoD and DOE, it can then be argued

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85 DOE, *The Department of Energy Strategic Plan*, 1, 15.
86 Ibid, 16.

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 new 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 multitude 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 U.S. military remains effective and relevant to 2050 and beyond.

Created 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 that it will lead the DoD to create. The vision should refer to a picture of the future with some implicit or explicit 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: 1) by clarifying the general direction for change, it simplifies hundreds or thousands of more detailed decisions, 2) it motivates people to take action in the right direction, even if the initial steps are personally painful, and 3) 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 backwards in time from an effective vision of the future to the present day, the guiding coalition can then identify the milestones,

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[87] U.S. Congress, *Energy Policy Act of 2005*, Sect 1006 (b)(1).
[88] Kotter, *Leading Change*, 68.
[89] Ibid, 69, 72.

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 they are trying to mitigate (loss of military ineffectiveness 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, and 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, bio-fuels, 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 paper does not permit detailed descriptions of the identified emerging energy options, however, a small synopsis is presented on each in Appendix B). Only after understanding these energy sources and technologies, as well as the nation's defense and energy objectives, strategies, capabilities, and limitations, are the members of the Office of Assured Energy ready to create an assured energy vision.

The visioning process can be lengthy and produce any number of possible outcomes, but for illustrative proposes, 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 (FCS) 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 10-15 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 non-activity periods, but would also be capable of enhancing unit survivability and flexibility by using excess on-board 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 CONUS 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 like Star Wars fantasy to some, imagine how the following vision statement may have sounded to the War Department in 1906:

> *In 1950 the U.S. 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—Chapter 3 examines how to develop the best strategy to create the vision of a petroleum-free Department of Defense.

Chapter 3
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 2020.
- Defense Science Board Task Force on Improving Fuel Efficiency in Weapons Platforms, OSD (AT&L), Jan 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 observation 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.

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[90] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden*, Summary Page.
[91] Friedman, *The World is Flat: A Brief History of the Twenty-First Century*, 279.
[92] Ibid.

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 *backwards* 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 eight 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 U.S. 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 are 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/electric powered force, there are two primary strategies: 1) allow market forces and timing to create and deliver necessary transformational capabilities (the DOE model), or 2) allow 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 Chapter 2, the unique

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[93] Kotter, *Leading Change*, 123.

acquisition lead times and vital responsibilities of the DoD may force it to address this problem long before market forces have identified winning solutions, and is therefore the basis for selecting the latter option to continue examining in this paper. A strategy of waiting for market forces to deliver options is not without merit, and a more detailed comparison of market-led vs. DoD-led strategies is outlined against a status-quo standard in Appendix C.

Working backwards from the vision then, the overarching strategy can be imagined to address the following tasks: 1) acquire alternate-fueled systems, 2) create an alternate fuel delivery infrastructure, 3) develop new energy standards, 4) determine a new energy force structure, 5) conduct R&D to acquire transformational technologies, and throughout the process, 6) protect against negative oil peaking effects to allow sufficient transformation time, 7) minimize transformation costs, and 8) 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: 1) a near-term (2006 – 2020) DoD-wide focus on establishing proper strategic leadership, energy efficiency, conservation, acquisition reform, bridge energy sources, and research & development (R&D), 2) a mid-term (2020-2035) focus on infrastructure and technology transition, and 3) 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+B 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/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 directly impact military capability. 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 DoD's greatest contribution to America's long-term energy security

Stage I – 2006-2020 Near-Term Strategy

Five upfront activities can be initiated through effective and immediate DoD policy changes: 1) promoting the "Office of Assured Energy", 2) increasing energy efficiency and conservation, 3) promoting acquisition reform**,** and 4) developing bridging energy sources to buy time to 5) complete intensive R&D efforts for the "new energy" beyond petroleum.

Promoting 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 4th 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, 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]

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[94] Lovins, *Winning the Oil Endgame*, 138
[95] Kotter, *Leading Change*, 85
[96] Kotter, *Leading Change*, 85-100.

Increasing efficiency & 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, etc) 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 while 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:

1. Base investment decisions on the true cost of delivered fuel, warfighting, and environmental benefits
2. Strengthen warfighting and fuel logistics links in wargame modeling
3. Have leadership incentivize fuel efficiency throughout DoD
4. Specifically target fuel efficiency improvements through investments in S&T and systems designs
5. Explicitly include fuel efficiency in requirements and acquisition processes

Arguably, it is the report's third suggestion, "*Have leadership incentivize fuel efficiency throughout 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* (emphasis added).[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 Chief's 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.

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[97] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden*,, ES-7.

[98] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden*,, ES-7.

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 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 KPPs"[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]

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[99] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden*,, ES-2.

[100] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden*,, ES-3.

There are several examples of the type of efficiency-related changes 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 key performance parameter (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 minimizing 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/energy quality, operating limits, etc) 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 sound one of

KPP Enforcement

Strict KPP eforcement has been problematic at times as program managers are forced to make cut-or-continue acquisition decisions on programs with billions of dollars already invested. However, with sufficient OSD emphasis, as evidenced in recent universal interoperability KPP enforcement successes, a universal energy efficiency KPP can also succeed.

Modular Upgradeability

Take the next generation hybrid HUMVEE as an example of the concept of modular upgradeability. Since the vehicle would be expected to last 15 years, it would be required to incorporate state-of-the-art systems at IOC, but then be designed to accept efficiency replacements as the technology matured. Original electric motors could be replaced by superconducting types. The JP-8 powered engine could be replaced by a high efficiency FFV or bio-diesel version. Perhaps the entire engine/generator power pack could be removed by a hydrogen fuel cell. Batteries could be exchanged for better components with each life-cycle replacement. Heavy structures and armor could be replaced by light-weight nano-materials. The result is that at the end of the vehicle's original chassis life cycle, the system would look radically different from how it entered service 15 years earlier.

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 liquification; nuclear power; possibly methane hydrates; and renewables like biofuels, solar, wind, and geothermal power.

Catalyzed by the 2002 OSD(AS&C) Clean Fuels Initiative, the DoD began exploring the mechanics of liquid fuel production from Western U.S. oil shale and Canadian tar sands through the German-developed Fischer-Tropsch process used in WWII.[101] The Clean Fuels Initiative segregated development into two parallel foci: 1) Total Energy Development (TED) for overcoming the economic and technical obstacles necessary to enable large-scale industrial fuel production, and 2) certifying a Joint Battlespace Use Fuel for the Future as a single non-petroleum-derived fuel suitable for use in all current, legacy, and emerging systems.[102]

Congress's Energy Policy Act of 2005 formally authorized DoD to pursue development of coal/shale/sands fuel extraction technologies with the statement, "The SECDEF 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), in his Oct 2005 post-Hurricane Katrina

[101] Barna, *OSD/AT&L Clean Fuel Initiative Briefing to Sen. John Thune's Staff*,.
[102] Ibid, Slide 9..
[103] ,U.S. Congress, *Energy Policy Act of 2005,* Section 2398a(a).

memo to USD(AT&L) with the statement (also subsequently endorsed by the Air Force[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 IOC 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 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 only 400,000 bbls of oil a day by 2020, the fact that Canada already produces one million bbls of oil a day using these techniques from Albertan tar sands (of which 95 percent is already sold to the U.S)[106], and the existence of Congressional pre-approval, makes this low-risk decision virtually inevitable. Many would claim this event marks the end of U.S. petroleum worries; there is no need to be concerned about alternate energies if DoD can catalyze industrial production by 2020—Hubbert's Peak becomes a non-event. 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 potentially long-term energy solution : 1) increased lines-of-communication (LOC)

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[104] Hoffman, *Memorandum to OSD(AT&L)*, 23 January 2006.
[105] Young, *Memorandum to OSD(AT&L)*, 11 November 2006.
[106] Fialka, "In Oil Quest, U.S. Says Rock On", 4.

demands, 2) potential environmental harm (strip mining, high water consumption, CO_2 emissions), 3) increased public-sector synthetic fuel consumption, and 4) 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. DoD's universal adoption of oil-shale fuels by 2020 will create a unique distribution situation not seen since the U.S. last exported fuel: the flow of full tankers *leaving* U.S. sea ports! 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 U.S. 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 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 in the theory for global warming. The significant amounts released during the FT

[107] Cavallo, "Oil: Caveat Empty."

extraction process can be sequestered below ground, but widescale adoption of synthetic fuel does not prevent release of CO_2 at the point of end use combustion. Consuming approximately only 400,000 of the world's estimated 120M bbls a day by 2020,[108] one could successfully argue that 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 DoD conversion to shale-oil: purchase competition from growing public sector synthetic fuel demand.

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/bbl 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 stampede of public-sector consumption for the fields of Wyoming. On the one hand, increased economies of scale should help drive down production costs for 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 Nov/Dec 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 U.S. 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]

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[108] Caruso, *World Energy and Economic Outlook to 2025*, Slide 17.
[109] Barna, Power and Energy, *A Plan for Reducing DoD's Reliance on Foreign Oil and Assuring DoD's Continued Access to Energy*, 6.
[110] Ibid, 2.
[111] Deutch, "Think Again: Energy Independence", 21.
[112] Young, *Memorandum to OSD(AT&L)*, 11 November 2005, Atch 1.

The final concern with 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 U.S. 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 U.S. 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 mean time, other bridging options exist for non-mobility 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 DoD is accomplishing true energy leadership. DoD leads the federal government in the purchase of Green Energy by responding to a 2 Nov 2004, DoD-wide, DUSD(AT&L) for Installations and Environment Memorandum for Installation Energy Policy Goals in which the Honorable Philip W. Grone states, "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

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[113] U.S. Congress, Energy Policy Act of 2005, compiled from various pages.
[114] Grone, Memorandum for Installation Energy Policy Goals, 1.

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-yr contract that saved $42M over fluctuating conventional electrical prices; Fairchild AFB is nearly 100 percent Green Energy, supporting local wind farms; and Dyess AFB became the 2003 Green Power Partner of the Year as the nation's largest singe-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 U.S. military installations came from renewable sources."[118] And that, "While the current level of DoD's renewable energy use meets the federal goal set by DOE, it only represents a small fraction of the possibilities."[119] Because the Air Force has already demonstrated the ability to operate one base on 100 percent renewable power, 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 U.S., with 2,500 MW of new capacity installed causing a 35 percent increase in national production capacity and the U.S. to be placed 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

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[115] Ibid.
[116] U.S. Air Force, "Air Force Leads in Purchase of Renewable Energy".
[117] U.S. Air Force, "Air Force Leads in Purchase of Renewable Energy".
[118] DoD, *Report to Congress: DoD Renewable Energy Assessment, Final Report.*iii.
[119] Ibid iii.
[120] American Wind Energy Association, "U.S. Wind Industry to Break Installation Records, Expand by More Than 35% in 2005.".

technologies such as solar-electric shingles, thin-film solar, and solar day lighting offering opportunities for bases to pay a one-time 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 enlightens, "…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 & development – The final required element in the DoD's quest for foreign oil independence is the recreation 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, U.S. 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 U.S. with a quickly aging science and engineering community and the

[121] DoD, *Report to Congress: DoD Renewable Energy Assessment, Final Report*,ii.
[122] DoD, *Report to Congress: DoD Renewable Energy Assessment, Final Report*,iii.
[123] Kotter, *Leading Change*, 122.

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 acknowledgement of this problem in his 31 January 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 pre-eminence in S&T. 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 report continues, "The US faces enormous challenges because of the disadvantage it faces in labor costs. S&T 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

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[124] Committee on Prospering in the Global Economy of the 21st Century, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, ES-7.
[125] Committee on Prospering in the Global Economy of the 21st Century, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future,*, ES-7.
[126] President Bush, *2006 State of the Union Address*.
[127] Committee on Prospering in the Global Economy of the 21st Century, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future,*ES-6 .

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 U.S could create an entirely new, leading-edge, commercial sector for the global market; a sector that could propel the U.S. economy for decades and turn this nation into a new energy or energy technology exporter, much like the U.S. achieved in the 1940's and 50's when it dominated the export of petroleum development technology.

Solving the DoD's and country's energy future problem will take 20-40 years—an inspiring and exciting potential lifetime career for a new engineering graduate. Might DoD partner with DOE to create a world-renown "New Energy" Research Center of Excellence? To generate the necessary intellectual enthusiasm and capability for this endeavor, the NAS proposes four recommendations 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* (emphasis added), and enhance the quality of life.
>
> > **B-1:** *Increase the federal investment in long-term basic research by 10 percent a year over the next 7 years* (emphasis added). Special attention should go to the physical sciences, engineering, mathematics, and

[128] Ibid, ES-2 .

[129] Committee on Prospering in the Global Economy of the 21st Century, *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future,,* ES2-ES6.

information sciences and to *DoD basic research funding* (emphasis added).

B-4: Allocate at least 8 percent of the budgets of federal research agencies to discretionary funding

B-5: 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 Unites States and throughout the world.

C-1: 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-yr competitive undergraduate scholarships each year to US citizens attending US institutions

C-2: 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 $2 million 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+ approaches to solving the problem with a clear demonstration of what works, and what doesn't.[130] Much like the Gossamer Albatross and Spaceship One were inspired by standing prizes, the DoD may find its energy answers in a team of bright college seniors 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 as 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 FY2005 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 five years.[132] Four areas of possible focus spring to the forefront: 1) efficiency technologies, 2) nano-science, 3) Energy and Power Technology Initiatives, and 4) infrastructure technologies.

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

> Specifically target fuel efficiency improvements through investments in S&T 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.

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[130] Lerner, "Robots Go to War", 48.
[131] Brody, "What Matters Most Depends Where You Are", 52.
[132] President Bush, *2006 State of the Union Address*; and U.S. House Committee on Energy and Commerce, "Energy Policy Act of 2005", 4.

S&T community should make platform efficiency a primary focus to identify, track, and package technologies that improve efficiencies. It is fundamental that DoD support fundamental (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 here matters—programs such as the Versatile Advanced Affordable Turbine Engine (VAATE) 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 1940's and 50's for the "Suntan" project.[134]

The exciting and new field of nano-science offers great hope for a DoD energy vision. As part of the National Nanotechnology Initiative, the National Science and Technology Council's (NSTC) Nanoscale Science, Engineering, and Technology Subcommittee (NSET) 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, etc) take place on the nano-scale."[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

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[133] Defense Science Board Task Force on Improve Fuel Efficiency of Weapons System Platforms, *More Capable Warfighting Through Reduced Fuel Burden,*, ES-7.

[134] NASA, *Liquid Hydrogen as a Propulsion Fuel, 1945-1959,* Ch 8.

[135] Committee on Technology, *Nanoscience Research for Energy Needs, Report of the National Nanotechnology Initiative Grand Challenge Workshop, March 16-18, 2004,* v.

[136] Committee on Technology, *Nanoscience Research for Energy Needs, Report of the National Nanotechnology Initiative Grand Challenge Workshop, March 16-18, 2004,* v.

March 2004 National Nanotechnology Grand Challenge Workshop identified nine research targets in energy-related S&T in which nanoscience is expected to have the greatest impact:[137]

1. Scalable methods to split water with sunlight for hydrogen production
2. Highly selective catalysts for clean and energy-efficient manufacturing
3. Harvesting solar energy with 20 percent power efficiency and 100 times lower cost
4. Solid state lighting at 50 percent of the present power consumption
5. Super-strong and lightweight materials to improve the efficiency of cars, planes and the like
6. Reversible hydrogen storage materials operating at ambient temperatures
7. Power transmission lines capable of 1 gigawatt transmission
8. Low-cost fuel cells, batteries, thermoelectrics, and ultra-capacitors build from nanostructured materials
9. 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 nano-science 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 & distribution categories, EPTI will draw heavily from nano-science 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-

[137] Ibid, vi.

[138] Barna, "Power and Energy, A Plan for Reducing DoD's Reliance on Foreign Oil and Assuring DoD's Continued Access to Energy", 4-5.

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".

Energy infrastructure is perhaps the least glamorous of all the research areas, but 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/energy research must exist 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, etc. 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 (i.e., Betamax vs. VHS, CD and DVD formats, etc). The computer industry did not expand rapidly until universality and modularity were adopted that allowed users to custom configure and continually upgrade their systems, preserving their legacy investment. This model can be seized upon and articulated early by 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 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 1) adjusting force structure for the "new energy" future, 2) adjusting operational training and procedures, and 3) investing in "new energy" infrastructure and transition

[139] Barna, "Power and Energy, A Plan for Reducing DoD's Reliance on Foreign Oil and Assuring DoD's Continued Access to Energy", 4..

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/energy limitations–the next opportunity to formally adjust force structure will occur in 2009. [140] Four years from now the state of world/DoD petroleum supplies may be much more acute, at which point the DoD would likely be required to address energy efficiency/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.

2009 QDR force structure decisions will be reaching full effect by 2020. In the proposed 40+-year transformation strategy, the U.S. 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 risk/cost analyses of extending inefficient system lifespans, and plan to accept certain mission limitations and vulnerabilities for a period if necessary. The sooner replacements are produced, the smaller this vulnerability window—the U.S. 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 & Training Procedures – Operations and maintenance (O&M) costs—the most energy

[140] Brown, Mike, E-mail to Author, 27 September 2005.

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 decision makers to carefully select future engagements. If so, then operational commanders will also be required to integrate maximum fuel efficiency and opponent energy limitations in their planning calculus. Since within two 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 that in turn drive certain, less energy-intensive courses of action. As a minimum, 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 DoD will have to address is incentivizing commercial development for manufactured liquid hydrocarbon fuels—this is akin to 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

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[141] OMB, Department of Defense FY2006 Budget.

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 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 bio-energy 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+ percent more-efficient LED lighting. Wind power farms subsidized by long-term DoD purchase contracts could become the norm vs. 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 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: 1) proximity to raw energy resources, 2) economies of scale, and 3) 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, technology has also balanced the playing field, increasing the efficiencies of smaller producers, automating control and maintenance functions through computers and better design, and

[142] Young, Memorandum to OSD(AT&L), 11 November 2005.

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 Lt Gen 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 be the most difficult phase of an energy transition. Fortunately, if the 2005 EPAct'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/more reliable linear electric actuators vs. 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-

[143] Naval Research Advisory Committee, "Future Fuels", Slide 2.

case cost-activity analysis to determine if and when such a conversion is possible (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 likely that insufficient time will exist to create a fully converted and viable force for Stage III.

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

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 III the DoD would need to focus on 1) completing a full conversion of all infrastructure and systems to the "new energy" standard, 2) ensuring distributed, ubiquitous, and adequate energy production exists to provide greater agility and survivability, and 3) continuing R&D to develop even more superior forms of energy production and use. By envisioning and creating its own energy future, DoD would 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 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 manners 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/natural gas facilities; ubiquitous solar, wind, geothermal, thermoelectric, and ocean tide/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, but in only the rarest of cases will it rely on foreign fuel stocks—only if the risk/benefit analysis demonstrates 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/volume constraints until technologies are most mature (remember that 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 nation grow comfortable with the new energy paradigm and 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 air & space propulsion, nuclear fusion, space solar generation, moon energy exploration, and matter/anti-matter propulsion to name a few.

As Chapter 3 has demonstrated, the journey to DoD's energy future will be both monumental and complex, requiring enormous strategic leadership to accomplish. 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]—it is therefore a problem the DoD will have to solve before the end of this century, the only questions are therefore when and where will it begin to do so?

[144] NASA, *Liquid Hydrogen as a Propulsion Fuel, 1945-1959*, Ch 8.
[145] Caruso, *When Will Oil Production Peak?,* Slide 2.

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, & inter-agencies**
4. **Build strategy backwards 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 & technology**
        ii. **Reform/streamline acquisition system to reward energy efficiency, adopt new standards, and support modular**

Figure 10 – A Methodology to Achieve DoD Petroleum Independence

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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 dependent upon its technological tools for success. Some of these combat systems now take over two decades to acquire and have 40+ 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

[146] Lovins, Winning the Oil Endgame, 264.
[147] Ibid, 3.

combination of long systems acquisition lead times, an overwhelming petroleum dependence, and a non-transferable 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 simultaneously 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 paper 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 U.S. 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+ year energy transformation process. Consisting of permanent representatives from OSD, the Services, and inter-agencies, 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 U.S. military unconstrained by conventional paradigms, this paper proposed a three-stage transformation strategy to 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 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 & 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 efforts that strive for ever greater energy answers.

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 U.S., and the world will all inevitably have to face in the next 100 years. The Kotter-based organizational change methodology presented in this paper 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, bi-partisan, 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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Appendix A

Peak Oil Predictions

Projected Date	Source of Projection	Background
2006-2007	Bakhitari, A.M.S.	Oil Executive (Iran)
2007-2009	Simmons, M.R.	Investment banker (U.S.)
After 2007	Skrebowski, C.	Petroleum journal editor (U.K.)
Before 2009	Deffeyes, K.S.	Oil company geologist (ret., U.S.)
Before 2010	Goodstein, D.	Vice Provost, Caltech (U.S.)
Around 2010	Campbell, C.J.	Oil geologist (ret., Ireland)
After 2010	World Energy Council	World Non-Government Org
2012	Pang Xiongqi	Petroleum Executive (China)
2010-2020	Laherrere, J.	Oil geologist (ret., France)
2016	EIA nominal case	DOE analysis/ information (U.S.)
After 2020	CERA	Energy consultants (U.S.)
2025 or later	Shell	Major oil company (U.K.)

Table 4 – Peak Oil Predictions[148]
1

[148] Hirsch, "The Inevitable Peaking of World Oil Production", 9.

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Appendix B
Alternative Energy Options

The Energy Policy Act of 2005

The President's 2001 National Energy Policy spawned a massive, 4-year Congressional effort to craft a comprehensive 1,724–page national Energy Policy Act signed into law in August of 2005.[149] Tasking DOE with primary execution responsibility and backed with a 5-year funding plan of almost $4B for energy and conservation, $3+B for renewable energy efforts, and $2.5B in fossil fuel efforts, this historic act addressed every aspect of energy policy.[150] A small snapshot of examples includes reducing federal building energy usage 20 percent by 2015, reauthorizing the Renewable Energy Production Incentive program and requiring the federal government to use 7.5 percent or more renewable energy by 2013, increasing the Strategic Petroleum Reserve from 700M to 1B barrels, authorizing DOE to develop oil shale liquid fuel development with DoD, spending $1.8B to fund the Clean Coal Power Initiative, and renewing the Price Anderson nuclear liability protection laws for another 20 years to stimulate nuclear reactor development. It also authorizes spending $2.15B over 5 years to create a state-of-the-art national hydrogen program designed to place 2.5M hydrogen-powered vehicles on the road by 2020 as well as a hydrogen fuel cell Clean School Bus program and a Hybrid Retrofit and Electric Conversion program to enhance or replace traditional internal combustion engines, spending $6M to revise CAFÉ standards, development of superconducting power transmission lines as part of a comprehensive electrical infrastructure upgrade, and introducing 5B gallons of renewable liquid fuels into the market place by 2010.[151]

The Energy Policy Act of 2005 charged DOE with extensive R&D tasks ($783M in FY07, $865M in 2008, $952M in FY09) [152] to include conducting a balanced set of programs of energy research, development, demonstration, and commercial application with the general goals of:[153]

1. Increasing the efficiency of all energy intense sectors through conservation and improved technologies
2. Promoting diversity of energy supply
3. Decreasing the dependence of the U.S. on foreign energy supplies

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[149] U.S. Congress, *Energy Policy Act of 2005*.
[150] U.S. House Committee on Energy and Commerce, "Energy Policy Act of 2005", 4.
[151] Ibid, 1-5.
[152] U.S. Congress, *Energy Policy Act of 2005*., Sect 911(b).
[153] Ibid, Sect 902(a).

4. Improving the energy security of the US
5. Decreasing the environmental impact of energy-related activities

Specific R&D programs reflect research vision and bring the potential to forever alter the planet's energy paradigms. For example, within 2 years DOE is to build a solar-hydrogen powered car and report on the feasibility of constructing a commercial pilot plant for hydrogen-production using solar energy only.[154] Starting with $15M in FY07 and increasing to $50M in FY10, the National Research Council is to explore the feasibility of extracting up to 200,000 trillion cubic feet of methane hydrate from deep sea regions,[155] to explore the feasibility of distributed energy programs and small scale generation,[156] and to conduct fundamental research in the Next Generation Lighting Initiative.[157] In addition to the assigned research tasks, DOE was also charged with three important organizational/policy changes: 1) to create S&T graduate, post-doctoral, and senior research fellowships with post-program DOE employment requirements,[158] 2) to report to Congress by FY06 on the advisability of creating a high-risk research agency within DOE modeled after the DoD's highly successful Defense Advanced Research Projects Agency (DARPA),[159] and 3) to incorporate a new SES3 Undersecretary of Science position responsible for coordinating all DOE S&T activity.[160] This last change, creation of an Undersecretary of Science position, consolidates all research activity under one high-level office singularly responsible for providing focused strategic energy research leadership and affecting productive interagency coordination.

Existing and Emerging Energy Alternatives

DOE energy research will focus on three main areas of energy creation and utilization: 1) improving existing mainstream energy systems such as petroleum, natural gas, nuclear, hydroelectric, and coal, 2) improving and developing energy distribution systems to include energy carriers such as electricity and hydrogen, and 3) enhancing the maturation of emerging energy systems such as a) the family of renewables (biofuels, wind power, solar power, oceanic), b) previously underutilized hydrocarbon sources such as tar sands, oil shale, and methane hydrates,

[154] Ibid, Sect 933.
[155] Ibid, Sect 968(a)(2).
[156] Ibid, Sect 924(b)(1).
[157] Ibid, Sect 912.
[158] Ibid, Sect 984A.
[159] U.S. Congress, *Energy Policy Act of 2005*, Sect 1821(b).
[160] Ibid, Sect 1066.

and c) the exotic world of six-sigma technologies (nuclear fusion, matter/anti-matter, etc). The plethora of problems and potential solutions in both the creation and utilization realms ensures no shortage of R&D requirements and guarantees short to mid-term turmoil associated with identifying winning services or technologies in a period of high innovation and experimentation.[161] Detailed analysis of each opportunity would consume several volumes beyond the scope of this paper; consequently the following paragraphs attempt to only briefly discuss the status and main issues in each major energy area as needed to support this report.

Petroleum

Petroleum distillates are the primary mobility/maneuver fuels of the DoD and the planet, and possess an uncertain future regarding peak production date estimates. Concentrated in certain regions of the world, it is sold as a single-price commodity through an established exploration and distribution network that the Paris International Energy Agency predicts will take $5 trillion to maintain over the next 30 years.[162] DoD is the world's single largest institutional user today, consuming approximately 134 million barrels a year.[163] The U.S. is expected to import 68 percent of its requirements by 2025.[164]

Natural Gas

An annual U.S. 19 trillion cubic feet demand is used to fuel 16 percent of U.S. electrical requirements (expected to rise to 24 percent by 2025) and to satisfy a major portion of U.S. heating requirements. 2,500 trillion of world's 6,000 trillion cubic feet reserves are owned by the Middle East—North American reserves are only approximately 250 trillion cubic feet,[165] and U.S. imports are expected to grow to 6 trillion cubic feet/yr by 2025.[166] Natural gas is presently the primary feedstock to produce most U.S. hydrogen. With the exception of liquefied natural gas, it must be utilized via direct connection to source. Natural gas is used by the DoD to either directly heat facilities or indirectly produce electricity via commercial producers.

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[161] Lovins, *Winning the Oil Endgame*, 252-253.
[162] Lynch, David. "Debate brews: Has oil production peaked?", 4.
[163] Defense Energy Support Center, *DESC FY2004 Fact Book*, 21.
[164] Caruso, Statement Before Energy and Air Quality Subcommittee.
[165] Caruso, "World Energy and Economic Outlook to 2025", Slide 20.
[166] Caruso, Statement Before Energy and Air Quality Subcommittee.

Nuclear

All existing U.S. power plants are fission type and are expected to continue operating through 2025, but no new plants are expected to be built either.[167] Nuclear power share of U.S. electrical production will drop from 20 percent to 14 percent in 2025.[168] Japanese aggressively pursuing breeder reactor technology which will produce more power than it consumes, but will also produce plutonium byproducts that could complicate world counter proliferation efforts. Many nations are seeking to develop hot fusion technology. Aside from nuclear powered sea vessels, DoD uses nuclear power indirectly through commercial electricity purchases.

Coal

The U.S. possesses the world's largest coal reserves, approximately 270 of the world's 1,001 billion short tones—an amount sufficient to power America for 250 years at present consumption rates.[169] Major environmental drawbacks are from mining activity and heavy carbon dioxide production. New technologies are demonstrating ability to sequester nearly all carbon emissions. Coal can be converted into natural gas, hydrogen, or liquid hydrocarbon fuel. The DoD presently uses coal indirectly through commercial electricity producers.

Hydroelectric

The U.S. derives 6.5 percent of electrical energy from hydroelectric power.[170] No significant production increases expected (other than efficiency increases) due to maximization of existing sites.

Biofuels

[167] Caruso, Statement Before Energy and Air Quality Subcommittee
[168] Ibid.
[169] Caruso, Statement Before Energy and Air Quality Subcommittee, and Caruso, "World Energy and Economic Outlook to 2025", Slide 22.
[170] Energy Information Agency. "Generation and Consumption of Fuels for Electricity Generation, November 2005."

Biofuels are a rapidly growing energy segment due to discovery of bio-engineered catalysts that produce gasoline-compatible ethanol from cellulosic plant elements (vs. sugars/starches) and due to improvements in producing organic waste-stream bio-diesel compatible with existing diesel engines. Ethanol and bio-diesel are both compatible with fuel-cell reformers. Virgin Airways is the first airline to begin building bio-fuel production plants to power its 100-aircraft fleet.[171]

Wind Power

Rapid European technology advancements enable large scale, low cost wind-power production at rates comparable to coal-fired power plants—Denmark obtains 20 percent of electricity from wind power.[172] U.S. led world capacity installation in 2005 to 2,500 MW total; demand so great that all commercial turbine production has been purchased through mid-2006.[173] Provides secure, price-stable source of electricity. U.S. Air Force is the largest single green power consumer in federal government, primarily through wind power.

Solar Power

Solar energy technology provides photo-voltaic (PV) electrical power and solar heating. Significant nano-technological breakthroughs are driving cost reductions, efficiencies, and flexibility to record levels. The ability to print thin-film photovoltaic ribbons has enabled the production of PV roof shingles and California Million-Roof Solar Initiative. DoD installation structures provide ideal PV and solar heating platforms—Energy Policy Act of 2005 directs installation of PV systems on 20,000 federal buildings by 2010.[174]

Oceanic

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[171] Kulczycki, "Green Vehicle News. "
[172] Danish Wind Energy Association. "Did You Know?".
[173] American Wind Energy Association, "U.S. Wind Industry to Break Installation Records, Expand by More Than 35% in 2005.".
[174] U.S. Congress, *Energy Policy Act of 2005*, Sect 3177.

New technologies are entering pilot stage demonstrations to produce electrical power from coastal tide, ocean current, and temperature gradient sources. This capability would be best suited for coastal installations (U.S. Navy primary), but could be adapted to ship electricity or hydrogen to distant users.

Hydrogen

Hydrogen, the most abundant element in the universe, is an actual energy transporter vs. an original energy source (it is similar to electricity in this regard). Hydrogen possesses four times the energy density of petroleum by weight and can be either directly combusted to produce mechanical energy or consumed in fuel cells to produce electricity and heat. Hydrogen can be produced on a large scale or locally from virtually any renewable or hydrocarbon source, but presently requires electrical or hydrocarbon "feedstock" energy to produce. Hydrogen must presently be stored in 5,000-10,000 psi compressed gas or super-cooled liquid form, but new nano-technology breakthroughs provide for the prospect of stable ammonia hydrate solid form storage and photolysis-based production through direct sunlight exposure.

Solid-to-Liquid Hydrocarbon Conversion

Synthetic fuel production utilizes the Fisher-Tropsch process developed by Germany before WWII to convert coal, tar sands, and shale oil into clean liquid hydrocarbon fuels. The process is presently in use by South Africa and Canada, with Canada producing 1M bbls of oil a day.[175] North America possesses 3.7 trillion bbl oil equivalent—1.7 trillion in Alberta tar sands and 2.0 trillion in primarily U.S. western and south-central states that in total surpass world liquid oil reserves by 40 percent[176]. In the Energy Policy Act of 2005 "Congress declares that it is the policy of United States that United States oil shale, tar sands, and other non-conventional fuels are strategically important domestic resources that should be developed to reduce the growing dependence of the United States on politically and economically unstable sources of

[175] Fialka, "In Oil Quest, U.S. Says Rock On", 4.
[176] Office of Deputy Assistant Secretary for Petroleum Reserves, *Strategic Significance of America's Oil Shale Resource; Assessment of Strategic Issues*., 23.

foreign oil."[177] DoD and DOE are exploring establishment of a pilot production facility with the goal of providing all DoD liquid fuels from shale oil at an estimated 2M bbl/day production by 2020 with a 10M bbl/day ultimate capacity.[178] Process requires potential strip mining, high water consumption, and carbon dioxide emissions that may present significant environmental constraints.

Methane Hydrates

Methane hydrate is a solid crystalline form of methane that can be converted into hydrogen or hydrocarbon fuels. With potentially up to 200,000 trillion cubic feet of methane available,[179] methane hydrates offer the largest longest term potential for military fuels, but significant research is required to enable recovery of those materials in a safe and efficient manner.[180] Found primarily under the ocean floor, the U.S. Navy is researching locations of vast offshore deposits and may have deep underwater technologies that could be applied to the recovery. Methane would be liberated from the hydrate and processed on a ship or barge into transportation fuels using the Fischer-Tropsch process.

Material Sciences/Nanotechnology

Nanoscience is the study of the unique ability to characterize, manipulate, and physically assemble material structures at the atomic and molecular levels. By producing previously inconceivable material properties, nanotechnology holds the potential to revolutionize the energy industry. DOE's Basic Energy Sciences Advisory Committee has established the following energy goals for nanoscience to achieve:[181]

- Scalable methods to split water with sunlight for hydrogen production

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[177] U.S. Congress, Energy Policy Act of 2005, Sect 369..
[178] Office of Deputy Assistant Secretary for Petroleum Reserves, *Strategic Significance of America's Oil Shale Resource; Assessment of Strategic Issues*., 23.
[179] U.S. Congress, Energy Policy Act of 2005, Sect 933.
[180] Office of Deputy Assistant Secretary for Petroleum Reserves, *Strategic Significance of America's Oil Shale Resource; Assessment of Strategic Issues*, 23.
[181] Committee on Technology, *Nanoscience Research for Energy Needs, Report of the National Nanotechnology Initiative Grand Challenge Workshop, March 16-18, 2004, v.*

- 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
- Super-strong 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 Gw transmission
- Low-cost fuel cells, batteries, thermoelectrics, and ultra-capacitors built from nanostructured materials
- Materials synthesis and energy harvesting based on the efficient and selective mechanisms of biology

Fuel Cells

Fuel cell are a class of power production technology that use non-combusting chemical reactions with reformed hydrocarbon or hydrogen fuels to produce electricity, heat, and water. Originally designed for the space program, fuels cells now range from industrial applications to micro sizes that power cell phones, laptops, individual soldiers and micro-air vehicles due to energy densities superior to that of batteries.[182] This rapidly growing market segment is now seen as a follow-on to hybrid automotive technology. DARPA is also working on fuel cell technology powered by high-energy propellants and explosives.[183]

"Six-Sigma" Technologies

"Six Sigma" technologies represent those extreme fields of science which are shown to be theoretically possible, but as of yet lack any physical evidence of existence or the means to be applied toward useful problem solving. The atomic bomb was a six-sigma technology before the invention of quantum physics. Generally, six-sigma concepts require decades of research and several fundamental scientific discoveries before becoming realistically possible. Modern six-sigma concepts

[182] Gibson, Allen. "Powering the Battlefield: Fuel Cells and Renewable Energy."
[183] Ibid.

with energy solution applicability include matter/anti-matter; anti-gravity, and nuclear fusion.

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Appendix C

Energy Transformation Strategy Comparison

Three Possible Energy Transformation Strategies for DoD

There are three major strategies the DoD can take with respect to its energy future: 1) Embrace a More Efficient Petroleum-Based Status Quo, 2) Await Industry-Led Energy Transformation or 3) Initiate a DoD-Led Energy Transformation. Each successive option acknowledges a significantly greater level of energy security urgency and level of effort to complete. While a detailed paper could be written on each of these scenarios, this appendix simply serves to highlight the major benefits and risks of each (see Table 5 on the following page) as they would be observed in 2050, allowing the reader to independently opine about the plausibility and merit of one over the other.

In the Status Quo Strategy, the DoD remains reliant upon petroleum and concentrates primarily on energy conservation and source protection. This scenario holds fundamental that technology will continue to find additional oil resources and more efficient methods to use them, and that the DoD will pay close to market prices for that energy. The benefits are that virtually zero scarce funds must be spent on infrastructure, force structure, or doctrine changes—there is very little institutional upheaval. On the negative side, this strategy forces the DoD to pay unpredictable but likely rising commodity prices, to remain operationally tethered to fuel logistics lines, to assure unrestricted U.S. and allied access to petroleum supplying nations, and to be prepared to face a strategic competitor that may someday develop and use an operationally advantageous energy source. The largest concern for Status Quo proponents is that distant peak predictions turn out to be false or are artificially accelerated due to a major geopolitical event,

Strategy	Philosophy	Benefits	Dangers
A More Efficient Status Quo	• Rely on petroleum future via new and existing oil fields • Purchase energy via global free-market methods • Increase efficiencies and conservation for infrastructure & combat systems	• Only military infrastructure & systems maintenance required • Minimal acquisition/development changes needed • Present force structure & doctrine preserved • Reduced demand through more efficient systems and practices	• Energy costs consume greater percentage of budget, reducing training • During crises military readiness comes at expense of civilian energy demands • Oil competition from rising powers limits supply • Import producer volatility; petro-dollar support to failing states • Increased security risks associated with single-point-failure, of centralized energy production and distribution • Strategic opponent may develop new disrupting energy source • No "Plan B"
Industry-Led Transformation	• Increase efficiencies and conservation for infrastructure & combat systems • Switch to alternate fuels only after commercial sector development & transition	• Minimize operational/transition risk and development costs by relying on the commercial/international sector to conduct R&D • Energy infrastructure established • Reduced demand through more efficient systems and practices	• 20+ yr military acquisition timelines create a potential 20-year capabilities gap after commercial energy conversion • Proprietary technology possessed by non-friendly entities • Potential for abrupt and painful force structure/doctrine changes • Delayed oil energy costs consume greater percentage of budget • Prolonged oil competition with unconverted, exploding population developing countries • Longer exposure to oil producer volatility, failing state petro-dollars
DoD-Led Transformation	• Define and strive toward a DoD alternate energy vision and 40-yr strategy/timeline • Focus on efficiency/conservation; distributed energy production • Develop bridge energy sources for those systems/missions not easily converted • Heavy R&D/educational development • Acquisition reform toward efficiency KPPs, modular upgradeability & new energy standards • Leverage commercial sector advancements • Employ new energy sources into legacy systems to preserve investment/capabilities • Deploy clean-sheet alternate energy weapon systems for the long-term while continuing research toward 3-sigma solutions	• Consolidated, defined goal that many eager soldiers, citizens, and industry can focus efforts on (with civilian spill-over benefits) • Most rapid freedom from paying and protecting non-friendly energy producers • Forced operational efficiencies through decades of concerted effort • Increased security through distributed and/or autonomous power production • Potential environmental benefits—improves public image • Forms strong inter-agency partnership with gov't agencies, industry, and academia • Enhanced national intellectual base • By default, DoD establishes national/international new energy standards	• Budget sacrifices - $ billions of potentially unavailable investment capital required • An eclipsing technology might negate all investment to date • Streamlined acquisition could lead to unfulfilled promises • Effort may stall mid-stream when new oil reserves are found or energy prices decline

Table 5 – Three Possible DoD Future Energy Strategies

and the nation suddenly finds itself without a “Plan B” if petroleum production were to decline rapidly after peaking as EIA predicts it will (it is important to note that military fuel scarcity is not considered a primary detractor of this strategy since even under the most extreme conditions the U.S. is expected be able to domestically and indefinitely produce adequate petroleum [300,000-400,000 barrels/day, only 1.5 percent of national demand][184] to supply what would be the nation’s highest-priority DoD mission; this same claim cannot be stated with as much confidence for the industrial complex supporting the U.S. military or for several U.S.-allied militaries).

The Industry-Led Strategy has its roots in the Status Quo Strategy in that both place great faith in free market forces. Using the new industry-led technology development model increasingly in vogue since the end of the Cold War, in an industry-led energy transformation DoD waits for the ever more R&D- and investment capital-capable international commercial sector to develop, test, and deploy a new technology before acquiring it for military purposes. The major benefit here is that the R&D and infrastructure development risk is transferred away from DoD to some other entity and the DoD can quickly buy off-the-shelf products from the best qualified vendor. This configuration becomes limiting though in that DoD’s only mechanism to drive significantly larger commercial forces would be at the system end through contract specifications; there would be little opportunity to drive options early in the process—DoD could only take-it or leave-it when it came to the technologies offered. Additionally, if a desired commercially developed alternative belonged to a foreign multi-national corporation or a foreign government, the U.S. could not be guaranteed access to that technology. Finally, the worst-case situation in one in which a typically shorter-minded free-market system recognizes and responds to an impending petroleum crisis just in time to solve what is essentially a civilian transportation problem, but too late for longer-range military requirements. For the DoD this is not only a race against time, but also against other global military powers. Because major new weapon systems with 30-year life spans can take 25 years to field, it is conceivable that a 10-15 year capability gap could exist as increasingly more unsupportable petroleum systems must be maintained while awaiting arrival of “new energy” system acquisitions that must be initiated from scratch.

The final option, in which the DoD leads an energy transformation, proposes that the DoD develops an alternate energy vision for some future date, and then goes about methodically identifying and constructing with

[184] Lovins, *Winning the Oil End Game*, 26.

partners the milestones necessary to achieve that envisioned future. Precision guided munitions capability is an example of how the DoD recognized the benefits of truly precise aerial bombing, envisioned a GPS-enabled solution, and then spent two decades and billions of dollars creating today's reality. The spiral development approach of an envisioned national missile defense system is another example of such a program currently in progress.

A DoD "new energy" initiative would focus thousands of willing and interested minds thereby preserving our nation's shrinking science & technology (S&T) intellectual base, protect operational freedom and national security from energy cost and supply constraints; and most importantly, retain strategic initiative and technological advantage. In addition to primary R&D efforts, the collaborative program would place significant emphasis on efficiency, bridge energies, spiral development, acquisition reform, modularity, and the early creation of "new energy" standards. Transformational successes could serve as models for the civilian sector. On the negative side, diverting significant resources to early R&D will be disruptive to existing near-term programs (potentially even weakening some risk-managed capabilities in a zero-sum resource environment), a better, later-developed technology might strand hundreds of billions of dollars and decades of earlier work, massive new petroleum discoveries might undermine the entire effort, or streamlined acquisitions may fail to deliver on expected promises. A DoD-Led Strategy is also not without significant risk.