THE DEPARTMENT OF DEFENSE'S ENERGY POSTURE FOR THE 21st CENTURY: A SUMMARY OF PROGRESS AND POLICY AND A CRITICAL EXAMINATION OF STRATEGIC, OPERATIONAL, AND FINANCIAL VULNERABILITIES

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THE DEPARTMENT OF DEFENSE'S ENERGY POSTURE FOR THE 21st CENTURY: A SUMMARY OF PROGRESS AND POLICY AND A CRITICAL EXAMINATION OF STRATEGIC, OPERATIONAL, AND FINANCIAL VULNERABILITIES

The Department of Defense (DoD) has good reason to be concerned with energy and fuel efficiency. The DoD is the largest single consumer of energy in the United States. Of all the energy consumed by the DoD, twenty-five percent goes towards facilities, and the remaining seventy-five percent, goes toward fuel consumption which either powers vehicles or deployed bases in warzones. This thesis shows that while the DoD is managing its facility based energy consumption moderately well, it has developed a true Achilles' heel regarding fuel consumption. The current posture towards fuel consumption is troubling for many reasons. In general, America's fuel consumption threatens its status as a national power. Pertaining to the DoD specifically, regression analysis shows that fuel costs more when the DoD needs it most -- during times of conflict. The DoD is truly unprotected from large swings in fuel prices and the Strategic Petroleum Reserve will not quickly help in a national crisis. These facts have lead to emergency budget allocations in the past just to keep the military operational. The DoD's current posture on fuel consumption also leads to severe operational and strategic handicaps. As an organization, the DoD should recognize these drawbacks and work to revamp its relationship with fuel consumption.

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Introduction

The Department of Defense (DoD) has good reason to be concerned with energy and fuel efficiency. The February 2008 report of the Defense Science Board (DSB) Task Force on DoD Energy Strategy declared that "[t]he Department of Defense is the largest single consumer of energy in the United States" ("More Fight Less Fuel" DSB p. 11 2008). The United States Energy Information Administration (EIA) of the Department of Energy (DoE) has calculated that the United States consumes approximately 100 quadrillion BTUs[1] of energy each year ("U.S. Primary Energy Consumption by Source and Sector, 2008." EIA 2009). It consumes more than any other country on the planet. This means that the Department of Defense is most likely the top energy-consuming organization in the top energy-consuming nation in the world. Energy consumed by the DoD also represents approximately 80% of all energy consumed by the Federal Government ("More Fight Less Fuel" DSB p. 11 2008). This distinction deserves further discussion. In a Brookings Institution report, Colonel Gregory J. Lengyel of the United States Air Force stated that "[t]he United States of America has a National Security problem, in which the Department of Defense … has a unique interest – energy security. Energy is the life-blood of the US economy and dependence on imported energy is a looming national crisis" (p. 7 2007). He points out that abundant and cheap energy has been the norm and not the exception in the past for the American consumer and the American Warfighter (Lengyel p.7 2007). The broad conclusions of this paper are that while the DoD has made significant progress in reducing its permanent facility-based energy consumption, it has developed a true Achilles' heel regarding vehicle fuel

[1] BTU stands for British Thermal Unit, a measurement of thermal energy. It is equivalent to 1/3 of a watt of electrical power or 1055.06 Joules. A BTU is the amount of energy needed to heat one pound of water one degree Fahrenheit. To provide a frame of reference, one gallon of gasoline provides 124,000 BTUs according to the EIA energy calculations page.

consumption and fuel consumption to power forward-deployed bases such as those in Afghanistan. These current fuel consumption practices are a true problem for the DoD and it is on these issues that the DoD's energy and innovation policies need to be squarely focused.

Section A of this paper builds brief energy profiles for the United States and the Department of Defense. Section B analyzes the United States' oil consumption as it relates to the country's financial well being and trade deficit. Section C examines the statistical relationship between oil prices and conflicts and concludes that oil has the potential to cost the DoD the most precisely when it needs it the most -- during times of conflict. Section D examines the DoD's fuel purchasing practices and shows why the DoD has no true protection against fuel crises or rapid price increases. Section E contains operational and strategic case studies demonstrating the effect of large fuel needs and extensive supply chains on operations in Afghanistan. Section F looks at the public relations possibilities of the DoD's current relationship with fuel. Section G discusses policies that affect the DoD and its energy use. Section H closely examines progress made to date by the Pentagon on energy efficiency. In order to better understand the DoD's current efforts, Section I and J contain detailed case studies an order to verify the assumptions of this paper. Section I reviews the DoD's efforts to reduce facility energy consumption and contains a detailed study of different efforts made at Offutt Air Force Base in Nebraska. Section J contains a fuel consumption study of Offutt Air Force Base. Sections I and J reflect the fact that the DoD has focused on reducing facility energy consumption, but has not focused at all on fuel consumption or fuel-efficient technologies as much. Section K examines the DoD's vision for the 21st century and contains a Strength Weakness Opportunity Threats (SWOT) implication matrix that maps general courses of action for the DoD in order to address its relationship with fuel consumption. Section K also explores the military stakes of not being a leader in new fuel efficiency technology.

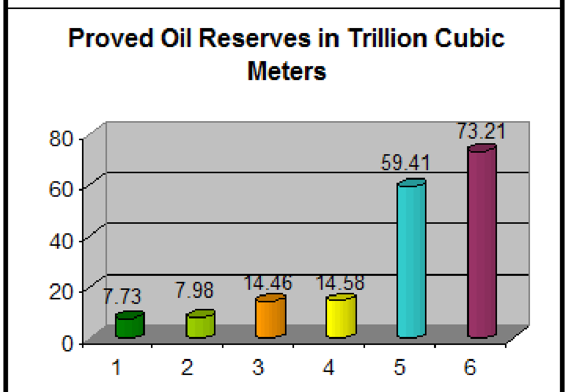
There are eight reasons why the Department of Defense should attempt to revamp its relationship with vehicle and forward operating base fuel consumption. The first reason is that America's oil importation practices threaten to destroy the building blocks of national power (Section B). The second (and perhaps most ignored) reason is that when the DoD needs fuel the most, it is likely to cost it the most. This is shown by statistical analysis of oil prices and conflict in section C. The third reason is that the DoD has no good recourse when fuel prices surge; not even the Strategic Petroleum Reserve (SPR) will help in a true crisis situation, as shown in the section F. The fourth reason is that the DoD's current relationship with fuel causes unwieldy supply chains that greatly increase operational risk. The fifth reason is that these increased operational risks stemming from long supply chains often weaken America's strategic position. Reasons four and five are demonstrated in the section E case studies. The sixth reason, demonstrated in section F, is that given all these other legitimate reasons, the DoD can now seize upon an opportunity to lead a green revolution that could be one of the most successful military public relations campaigns in U.S. history. The seventh reason, as shown in section K, is that the DoD's own vision for the 21st century demands a complete overhaul of its relationship with fuel consumption, even if this is not explicitly recognized. The eighth reason, also demonstrated in section K, is that the DoD as an organization is increasingly outmoded in regards to new and innovative fuel technologies. For all of the above reasons, it is imperative that the DoD re-examine its posture toward fuel consumption, both for vehicles and for powering deployed bases.

Section A: Overview of Energy Profiles: America and the DoD

1. America's Energy Profile

A brief overview of America's energy consumption profile is a useful pre-cursor to an analysis of the DoD's energy consumption profile. Two especially relevant factors are the country's sources of energy and how much energy the country imports overall. The energy consumed in America can be classified into three broad categories: Fossil Fuels, Nuclear, and Renewable. In an average year, America gets eighty-five percent of its energy from fossil fuels, eight percent from nuclear energy, and approximately seven percent from renewable energy. The Energy Information Administration figures for 2006 show that the United States imported approximately 35% of all energy consumed and stored during the year (EIA Feb 2008 Monthly Energy Review, p. 1.1 2008). Other sources such as an Army Corps of Engineers report put the estimate at twenty-six percent (Fournier and Westervelt p. v 2005).

Figure 1: World Oil Reserves



	South & Central America		Africa
	North America		Europe and Eurasia
	Asia Pacific		Middle East

Replicated from data found in the BP Statistical Energy Review 2008

Fossil fuels comprise the most critical energy resource to America. The country gets 85% of its energy from fossil fuel sources, which includes coal, natural gas, and petroleum. The most contentious factor regarding fossil fuel energy is that the country imports such a large amount of the petroleum that it uses. Some reports estimate that the United States imports over half of all the oil it uses -- approximately 56% of total consumption (Fournier and Westervelt p. v 2005). This number can vary depending upon assumptions and figures used. Using the DoE statistics for 2006 after adjusting for exports, it appears that 73% of oil consumed by America was imported (EIA Feb 2008 Monthly Energy Review p.7-15 2008). To put this in perspective, the DoE says that in 2007 the United States imported an average of over 10,000,000 barrels of oil and over 200,000 barrels of jet fuel every single day (EIA Feb 2008 Monthly Energy Review p. 3.3a 2008). Figure 1 above shows that this leaves America vulnerable due to our lack of oil reserves.

Nuclear and renewable energy are the remaining two sources of energy for America. Together they provide 15% of the country's energy. Within renewable energy, the largest two categories are Bio-Mass and Hydro-electric, providing 3.27% and 2.87% of total energy consumed respectively in 2006. Many are hoping, and arguing, that American use of renewable energy will grow over the coming decades. This picture, however, is unclear. Between 2006 and 2007, the total energy consumed by America grew by 2%, but the total renewable energy consumed went down by 1% (EIA "Renewable Energy Trends in Consumption and Electricity, 2007" 2008). Overall, world energy demand and consumption is expected to increase 44% by 2030 (EIA "International Energy Outlook 2009" 2009).

America imports approximately one-third of all energy consumed. A more specific look at production sources as well as inflows and outflows are provided on Table 1 on the following page. It shows the total BTUs for each category of energy that America produces, consumes, imports, and exports in order to give an overall picture of energy flows in and out of the country. The three major categories of fossil fuels, nuclear, and renewable are further broken down into sub-categories of energy production.

America produces 70.99 quadrillion BTUs domestically from fossil fuels, nuclear energy, and renewable energy. Of this 70.99 quadrillion BTUs, 4.87 quadrillion BTUs are exported, leaving approximately 66 quadrillion BTUs of domestic energy. Approximately 33 quadrillion BTUs are then imported to bring the country to its net energy consumption of between 98 and 99 quadrillion BTUs. It is a strategic weakness that we import well over two times the amount of oil we produce domestically at any given time (29.16 quad BTUs imported versus 13.1 quad BTUs produced domestically). The critical role of oil importation in our economy will be explored more in Section B.

Table 1: A Sample Picture of 2006 United States Energy Production, Consumption, and Importation/Exportation in terms of BTUs and Percentage												
	Fossil Fuels				Nuclear	Renewable						TOTAL ALL
	Coal	NG	Petro	Total		HE	GT	SPV	Wind	BM	Total	
Total BTUs Produced Domestically	23.8	18.99	13.1	55.95	8.21	2.87	0.34	0.07	0.264	3.279	6.83	70.991
Total BTUs Exported	1.31	0.73	2.75	4.87	0	0	0	0	0	0	0	4.87
BTUs Remaining After Export	22.49	18.26	10.35	51.08	8.21	2.87	0.34	0.07	0.264	3.279	6.83	66.121
BTUs Imported	1.02	4.29	29.16	34.47	0	0	0	0	0	0	0	34.47
BTUs after exports and imports	23.51	22.55	39.51	85.55	8.21	2.87	0.34	0.07	0.264	3.279	6.83	100.585
Total Consumed in BTUs	22.45	22.19	39.95	84.66	8.21	2.87	0.34	0.07	0.264	3.33	6.87	99.91
% of Overall Consumption	22.5%	22.2%	40.0%	84.7%	8.2%	2.9%	0.3%	0.1%	0.3%	3.3%	6.9%	100%
%Consumption Imported from abroad	4.5%	19.3%	73.0%	40.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	34.5%
	All Units Measured in Quadrillion BTUs											

Key	
Natural Gas	NG
Hydro-Electric	HE
Geo-Thermal	GT
Solar/PV	SPV
Bio-Mass	BM

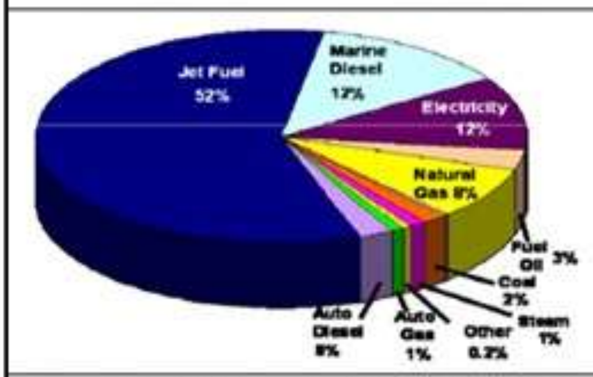
Source: All statistics calculated from the EIA, Monthly Energy Review, Feb 2008, 7-15.
*Figures maybe slightly adjusted for rounding and exclusion of trivial figures.

2. Department of Defense Energy Profile

The DoD's size in terms of people, energy consumption, and pollution is significant. The DoD as a whole employs around 3 million people, both military and civilian ("DoD 101 Defenselink" 2009). To run facilities and power vehicles, the DoD consumes electricity, coal, natural gas, petroleum, and water. By piecing together different reports, it is possible to determine how much the Department of Defense spends per year on these energy expenses.

A report entitled “More Fight Less Fuel” from the Office of the Under Secretary of Defense for Acquisition Technology and Logistics (OUSDATL) states that in 2006 the DoD spent “$13.6 billion to buy 110 million barrels of petroleum fuel (about 300,000 barrels of oil each day), and 3.8 billion kWh of electricity” (“More Fight Less Fuel” DSB p. 11 2008). In 2006, the DoD consumed nearly 1 quadrillion BTUs of energy (OUSDATL “Fiscal Year 2006 Energy Management Data Report” 2006). The Energy Information Administration has said that the precise consumption of energy by the United States equals approximately 100 quadrillion BTUs pear year (EIA Reference Case Projections 2009). Using this figure, it appears that DoD energy consumption amounts to nearly 1% of all the energy consumed in the United States. Specifically, for fiscal year 2006, the Department of Defense spent $13.8 billion on fuel, water, and energy which in total resulted in the consumption of 8.3E+14 BTUs of energy (0.8% of all energy consumed in the U.S.) and 85.4 billion pounds of carbon emissions (OUSDATL “Fiscal Year 2006 Energy Management Data Report” 2006).

Figure 2: FY06 Total DoD Energy Use



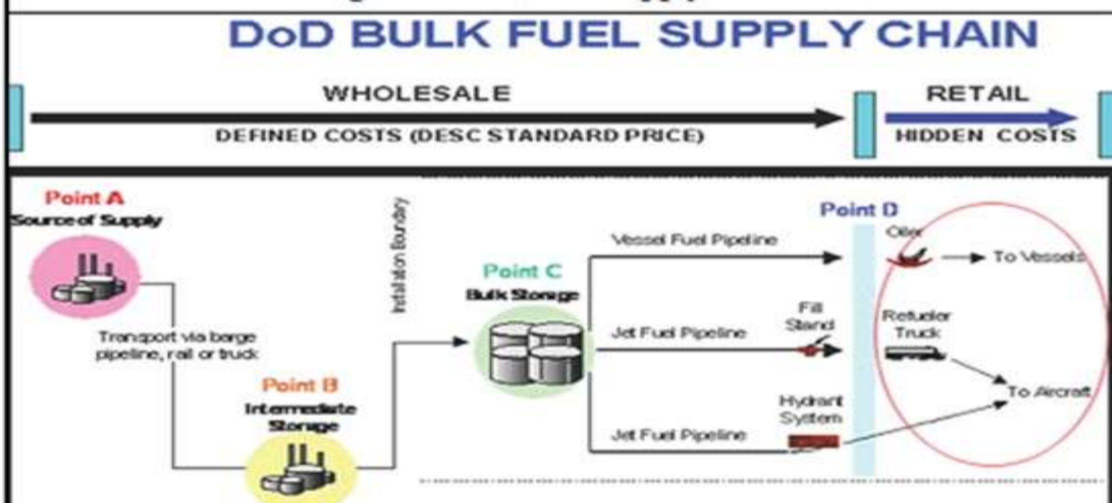
Source: *More Fight Less Fuel,* Office of the Under Secretary of Defense for Acquisitions, Technology, and Logistics

Approximately 25 percent of all energy consumed by the DoD was used to power facilities with the remaining 75% going toward fuel for vehicles (“More Fight Less Fuel”

DSB p. 11 2008). The Department occupies over 577,000 facilities valued at over $712 billion in over 5,300 different locations ("More Fight Less Fuel" DSB p. 11 2008). Figure 2 shows the distribution between petroleum and facility power consumption ("More Fight Less Fuel" DSB p. 16 2008). Of the 25 percent of energy consumed for facilities, the distribution is as follows: electricity at 12%, natural gas at 8%, fuel oil at 3%, and coal/steam/other at 3.2%.

There are also costs that are not readily apparent in the Department's energy consumption as shown by Figure 3 ("More Fight Less Fuel" DSB p. 15 2008). For example, the Defense Energy Support Center (DESC) FY06 Fact Book reports that the DoD spent $788,400,000 on transporting fuel and gas to locations where it was needed after it had been delivered to a whole sale point (35-36). This would bring purchasing and transportation costs to approximately $14.6 billion based upon figures from the previous sources.

Figure 3: DoD Fuel Supply Chain



Source: *More Fight Less Fuel*, Office of the Under Secretary of Defense for Acquisitions, Technology, and Logistics

This means that the approximate total for expenditures on fuel, energy, heating, and water during one year of Department of Defense operations is $14.6 billion. It should be noted that in years such as 2008 when there are large scale jumps in energy prices, this bill can rise to $20 billion and thereby cause emergency shortfalls in the budget (Zavis 2009). The $14.6 billion figure for fiscal year 2006 was chosen for analysis in the belief this was a more conservative baseline estimate and that not all years will see such huge jumps in energy prices.

Nonetheless, this nearly $15 billion annual energy bill is significant. To put this expense in perspective, it is estimated that the incremental cost of one new F-22 Raptor is approximately $138,000,000 ("Committee Staff Procurement Backup Book FY 2009 Budget Estimates" p. 1-13 2008). The F-22 is the next generation of stealth fighter aircraft that the Air Force plans to employ in the 21st century. This would mean that a $15 billion per year expenditure on fuel and energy would be enough to purchase 108 F-22 fighter jets. This $15 billion amounts to between 3% and 4% of total fiscal year 2006 defense spending when compared to the $455 billion for defense spending authorized by House Resolution 2863, the defense spending bill for 2006 (Wheeler 2006).

Figure 4: MRAP Vehicle

Source: "Unit Receives Task Force Marne's First MRAPs" by Sgt. Michael Connors, USA

Some may argue that it is unreasonable to expect such a large and geographically-diverse organization to carry out significant and rapid cuts in its energy expenses. Nevertheless, it is still worthwhile to examine the effects of a modest decrease in expenses of this nature. The Department of Defense would free up over $1 billion in its budget if it did nothing other than reduce its energy expenditures by 2.4% a year for three consecutive years. A 2.4% reduction of energy expenditures for three years in a row, using 2006 as a baseline, would result in approximately $348 million in savings in the first year, $339 million in the second year, and $331 million in the third year. Each year going forward, this "extra" $1 billion could purchase approximately seven hundred plus additional Stryker combat vehicles ("Military Transformation" GAO p. 20 2003), over one thousand Mine Resistant Ambushed Protected (MRAP) vehicles for the Army (Lowe 2007), six extra F-22s for the Air Force, or two to three of the new Littoral Combat Ships (LCS) for the Navy (O'Rourke p. 4 2009). The F-22, MRAP, and LCS are all cornerstone vehicles, which each respective service plans to employ heavily in the first half of the 21st Century. The possibilities should be tantalizing to DoD officials. The next section shows why both America and the DoD should care about America's energy profile, especially the nature of the country's relationship with fuel consumption. The specific composition of America's energy consumption affects the country's financial well being, which threatens the country's position as a superpower.

Figure 5: LCS High Speed Surface Ship

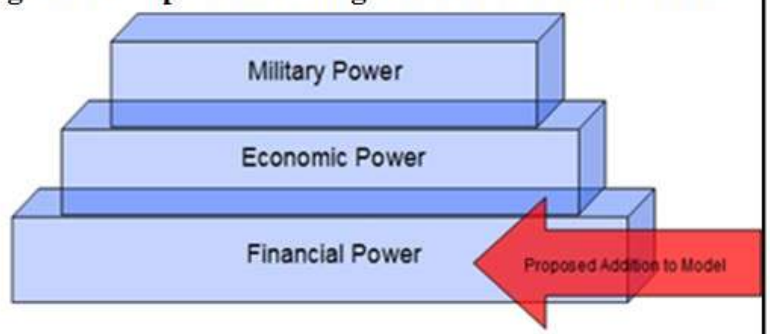
Source: "Littoral Combat Ship (LCS) High-Speed Surface Ship" at naval-technology.com

Section B: Components of a Superpower - Oil's Role in the Trade Deficit

The DoD should be concerned with fuel consumption in general due to its effect on long term national security. This paper proposes that most political scientists have ignored one of the crucial building blocks of a country's hard power. It also explains why the military should be concerned with America's oil consumption in general. Political scientists often see a country's power and influence divided into hard and soft power (Nye 2008). Soft power is the influence of a country's culture and policies on other countries. Although declining drastically in recent years, America's soft power traditionally has been strong: democracy, human rights, and Hollywood have helped. More pertinent to this paper, hard power is understood as a country's military and economic might. The economic might of a country is included in the concept of hard power because a strong economy provides the building blocks to build and fund a strong military. America is still a military, and to most degrees, an economic superpower. In the simplest terms, economic power can be understood as the size of an economy and how much it produces per person. The U.S. can still be considered an economic superpower because its economy is the second largest in the world with a GDP of $14.33 trillion versus the European Union's $18.85 trillion (CIA World Factbook: "GDP Official Exchange Rate" 2008). The CIA Factbook says the U.S. economy is large, technologically powerful, and produces $48,000 worth of goods per person (per capita GDP of $48,000) (CIA World Factbook: "United States Economy Overview" 2008). In terms of economic and military power, the country is still highly rated.

What political science does not examine is the idea that, under the economic building block, there is a third and more basic enabler of hard power: financial power or, financial well-being. If the financial well-being of a country declines, it will eventually affect the economic power of that country, which of course will then affect the ability to project military power, thereby damaging the country's hard power. Financial well-being can be understood as (1) the long-term difference between production and consumption (trade deficit or surplus), (2) a country's balance sheet (debt compared to assets), and (3) the terms on which a country can borrow money or finance its activities. When it comes to financial power, America's position is being threatened by its own behavior. The country has for long periods of time consumed far more than it has produced, fueling this consumption via debt and the sale of assets. The long-term sale of assets and assumption of debt is having a detrimental effect on the country's balance sheet, as the percentage of debt to national wealth is climbing quickly in both the public and private sectors. As a result, other countries have less and less faith in American currency and its ability to pay off debt, making it even harder and more expensive for the country to finance its consumption or borrow money. Each year, the amount of interest America owes foreign creditors increases while more and more wealth and money flow overseas. As a country and its citizens take on more debt, the terms on which it can finance investments or consumption become less and less advantageous, leading to higher interest payments, resulting in even more wealth leaving the country to be invested elsewhere. It is in this way that a poor financial state slowly begins to take its toll on the economic building block, as this unbalanced outflow of resources detracts from economic growth.

Figure 6: Proposed Building Blocks of National Power



1. The Trade Deficit

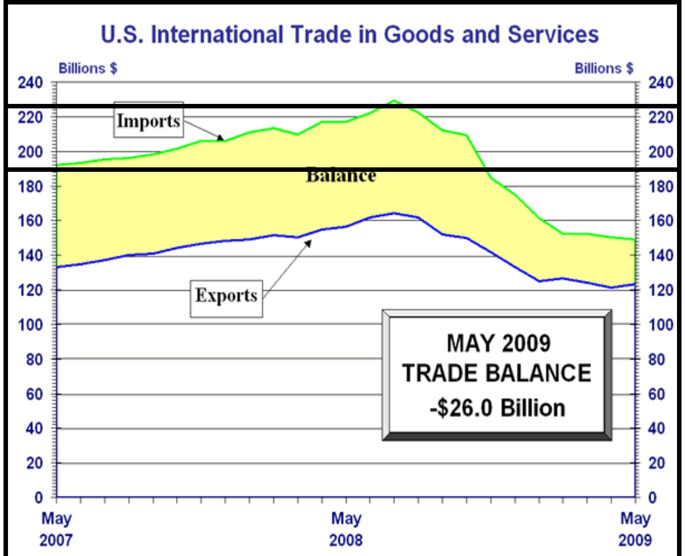
Returning to the focus of this paper, oil consumption plays a unique role in America's current imbalance of its finances. As mentioned earlier, every day the U.S. consumes a large amount of imported fuel. The DoE says that in 2007 the United States imported an average of over 10,000,000 barrels of oil and over 200,000 barrels of jet fuel every single day (Feb 2008 EIA Monthly Energy Review p. 3.3a 2008). The dollars used to buy this oil then flow overseas to companies or governments supplying the oil. The amount of money potentially flowing overseas each year based upon different prices is shown in the graph below. With oil at $60 a barrel, Americans spend approximately $219 billion a year on imported oil. In order to pay for this, the country and consumers either send dollars outright or issue IOUs (dollar denominated debt) to other countries. In other words, America is consuming more goods than it produces or sells, so in many cases it is funding its consumption with debt.

Table 2: Dollars Spent on Oil Importation

		Cost Per Barrel				
		$40	$60	$80	$100	$150
Fuel Type	Yearly Barrels	Total Spent on Fuel in Thousands of Dollars (Cost Per Barrel X Yearly Barrels)				
Oil	3,650,000,000	$146,000,000	$219,000,000	$292,000,000	$365,000,000	$547,500,000
Jet Fuel	73,000,000	$2,920,000	$4,380,000	$5,840,000	$7,300,000	$10,950,000

Importing so much oil impacts the country's trade balance each month because people spend a lot of money on that imported oil. When looking at America's trade balance for each month between May 2007 and May 2009, America has imported anywhere from to $25 to $60 billion more worth of goods that it exported ("U.S. International Trade in Goods and Services Highlights" 2009). Monthly imports exceeded exports by around $60 billion a month up until late 2008 when the economy slowed ("U.S. International Trade in Goods and Services Highlights" 2009). During the spring of 2009, exports exceeded imports by around $26 billion a month due to the weakened economy and increased saving by U.S. consumers ("U.S. International Trade in Goods and Services Highlights" 2009). As shown by the table above, if oil costs around $60 a barrel, Americans will spend $219 billion per year on oil. If oil stays around $60 a barrel, and the country was able to cut its consumption of imported oil by 20%, it would save $43.8 billion ($219,000,000,000 x 20%). This $43.8 billion would eliminate almost two whole entire months of the trade deficit for each year (assuming a trade deficit of approximately $26 billion a month). If oil approaches $100 a barrel, then a 20% reduction would save $73 billion and eliminate three months worth of the trade deficit each year, assuming the deficit remains steady. This would slow the increase in debt that America owes the rest of the world.

Figure 7: U.S. Trade Deficit 2007-2009



Source: "U.S. International Trade in Goods and Services Highlights" 2009

This outflow of money each month to pay for oil contributes to the U.S. trade deficit, as we import far more goods (to include oil) than we export. Before the 1970s, America regularly sold more abroad than it purchased (Buffet 2003). Because of this, the country was able to invest its surplus abroad, "with the result that our net investment—that is, our holdings of foreign assets less foreign holdings of U.S. assets—increased…from $37 billion in 1950 to $68 billion in 1970… [o]ur country's 'net worth', viewed in totality, consisted of all the wealth within our borders plus a modest portion of the wealth in the rest of the world" (Buffet 2003). In this manner, America's financial status matched its economic and military status as a superpower. The country produced more than it consumed and invested some of its excess wealth in other countries, some of which yielded interest -- further increasing American-controlled wealth.

Since that period though, things have changed drastically. Buffet goes on to write that: “[s]ince then, however, it's been all downhill, with the pace of decline rapidly accelerating in the past five years. Our annual trade deficit now exceeds 4% of GDP. Equally ominous, the rest of the world owns a staggering $2.5 trillion more of the U.S. than we own of other countries” (Buffet 2003). Part of that $2.5 trillion is invested in financial vehicles that effectively are claims on U.S. assets, or claims on future streams of U.S. income to include: “U.S. bonds, both governmental and private—and some in such assets as property and equity securities” (Buffet 2003). Buffet goes on to explain that the country is acting like an extraordinarily rich family that owns a large farm. In order to consume 4% more than it produces each year (trade deficit), it sells pieces of the farm away and increases the mortgage on what the family (country) still owns. Buffet estimates that, with $2.5 trillion of “net foreign ownership,” the country has already transferred 5% of its national wealth abroad. More importantly, “foreign ownership of our assets will grow at about $500 billion per year at the present trade-deficit level, which means that the deficit will be adding about one percentage point annually to foreigners' net ownership of our national wealth” (Buffet 2003). At this rate, it is possible that in another two decades the country will have sold 25% of itself, either directly or by selling claims to future income (debt) to foreign countries in order to finance its own consumption. Buffet writes that as foreign ownership of American assets grows, “so will the annual net investment income flowing out of this country. That will leave us paying ever-increasing dividends and interest to the world rather than being a net receiver of them, as in the past" (Buffet 2003). In this manner, as the country sells itself abroad, the trend reinforces itself with ever-increasing flows of interest and payments going overseas.

2. Sovereign Wealth Funds

The money and debt used to fund America's oil consumption are being amassed overseas into large pools of capital (Sovereign Wealth Funds) controlled by foreign governments and businesses entities. The Council on Foreign Relations defines Sovereign Wealth Funds (SWFs) as:

> government investment funds, funded by foreign currency reserves but managed separately from official currency reserves. Basically, they are pools of money governments invest for profit. Often this money is used to invest in foreign companies. For instance, China's SWF purchased stakes in the U.S. financial firms Morgan Stanley and the Blackstone Group in late 2007. Dubai's SWF has bought up shares of several Asian companies, including Sony (Teslik 2009).

Even though SWFs are a relatively new financial phenomenon to be featured in the popular media, their impact upon future flows of wealth will be significant.

For example, oil revenue has created very large and powerful SWFs across the world. As one example, *BusinessWeek* wrote:

> [d]eep inside a fortress of government ministries in Kuwait City, Bader M. Al Sa'ad moves billion-dollar chunks of wealth around the world like chess pieces. Slim and stately, the head of the Kuwait Investment Authority manages $213 billion on behalf of his government. His portfolio, one of the biggest so-called sovereign wealth funds in the world, is constantly replenished with money that flows into Kuwait in exchange

> for the oil that flows out. As prices top $100 a barrel, Kuwait's coffers are swelling (Thornton and Reed 2008).

The growth of Sovereign Wealth Funds is an example of how running these large trade deficits and sending money overseas to pay for consumption can have a snowball effect, increasing the amount of wealth leaving the country. *BusinessWeek* states that "[s]overeign wealth funds from the Persian Gulf are changing the face of global finance in ways that unnerve many Westerners. In recent months, Gulf funds have bought large chunks of Citigroup (C), the private equity giant Carlyle Group, semiconductor heavyweight Advanced Micro Devices (AMD), planemaker European Aeronautic Defense & Space (EADS), and many other big companies" (Thornton and Reed 2008). Now, whenever Citigroup issues a stock dividend, money that would have gone to American investors flows overseas to those SWFs that bought Citigroup stock with oil revenues. With this dividend income, the fund has the option of buying more American assets that yield even more dividends and so on – this is how wealth and financial influence is built up.

3. The Future of the Dollar

This outflow of wealth has put America in a disadvantageous situation. To compound problems with the trade deficit, the country has run a long and sustained government deficit. It has been widely reported in financial circles;"[t]he country's projected debt is growing so quickly that it would exceed the size of the economy in 2023, the nonpartisan Congressional Budget Office reported in its latest long-run economic outlook" (Calmes 2009). This fact alone is astonishing. This same report says that "[u]nder current law, the federal budget is on an unsustainable path—meaning that federal debt will continue to grow much faster than the economy over the long run…CBO's long-term budget projections raise fundamental questions about economic sustainability…" (Rutledge 2009). Furthermore, it states that "[i]f spending grew as projected and taxes were raised in tandem, tax rates would have to reach levels never seen in the United States" (Rutledge 2009). Again, the effect snowballs. The CBO reported that: "[h]igher debt results in permanently higher spending to pay interest on that debt (unless the debt is later paid off). Federal interest payments already amount to more than 1 percent of GDP; unless current law changes, that share would rise to 2.5 percent by 2020" ("The Long-Term Budget Outlook" CBO p. XII 2009). The 2009 GDP of the country is $14.097 trillion ("National Economic Accounts" 2009). Even using today's GDP figure, projected federal interest payments in 2020 equal approximately $475 billion ($14.097 trillion X 2.5%). This would mean that by 2020, every year, $475 billion of taxpayer money would go towards paying interest on government debts, rather than being used on the actual government's budget. The amount of dollars and debt issued to other countries to pay for consumption that America can't afford (trade deficit), combined with the projected levels of government debt (fiscal deficit), are hurting America's position in the world, as well as threatening to severely undermine its currency. Currencies are no longer backed by gold deposits, so the value of a currency is only as good as other countries' faith in that government to keep its economic and financial house in order.

The world's attitude about America's economic and financial well being has been rather lax in the past. Buffet wrote that "[w]e were taught in Economics 101 that countries could not for long sustain large, ever-growing trade deficits. At a point, so it was claimed, the spree of the consumption-happy nation would be braked by currency-rate adjustments and by the unwillingness of creditor countries to accept an endless flow of IOUs from the big spenders" (Buffet 2003). He goes onto to note that "that's the way it has indeed worked for the rest of the world, as we can see by the abrupt shutoffs of credit that many profligate nations have suffered in recent decades" (Buffet 2003). He argues that in the past the U.S. has enjoyed a special status and could behave as it wishes because the country's "past financial behavior was so exemplary" and because the country is still "so rich" (Buffet 2003). In the past, neither our capacity nor our intention to pay our bills was questioned and the country had a wealth of "desirable assets to trade for consumables" (Buffet 2003). The effect of this was our "national" credit card allowed us to charge "truly breathtaking amounts" (Buffet 2003).

This ability to run up large amounts of debt held by other countries leaves America with a distinct strategic disadvantage. For example, "China holds more than $2 trillion in foreign currency, mostly dollars, and has limited options for investing additional dollars. Essentially, it must hold those dollars or put them into Treasuries and other U.S. debt instruments. If it had other options, it would already be using them" (Morici 2009). Countries such as China which hold more American debt than they know what to do with are able to leverage this fact to gain the upper-hand in any political discussions. In this case, if China feels threatened enough it can threaten to sell its dollar holdings onto the world market and devalue the currency. Many believe that this would not happen as it would hurt China as well; nonetheless, the threat alone is enough to draw attention.

The world's laxness towards America's economic and fiscal problems is disappearing quickly. Other nations are beginning to doubt the country's debt-fueled consumption and the ability of the American consumer, or American government, to ever make good on all the debt they have taken on. One author, writing about the 2009 Brazil India China (BRIC) summit, said that:

> [w]hile the US plays its tiresome geopolitical games on Russia's eastern borders, Russian President Dmitri Medvedev was busy charting a new economic and political reality in the heart of Eurasia. 'The artificially maintained unipolar system', he lectured, is based on 'one big centre of consumption, financed by a growing deficit and ... one formerly strong reserve currency.' At the root of the global financial crisis, he concluded, is that the US makes too little and spends too much. Especially upsetting for Russia is its continued military largesse to Georgia, the missile shield in Eastern Europe and its invasions of Iraq and Afghanistan. 'The summit must create the conditions for a fairer world order,' he read out, as Presidents Hu Jintao of China, Luiz Inacio Lula da Silva of Brazil and the Indian prime minister looked on approvingly…. But there was more than colourful rhetoric in all this, despite the pooh-poohing of Western pundits, who deride the SCO and BRIC as a collection of misfits and wannabes. The BRICs have put the US dollar on notice, and are already finding alternatives as a means of clearing accounts. Medvedev called for the IMF to include the Russian ruble and the Chinese yuan in the basket of currencies used to value its financial products. But that is just for starters. Chinese Central Bank governor Zhou Xiaochuan says the goal is now to create a reserve currency 'that is disconnected from individual nations.' (Walberg 2009)

Up until this point, the dollar has been the currency that the world has used extensively. It has funded trade and been held as currency reserves by national banks. This is part of the reason the world has tolerated America's financial blundering: it is hard to switch away from the current international financial architecture that relies heavily upon the use of the dollar. Many countries hold a lot of dollars, so they do not want to see the dollar devalued or thrown out immediately.

Nonetheless, attacks against the dollar as a common currency are appearing more frequently in world discussions. As noted above, many countries are calling for an international currency not linked to any country. Furthermore:

> [e]ven more ominous for the threadbare dollar, though perfectly sensible in the computer age, is the revival of stone-age barter on a big scale, which bypasses the need for any reserve currency at all. Brazil's biggest trading partner, once the US, is now (surprise) China, and they are using barter deals to settler their accounts, bypassing the dollar altogether. Two weeks ago China reached an agreement with Malaysia to denominate trade between the two countries in yuan (Walberg 2009).

A shift away from using the dollar to finance and settle international trade means that the demand for dollars will drop. Additionally, if other countries stop buying American bonds (debt), this will also hurt the dollar, as people become more and more afraid to hold IOUs or dollar denominated debt they aren't sure the country pay back. Or if they do get paid back, it might be in dollars that are worth far less. America could always "print" more money to pay off this debt, increasing the amount of dollars in circulation, which could eventually lead to massive price inflation and leave the dollar worth very little. Either way, the most likely effect of either outcome is that the value of the dollar, relative to other currencies, will decline over the long run. Americans could face a situation in which they see the value of their savings dwindle as a dollar becomes worth less and less, and the goods bought from other countries end up costing more and more of those dollars. It appears that America's financial habits are severely threatening its status as a financial superpower. The loss of its financial status will hurt its ability to borrow money and will make the country a less ideal place to invest, thereby threatening its productivity and economic power. A decline in economic production hurts the federal budget via reduced tax revenue. Decreased government revenue makes it increasingly harder to maintain a position as a military superpower. This is how financial power can be seen as the crucial third building block of a country's hard power. In summary, one economist writes that "[t]he economy of the United States, long the world's dominant creditor, now the world's largest debtor, is fighting a losing battle against trade and financial imbalances that are growing daily and are caused by dislocations too fundamental to reverse" (Schiff p. 2 2008). While I share the assessment, I do not believe anything is too fundamental to reverse.

One distinct target of opportunity to reverse these trends back into a state of balance is the mass consumption of oil which fuels the trade deficit, as well as the mass consumption of oil the by DoD which contributes in a much smaller way to the government deficit. Given the DoD's resources and past victories in the face of adversity, it is uniquely situated as an institution to intensively focus on fuel and vehicle technology in order to market a breakthrough that will not only improve operational capability but also contribute to national security on an unprecedented scale by offering products or technology that can drastically improve the economic and financial status of the country via reduced fuel consumption. This in effect would help bolster the long-term national security of the country. The next section demonstrates that beyond the general well-being of the country, there is another reason that the DoD should be specifically concerned with fuel consumption. Conflict directly spurs price growth in oil.

Section C: Establishing a Link Between Conflict and Elevated Oil Prices

During times of conflict when the DoD needs fuel the most, it is costing the most. This paper finds that conflict appears to have a positive and statistically significant effect on oil prices over longer periods of times such as years, and shorter periods of time such as days, weeks, and months. This study is distinctive for two reasons. The first is that it analyzes the link between conflict and oil prices over longer periods of time, incorporating annual data that includes multiple conflicts and international confrontations over different decades while also accounting for macroeconomic data during these periods. This contrasts with studies that focus on the behavior of oil prices only in relation to one or two specific wars such as the Persian Gulf or Iraq War (Lee and Cheng 2007), or only in relation to generalized macroeconomic drivers such as GDP growth or oil market fundamentals (Hamilton 2009). The second distinctive attribute of this study is that it contains a shorter term higher-frequency analysis of daily oil prices in response to the December 2008 - January 2009 Gaza conflict. This differs from other studies in that it analyzes daily oil prices in relation to smaller scale conflicts in the Middle East, rather than in relation to a full scale war such as the Iraq War of 2003 (Looney 2003).

Besides being structurally different from other works on oil prices, the methods and conclusions of this study also differ in two smaller ways. Firstly, this paper differs in its chosen methods for capturing oil price data. Oil price data was entered as a percent change (either in day/day or year/year periods), such as 3.3% for the year 2002 rather than in dollar terms such as $60.55 a barrel in 2001 and $62.55 in 2002. The figures used to calculate the percentage were all inflation-adjusted into 2008 dollars. Entering the data as a percent change was done in an effort to more intuitively capture and display the volatility and response of oil prices to the conflict variable while also dampening the potential impact of trending prices. Capturing the data as a percent change rather than a dollar figure seemed more appropriate for graphing purposes as well. Secondly, this paper differs in the nature of its conclusions from other works. Rather than attempting to conclude with a generalized link between oil price and conflict (Looney 2003), or an extremely complicated analysis of the "jump" volatility of crude oil prices to war (Lee and Cheng 2007), this study falls in between by building a simple but statistically-relevant model to help predict conflict's impact on oil prices. The conclusions are that: (1) over longer periods of time, one can expect annual price jumps of 25-55% in world oil prices in the presence of significant large-scale conflict involving the United States and the Middle East, and (2) over shorter periods of time, conflict in oil-sensitive regions has the potential to cause daily price jumps of 8-12% in world oil prices.

In general, there is an extremely large and diverse body of studies that attempts to describe movements in oil prices. These reports range from ones that look at a number of macroeconomic factors such as commodity price speculation, demand, geological limitations, and OPEC pricing (Hamilton 2009) to inflation and investment factors (Yeyati 1996) to geopolitical tensions (Rush 2008). Still others look at internal and regional conflicts over oil itself (Lujala, Rod, and Thieme 2007) or the relationship between oil price shocks and the business cycle (Raymond and Rich 1997). The challenge was to determine what variables were relevant and applicable to this study.

Admittedly, the relationship amongst the variables is often fuzzy. Hamilton (2009) says that:

> [w]e have reviewed a number of theories as to what produced the high price of oil in the summer of 2008, including commodity price speculation, strong world demand, time delays or geological limitations on

> increasing production, OPEC monopoly pricing, and an increasingly important contribution of the scarcity rent. Rather than think of these as competing hypotheses, one possibility is that there is an element of truth to all of them (28-29).

It is a solid hypothesis that a large variety of macroeconomic and geopolitical factors affect the movement of oil prices. For this reason, a specific set of economic data was used in the study both in the long-term and short-term studies in an attempt to account for economic drivers of the price of oil. Of course, there are factors beyond economics that influence the movement of oil prices as well.

Some authors have found that there is a definite correlation between political conflict and oil prices. Lee and Cheng (2007) says that “[t]he political conflicts among oil production countries are the main reasons for causing sharply higher oil prices since 1985” (912). Lee and Cheng studied oil prices during the first Gulf War and then the 2003 U.S. invasion of Iraq. They found that the start of the wars in each case lead to large jumps in spot oil prices but that eventually as the wars ended the price of oil slowly fell back to “normal” prices levels (911).

Other authors have analyzed the effect of the first Persian Gulf War and agree that conflict, or the threat of conflict, seems to impact oil prices. In “Oil Prices and the Iraq War: Market Interpretations of Military Developments” Robert Looney (2003) says that:

> [i]n sum, oil prices were steadily declining throughout 1990 up to about a month before the invasion of Kuwait. This was a period of excess stocks, rather slack demand, and over-capacity among the major producers. There was little upward pressure on prices until signs of Iraq's belligerence became more and more apparent in July. As noted above, this was also a

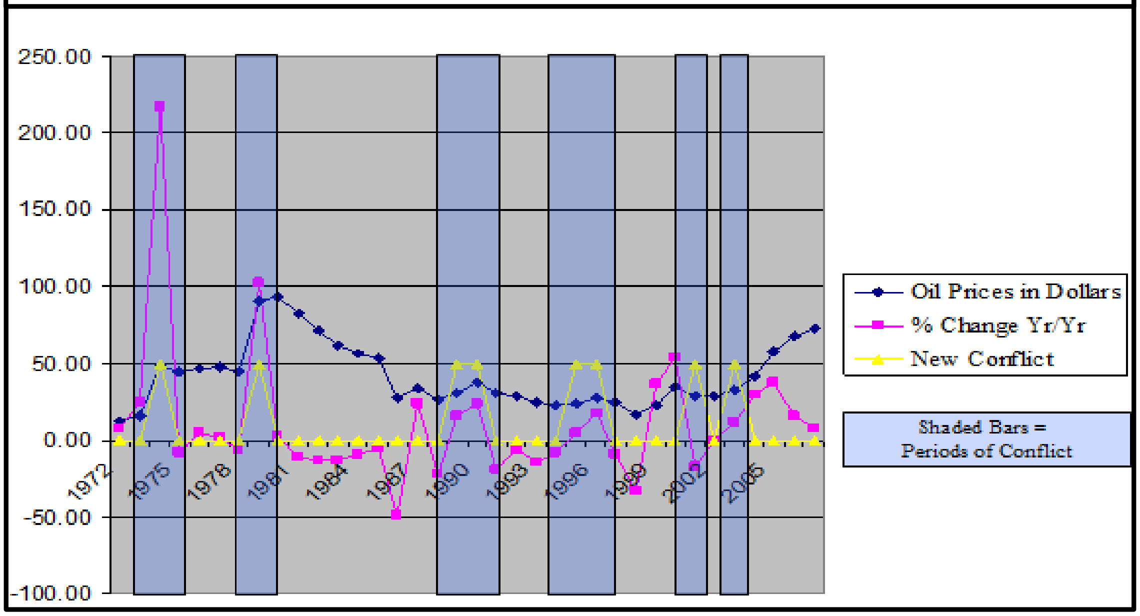
> period of upward sloping futures curves, indicating no risk premium was associated with concerns over future availabilities of oil. In other words, we can safely attribute most of the price increases from mid-July 1990 up to January 17 of 1991 as strictly associated with military-related events in Kuwait. In retrospect, it is also safe to say that the oil markets were good interpreters of military events as they pertained to future availabilities of oil.

It is apparent that the Persian Gulf conflict did have some effect upon oil prices. As Looney points out, even in a period of excess oil stocks, weak demand, and overcapacity, the threat of war drove a large increase in the price of oil.

1. Annual Oil Price Movements and Conflict: 1972-2007

What about the effect of different conflicts, or the threats of conflict, on oil prices over a longer period of time? Is this something with which the Department of Defense should concern itself? The answer is yes, definitely. This paper first examined oil prices and major world conflict from 1900 through 2007 and found that a general relationship was not apparent in the period of 1900-1971. However, the 1972 Oil Embargo seems to have altered, or at least reflected, a new underlying reality of world politics. This new reality is a geo-political link between large-scale American military action and oil prices. For every year between 1972 and 2007, this paper gathered the following data: the difference between world oil production and consumption, percent of U.S. net oil imports from OPEC countries, economic recessions, U.S. and world G.D.P. growth, and the initiation or threat of initiation of major conflicts. From 1972 onward, it appears that large scale U.S. military action, or the threat thereof, has a statistically significant and positive effect on oil prices. Figure 8 below graphs oil prices in dollars and the annual percent change in oil prices against periods of conflict as represented by the shaded boxes and yellow conflict line. Other than during the 2001 recession, it appears that there is a significant relationship between the onset of conflict and average annual oil prices. The model built in this paper mimics works by Hamilton (2009) and Brook, Price, Sutherland, Westerlund, and Andre (2004). To further investigate the appearance of Figure 8, a detailed regression analysis was performed.

Figure 8: Oil Prices and Conflict Chart 1972-2007



Conflict Data

As previously mentioned, this study gathered data from 1972 to 2007 on major conflicts, or threats of conflict, throughout the world that involved the United States. Specifically, the data set accounted for the following conflicts: the 1972 Oil Embargo, the Iran Hostage Crisis, the U.S. invasion of Panama, the Persian Gulf War, the Taiwan Straight Crisis, the start of Operation Enduring Freedom, and the start of Operation Iraqi Freedom.

Oil Price Data

The dependent variable for each year was the percent change in average oil prices from the previous year. This percent change was calculated from the average annual prices listed in the British Petroleum 2008 Statistical Review. All financial figures listed in the Statistical Review and used for calculation were inflation adjusted and given in terms of 2008 dollars.

Economic Data

For each year from 1972-2007, the following economic information was gathered and entered into the calculation: the difference between world oil production and consumption, percent of U.S. net oil imports from OPEC countries, economic recessions, and U.S. and world G.D.P. growth. These datasets were chosen to represent macroeconomic drivers that are commonly judged to affect oil price movements. All data and sources are described in Table 3 on the following page.

Table 3: 1972-2007 Oil and Conflict Regression Analysis Variables		
Variable Name	**Definition**	**Source**
WAR-START	Independent variable, 1 for years that the US engaged in a major conflict, or faced the threat thereof such as the Taiwain Straight Crisis. 0 in years with no conflict, or years of an on-going but previously initiated conflict (such as year 2 of war in Iraq would equal 0	Various
OPEC	This figure was entered as a percentage and represents the percent of oil imported to the U.S. that came from OPEC nations	From the Energy Information Agency, Dept of Energy, Table 5.7 "Petroleum Net Imports by Country of Origin 1960-2007" http://www.eia.doe.gov/emeu/aer/pdf/pages/sec5_17.pdf
RECESSIONS	This figure was entered as a 1 for the years that the National Burea of Economic Research (NBER) reported the economy to be in contraction, 0 for years it was not	Recession years were identified as reported by NBER on their website http://www.nber.org/cycles.html
CONSUMED	This variable was the percent consumed of all oil produced throughout the world in that year. This ranged from 95% in years of surplus to 105% in years that reserves were consumed	The figures for consumption and production came from British Petroluem Statistical Review of World Energy 2008 http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622
USGDP	Annual GDP growth of the United States	All data came from the Earth Trends Environmental Data Base with the exception of 2007 which came from Indexmundi online data base http://earthtrends.wri.org/text/economics-business/variable-227.html http://www.indexmundi.com/united_states/
WGDP	Annual GDP growth of the world	All data came from the Earth Trends Environmental Data Base with the exception of 2007 which came from Indexmundi online data base http://earthtrends.wri.org/text/economics-business/variable-227.html http://www.indexmundi.com/world/
CHANGE	Percent change in average oil price from previous ye	Calculated from average annual prices given in the British Petroleum 2008 Statistical Review http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622
All online sources accessed June 2009		

After entering all the data and running the regression analysis, the following equation was generated (standard error figures in parenthesis under coefficients):

$$CHANGE = \underset{(357.2238)}{975.9500795} + \underset{(15.25766)}{40.1221546} * WAR\_START - \underset{(.850284)}{1.17176301} * OPEC$$

$$- \underset{(19.28818)}{13.65122692} * RECESSIONS - \underset{(319.2517)}{898.4729775} * CONSUMED - \underset{(6.303208)}{10.4255037} * USGDP$$

$$+ \underset{(8.134185)}{10.39905618} * WGDP$$

Regression analysis with this dataset produced the following figures specifically:

Table 4: 1972-2007 Oil and Conflict Regression Analysis Results Summary

Dependent Variable: CHANGE
Method: Least Squares
Sample: 1972 2007
Included observations: 36

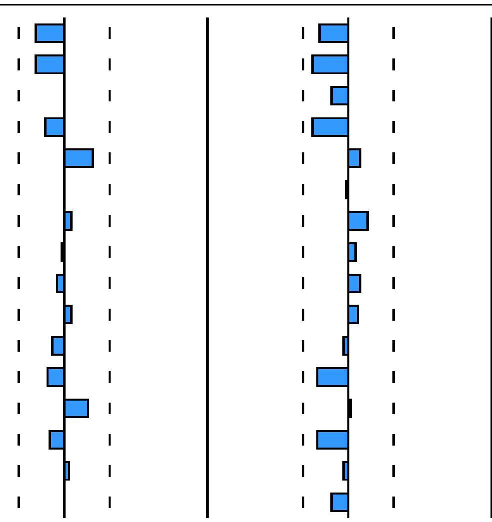
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	975.9501	357.2238	2.732041	0.0106
WAR_START	40.12215	15.25766	2.62964	0.0135
CONSUMED	-898.473	319.2517	-2.814309	0.0087
OPEC	-1.171763	0.850284	-1.378084	0.1787
RECESSIONS	-13.65123	19.28818	-0.707751	0.4847
USGDP	-10.4255	6.303208	-1.654	0.1089
WGDP	10.39906	8.134185	1.278439	0.2112
R-squared	0.436502	Mean dependent var		10.93083
Adjusted R-squared	0.319916	S.D. dependent var		44.23949
S.E. of regression	36.48308	Akaike info criterion		10.20424
Sum squared resid	38599.43	Schwarz criterion		10.51215
Log likelihood	-176.6763	F-statistic		3.744036
Durbin-Watson stat	2.35931	Prob(F-statistic)		0.007022

Overall, the results point to a relationship between conflict and rises in the price of oil. The growth equation generated is significant in its ability to capture oil price movements with the coefficient of determination, or R-squared, equal to 0.4365. A Durbin-Watson stat value of 2.35931 would seem indicative of no serial auto-correlation amongst the error terms. To further investigate this, the residuals for each year were analyzed to make sure that auto-correlation was not occurring within the results. As shown in the figure below, the auto-correlation stays within confidence intervals meaning that it is not statistically significant. It would seem that the error terms do not have a systematic pattern. In other words, the residuals do not fall into a specific pattern and do not demonstrate any first order serial correlation. This indicates that the model has not failed to capture the relevant data.

Figure 9: Autocorrelation Chart for 1972-2007 Regression Analysis

Date: 07/03/09 Time: 11:44
Sample: 1972 2007
Included observations: 36

Autocorrelation Partial Correlation



	AC	PAC	Q-Stat	Prob
1	-0.208	-0.208	1.6877	0.194
2	-0.210	-0.264	3.4540	0.178
3	-0.004	-0.128	3.4546	0.327
4	-0.141	-0.264	4.3017	0.367
5	0.215	0.085	6.3401	0.275
6	0.003	-0.017	6.3405	0.386
7	0.052	0.146	6.4663	0.486
8	-0.011	0.054	6.4722	0.594
9	-0.048	0.098	6.5889	0.680
10	0.048	0.064	6.7083	0.753
11	-0.088	-0.040	7.1326	0.788
12	-0.124	-0.228	8.0044	0.785
13	0.170	0.021	9.7230	0.716
14	-0.109	-0.228	10.466	0.727
15	0.039	-0.041	10.566	0.783
16	-0.003	-0.119	10.566	0.835

The conflict (WAR-START) variable has a statistically significant effect on the price of oil. It has a t-stat of 2.62964 and a p value of .0135. The p value indicates that there is only a 1.3% chance the conflict variable has a coefficient of 0 and does not affect oil prices. Within the equation generated, the conflict variable has a coefficient of 40.12 and a standard error of 15.2 Therefore, we can expect the price of oil to rise between 25 and 55 percent (40.1 ± 15.2) in years that America initiates large scale military conflict. Using 2006 as a sample year ($10,056,343,400 spent on fuel), a new conflict could cost the DoD between $2,514,085,850 (25 percent) and $5,530,988,870 (55 percent) extra each year. In a worst case scenario, the DoD could pay $5.5 billion extra in fuel costs that year for initiating a new conflict. The DoD should incorporate these apparent relationships between conflict and long term oil prices into its daily operating procedures, plans and programs, and long-term strategic vision.

2. Oil Price and Conflict: Short Term Correlations

It appears that there may also be a relation between oil prices and international conflict during shorter periods of days, weeks, and months as well. Shorter term oil price regression analyses are important for two reasons. Firstly, a lot can happen within one year, so an effort was made to see if oil prices and conflict also seemed linked on a shorter time scale. Secondly, the DoD continually purchases fuel throughout the year, so even a price rise lasting one to two weeks can add up to a significant amount of money. It will be shown in a later section that even though the DoD contracts its fuel prices, there are clauses in the contracts that link the price the DoD pays to the market price of fuel, meaning higher prices ultimately do cost the DoD more money. Figures 10 and 11 on the following pages contain a graphical representation of the data being investigated.

In order to study short term correlations, two specific regression analyses were performed. The first one covered the last week of December 2008 through the end of January 2009, and the second one covered the last week of December 2008 through the entire first quarter of 2009. These dates were chosen to include the Israeli-Hamas conflict in Gaza which overtly started in late December 2008 and continued through late January 2009. However, the longer regression study encompassing price data and economic reports from the whole first quarter of 2009 was done even though conflict was absent two out of three of the months; this was done to see if conflict still emerged as statistically significant variable. Conflict again emerged as a statistically significant and relevant variable when analyzing short term movements of oil prices.

Figure 10: Oil Prices and Conflict Chart January 2009

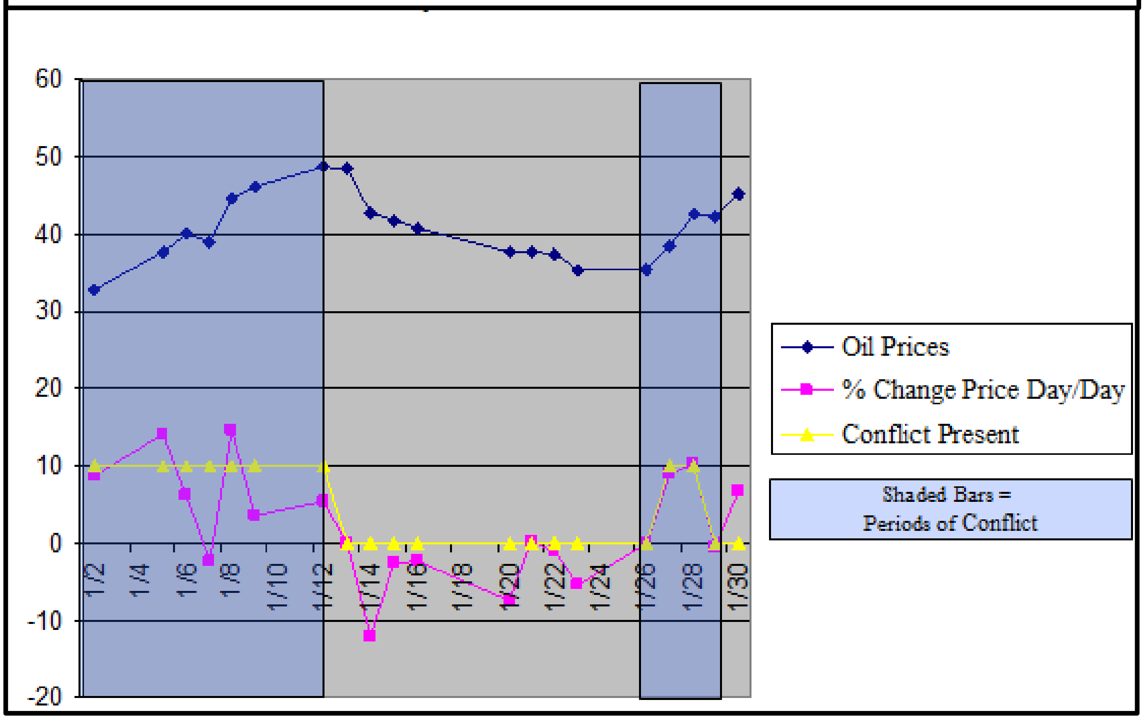
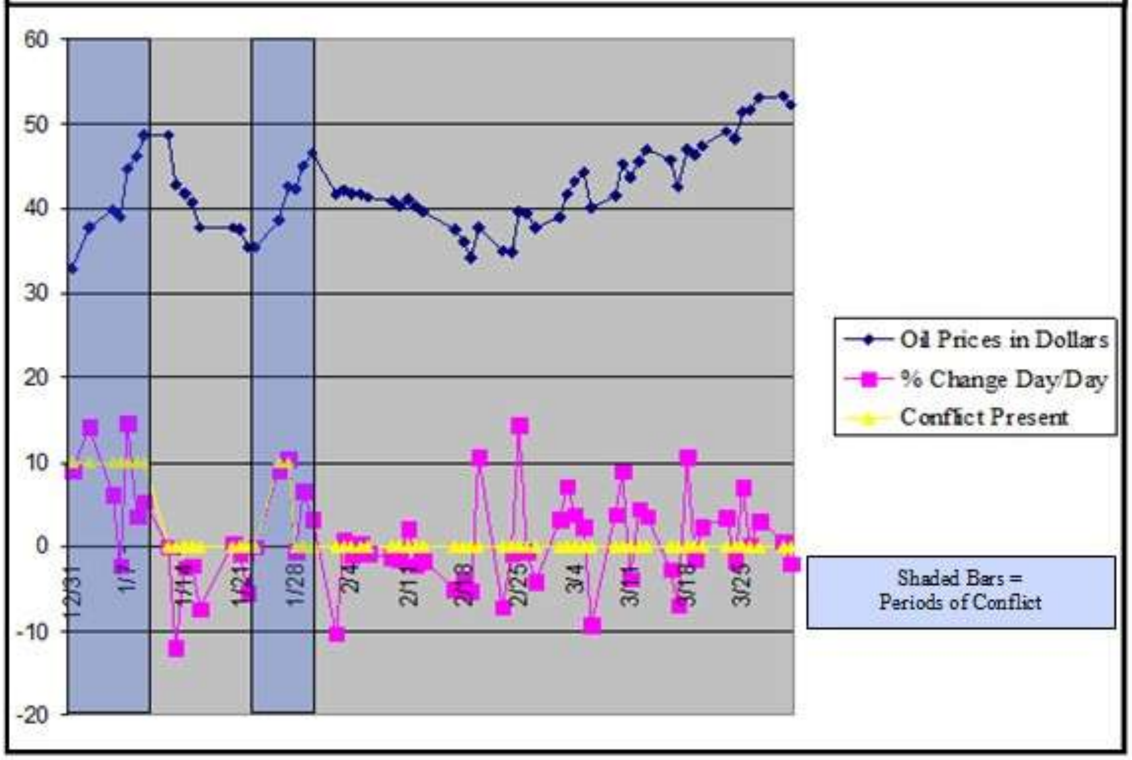


Figure 11: Oil Prices and Conflict Chart 1st Qtr 2009



Conflict Data

Conflict data was entered as 1 or 0 depending upon the event. Trading days from December 24th through January 5th were all entered as 1 to reflect conflict, as this was this period that Hamas initiated high levels of rocket attacks into Israel and Israel retaliated with air strikes and a full ground invasion. January 7th was entered as 0 because Israel agreed to halt bombing to allow civilian aid into Palestine and it was hoped that this marked the start of the end of the conflict. The first two trading days after Israel and Palestine agreed to a ceasefire were also marked as 1 to represent conflict because it was during this period Hamas continued its rocket attacks and Israel continued its airstrikes, giving rise to a fear that the conflict would escalate (even though a ceasefire had been agreed upon). All other days without significant new war news, or after the conflict finally did end, were marked as 0s on the conflict table. Entries of conflict came from timelines of the conflict as reported by major news sources ("Last Israeli Troops Leave Gaza" "Timeline – Israeli-Hamas Violence Since Truce Ended" "Gaza Crisis: Key Maps and Timelines" Dec 2008-Jan 2009).

Oil Price Data

The daily spot price of oil was analyzed for the first quarter of 2009 in light of the Gaza War. Daily prices were entered using the Energy Information Administration's database of crude oil spot prices at the Cushing, Oklahoma pricing point. Cushing is a major trading hub for oil and is known as a price settlement point for West Texas Intermediate and the New York Mercantile Exchange.

Economic Data

The results of the following economic reports were entered into the regression analysis: Leading Economic Indicators, Nonfarm Payroll report, Retail Sales, and changes in crude oil stockpiles. All the economic reports except changes in crude stockpiles were entered as 0 if they matched the market expectations, or as a 1 if they were a positive surprise. For economic reports that had negative surprises in that period, a separate variable was created in which a negative 1 was entered for the negative surprises. The change in crude stockpiles was entered as the percent change in crude stockpiles each month as there was no available information at what the market expectation was each month for that report.

The conflict variable emerged as statistically significant, showing a positive effect on oil prices, in both the January regression and the regression covering the entire first quarter of 2009. The following three pages contain summary charts of the variables used as well as summary charts of both regression analyses performed.

Table 5: Higher Frequency Oil and Conflict Regression Analysis Variables		
Variable Name	Definition	Source
CONFLICT	Independent variable, 1 on days major conflict occurred, 0 for all other days	As reported through major network news centers. Articles cited in the conflict variable section of regression analysis.
LEI	Leading Economic Indicators report released by The Conference Board the first few business days of each month. 1 was entered for a positive surprise and 0 entered if the report matched current market expectations	The Conference Board website http://www.conference-board.org/economics/bci/
PAYROLL	Nonfarm payrolls report released by the Bureau of Labor Statistics the first Friday of every month. -1 entered if report was significantly worse than market expectations and 0 entered if the report matched current market expectations (No positive surprises in this period).	Bureau of Labor Statistics website http://stats.bls.gov/news.release/empsit.toc.htm.
POS_SALES	Retail Sales report released by the Census Bureau of the Department of Commerce around the 13th of every month. 1 was entered for a positive surprise and 0 entered if the report matched current market expectations	Dept. of Commerce, Census Bureau website http://www.census.gov/svsd/www/advtable.html
NEG_SALES	Retail Sales report released by the Census Bureau of the Department of Commerce around the 13th of every month. -1 was entered for a negative surprise and 0 entered if the report matched current market expectations	Dept. of Commerce, Census Bureau website http://www.census.gov/svsd/www/advtable.html
STOCKPILE	Changes in U.S. crude oil stockpiles, released weekly by the Energy Information Administration. Percent fluctation in stockpiles was entered directly into data sheet.	Energy Info. Administration oil data website http://www.eia.doe.gov/oil_gas/petroleum/data_publications/weekly_petrol
PRICE	Percent change in price from the previous day as calculated from the Energy Information Administration's oil price and data website.	Energy Info. Administration oil data website http://tonto.eia.doe.gov/dnav/pet/pet_pri_spt_s1_d.htm
All online sources accessed in June 2009		

After entering all the data and running the regression analysis, the following equation was generated for the January data (standard error figures in parenthesis under coefficients):

$$\text{PRICE} = \underset{(1.406676)}{-1.812201309} + \underset{(2.240034)}{9.331164757} * \text{CONFLICT} + \underset{(5.170743)}{4.872201309} * \text{LEI}$$
$$\underset{(6.365549)}{-5.531096563} * \text{STOCKPILES}$$

Regression analysis with the January dataset produced the following figures specifically:

Table 6: January Regression Analysis				
Dependent Variable: PRICE Method: Least Squares Sample(adjusted): 12/24/2008 1/31/2009 Included observations: 25 after adjusting endpoints				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.95674	1.223567	-0.781927	0.443
CONFLICT	10.69049	2.394536	4.464536	0.0002
LEI	4.01674	4.969378	0.808298	0.428
STOCKPILES	-6.191617	6.08622	-1.017317	0.3206
R-squared	0.559185	Mean dependent var		1.5096
Adjusted R-squared	0.496212	S.D. dependent var		6.785745
S.E. of regression	4.816388	Akaike info criterion		6.127572
Sum squared resid	487.1495	Schwarz criterion		6.322592
Log likelihood	-72.59465	F-statistic		8.879693
Durbin-Watson stat	2.132137	Prob(F-statistic)		0.000538

After entering all the data and running the regression analysis the following equation was generated for the 1st Quarter 2009 data (standard error figures in parenthesis under coefficients):

$$\begin{aligned}PRICE = &\underset{(.697876)}{-\,0.1428952682} + \underset{(2.11626)}{9.996611525}*CONFLICT + \underset{(3.491049)}{10.68023143}*LEI\\ &+ \underset{(4.882463)}{0.2309173443}*NEG\_SALES + \underset{(3.488523)}{2.737895268}*POS\_SALES\\ &+ \underset{(4.883908)}{2.067104732}*PAYROLL - \underset{(1.172012)}{1.422128074}*STOCKPILE\end{aligned}$$

Regression analysis with the 1st Quarter 2009 data set produced the following figures specifically:

Table 7: 1st Quarter 2009 Regression Analysis

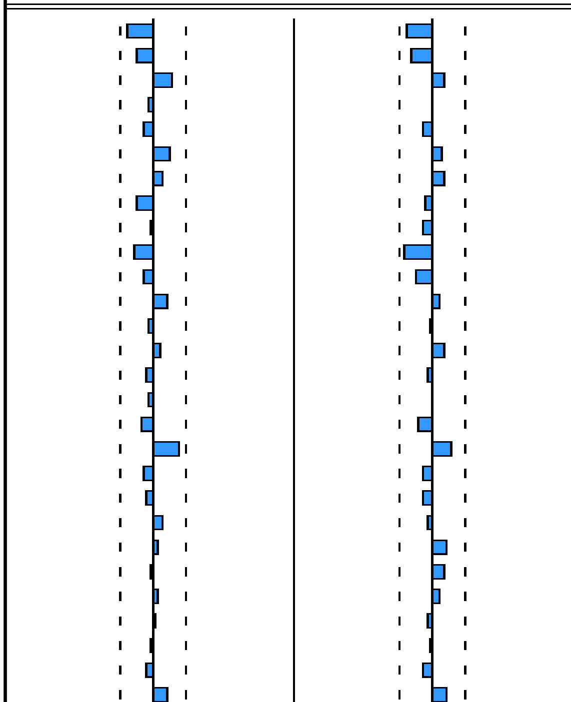
Dependent Variable: PRICE
Method: Least Squares
Sample(adjusted): 12/24/2008 3/31/2009
Included observations: 66 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.142895	0.697876	-0.204757	0.8385
CONFLICT	9.996612	2.11626	4.723716	0
LEI	10.68023	3.491049	3.059319	0.0033
NEG_SALES	0.230917	4.882463	0.047295	0.9624
POS_SALES	2.737895	3.488523	0.784829	0.4357
PAYROLL	2.067105	4.883908	0.423248	0.6737
STOCKPILE	-1.422128	1.172012	-1.213407	0.2298
R-squared	0.37777	Mean dependent var		0.916818
Adjusted R-squared	0.314493	S.D. dependent var		5.838237
S.E. of regression	4.83379	Akaike info criterion		6.089143
Sum squared resid	1378.566	Schwarz criterion		6.321379
Log likelihood	-193.9417	F-statistic		5.970047
Durbin-Watson stat	2.362317	Prob(F-statistic)		0.000064

For the January and first quarter study the coefficient of determination, or R-squared, for the growth equations were .559 and .377 respectively. The Durbin-Watson stat values were 2.13, and 2.36 respectively. As shown in Figure 12, the auto-correlation figures for the first quarter of 2009 stay within confidence intervals meaning that they are not statistically significant. The effect of the CONFLICT variable had a statistically significant effect on the price of oil with t-stats of 4.46 and 4.72 and p values approaching 0 for each study. This would indicate that the probability the conflict variable has a true coefficient of 0 is nearly 0%.

Figure 12: Autocorrelation Chart for 1st Qtr 2009 Regression Analysis

Date: 07/04/09 Time: 15:05
Sample: 12/24/2008 3/25/2009
Included observations: 66



	AC	PAC	Q-Stat	Prob
1	-0.186	-0.186	2.3786	0.123
2	-0.122	-0.162	3.4249	0.180
3	0.144	0.093	4.9009	0.179
4	-0.028	0.001	4.9565	0.292
5	-0.081	-0.058	5.4356	0.365
6	0.115	0.077	6.4329	0.376
7	0.062	0.091	6.7209	0.459
8	-0.117	-0.055	7.7795	0.455
9	-0.023	-0.067	7.8198	0.552
10	-0.138	-0.210	9.3428	0.500
11	-0.066	-0.131	9.6994	0.558
12	0.113	0.049	10.759	0.550
13	-0.040	-0.012	10.897	0.619
14	0.049	0.095	11.100	0.678
15	-0.050	-0.040	11.317	0.730
16	-0.029	-0.005	11.395	0.784
17	-0.091	-0.106	12.156	0.791
18	0.191	0.132	15.584	0.622
19	-0.069	-0.077	16.040	0.655
20	-0.049	-0.067	16.270	0.700
21	0.077	-0.025	16.860	0.720
22	0.040	0.114	17.026	0.762
23	-0.024	0.083	17.087	0.805
24	0.036	0.044	17.227	0.839
25	0.015	-0.039	17.253	0.872
26	-0.011	-0.012	17.266	0.901
27	-0.045	-0.073	17.498	0.918
28	0.105	0.105	18.795	0.904

The CONFLICT variable has a positive and statistically significant effect on oil prices. For the regression study involving the first quarter of 2009, the CONFLICT variable had a coefficient of 9.96 and a standard error of 2.11. This means that days for which conflict is present, oil prices jump between 7.85 and 12.07% (9.96 ± 2.11). So in a scenario in which the DoD is spending $27,500,000 on fuel daily (2006 yearly expense divided into 365 days), a new conflict could cause extra expenses each day between $2.1 million (a 7.85% increase over $27.5 million) and $3.3 million (a 12.07% increase over $27.5 million). If the conflict lasted only one week it could in a worst case scenario cost an extra $21 million ($3.3 multiplied by 7 days). Assuming a median base salary of $32,000 for an Enlisted Grade 6 (Staff Sergeant), this extra fuel expense is enough to pay the annual base salary for 665 Staff Sergeants.

It appears then that over both longer and shorter periods of times, conflict has a statistical significant and positive effect on oil prices. For all three studies the t-stat of the conflict variable ranged between 2.6 for longer terms and 4.72 for shorter terms. R-squared for the growth equations ranged between .37 and .55. Durbin-Watson values ranged from 2.1 to 2.3. There is enough correlation here between conflict and elevated oil prices that the DoD should reconsider its position of not hedging in the fuel markets (especially when it knows conflict is imminent), and should also re-evaluate its daily operating procedures, plans and programs, and long-term strategic vision as they relate to fuel consumption. The DoD is probably spending the most for oil when it needs it the most. The following section builds on the current section by demonstrating that the DoD has no protection from volatile fuel prices and energy crises.

Section D: No Protection from High Prices, No Relief in a Crisis

Beyond the recognition of rising expenses, examining the DoD's financial exposure to fuel consumption is a difficult and often confusing task due to the fact that various sources of information do not always match up. For example, in 2007 DESC reported that it sold $11.9 billion worth of petroleum, natural gas, and aviation fuel to the DoD (DESC FY07 Factbook p. 17 2007). The official statistics from the FY07 Energy Management Data Report (EMDR) states that the DoD spent approximately $9.8 billion on fuels (OUSDATL "EMDR 2007" 2007). There is no readably identifiable way to reconcile this $2 billion difference in the figures reported.

Nonetheless, four clear financial facts do emerge. The first is that the DoD is not protected against the market price of fuel, despite official claims that it is. The second is that operational costs have been hidden from the official reported cost of fuel. The third is that the DoD has no short term recourse when fuel prices rise dramatically. The fourth is that the Strategic Petroleum Reserve would not effectively help during a true fuel crisis.

1. The DoD is not Protected from the Market Price of Fuel

The Defense Energy Support Center (DESC) buys fuel from all over the world to supply the armed forces. The Congressional Research Service reports that the "Defense Energy Support Center (DESC), the primary agency responsible for procuring DoD's ground and air transportation fuels, buys bulk energy commodities and 'resells' the fuel to various military customers — with a price markup to cover its cost of operation (e.g. storage, transportation, and maintenance)" (Andrews and Schwartz p.1 2008). In this way, DESC can be seen as a middleman, buying fuel from the wholesalers and supplying it to the customer, in this case the U.S. military.

From Arkansas to Afghanistan, DESC will charge its military customers all over the world one standard price for fuel. The DESC "Standard Prices Main Page" (Feb 2009) states that:

> [t]he standard price of fuel is a tool that was created by DoDs fiscal managers to insulate the Military Services from the normal ups and downs of the fuel marketplace. It provides the Military Services and OSD with budget stability despite the commodity market swings, with gains or losses being absorbed by a revolving fund known as the Defense Working Capital Fund (DWCF). In years that the market price of fuel is higher than the standard price, the DWCF loses money. In years that the market price is lower than the standard price, it makes money. This gain or loss can be made up by adjusting future standard prices or by providing our DoD customers with a refund. This decision is typically made by the Office of the Secretary of Defense, Comptroller. However, the DWCF must remain cash solvent. As a result, in rare instances such as fiscal year 05, the standard price is changed during the fiscal year so the fund remains solvent.

This means that military operations (although not the Department of Defense budget) are generally protected from moderate fluctuations in commodity prices. However, as mentioned above, this is not always true. The quote above says that prices rose uncontrollably in 2005. They also apparently rose uncontrollably in 2008 as DESC made the following hikes in July to the standard prices charged per gallon to the military: jet fuel from $3.04 to $4.07 (33.9%), motor gasoline from $3.15 to $4.19 (33.0%), and Diesel from $3.51 to$4.07 (16.0%) (Andrews and Schwartz p. 5 2008). So ultimately, when fuel prices rise, the DoD's budget has to cover the cost increases somehow, even if this increased cost is not apparent to the armed forces themselves.

DESC's contracts with fuel suppliers do "contain price adjustment clauses" and have "contract prices" that are "indexed to market price indicators" so that "contract prices are adjusted upward or downward as indicators rise or fall" (DESC FY07 Fact Book p. 43 2007). This means that the DoD's budget, through DESC, is fully exposed to fluctuations in the commodities market, even if the bulk of military operations is successfully isolated from price fluctuations in the short term. Over the long term, however, the DoD depends on the DWCF to finance all losses on fuel during the year to keep the standard price peg charged to the military for fuel.

2. Operational Costs are Often Hidden

If fuel contracts become more expensive, or if DESC spends large amounts of money getting the fuel from a purchase point to military units in the field, the military unit is still charged a standard price and the extra cost is made up via disbursements from the DWCF. There is no easily accessible public information available on the funding of the DWCF. The author contacted DESC and asked what the DWCF's budget was in an effort to find a more complete cost figure for the DoD's extensive fuel supply chain. DESC was unable or unwilling to provide an answer. One way or another, the cost of contracting, storing, shipping, and providing direct delivery of fuels adds up. In 2007, DESC spent $400 million on contracts for storage and distribution, $350 million for bulk fuel transportation, $371 million for port, depot storage, and pipeline service, and $4.8 billion on multi-year contracts to power posts, camps, and stations (DESC FY07 Fact Book p. 23-52 2007). Clearly, these are significant costs.

In fact, the ability to obscure this "operational" cost of fuel consumption is about to be curtailed and it is likely that fuel will become even more expensive on paper for the Department of Defense. Anthony Andrews (2009) of the Congressional Research Service wrote that:

> DESC's contract delivery price is based on lowest cost to the government FOB (free-on-board). A typical delivery point, a Defense Fuel Supply Point (government owned or leased tank farms), redistributes fuel to bases and installations. DESC levels the price of fuel for all DOD's 'customers' and includes a surcharge for its operating costs. The price does not include the logistical cost of delivery forward to the area of operation by, for example, air-to-air refueling, underway replenishment, or ground transport. In the past, these hidden logistical costs had not been factored into DOD's fuel costs. The Duncan Hunter National Defense Authorization Act for FY2009 (P.L. 110-417) now requires that analyses and force planning processes consider the requirements for, and vulnerability of, fuel logistics (14).

It will become harder and harder to ignore the financial bottom-line as it relates to the "hidden" operational cost of all the fuel consumption.

3. The DoD has no Good Short Term Recourse for Oil Prices.

When prices do rise rapidly, there is no good short term recourse for the DoD. In the past, the "DOD's only recourse has been to request supplemental appropriations to pay for the increased costs and supplies" (Andrews p.17 2009). Andrews goes on to cite Page 196 from the *Office of the Secretary Defense 2007 Operation and Maintenance Overview* by saying, "[f]or example, DoD identified $0.5 billion in the FY2007

Emergency Supplemental Request for increases in baseline fuel costs resulting from higher market costs in the first half of FY2007" (Andrews p.17 2009). In this case, the only established recourse for the DoD is to ask for emergency funding. DESC itself has no ability to hold down costs during rapidly increasing prices either. DESC does have the option to cancel a contract and search for a new bidder, so "[t]his limits DESC's risk in holding contracts for fuel priced above the going market rate, but does not hold down costs during rapidly escalating prices (Andrews p. 17 2009). Neither the DoD nor DESC is protected or hedged from rapidly increasing fuel prices.

Instead of attempting to hedge fuel prices in the market, the DoD wanted to offset increased fuel expenditures by oil lease revenues from the Department of the Interior during times of increased oil prices (Andrews p. 17 2009). However, Andrews (2009) explains that the bulk of these oil lease revenues is from "Outer Continental Shelf (OCS) leases, and those revenues are already statutorily allocated among various government accounts, including coastal states" (17). This does not seem to be a viable option. Beyond a lack of viability, it does not seem to be a true solution due to the fact it opts to siphon away government revenues from another source, rather than address the DoD's vulnerability to fuel prices.

4. Even in a Crisis the Strategic Petroleum Reserve (SPR) Would Not be Effective

There is a general belief that the SPR would save the military during a fuel crisis, but this belief may be misplaced. During 2006, 40% of the crude oil refined in the U.S. was heavier than the oil stored in the SPR (Rusco p. 5 2008). Refineries that are equipped to process heavy oil cannot operate at full capacity if they are processing lighter oils (Andrews p. 17 2009). Therefore, "U.S. refining throughput would decrease by 735,000 barrels per day, or 5 percent, substantially reducing the effectiveness of the SPR during an oil disruption" (Rusco p. 5 2008). Nearly half of the nation's refineries are geared toward oil that is heavier than what we have stored inside our SPR. It would take time to retool these refineries and set up large scale refining of the SPR stockpile. Given that half the nation's refineries would not be operating at full capacity, it seems that a throughput drop of ¾ of a million barrels is a best case scenario. Even the predicted scenario of a 5 percent drop in oil throughput could cause significant disruptions in the energy markets and would take time to sort through, none of which would make this a good option for the DoD in a true crisis scenario.

This section described why the DoD is not protected against the market price of fuel, how operational costs have been hidden from the official reported cost of fuel, why the DoD has no short term recourse when fuel prices rise dramatically, and finally, why the SPR would not effectively help during a true fuel crisis. Furthermore, it focused on the financial aspects of the DoD's current posture on fuel consumption. The following section examines the consequences of this posture that extend far beyond the financial realm, into the operational and strategic realm.

Section E: Operational and Strategic Case Studies

1. Operational Case Study: DoD Operations and Fuel Management in Afghanistan

Despite recent efforts to overhaul DoD energy policy, it is still clear that American military operations, especially overseas, are energy intensive. The dependence on large amounts of fuel to power vehicles and provide electricity at many deployed bases has direct operational ramifications that affect supply chains as well as combat units on the ground. This can be seen by examining American military operations in Afghanistan. Every day, hundreds of tanker trucks loaded with fuel depart from Karachi in Pakistan to travel through the Torkham pass into Afghanistan to supply the NATO mission there (Tanoli 2008). The fuel is used by NATO forces for vehicles, heating, and electrical generation. Figure 13 features a picture from an ABC news article entitled "U.S. Supply Lines at Risk along Pakistan Border" (2008). In this particular case, the Taliban movement in Pakistan (Tehrik-i-Taliban Pakistan) led by Baitullah Mehsud hijacked 13 supply trucks destined for U.S. forces in Afghanistan and managed to capture, among other things, American military vehicles (Schirfrin and Khan). The next photograph above shows a supply truck after being

Figure 13: Photo of Captured U.S. Humvee

Source: "U.S. Supply Lines at Risk along Pakistan Border." Schifrin 2008

Figure 14: Ambushed Supply Truck in Ghazni Province

Source: AP Photo, Destroyed Truck in Ghazni Province. Sadeq 2007 attacked by Taliban militants along one of Afghanistan's major highways in the Ghazni Province.

Setting up stable supply chains that can handle large amounts of goods and fuel is a continuing problem for the military. There are only two routes into Afghanistan from Pakistan. There is the overland route running through Pakistan's North West Frontier Province (NWFP), into the tribal badlands, and on into Afghanistan. The other route runs from the Balochistan province of Pakistan and into the Kandahar region in southern Afghanistan. While the Balochistan route is more secure on the Pakistan side of the border, it "runs through Taliban country in Afghanistan — especially along the Ring Road to reach Kabul and Bagram Air Base. This is why some three-fourths of the food, fuel and military hardware that transit Pakistan are ferried along the NWFP route and over the Khyber Pass" (Stratfor "Afghanistan: The Logistical Alternative" 2009).

Taliban militants have frequently been successful in both Afghanistan and Pakistan at destroying large supply convoys driven by contractors that were meant to supply for the U.S. military. In December of 2008, the *Los Angeles Times* reported that "[i]n one of the largest and most brazen attacks of its kind, suspected Taliban insurgents with heavy weapons attacked two truck stops in northwest Pakistan on Sunday, destroying more than 150 vehicles carrying supplies bound for U.S.-led troops in Afghanistan" (King 2008). Such instances often leave United States military power looking impotent. In most cases of supply line attacks, one will read something like this: "[t]he guard said that militants stormed a truck terminal and fought a light gun-battle with security personnel, who surrendered. The militants told the guards to stop working for NATO, and then poured gasoline over the containers and lit them" (King 2008). These attacks on U.S. supply lines and trucking companies servicing the U.S. military are not isolated incidents.

Additionally, a significant percentage of the money the U.S. military pays for supply contracts goes to the Taliban. Contractors serving the military will often attempt to pay off the Taliban in an attempt to buy safe passage for their convoys. The United Kingdom newspaper *The Times* reported that:

> [t]he controversial payments were confirmed by several fuel importers, trucking, and security company owners. None wanted to be identified because of the risk to their business and their lives. 'We estimate that approximately 25 per cent of the money we pay for security to get the fuel in goes into the pockets of the Taliban,' said one fuel importer (Coghlan 2009).

Twenty-five percent may seem like a high number, but this is consistent with other estimates given by contractors in Afghanistan. This, in effect, means that a portion of the large amount of money spent on fuel and supply contracts in Afghanistan by the U.S. taxpayer ends up in the hands of the Taliban to be used against U.S. military forces. Sadly, this seems unavoidable, as the contractors are only acting rationally in an attempt to protect their drivers and convoys. Because our military operations are so dependent upon energy that comes from fuel that has to be shipped in -- rather than energy that can be generated on our deployed bases themselves -- there is no readily-apparent solution.

Bruce Riedel, a former CIA agent and senior fellow at the Brookings Institute, noted that "Afghanistan is a landlocked country. Everything we want to use to eat, drink and to shoot has to come in from outside…[t]he Taliban and al Qaeda recognize completely that this is a vulnerability and a place where it's easier for them to operate inside Pakistan than it is for us, and the way to really turn the screws on the NATO forces in Afghanistan is to go after the logistics pipeline" (Schifrin 2009). The necessary supply chain needed to support our bases is a clear vulnerability.

This fact is becoming increasingly relevant. After the majority of this paper was written, the issues contained within it started to appear with more frequency in the news. A May 2009 article from NDIA's National Defense Magazine says that:

> [t]he war in Afghanistan is testing the limits of 'deployable energy'. As the Pentagon prepares for a troop buildup, officials worry about the huge logistical challenge of having to ship enormous amounts of fuel and power generators to military bases that are located in remote areas and have no access to local grids. The gargantuan demand for generators is straining the military's already overburdened logistics support system, said officials. Transporting fuel on dangerous mine-infested roads also creates additional hazards for troops and contractors (Erwin 2009).

The entire fuel supply situation –necessary for supplying both aircraft and generators --creates disarray, detracting from the mission.

Figure 15: Metro Hospital Project

Source: HDR Lecture, Michaela Wittman, 2008

This should be a major issue for the Pentagon. The DoD still lacks clarity on the actual consumption and demand of these forward deployed bases. The Director of Defense Capabilities at the GAO said that '"[w]e found that the information on fuel demand management strategies and reduction efforts is not shared among locations, military services, and across the department in a consistent manner" (Erwin 2009). The Pentagon "is having difficulties managing energy consumption at forward locations is the absence of data about fuel demand…The U.S. military currently operates several hundred bases in Iraq and Afghanistan. In 2008, the Defense Department supplied more than 68 million gallons of fuel each month on average to support those installations" (Erwin 2009). Solis also said, "[f]uel demand for these operations is higher than for any war in history," (Erwin 2009).

Figure 16: McKinney Green Building

Source: HDR Lecture, Michaela Wittman, 2008

The good news is that there are opportunities to address these issues. As the DoD strives to reach that 30 percent reduction in facility energy consumption by 2015, it will probably have to seek out or develop more unique or efficient innovations. It will then have the opportunity to leverage some of these new technologies into portable applications that can be used at forward and deployed bases around the world, or vice versa. New possibilities manifest each day such as vegetated roofs as in the Metro Hospital project in Wyoming, Michigan as seen in Figure 15 (Wittman 2008), parking lots that recycle rain water into cisterns near buildings like McKinney Green Building in McKinney, Texas as seen in Figure 16 (Wittman 2008), and even solar power cells that can be sprayed onto materials just like paint (Marshall 2008) with the potential to be 5 times more effective than current technology and a lot cheaper (Lovgren 2005).

In fact, possibilities are continually emerging out of current technology. A *Los Angeles Times* article reports that at Fort Irwin, the Army has started to experiment with powering operations with solar panels, tents with foam insulation, wind tunnels, and plug-in cars. The article reports that:

> [t]he desert base, which houses the Army's premier training center for troops deploying to Iraq and Afghanistan, has become a testing ground and showcase for green initiatives that officials estimate could save the services millions, trim their heavy environmental 'boot-print' and even save lives in the war zones, where fuel convoys are frequent targets (Zavis 2009).

These experiments are a good start for the DoD. However, the problem of vehicle and deployed base fuel consumption is still a major operational drag whose solution in the future will likely require much more than the one testing center at Fort Irwin.

2. Strategic Case Study: Political Bargaining for Costly Supply Lines

While the operational consequences of the fuel issue are starting to become more relevant and recognized, it should be noted there are dire strategic consequences as well. As shown by the above examples, at times the Department of Defense has to fight wars in places that require bases to be located in areas that are not easy to resupply. This can extend the fuel supply chain for thousands of miles -- often through unstable parts of the world. In this case, the supply chain needs to run from ports in the Arabian Sea to major roads that run through Pakistan and its mountain passes, and finally into Afghanistan.

There are often constricting strategic consequences as well for extended fuel supply lines running through unstable areas. Studying the Afghanistan example will show how the need to extend heavy logistical supply lines into just one landlocked country can have an almost never-ending chain of strategic implications. In the case of Afghanistan, the American military has ended up relying on the one set of supply lines that it could secure through Pakistan. The instability of these supply lines has put the military effort in a precipitous situation. To make the search for alternatives even more difficult, the U.S. would have to look for another place, like Pakistan, that has the capability to refine large amounts of oil that arrives by sea into diesel and high quality jet fuel (Stratfor "Afghanistan: The Logistical Alternative" 2009). In other more eloquent words: "[t]he imperative to find an alternative route is compounded by the interrelated need to find dramatic excess capacity for refining not only diesel but also higher-quality jet fuel" (Stratfor "Afghanistan: The Logistical Alternative" 2009). Riedel points out that "the American military and NATO military officials are well aware of their vulnerability here and have been looking for a long time for alternatives to develop so we don't have to rely on Pakistan…[b]ut the problem is the geography doesn't change. There is no other way to bring in supplies" (Schifrin 2009).

Riedel makes a compelling case, however, this is not exactly correct. Riedel would have been better off to say that there are no other ways to bring in supplies that do not require significant political bargaining with Iran or Russia. In this case, America's known need to supply bases in Afghanistan has forced it into a situation in which it must decide which is more important: developing alternative supply lines into Afghanistan or not acquiescing to Russia or Iran on current issues of contention. This, in effect, has given both Iran and Russia the upper-hand in bargaining over international issues. The need to establish other supply routes in Afghanistan has significantly weakened the United States' political bargaining power in negotiating issues such as Iran's nuclear program or Russia's encroachment on democracy in its border states.

In this case, the U.S. will have to spend a significant amount of time and energy forming and shaping political opinions in order to develop another logistical route into Afghanistan – and there is no easy or clear solution to the matter. Stratfor points out that there is a relatively short and straightforward route through Iran connecting the port of Chahbahar to Afghanistan's major road infrastructure. (Stratfor "Afghanistan: The Logistical Alternative" 2009). Initially, this option sounds appealing. However, "using this route could require trucking the entire way, and Iran utterly lacks refining capacity. Of course, these relatively tactical problems pale in comparison to the profound differences between Washington and Tehran still to be worked out" (Stratfor "Afghanistan: The Logistical Alternative" 2009). Looking to the north and Central Asia, there is some fuel shipped in across the Caspian Sea. However, there is no good indication that shipping capability across the Caspian Sea could expand "meaningfully"; furthermore, if this route was taken, the cargo would have to be transferred from rail to ship back to rail -- in addition to the rail and truck transfers needed in Afghanistan (Stratfor "Afghanistan: The Logistical Alternative" 2009). Even if shipping capacity across the Caspian was not an issue, the fact remains that Russia could sever Georgia's east-west rail links at any time it wanted (Stratfor "Afghanistan: The Logistical Alternative" 2009), which makes the Caspian option even less enticing.

Figure 17: "Logistics and Afghanistan"
STRATFOR map depicting current and potential Afghanistan supply routes

Source: "Logistics and Afghanistan" STRATFOR map, 2008.

Because of the above facts, it is likely the U.S. will look for supply route further north – through countries such as Turkmenistan, Usbekistan, Kzakhstan, and Russia. Turkmenistan is isolated and politically fragile as a new ruler has taken power after years of authoritarian rule. It has been mentioned that "enacting new policies under the new government remains problematic to say the least" (Stratfor "Afghanistan: The Logistical Alternative" 2009). Beyond that, the U.S. must choose to use a Russian or Ukranian port of entry (subject to organized crime and espionage) or use a more secure port that will require all the cargo to be swapped between European/Turkish rail gages and the Soviet rail gauges (Stratfor "Afghanistan: The Logistical Alternative" 2009). None of the above options seem like an ideal solution.

All of the aforementioned problems are just minor logistical sticking points compared to the giant political task of getting Russia to agree at all to this type of supply arrangement for Afghanistan. Stratfor puts it perfectly by saying that "[t]he problem is that while the Kremlin has been reasonably cooperative up to this point when it comes to U.S. and NATO efforts in Afghanistan, such an understanding may not be possible completely independent of the clash of wills between Russia and the West" (Stratfor "Afghanistan: The Logistical Alternative" 2009).

Figure 18: Marines Arrive at Manas Air Base

Source: "Transit Center at Manas Website." 2009

Even if the optimal solution from a logistical point of view seems to be bargaining with Russia, there is no guarantee that Russia will cooperate with America. The Russian government is focused on extending its sphere of influence in an attempt to build a buffer zone while pushing Western influence out of neighboring states. Despite recent Russian-American negotiations on the supply line issue, Kyrgyzstan announced on 3 February 2009 that" it would order the closure of a US airbase on its soil whose presence has irritated Moscow, on the same day it received a generous Russian financial aid package" (AFP "Kyrgyzstan vows to close key US airbase" 2009). It is no secret that Manas Air Force Base in Kyrgyzstan serves as a "vital supply route for NATO forces in Afghanistan but its location deep in former Soviet territory has annoyed an increasingly assertive Russia keen on restoring its influence in Central Asia" (AFP "Kyrgyzstan vows to close key US airbase" 2009). In this way, other countries get to play political games with the U.S.'s vulnerability.

The base's around- the-clock missions include aerial refueling, combat airlift and airdrop, aero medical evacuation and strategic airlift operations "while providing support for Coalition personnel and cargo transiting in and out of Afghanistan" (Air Force Link"376th AEW Manas Airbase" 2009). The base processes roughly 15,000 people and 500 pounds of cargo each month in support of Operation Enduring Freedom in Afghanistan (Air Force Link "Potential closure of Manas Air Base won't disrupt operations**"** 2009**).** U.S. troop levels in Afghanistan are currently around 32,000 (AP News "U.S. Troop Levels in Afghanistan Top 32,000" 2008). This means that on any given month, a significant chunk of overall force levels move in and out of Afghanistan via Manas Air Base. If America did not need Russia's cooperation on supply lines it would be politically free to push back on this attempt to close the airbase by offering increased incentives to Kyrgyzstan to keep the base open. However, it cannot immediately do this because if the fuel stops flowing into Afghanistan for even a short period of time, military operations will shut down. The fact that fuel must keep flowing into Afghanistan has severely handicapped the country's bargaining position.

It is no surprise that on the very same day of Kyrgyzstan's announcement, Gen. John Craddock, NATO's senior military commander, announced that NATO "would not oppose individual member nations reaching bilateral deals with Iran for the transit of supplies to Afghanistan" (Stratfor "Geopolitical Diary: NATO Members Free To Seek Iranian Supply Route" 2009). It was noted that "[t]hese are not small or off-the-cuff statements, and they signal a significant development in the West's relationship with

Iran" (Stratfor "Geopolitical Diary: NATO Members Free To Seek Iranian Supply Route" 2009). This supply dilemma has left the United States in a complicated strategic position as its logistics needs have forced it to soften its position against both Russia and Iran. This section demonstrated that the DoD's current posture regarding fuel consumption results in a complex and tangled array of operational and strategic disadvantages. The following section describes some of the public relations benefits that the DoD could reap if was able to change its fuel consumption behaviors.

Section F: Potential Public Relations Boost

Beyond the reasons mentioned earlier, there is another potentially powerful reason for the DoD to change its fuel consumption practices. There is an opportunity for the organization as a whole to emerge as a world leader in the green movement and to reap the public relations benefits thereof. This would be a refreshing turn for the organization given the widespread belief that much of the Iraq war was about oil.

Those that believe the war was mainly about oil are not without their reasons. Just weeks before the war started, Larry Lindsey, who was the head of President Bush's National Economic Council said that "the successful prosecution of the war would be good for the US economy" (Salameh 2008). Obviously, "a key reason for this claim was the belief that it would keep oil prices low" (Salameh 2008). The results of this paper show that the exact opposite of that belief is true. Engaging in conflict in the Middle East results in higher oil prices. Nonetheless, it was a popular view at the time that the war would lead to lower oil prices. One World Bank consultant noted that on that same day Larry Lindsey argued for the economic benefit of the Iraq War, *The Wall Street Journal* contained an editorial that argued that "[t]he best way to keep oil prices in check is a short, successful war on Iraq" (Stiglitz and Bilmes p. 218 2008). This consultant goes onto argue that:

> [t]he United States supported by 'Big Oil', wanted to change the rules of the game. They wanted to regain influence over the great Middle East oilfields from which Western oil companies (the Seven Sisters) were expelled four decades ago. In a sense, they wanted to turn the clock back to a time before the great wave of nationalizations in the 1970s. Under pressure from the US occupation, the Iraqi cabinet passed on 26 February

> 2007 a new national hydrocarbon law, which is yet to be approved by the Iraqi Parliament. Under the proposed draft law, 63 of Iraq's 80 known oilfields will be open to foreign multinationals, which in this case would be American oil companies given the American occupation of Iraq while granting the Iraqi National Oil Company (INOC) control over just 17 of the fields. The new Iraqi system will stand in sharp contrast to neighbouring Kuwait, Iran and Saudi Arabia, who will maintain their national oil companies, having outlawed foreign control over oil development projects in their respective countries (Salameh 2008).

The U.S. military plays a high visibility role in theories such as these because it is not only the most powerful tool of U.S. foreign policy, but also an oil consumer itself. This is exactly why it would be such a noticeable and powerful public relations move if the military were to lead a green revolution in technology.

Proponents of green technology are taking note of this potential. A recent article noted that: "[t]he Defense Department derives 9.8% of its power from alternative sources and is looking to expand use of wind, solar, thermal and nuclear energy. Some believe that the military has the potential to become a catalyst, helping to turn more expensive power sources into financially viable alternatives to coal and petroleum" (Zavis 2009). This same article quotes Matthew Kahn, an environmental economist at UCLA, as saying "[i]f the military were to go green, I think that this really could achieve some environmental goals, for a very simple reason: the military is so big" (Zavis 2009). Given recent beliefs about the war in Iraq that the U.S. military prosecuted, and its reputation as a fuel hog, the U.S. military has an opportunity given its size and resources to lead a green revolution that could turn critics to supporters the world over and become one of the most successful U.S. military public relations campaigns in history.

Section G: Policy Background

Previous sections examined the financial, operational, and strategic impacts of the DoD's fuel consumption practices. In order to better understand the DoD's quandary, this section will examine national-level policies which have shaped the DoD's energy practices over recent years. Recent policy passed by the government has focused on facility energy consumption by the DoD, but largely ignored the Department's fuel consumption practices. There are a host of government policies which must be examined because they have impacted the direction of the DoD and its energy policy. Department of Defense policy on energy management and procedures is affected by broad federal legislation as well more specific National Defense Authorization Acts. For the DoD, the cornerstone reports regarding energy consumption are the annual Energy Management Data report from office of the Undersecretary of Defense Installations and Environment, and the Defense Energy Support Center's yearly fact book. The form and shape of these reports is affected by pieces of legislation such as the Energy Policy Act of 2005, Executive Order 12423, and the Energy Independence and Security Act of 2007. H.R. 4986 the National Defense Authorization Act for Fiscal Year 2008 also stipulates certain behavior the Department of Defense has to follow regarding energy management.

The most significant policy change probably came from Executive Order 13423. Executive Order 13423, ordering all federal agencies to decrease energy consumption by 3% a year, was signed on 24 January 2007 by President Bush. It should be noted that the 3% per year reduction in energy is taken to apply to facilities as shown by 2003 baseline standard consisting only of facility consumption (OUSDATL "Revised 2003 Baseline Report" 2005). Although facilities make up 25 percent of total DoD energy consumed, they comprise far less of the total dollar amount spent, as most of the DoD's energy expenditure goes toward fuel. Of the $13.6 billion spent in fiscal year 2006, most of it ($10+ billion) went toward fuel. This means that a 3% reduction effort in energy consumed, aimed mostly at facilities, will not result in a straight line 3% savings in monetary expenditures as well.

Executive Order 13423 was not the only piece of legislation to affect the DoD and its energy policy. Rather than quote paragraph after paragraph of regulations, the next two pages simplify and highlight the main ways in which the Energy Policy Act of 2005, Executive Order 13423, the Energy Independence and Security Act of 2007, and the National Defense Authorization Act of 2008 affect the Department of Defense.

Energy Policy Act of 2005

The Energy Policy Act of 2005 included the following relevant sections (all information below taken from full text of Energy Policy Act 2005 from the EPA):

- Section 102 extends the annual federal energy reduction goal of 2% from FY 2006 to FY 2015, and amends the reporting baseline from 1985 to 2003 (Section 102 Energy Management Requirements 119 Stat 606).
- Section 103 directs federal agencies to meter electricity use in all federal buildings by Oct. 1, 2012, using advanced meters or metering devices that provide data at least daily. (Section 103 Energy Use Management and Accountability 119 Stat 608).
- Section 104 amends NECPA section 553 to direct agencies to purchase ENERGY STAR® and FEMP-designated products when procuring energy-consuming products, except when it is not cost effective or doesn't meet functional requirements of the agency. (Section 104 Procurement of Energy Efficient Projects 119 Stat 609).
- Section 203 requires that renewable electricity consumption by the Federal government cannot be less than 3% in FY 2007 to FY 2009, 5% in FY 2010 to FY 2012, and 7.5% in 2013 and thereafter. (Section 203 Federal Purchase Requirement 119 Stat 652).
- Section 204 amends subchapter VI of chapter 31 of title 40, United States Code in order to establish a photovoltaic energy commercialization program for the procurement and installation of photovoltaic systems in public and Federal buildings. This section requires the installation of 20,000 solar energy systems in Federal buildings by 2010. (Section 204 Use of Photovoltaic Energy in Public Buildings 119 Stat 653).

Executive Order 13423

All information below was taken from full text of Executive Order 13423, reprinted in Federal Register.

- “Improve energy efficiency and reduce greenhouse gas emissions of the agency, through reduction of energy intensity by (i) 3 percent annually through the end of fiscal year 2015, or (ii) 30 percent by the end of fiscal year 2015, relative to the baseline of the agency’s energy use in fiscal year 2003”(3919).
- “Beginning in FY 2008, reduce water consumption intensity, relative to the baseline of the agency’s water consumption in fiscal year 2007, through life-cycle cost-effective measures by 2 percent annually through the end of fiscal year 2015 or 16 percent by the end of fiscal year 2015” (3919).
- “Require in agency acquisitions of goods and services (i) use of sustainable environmental practices, including acquisition of biobased, environmentally preferable, energy-efficient, water-efficient, and recycled-content products, and (ii) use of paper of at least 30 percent post-consumer fiber content” (3919).

Energy Independence and Security Act of 2007

All information below comes from the CRS Report for Congress “Energy Independence and Security Act of 2007: A Summary of Major Provisions.”

- “Section 431 requires that total energy use in federal buildings, relative to the 2005 level, be reduced 30% by 2015. Section 432 directs that federal energy managers conduct a comprehensive energy and water evaluation for each facility at least once every four years through the end of fiscal year 2015, or (ii) 30 percent by the end of fiscal year 2015, relative to the baseline of the agency’s energy use in fiscal year 2003” (CRS-8).
- “For new federal buildings and major renovations, Section 433 requires that fossil-fuel energy use — relative to the 2003 level — be reduced 55% by 2010 and be eliminated (100% reduction) by 2030” (CRS-8).
- “Section 434 requires that each federal agency ensure that major replacements of installed equipment (such as heating and cooling systems), or renovation or expansion of existing space, employ the most energy efficient designs, systems, equipment, and controls that are life-cycle cost effective” (CRS-8).

National Defense Authorization Act Fiscal Year 2008

Below information taken from full text document of National Defense Authorization Act 2008.

- Section 828 gives authorization to the Secretary to enter into multiyear contracts, for up to ten-year periods, for the purchase of electricity from sources of renewable energy. It then provides further circumstances under which the Secretary may enter into such multiyear contracts for periods greater than five years. (Section 828 Multiyear Authority for Electricity from Renewable Sources HR 1585-225)
- Section 2861 amends Section 2913 of title 10, United States Code by striking subsection (e). This removes the $7 million ceiling for congressional notification regarding the cancellation of a DOD energy savings performance contract. It then establishes a $10 million ceiling used by all other federal agencies. (Section 2861 Repeal of Congressional Notification Requirement HR 1585-556).
- Section 2863 requires that (1) each building constructed or significantly altered by the Secretary or a military department Secretary be equipped to the maximum extent with energy-efficient lighting fixtures; and that (2) light bulbs replaced in the normal course of maintenance to be replaced with energy-efficient fixtures. It also authorizes the Secretary to waive such requirements if necessary to protect national security. (Section 2863 Use of Energy Efficient Fixtures and Bulbs in DoD Facilities HR 1585-557).
- Section 2864 Requires a report from the Under Secretary to the defense and appropriations committees on progress made toward the DoD goal of producing /procuring at least 25% renewable energy to meet DOD's electricity needs by 2025. (Section 2864 Reporting Requirements Relating to Renewable Energy HR 1585-558).

Although all of the above legislation is significant and effective, it focuses almost exclusively on the 25% of energy consumption used by DoD facilities, and not the larger target of opportunity: the 75% consumed in the form of fuel. To an analyst, this seems curious, as not much is officially mentioned about this fact. It is likely no one wants to be seen as threatening pilot training, navy patrols, the critical re-supply of warzones and other such operations that the military cannot curtail. This does not mean, however, that a huge fuel budget is not a strategic and operational weakness. Given the policy orientation, it is no surprise then, that the DoD has made a lot of progress in tackling its facility-based energy consumption (but not fuel-based consumption) as shown in the following three sections.

Section H: Current DoD Efforts

In fact, the DoD has made significant progress in reducing, or at least offsetting, its facility-based energy consumption. There appear to be four primary approaches to improving facility energy usage: reducing overall facility energy consumed, increasing the percentage of renewable energy consumed to power facilities, the creation of executive steering groups, and the use of new incentives. The 2007 Annual Energy Management Report (AEMR) says that "[t]he Department of Defense (DoD) continues to make significant progress toward achieving the goals of the Energy Policy Act of 2005 (EPAct 2005) and Executive Order (EO) 13423" (OUSDATL "Annual Energy Management Report 2007" p. 1 2007)". The report summarizes that the combined mandates of EPAct 2005 and EO 13423 establishes 2003 as a new energy baseline to measure future reductions, increases the annual reduction to 3% a year from 2% a year, increases the percentage of renewable energy required to 7.5 percent by 2013, increases the required efficiency of new construction to 30 percent below the current standard, and requires that all facilities meter electricity consumption (OUSDATL "AEMR 2007" p. 1 2007).

In terms of reductions, the DoD has made substantial improvements in its practices which have resulted in reported energy savings. During fiscal year 2007, the DoD claimed to achieve a 10.1 percent decrease in facility energy consumption as measured by BTU per gross square foot as compared to the new 2003 baseline (OUSDATL "AEMR 2007" p. 1 2007). However, the new 2003 baseline figure is a significantly higher BTUs/GSF figure than originally reported in the FY 2003 Energy Management Data Report (101,522 BTU/GSF vs. 116,134). This means that some of the reported reduction actually came in the form a new baseline figure rather than true progress.

Additionally, the DoD has increased its use of renewable energy. It "continues to make progress in installing renewable energy technologies and purchasing electricity generated from renewable sources (solar, wind, geothermal, and biomass) when life cycle cost-effective" (OUSDATL "AEMR 2007" p. 1 2007). The National Defense Authorization Act of 2007 re-emphasized an earlier DoD goal to produce or procure renewable energy equivalent to 25 percent of all facility electrical consumption (OUSDATL "AEMR 2007" p. 1 2007). In fiscal year 2007, the DoD managed to produce or procure 12,054 trillion BTUs worth of renewable energy which equaled approximately 12% of all facility electrical consumption (OUSDATL "AEMR 2007" p. 1 2007).

The Department of Defense has approached energy management efforts through a combination of appointing responsible parties within the different services, top-down mandates, and establishing incentives for reductions. The Deputy Under Secretary of Defense, Installations and Environment "instituted an EO 13423 working group charged with horizontal and vertical integration of all aspects of implementation. This Integrated Product Team includes members of myriad other working groups to ensure that EO 13423 goals are imbedded across the Department" (OUSDATL "AEMR 2007" p. 3 2007).

Each service has a "working group" style of committee geared toward carrying out DoD energy management policy. The Department of the Army has an Agency Energy Team staffed by people from the Office of the Assistant Chief of Staff of Installations and the Army Corps of Engineers. In the Navy, the Deputy Assistant Secretary of the Navy for Installations and Facilities serves as the Chairman of the Department of Navy

Shore Energy Policy Board. In the Air Force, the Secretary of the Air Force (SECAF) "issued a memorandum, which outlines the energy strategy of the Air Force and communicates the commitment to meet the goals stated by the President in EO 13423" (OUSDATL "AEMR 2007" p. 4 2007). In order to accomplish this task, the SECAF directed that all Major Commands (MAJCOMs) within the Air Force update and direct energy policies and instructions, and that every installation create Energy Management Steering Groups (EMSGs) to guide policy (OUSDATL "AEMR 2007" p. 4 2007).

In addition to steering groups, the Air Force established a Model Energy Base Initiative (MEBI) in which it designated two bases, Barksdale and McGuire, to serve as model energy bases. The hope is that these bases will showcase energy projects and energy management practices as they implement the three-pronged Air Force Energy Strategy of reducing demand, increasing supply, and culture change (OUSDATL "AEMR 2007" p. 7 2007). The Department of Defense says that Barksdale and McGuire Air Force Bases:

> [s]erve as test beds for new energy technologies and practices that can be disseminated to other bases after they are proven. Both of these bases are located in strategic areas of the country; Barksdale is located in Louisiana and will emphasize technologies and practices that will reduce cooling demand and McGuire is located in New Jersey, and emphasizes technologies and practices that will reduce heating demand. Additionally, both bases have active flying missions and will showcase technologies and management practices to reduce aviation fuel consumption (OUSDATL "AEMR 2007" p. 7 2007).

The quality of thinking behind this initiative deserves merit because the Air Force has chosen to facilitate innovative energy management across very different climates at bases that are also very operationally active.

Some of the best efforts from the DoD to control its energy expenditures come in the form of incentives, awards, and competitions. The Air Force competed in the 2007 Federal Energy and Water Management Awards program and was awarded eight winners out of 13 submissions (OUSDATL “AEMR 2007” p. 8 2007). Several Air Force MAJCOMs and bases have developed independent programs to reward energy reduction initiatives. Air Combat Command (ACC) is one the largest Commands in the Air Force comprised of over 100,000 military members and civilian employees and 1700 plus aircraft. During fiscal Year 2007, ACC provided $1 million worth of funds for a base energy program that recognized bases for improving energy savings over the previous year (OUSDATL “AEMR 2007” p. 8 2007). It also provided $3.4 million to promote innovative ideas regarding energy management. This $3.4 million ultimately funded 21 projects that reduced energy consumption by 42 billion BTUs and saved $600,000 per year (OUSDATL “AEMR 2007” p. 8 2007).

So far, the DoD has attempted to comply to new energy legislation through demand reduction, increased use of renewable resources, the creation of executive steering groups, and the implementation of incentives to improve energy efficiency. Looking at facilities alone, the results thus far have been encouraging. To better understand how the Department has been revamping its facility energy consumption, the following section contains a case study of reduction efforts made at Offutt Air Force Base in Nebraska, as well as a more in-depth analysis of Department wide facility energy consumption.

Section I: Offutt Air Force Base Facility Energy Reduction Effort Case Studies

As noted in the previous section, the DoD has made a lot of progress in reducing the energy needs of its facilities. An extensive case study of an energy reduction initiative at Offutt Air Force Base in Omaha, Nebraska will help display just how military bases across the world have been able to reduce their facility-based energy consumption. As will be demonstrated, the key to facility-based energy consumption is a mixture of revamping and streamlining base processes, closing down unused workspace, and incorporating newer and efficient technology in building upgrades.

1. Offutt Air Force Base Task Order #9 Feasibility Energy Analysis Case Study

This case study first audited and established electricity and natural gas use in 29 target facilities over the course of one year of operations. It then compiled a list of equipment that could be upgraded and changed out for more environmentally-friendly and efficient components. The cost savings on energy and operating and maintenance was calculated over the course of ten years and applied against the total cost of implementing all aspects of the project. The following discussion contains examples of some of the modifications made and the final statistics of the project regarding finances and energy consumption.

Figure 19: Inside the Bennie Davis Maintenance Facility

Source: "Offutt Photo Archive." 2008

Bennie Davis Maintenance Building Overhaul

The Bennie Davis Maintenance Hangar is one of the largest buildings on base (488,000 sq. feet). A variety of aircraft maintenance and shop functions take place in this building. In the workshop area, the existing cooling tower and chiller were removed. They were replaced with a new tower and highly efficient chiller that used the Honeywell direct digital control system ties to a base-wide Environmental Management System (EMS). The new cooling system for the shop reduced electricity used for cooling purposes from $7.8M kWh to 6.4M kWh per year while reducing the cost of operations by 10 percent ($31,600) per year (Viron Table M-1 2003).

Next, the two Scotch-Marine boilers for the building were replaced with a single modular boiler system that was also connected to the Honeywell direct digital control system that was tied into the base-wide EMS System (Viron C-2 2003). The digital controls and individual boiler enable/disable status option allowed much more efficient use of the boilers as they would were used only at precisely needed times. These modifications to the boiler system reduced yearly MCF consumption by 38% from 12,600 MCF to 7875 MCF. The cost of operating the system was reduced by 16.4% and approximately $30,000 was saved each year going forward.

The hangar bay doors in the building have a door track heating system which prevents the doors from freezing shut or malfunctioning due to ice accumulation during periods of cold weather. The system works by circulating glycol through a tube circuit that is imbedded in the ground below the tracks (Viron C-2 2003). It is capable of circulating 165 gpm (gallons per minute) of glycol through the circuit at 200 degrees Fahrenheit (Viron C-2 2003). The system runs on an outside air temperature reset schedule which means that when a certain temperature is reached outside, the system initiates the process to heat the glycol to 200 F and circulate it. Upon further study, it was found that the system was set to heat the glycol to 120 degrees when the outside air temperature was 75 degrees, and to 200 degrees when the outside air temperature was -20 degrees. The obvious concern is that freezing will not occur until the outside temperature falls below 32 degrees. Any system operation above an outside temperature of 32 degrees is resulting in wasted energy.

Two changes were made to increase the efficiency of the system. Firstly, the system reset levels were changed (as shown in Table 8). Secondly, it was determined that at an outside temperature above 33 degrees the “heat exchanger steam control valves would be closed and glycol circulating pumps disabled” (Viron C-3 2003). In effect, this would shut down the system in temperatures above 33 degrees because there was no danger of the system components freezing.

Table 8: Proposed Outside Air Temperature Reset Schedule

Outside Air Temperature, F	Glycol Temperature, F
-20	150
33	90

Source: Removed/Replace Equipment C-3 Viron Feasability Energy Analysis Offutt Air Force Base

These simple changes to the system operating parameters were able to reduce energy needed by 7,400 kWh and operation expenses by 56% per year ($40,000) (Viron Table M-1 2003). The system remained fully functional and 100% operationally ready.

Figure 20: Hydrotherm Boilers

Source: HV-125 Natural Gas Boiler, www.drillspot.com, 2009

High Efficiency Hot Water Boilers

After analyzing a number of buildings, it was realized that the base could score huge efficiency gains by replacing older Weben Jarco hot water boilers with the

Hydrotherm AM series boilers seen in Figure 20. The Hydrotherm AM boiler has one of the highest efficiency ratings in the industry. The results of this effort are displayed in Table 9, below. The base was able to reduce the amount of amount of natural gas consumed by targeted facilities by 44% on average while achieving a cost savings of close to $75,000 per year going forward. Ultimately, because of this initiative the base was able to cut its gas consumption by over 11,500 MCF (thousand cubic feet) per year.

Table 9: Summary of Results from Boiler Replacement Initiative

	Boilers replaced	Bldg. Sq. ft.	Baseline MCF Usage	Baseline Annual Cost	New MCF Usage	MCF Reduction	MCF Percent Reduction	Annual Savings	Cost Percentage Reduction
Contracting Sq	5	57156	4001	$57,620.00	2223	1778	44.44%	$11,114.00	19.29%
Base Ops	4	25843	1809	$25,890.00	1005	804	44.44%	$5,025.00	19.41%
Education Center	4	60546	4238	$60,656.00	2355	1883	44.43%	$11,773.00	19.41%
Family Center	3	27351	1915	$27,401.00	1064	851	44.44%	$5,318.00	19.41%
Pease Hall	4	33839	2369	$33,901.00	1316	1053	44.45%	$6,580.00	19.41%
McCoy Hall	4	33729	2361	$33,791.00	1312	1049	44.43%	$6,558.00	19.41%
Vandenburg Hall	3	23427	1640	$23,470.00	911	729	44.45%	$4,555.00	19.41%
W.I.C.	3	32555	2279	$32,614.00	1266	1013	44.45%	$6,330.00	19.41%
Castle Hall	4	26272	1839	$26,320.00	1022	817	44.43%	$5,108.00	19.41%
Alert Facility	4	25482	1784	$25,528.00	991	793	44.45%	$4,955.00	19.41%
Flight Medicine	4	25482	1784	$25,528.00	991	793	44.45%	$4,955.00	19.41%
Total	**42**	**371682**	**26019**	**$372,719.00**	**14456**	**11563**	**44.44%**	**$72,271.00**	**19.39%**

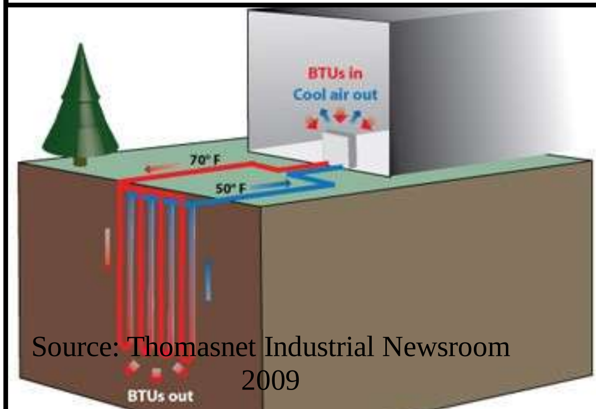
Source: Table M-1 Viron Feasability Energy Analysis Offutt Air Force Base

Auto Skills Shop

The Auto Skills Shop building had a gas duct furnace which was replaced with high-efficiency infra-red tub heaters that utilized a U-tube design which allowed for higher efficiency and eliminated the escapement of heating gases. It is estimated that "improperly sealed and insulated ductwork is responsible for an energy loss of $5 billion annually in the U.S." (Masters 2006). An example of an infra-red tube heater can be seen at right. Installing this heating system managed to cut natural gas consumption by over

75%, reduce electricity consumption by a modest percent, and lower overall energy expenditures in the building by 38.6% (Viron Table U-1 2003).

Figure 21: High Efficiency Infrared Tube Heaters



Source: Thomasnet Industrial Newsroom 2009

Figure 22: Side-view of Geothermal Heat Pump Systems

Source: Nyserda.org website 2009

Control Tower Modifications

In the base control tower, the existing water-cooled air conditioning unit and electric strip duct heaters in the 8th floor mechanical room were demolished and replaced with a series of geothermal heat pump systems connected to the base's EMS (Viron C-3 2003). Heat pumps work by moving heat from one place to another. While similar to ordinary heat pumps, geothermal heat pumps use the heat of the Earth to "provide heating, air conditioning and, in most cases hot water" (California Energy Commission 2006). In winter, the pump will extract heat from the Earth and circulate into your house; in the summer, it will extract heat from your house and discharge it into the ground. The advantage of the geothermal pump is that approximately 70 percent of the energy used is renewable and come from the ground (California Energy Commission 2006).

In this case three pumps were installed to include an interior distribution system, main trunk lines, circulation pumps, and an exterior distribution system with vertical wells and piping (Viron C-3 2003). The pumps were able to reduce spending on water to heat and cool the building by 100%. Before modifications the control tower used 2,628,000 gallons of water a year (Viron B-1 2003). The heat pumps also reduced electricity needed by the building by approximately 25% per year (Viron M-1 2003).

Capehart Chapel

Capehart Chapel is a large building that hosts services of all religious types for the Offutt community. A series of 23 water-sourced heat pumps were installed to replace existing air handling units that served the chapel. As with the control tower, complete heat exchanger systems, circulation lines, and circulation pumps were installed as well. These modifications increased the efficiency of the chapel's heating/cooling systems by 55% and saved 155,500 kWhs and $13,000 per year (Viron M-1 2003).

Figure 23: Offutt Air Force Base Capehart Chapel

Source: "Offutt Photo Archive." 2008

Other Modifications

Other buildings on base received modifications and upgrades similar to the examples above. In addition to this, other methods to reduce energy consumption included consolidating work centers and mothballing certain floors of buildings that were no longer needed, as well as replacing large amounts of older lighting fixtures with newer and more energy efficient lighting fixtures. Tables 10 and 11 present a summary of results from the entire initiative.

Table 10: Offutt AFB Task Order Nine Savings Calculations Summary

		Baseline Data			With Energy Modifications						
Building	**Change**	**kWh**	**MCF**	**Annual Cost**	**kWh**	**MCF**	**Annual Savings**	**Cost Savings**	**Energy Savings**	**Type**	**Percent Energy Savings**
Contracting Squadron	New Boilers	1,508,913	4001	$57,260	1,508,913	2,223	$11,114	19.40%	1,778	MCF	44.40%
Dentention Center	Chiller Upgrade	192,323	510	$7,298	156,179	510	$773	10.60%	36,144	kWh	18.80%
Family Services	New Boilers	1,598,408	4238	$60,656	1,598,408	2355	$11,773	19.40%	1883	MCF	44.40%
Band	New Boilers	722,064	1915	$27,401	722,064	1064	$5,318	19.40%	851	MCF	44.40%
Elkhorn station	Pumps /	825,400	N/A		479,650	NA			345,750	KWh	41.90%
	Lighting	N/A	12,906	$75,592	N/A	0	$51,900	68.70%	12,906	MCF	100.00%
Auto Skills	Infrared heat, new	342,143	N/A		233,143	NA			109,000	KWh	31.90%
	lighting	N/A	1,597	$32,200	N/A	581	$8,700	27.00%	1,016	MCF	63.60%
Pease Hall	New Boilers	893,346	2369	$33,901	893,346	1316	$6,580	19.40%	1053	MCF	44.40%
McCoy Hall	New Boilers	890,442	2361	$33,791	890,442	1312	$6,558	19.40%	1049	MCF	44.40%
Vandenburg Hall	New Boilers	618,470	1640	$23,470	618,470	911	$4,555	19.40%	729	MCF	44.50%
Daycare WIC	New Boilers	859,449	2279	$32,614	859,449	1266	$6,330	19.40%	1013	MCF	44.40%
Bennie Davis Hangar	New Chiller Plant	7,867,830	20862	$298,568	6,389,183	20862	$31,608	10.60%	1,478,647	kWh	18.80%
	New Steam Boilers	4,751,982	12600	$180,328	4,751,982	7875	$29,531	16.40%	4725	MCF	37.50%
	Door Mod	/	11278	$70,777	/	4984			6294	MCF	55.80%
	Door Mod	13400	/	$70,777	5922	/	$39,500	55.80%	7478	kWh	55.80%
Castle Hall	New Boilers	693,578	1839	$26,320	693,578	1022	$5,108	19.40%	817	MCF	44.40%
Alert Facility	New Boilers	672,722	1784	$25,528	672,722	991	$4,955	19.40%	793	MCF	44.50%
Flight Medicine	New Boilers	672,722	1784	$25,528	672722	991	$4,955	19.40%	793	MCF	44.50%
Control Tower	New Heat Pumps	31,891	0	$5,192	24,027	0	$6,213	120%	7,864	kWh	24.70%
Base Ops	New Boilers	682,253	1809	$25,890	682,253	1005	$5,025	19.40%	804	MCF	44.40%
Capehart Chapel	Heat Pumps	630,377	1671	$23,922	474,922	/			155,455	Kwh	24.70%
					/	84	$13,247	55.40%	1587	MCF	95.00%
New Chiller Plant	New Plant	N/A	N/A	$117,053	N/A	N/A	$67,701	57.80%	**Increases energy processing efficiency**		

Baseline kWh	**24,467,713**	**Baseline MCF**	**87,443**	**Basline $ Cost**	**$1,254,066**
Total kWh Saved/Yr	**2,140,338**	**Total MCF Saved/Yr**	**38,091**	**Total $ Saved/Yr**	**$321,444**
Percent Reduction	**8.75%**	**Percent Reduction**	**43.56%**	**Percent Reduction**	**25.63%**

Source: Calculated from Task Order Nine Financial Documents, not publicly available.

Table 11: Summary of Project Financial Statistics

Direct Costs of Project	
1. Report Cost	$21,541
2. Implementation	$2,836,406
3. Engineering	$286,295
4. Project Mgmt	$190,863
5. Construction Mg	$286,295
6. Commissioning	$143,147
7. Verification	$5,000
8. Bonding, Permits,	$95,432
9. OPPD Costs	$349,011
Sub Total Direct C	**$4,213,990**
Overhead	$572,589
Profit	$334,011
Total Project Cost	$5,359,168
Total Project Cost	**$5,120,590**

Total Program	
Principal Payments/Cost	($5,120,590)
Construction Period Savings	$192,879
Energy Savings	$3,859,543
O&M Savings	$1,070,945
Total Savings	$5,123,367
Net Savings	$2,777

Cash Flows To Pay for Project

Years	1	2	3	4	5
Principal Payment	($600,777)	($427,091)	($444,174)	($461,941)	($480,419)
Total Savings Generated					
Construction Period Savings	$192,879	$0	$0	$0	$0
Annual Energy Savings at 4%	$321,465	$334,324	$347,697	$361,604	$376,069
Annual O&M Costs at 4%	$89,200	$92,768	$96,479	$100,338	$104,351
Total Annual Savings	$603,544	$427,092	$444,175	$461,942	$480,420
Net Savings	$2,767	$1	$1	$1	$1
Years	6	7	8	9	10
Principal Payment	($499,636)	($519,621)	($540,406)	($562,022)	($584,503)
Total Savings Generated					
Construction Period Savings	$0	$0	$0	$0	$0
Annual Energy Savings at 4% Growt	$391,111	$406,756	$423,026	$439,947	$457,545
nual O&M Costs Savings at 4% Gro	$108,525	$112,866	$117,381	$122,076	$126,959
Total Annual Savings	$499,637	$519,622	$540,407	$562,023	$584,504
Net Savings	$1	$1	$1	$1	$1

Source: Calculated from Task Order Nine Financial Documents, not publicly available.

Ultimately, the base was able to finance a project that created a positive present value of savings while reducing energy consumption. After reviewing the documents, it appears that the project was analyzed using a 0% discount rate to cash inflows and outflows as there is no cost of funds for a military base from a financial perspective. For large capital projects, a military base will allocate some of its budget, but does not borrow money. Therefore, an interest rate, or discount rate, is not as important as it is in the private sector. This is somewhat disingenuous, but it is how the plan appears to have been crafted. Nonetheless, after the tenth year of the project -- when the base no longer has to make principal payments on the project -- the hard dollar monetary savings, or cost avoidance, will be well over $600,000 per year. Using a Life Cycle Cost Analysis of 11 years (rather than the 10 year cash flow chart above) the government calculated the present value of net savings to be $521,679. Additionally, the total life cycle reduction in electricity consumption and greenhouse gas emissions was 28,512,706.9 kWh and 29,000,000 kilograms respectively (Viron LCC Y-2 2003).

Offutt continues to improve its facility energy efficiency. It just completed the new Air Force Weather Agency (AFWA) headquarters building that earned a gold LEED rating (Hansen 2008). The building will use 50 to 60 percent less energy and 20% less water than a regular building of its size (Hansen 2008). The building became LEED-certified by “improving environmental efficiency of heating, ventilation and air conditioning equipment, improving recycling capabilities and employing the latest energy efficiency practices to conserve electricity” (Hansen 2008). The following chart summarizes Offutt’s consumption and cost of energy and water from 2003 to 2008. Offutt is representative of the DoD in that it has managed significant accomplishments since 2003.

Table 12: Offutt Air Force Base Fiscal years 2003-2008 Energy Consumption and Costs						
Units Consumed						
Electricity	2003	2004	2005	2006	2007	2008
KwH	172,600,706	169,587,762	172,215,228	155,520,446	156,882,482	164,509,881
		-1.75%	1.55%	-9.69%	0.88%	4.86%
				2003 to 2008 Difference		**-5%**
Gas	2003	2004	2005	2006	2007	2008
MCF	752,933	614,938	525,656	331,867	390,328	407,940
		-18.33%	-14.52%	-36.87%	17.62%	4.51%
				2003 to 2008 Difference		**-46%**
Water	2003	2004	2005	2006	2007	2008
KGAL	565,414	424,894	325,118	194,016	179,010	164,101
		-24.85%	-23.48%	-40.32%	-7.73%	-8.33%
				2003 to 2008 Difference		**-71%**
Sewage	2003	2004	2005	2006	2007	NA
KGAL	325,674	297,423	252,881	135,834	125,310	NA
		-8.67%	-14.98%	-46.29%	-7.75%	N/A
				2003 to 2008 Difference		**-61.52%**
Total Costs						
Electricity	2003	2004	2005	2006	2007	2008
Cost	$4,537,800	$4,696,109	$5,439,638	$5,586,359	$5,904,181	$6,467,472
		3.49%	15.83%	2.70%	5.69%	9.54%
				2003 to 2008 Difference		**43%**
Gas	2003	2004	2005	2006	2007	2008
Cost	$4,398,014	$4,356,859	$4,649,586	$3,664,143	$4,073,174	$3,928,560
		-0.94%	6.72%	-21.19%	11.16%	-3.55%
				2003 to 2008 Difference		**-11%**
Water	2003	2004	2005	2006	2007	2008
Cost	$445,315	$378,332	$298,218	$210,051	$201,438	$200,859
		-15.04%	-21.18%	-29.56%	-4.10%	-0.29%
				2003 to 2008 Difference		**-55%**
Sewage	2003	2004	2005	2006	2007	2008
Cost	$425,347	$463,570	$392,375	$130,867	$131,438	Data Not Available
		8.99%	-15.36%	-66.65%	0.44%	
			2003 to 2007 Difference		**-69.10%**	
Source: Calculated from Offutt Air Force Base Financial Archives, not publicly available.						

2. Relating Offutt's Efforts to the DoD's Progress

With three major caveats, it is clear in many respects that the DoD has made progress towards reducing its facility energy consumption. The first caveat is that the DoD has a category of buildings that are exempted from the energy reduction initiatives. Energy for these buildings is not reflected in any of the figures on these pages. In 2006, this exempt category counted for $250 million of expenses and 12,794.8 billion BTUs of consumption compared to the regular DoD buildings that cost $3.25 billion and 210,558 billion BTUs. In reality, then, these buildings add about 8% in monetary cost and a 6% increase in total BTUs consumed.

The second major caveat is that the DoD upwardly revised its energy consumed in 2003, its baseline year for energy reductions. This makes it easier to make its future reduction goals. The DoD currently claims that in FY07 it reached a 10% reduction in BTUs/1000 GSF relative to the 2003 baseline ("AEMR 2007" OUSDATL p. 22 2007). It also says that it has re-evaluated the 2003 baseline to have been 116,134.4 BTUs/1000 GSF due to the Army over-reporting its occupied GSF figure for 2003. This higher BTUs per 1000 GSF figure has made it a lot easier to show energy reductions over the following years. The author did not feel comfortable using this figure as there was not a detailed explanation, nor was it clear if the figures for the following years were misreported due inaccurate data about occupied GSF. If the Army did over-report the figures for 2003 and the consumption figure really was 116,134 BTUs/1000 GSF for F&03, then in FY04 alone, without any significant explanation, the DoD would have achieved a roughly 7% reduction in consumption (108,367 BTUs/100GSF).

The third major caveat is that the DoD is able to offset its reported total energy consumed with increased use of renewable energy. This ability can skew reality. For example, if the DoD increases its consumption of coal by 5,000 BTUs and its consumption of solar energy by 6,000 BTUs it can then report a 1,000 BTU decrease in energy consumed, even though in reality it increased overall energy consumption by 11,000 BTUs. In 2007, the DoD did consume approximately 108,000 BTUs/1000 GSF but around 3,900 BTUs//1000 GSF came from renewable energy sources which lead the DoD to report their overall energy consumption as 104,600 BTUs/1000 GSF.

The DoD has been able to reduce its consumption of traditional energy and offset it with consumption of renewable energy. Through offsetting renewables, the Department has managed to reduce its reported amount of energy consumed by a small amount over 2004-2007 fiscal years. Table 13 is a five year side by side comparison of reported energy consumed by the DoD. For each year after 2003, there is a percent increase or decrease level from the previous year. For the most part there have been reported year over year reductions.

Table 13: Year over Year Changes in DoD Energy Consumption by Category

		2003	2004		2005	
Energy Type	Units	Totals	Totals	% Up or Down	Totals	% Up or Down
Electricity	MWH	28,158,678.0	28,604,816.2	1.56%	27,953,958.9	-2.33%
Fuel Oil	Thou. Gal.	223,511.6	203,559.9	-9.80%	184,242.8	-10.48%
Natural Gas	Thou. Cubic	76,988,002.3	71,197,996.9	-8.13%	72,615,256.3	1.95%
LPG/Propane	Thou. Gal.	14,756.2	15,939.6	7.42%	19,256.6	17.23%
Coal	S. Ton	586,853.8	614,442.9	4.49%	607,141.3	-1.20%
Purch. Steam	BBtu	9,535.8	8,951.9	-6.52%	9,263.7	3.37%
Other	BBtu	1,226.9	2,035.1	39.71%	3,806.8	46.54%

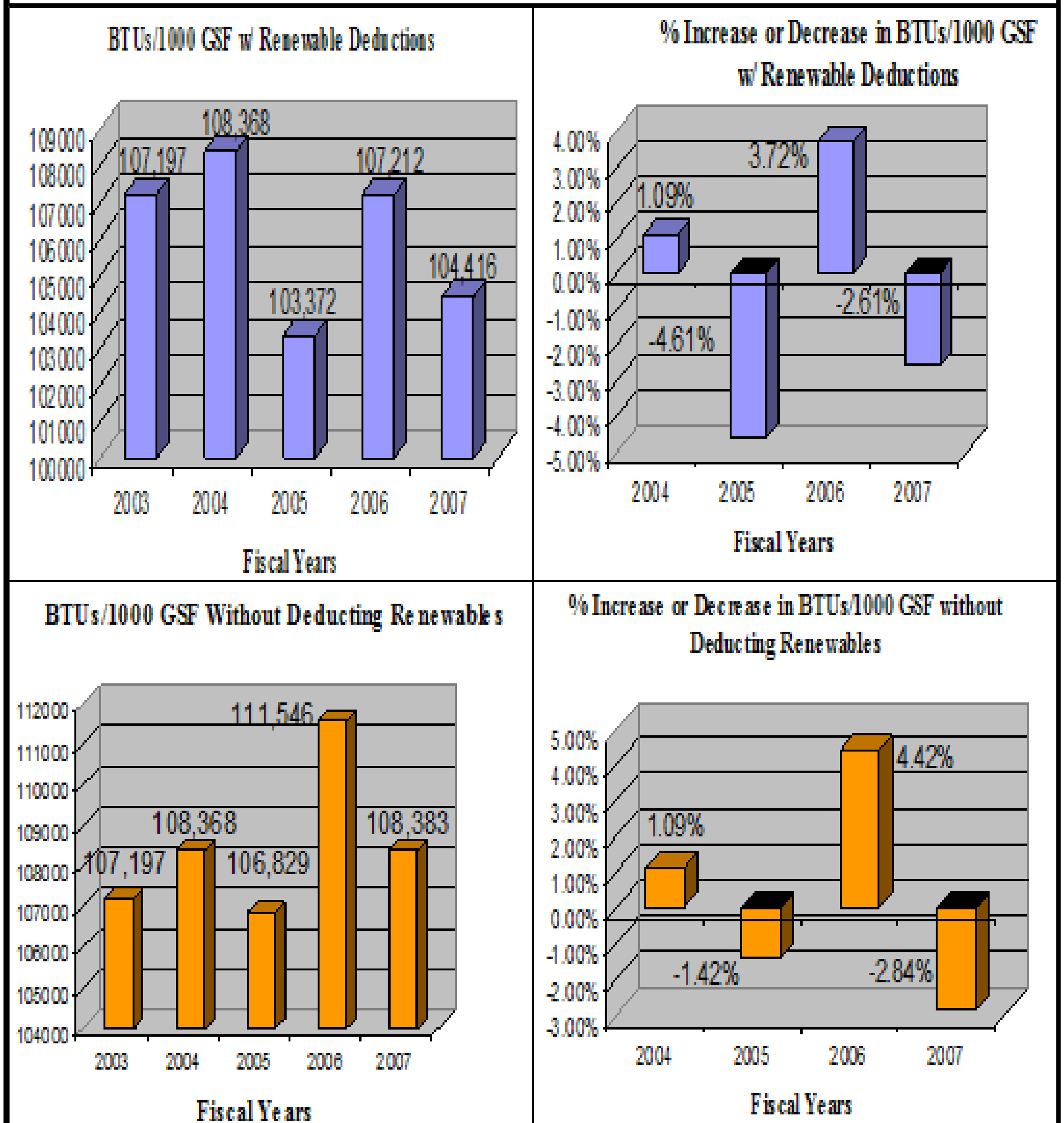
		2006		2007	
Energy Type	Units	Totals	% Up or Down	Totals	% Up or Down
Electricity	MWH	27,199,447.2	-2.77%	26,998,532.6	-0.7%
Fuel Oil	Thou. Gal.	174,870.7	-5.36%	157,936.2	-10.7%
Natural Gas	Thou. Cubic	64,453,026.3	-12.66%	65,109,519.0	1.0%
LPG/Propane	Thou. Gal.	13,528.9	-42.34%	13,929.3	2.9%
Coal	S. Ton	689,343.2	11.92%	620,122.7	-11.2%
Purch. Steam	BBtu	8,197.0	-13.01%	6,895.9	-18.9%
Other	BBtu	615.5	-518.49%	499.1	-23.3%

Source: Compiled using information from the 2003 through 2007 Annual Energy Management Data reports available from the Office of the Under Secretary of Defense for Acquisition Technology and Logistics.

However, a less clear trend emerges without the ability to subtract renewable energy use from the total amount of energy consumed. As mentioned before, some of the reductions reported are not true reductions in energy consumed per se because “[t]he reduction in energy use can be attributed to…use of renewable energy that is not counted in the total energy use subject to energy reduction goals, and the recalculation of the FY 2003 baseline” (OUSDATL “AEMR 2007” p. 22 2007). This means that the DoD subtracts the renewable energy it has started to consume from its overall energy consumption calculation in order to lower the bottom line figure of BTUs consumed per gross square foot.

After adjusting for the fact that renewable energy was not included in the total energy consumed, it appears that DoD facility energy consumption has not dropped markedly. After adjusting for renewable energy, it appears the DoD has maintained its energy consumption around 108,000 BTUs/1000 GSF, with a low of 106,829 BTUs/1000 GSF in 2005 and high of 111,546 BTUs/GSF in 2006. 2003 through 2007 are compared in Figure 24 both with and without renewable energy deductions applied to the energy consumed. The percentage increase/decrease charts below start with data from 2003 and use 107,197 BTU/1000 GSF for the 2003 figure. This figure was calculated from that year’s Energy Management Data Report by averaging BTU/1000 GSF consumption of all standard facilities and energy intensive facilities. The figures for 2004 and 2005 are calculated in the same manner. In the FY2006 reports and onward, the DoD grouped these two categories of buildings together in one category under “EPACT/EO 13423 Goal Subject Buildings”. The bottom line is that the military’s use of renewable energy has increased greatly, but there have not been marked reductions in the overall amount of energy consumed by DoD facilities.

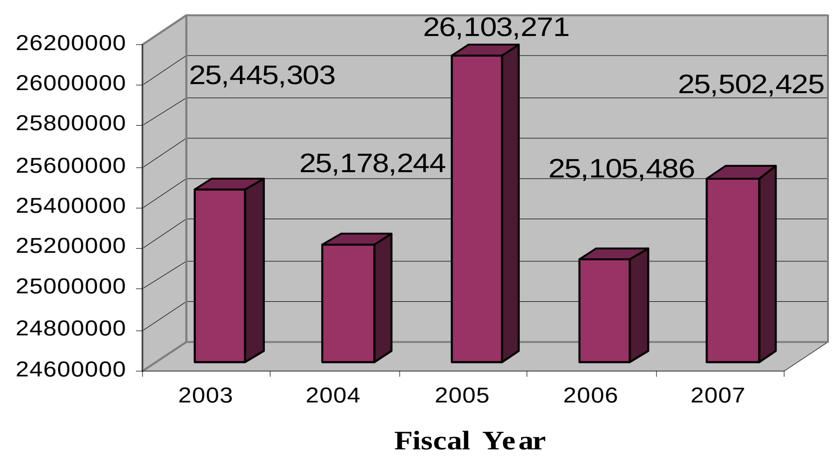
Figure 24: Side by Side Comparison of BTUs Emitted per 1000 GSF with and without Renewable Energy Deductions



Source: Compiled using information from the 2003 through 2007 Annual Energy Management Data reports available from the Office of the Under Secretary of Defense for Acquisition Technology and Logistics.

In terms of pollution emissions, even with increased use of renewable energy, the figures reported by the DoD show, at best, flat progress. By combining metric emissions for standard and energy intensive buildings for 2004 and 2005, using the emissions numbers for goal subject facilities in 2005 and 2006, and converting it all to Metric Ton Carbon Dioxide Equivalents (MTCO2E) to match the 2007 data, one can see below that emissions have held in a steady range. This is because its consumption of traditional energy sources has not declined dramatically; rather the DoD has been subtracting renewable energy consumed from its overall BTUs/1000 GSF figure.

Figure 25: DoD Green House Gas Emissions (MTCO2E)



Source: Compiled using information from the 2003 through 2007 Annual Energy Management Data reports available from the Office of the Under Secretary of Defense for Acquisition Technology and Logistics.

Conclusions about the DoD and Permanent Facility Energy Practices

After all the analysis and second guessing is said and done, the DoD has publicly claimed its 2003 baseline figure is now 116,134.4 BTUs/1000 GSF. The DoD has now officially committed itself to reducing its facility energy consumption by 30 percent by 2015 as required by Executive Order 13423. This means that by the end of fiscal year 2015, the DoD must have its BTUs/1000 GSF figure down to approximately 81,000

BTUs/1000 GSF. It is evident that the DoD is taking strong measures to reduce consumption (or at least offset it) via renewables as shown by the initial summary of DoD efforts and the case study of Offutt Air Force Base. The DoD should be applauded for becoming a large consumer of renewable energy. In this way, it is diversifying its energy sources and keeping its pollution emissions from growing any larger. However, the Department will need to continue increasing its consumption of renewable energy while also striving to actually reduce the amount of energy consumed overall through awareness training, efficiency upgrades, new technology implementation, and building consolidation if it wants to seriously improve its bottom line and meet its mandate. While the DoD is focusing on facility energy consumption, the next section shows that it has been ignoring a much larger target of opportunity -- fuel consumption. This is important because, as mentioned earlier, fuel consumption accounts for 75% of the DoD’s total energy consumption.

Section J: Fuel Consumption Case Study

1. Offutt AFB Fuel Consumption Case Study

This next case study will examine jet fuel consumption for Offutt Air Force Base (AFB) through fiscal years 2004, 2005, and 2006. After fiscal year 2006, the tracking of fuel expenditures was outsourced from Offutt AFB to a regional cost center. The financial analyst being interviewed for the fuel consumption case study said that regional center could not be counted on to provide accurate figures. This is why the figures for FY 2004-2006 are used as a case study – there is complete confidence in their accuracy.

The Operations Group of Offutt Air Force Base has a diverse set of aircraft and missions. It employs 46 aircraft, including 13 models of seven different types of airplanes. The overall mission of the base is to provide intelligence, reconnaissance, and surveillance support to war fighters and national leadership. Through interviews and data mining it was possible to collect information on fuel expenditures and flight hours for the aircraft of Offutt Air Force Base during fiscal years 2004, 2005, and 2006. One of the base aircraft will be profiled in order to give an example of its purpose as well as year and hourly cost to operate the airplane. This will be followed by charts containing detailed analysis of fuel consumption and flight hours flown for three targeted years of this case study.

Figure 26: RC-135U Aircraft

Source: “Offutt Photo Archive.” 2008

RC-135U Combat Sent

The mission of the RC-135U Combat Sent is to provide strategic electronic reconnaissance information to national leaders and theater commanders. This aircraft locates and identifies “foreign military land, naval and airborne radar signals” and then “examines each system, providing strategic analysis for warfighters” (Air Force Link “RC-135 U Combat Sent” 2007). It is an older aircraft that requires a lot of resources to operate. The airframe weighs 165,700 pounds, has a fuel capacity of 130,000 pounds, employs four CFM International F108-CF-201 high bypass turbofan engines, generates 85,000 pounds of thrust, and first entered service in 1964 (Air Force Link “RC-135 U Combat Sent” 2007). In 2004 it flew 87 sorties for a total of 645 flight hours. The cost per hour in fuel to operate the airplane is $3,176.02. The total fuel expenditures on fuel for this airframe during fiscal year 2004 came to $2,048,850. These figures exclude any flying that the aircraft might have done for Operation Enduring Freedom or Operation Iraqi Freedom as this information is not published. In reality, then, the total flight hours for the year and the total cost spent on the aircraft are probably higher than reported. The cost per hour to operate figure remains accurate.

Sample Data Template: 2006 Flying Hours Summary

Using four different reports on flying hours, it was possible to compile a flying hours chart that covers the relevant data for each year. Table 14 below shows the data for 2006. PEC stands for Program Element Code and denominates a certain category of funds depending upon the mission being fulfilled. Breaking down the flight hours for each aircraft type within each PEC it was possible to determine the amount spent on operating each airplane for the year as well as the average cost per hour for each airframe. S stands for sorties or number of missions flown. C stands for category. A 693 expense under the C Column means that it was fuel spent on Aerospace Ground Equipment needed to operate the airplane. A 699 expense is fuel used by the airplane. The vast majority of expenses are fuel use by the aircraft themselves.

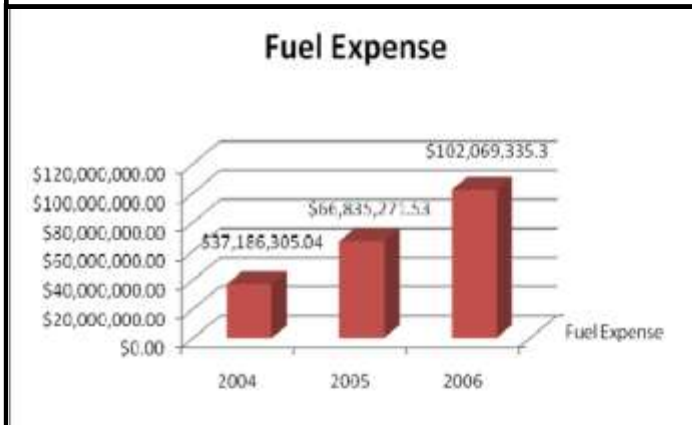
Table 14: FY 2006 Flying Hours Summary										
FY06 Flying Hours Report					Analysis		FY06 Flight Fuel Expense Report			
Aircraft Type	PEC	S	Flight Hours	% of PEC Hours	Cost based on % PEC Hours	Cost per Flight Hr	PEC	C	Budgeted	Actual Cost
RC-135V	35207	69	2623	34.5%	$18,272,522.4	$6,966.00	35207	693	432,943.40	435,534.12
RC-135W	35207	322	2218	29.2%	$15,451,987.8	$6,966.00		699	52,742,724.97	52,906,792.58
RC135U	35207	107	835.5	11.0%	$5,820,095.5	$6,966.00		Total	52,742,724.97	52,906,792.58
TC135W	35207	359	1918	25.3%	$13,362,186.9	$6,966.00	35145	699	3,978,508.22	3,980,904.79
TC135W	31314	117	618.6	36.7%	$2,968,722.4	$4,799.10		Total	3,978,508.22	3,980,904.79
WC135C	31324	76	380.8	92.6%	$1,594,363.4	$4,186.88	32015	693	23,082.17	23,082.11
RC135S	31314	126	1068	63.3%	$5,126,397.1	$4,799.10		699	20,503,372.77	20,308,424.80
TC135S	31334	0	0	0.0%	$0.0	NA		Total	20,526,454.88	20,331,506.91
WC135W	31324	7	30.4	7.4%	$127,281.1	$4,186.88	31324	699	1,721,644.56	1,721,644.56
OC135B	35145	215	1007	100.0%	$3,980,904.8	$3,953.23		Total	1,721,644.56	1,721,644.56
E4B	32015	415	1755	100.0%	$20,331,506.9	$11,584.90	31314	699	8,095,119.46	8095119.46
								Total	8,095,119.46	8,095,119.46
Total PEC Hrs							27253	693	8,714.00	8,714.00
35207	7595							699	14,984,127.50	15,024,653.04
31314	1687							Total	14,992,841.50	15,033,367.04
31324	411.2							Total	102,057,293.59	102,069,335.34
35145	1007									
32015	1755									
27253	2988									
Total	15443									

Source: Calculated from Offutt Air Force Base Financial Archives, not publicly available.

Trend Analysis

Examining fiscal years 2004-2006, it quickly becomes apparent that Offutt's expenditures on jet fuel rose dramatically. While the number of hours flown by aircraft rose 6% in 2005 and less than 1% in 2006 the increase in money spent on fuel for those years 79.73% in 2005 and 52.72% in 2006. This is indicative of a DoD-wide trend.

Figure 27: Offutt's Fuel Expense ('04-'06)



Source: Calculated from Offutt Air Force Base Financial Archives, not publicly available.

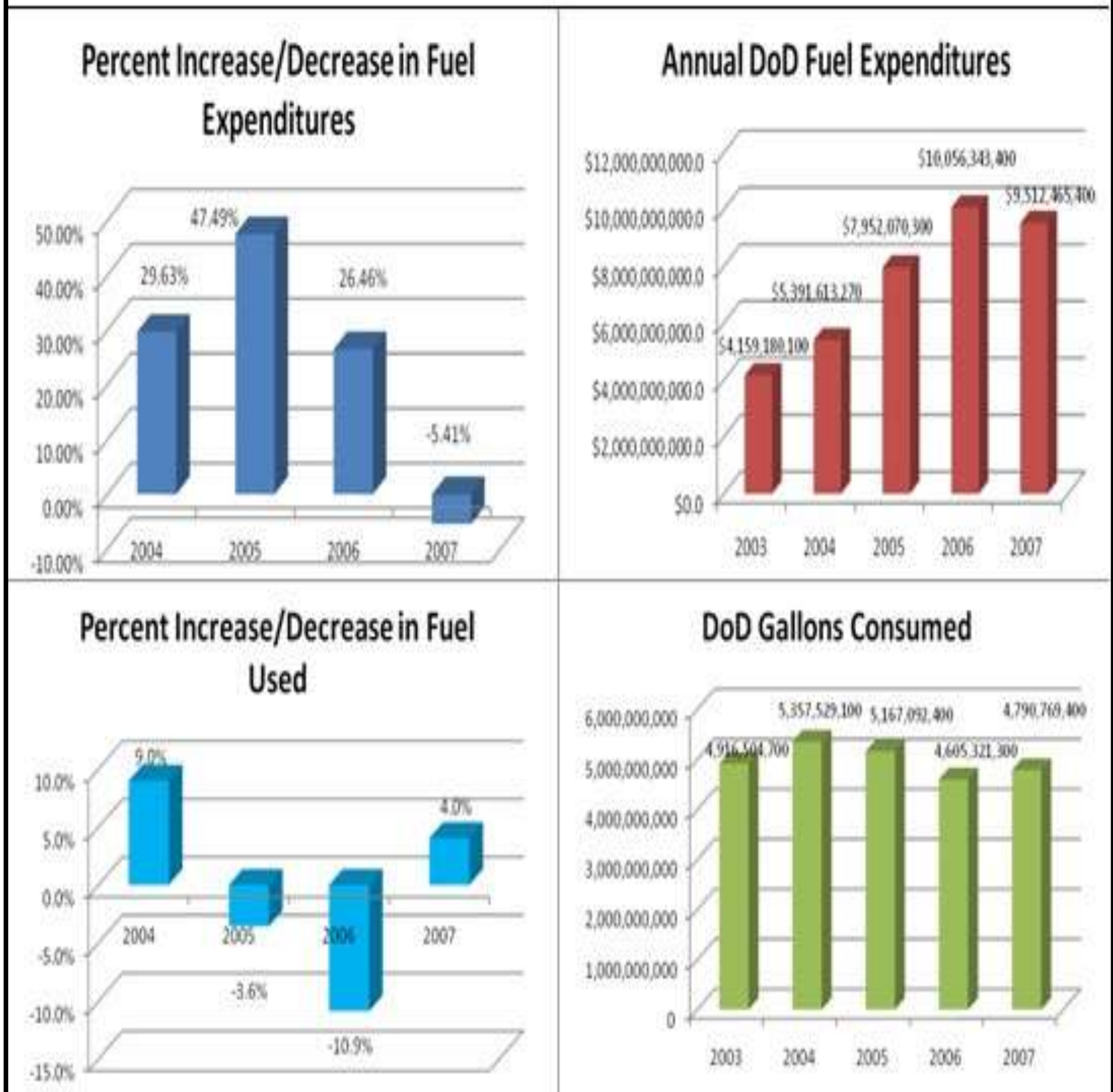
2. Relating Offutt's Fuel Consumption to DoD Wide Fuel Consumption Analysis

In fact, total DoD spending on aviation and ground fuel has risen considerably over the same years that the DoD has been reducing/offsetting facility energy consumption. The number of gallons of all types of fuel consumed by the DoD has fluctuated between 4.9 and 5.3 million between FYs 2003-2007. Although around half the fuel purchased every year is aviation fuel (JP-8 and JP-5), this does not mean that the other categories such as ground and marine fuels are monetarily insignificant. In FY 2007, almost $2 billion alone was spent on regular diesel fuel (Andrews p. 2 2009) and "[a]t peak, in FY1997, JP-8 represented 56% of DOD-related fuel purchases. By FY2007, when DoD fuel costs showed a dramatic increase, JP-8 purchases actually declined to 50% of total petroleum product purchases" (Andrews p. 3 2009).

3. Conclusions about the DoD and Fuel Consumption

Over time, the amount of money the DoD spends on fuel has been rising dramatically. It is of note, as shown in Figure 28, that even in 2005 and 2006 when the DoD was able to reduce its fuel usage by 3.6 and 10.9 percent, the amount spent on fuel rose by 47.49 and 26.45 percent respectively. In 2007, even though fuel usage increased 4.0 percent, total costs decreased by 5.41 percent as the price paid for jet fuel had declined from $2.38 to $2.00 per gallon. Nonetheless, these costs are significant and have trended higher over time. Even after adjusting for inflation, the DoD's fuel costs increased 373% from FY 1997 – 2007 (Andrews p. 3 2009). In fact, "[t]he average cost of all petroleum products purchased (in dollars per barrel) rose nearly 300% between 1997 and 2007" (Andrews p. 3 2009). With only a cursory glance, the relationship between defense operations and fuel usage deserves further study by the DoD. The results of the fuel consumption case study and overall DoD fuel consumption analysis validate the results of the earlier sections of this paper: the DoD's fuel consumption practices are a true financial, operational, and strategic problem. The next section will build on this by analyzing the DoD's vision for the future compared to its current fuel consumption practices.

Figure 28: DoD Fuel Consumption and Expenditures Summaries for 2003-2007



Source: Compiled using information from the 2003 through 2007 Annual Energy Management Data reports available from the Office of the Under Secretary of Defense for Acquisition Technology and Logistics.

Section K: The DoD's Vision for the 21st Century and the Military Stakes

Section K examines: (1) the mismatch between the DoD's future goals and current policies, (2) implications and suggested actions, and (3) the argument that failing to change could have dire consequences. Previously, this paper examined the immediate effects of reliance on extensive fuel consumption: reduced effectiveness of the warfighting forces in operational contexts, a weakened strategic position for the country, and dangerous budget swings and monetary misallocation. It is also important to examine how the DoD's current posture on fuel and energy matches with its vision of the future.

1. A Mismatch Between Future Goals and Current Policies

In February 2005, the DoD released a blueprint document regarding how it will face the challenges of the future entitled Facing the Future: Meeting the Threats and Challenges of the 21st Century. The document stated that "[w]ithin the Department of Defense, an unprecedented process of study and review was initiated to determine how our Armed Forces might best be arranged to meet the threats of the 21st century" (Office of the Assistant Secretary for Public Affairs OASPA p. 14 2005). The report highlighted four important areas of focus: (1) A New Force-Sizing Construct, (2) A New Way of Balancing Risk, (3) A New Approach to Force Planning, and (4) Six Transformational Goals.

Facing the Future: Meeting the Threats and Challenges of the 21st Century Summary:

(1) New Force-Sizing Construct :

- "the Department decided to move away from the two Major Theater War (MTW) force-planning construct which called for maintaining forces capable of marching on and occupying the capitals of two regional adversaries, nearly simultaneously, and changing their regimes. The new approach emphasized deterrence in four critical theaters, backed by the ability to swiftly defeat two aggressors in the same timeframe, while preserving the option for one major operation to occupy an aggressor's capital and replace the regime. It also called for the ability to execute several lesser contingencies. With this adjustment, U.S. defense planners gain increased flexibility in planning for a wider array of contingencies, and greater flexibility in investing for the future" (14).

(2) New Way of Balancing Risk:

- "Senior military and civilian leaders agreed that a new framework for assessing risk was needed – one that addressed not just near-term warfighting risks, but other types of risk as well. Four specific categories of risk were identified: Force management risks, which pertain to the ways in which we sustain our personnel, equipment and infrastructure; operational risks, which concern the ability of U.S. forces to accomplish the missions called for in near-term military plans; future challenges risks, which address the investments and changes needed today to permit us to meet the military challenges of the mid- to more-distant future; and institutional risk, which involves inefficient processes and excessive support requirements that hinder the ability to use resources efficiently" (15).

(3) <u>New Approach to Force Planning:</u>

- "to contend with a world of surprise and uncertainty, the Department shifted its planning from the 'threat-based' model that guided DoD thinking in the past to a 'capabilities-based' model for the future. Under the threat-based model, planners would look at a threat posed, for example, by North Korea or Iraq or the former Soviet Union, and fashion a force to fit it. Under a capabilities-based model, planners would examine the capabilities that exist to threaten the United States, such as chemical, biological, nuclear, or cyber space capabilities, and fashion a response to contend with those capabilities regardless of where they might originate" (15).

(4) <u>Six Transformational Goals:</u>

- "to support a capabilities-based approach to force planning, the Department worked to focus transformation efforts by defining goals. Historically, successful cases of transformation have occurred in the face of compelling strategic and operational challenges" (16).

- The six transformational goals identified in the QDR were:
    - i. "To defend the U.S. homeland and other bases of operations, and defeat nuclear, biological and chemical weapons and their means of delivery;
    - ii. To deny enemies sanctuary;
    - iii. To project and sustain forces in distant theaters in the face of access denial threats;

iv. To conduct effective operations in space;
v. To conduct effective information operations; and
vi. To leverage information technology to give our joint forces a common operational picture" (16).

In summary, these goals help define a future vision for the DoD which rests upon (a) enhanced mobility and flexibility, (b) increased emphasis on the ability to manage and sustain forces/equipment/supply lines, (c) limiting inefficient and excessive processes, and (d) identifying critical areas of investment to protect future dominance. As shown by previous sections of this paper, the DoD's current operations regarding fuel consumption are not tenable with the DoD's vision for the future. This is because the future vision rests upon goals of enhanced mobility, flexibility, sustainable supply lines, and reduced inefficiencies. Current fuel operations and policies are the exact antithesis of what the DoD wants to because they (a) reduce mobility and flexibility, (b) make it extremely hard to manage and sustain forces, (c) cause excessive inefficiencies and expenditures, and (d) are not identified as a critical investment area. In an effort to further define this mismatch of reality and future goals, the next section focuses on the implications and suggested courses of actions that the DoD could take in an effort to mold its practices to conform to its vision for the future.

2. Implications and Suggested Courses of Action

In order to juxtapose the mismatch and determine suggested actions, a Strength, Weakness, Opportunity, Threat (SWOT) Implication Matrix was created. It pits all four categories against each other and shows the implications that emerge when each quadrant is matched against the other. For example, quadrant one lists ideas that emerge when the DoD's internal strengths are juxtaposed against external opportunities in the world. In turn, each of the four quadrants is populated by juxtaposing one category of internal factors (strengths/weaknesses) against one category of external factors (opportunities/threats). The matrix shows that at the heart of its vision for the 21st century, a revolution in fuel and energy technology is needed. The Pentagon will have to realize this and adjust its actions accordingly if it wishes to have the flexible and efficient force that it desires.

Table 15: DoD Fuel Usage and Consumption: A Strength, Weakness, Opportunity, Threat (SWOT) Implication Matrix

		Internal Factors	
		Strengths	**Weaknesses**
		1. Extensive monetary resources	1. Operations depend on steady and cheap consumption of fuel all over the world
		2. Diverse human capital	2. 75% of energy budget goes toward fuel purchases
		3. Advanced research and technology institutions and ability to execute scientific research without near term concerns of financial profit	3. Materially intense operations require robust and lengthy supply chains 4. Force management risks (maintaining equipment and infrastructure)
		4. Some success with permanent facility based energy reduction, with a mandate for future reductions that will force further innovation.	5. Insitutional risk: inefficient processes and excessive support requirements that hinder the ability to use resources efficiently 6. Aging aircraft fleet: average age of airframe is 25 years compared to 8.7 years in 1967 (Brook)
External Factors	**Opportunities**	**Quadrant (1): SO Implications**	**Quadrant (2): WO Implications**
	(1) Establish a capabilities based model for the future of DoD operations	(1)-1.,2.,3. Focus defense research agencies on fuel/energy technology needed to reduce supply chain and fuel requirements: expand capabilities to succesfully operate in multiple theatres	(1)-1.,2.,3. Work toward ability to conduct operations that are not completely reliant on abundant and consistent fuel supply
	(2) Future Challenge risk: Necessary investments and changes needed today to meet challenges of mid to distant future	(2)-1. Make research into relevant technologies a funding priority (fuel cells, hybrids, solar/microwave power, gliders, drones, efficient aircraft engines) (2)-3. Create pipeline of members to receive advanced scientific degrees and join special research projects in partnership with defense contractors and industry	(2)-4.,5.,6. Energy and fuel research must become a priority, akin to weapons research, in order to maintain dominance in future operations
	(3) Opportunity to lead revolution in military technology	(3)-3. Partner with allies in an effort to benchmark current energy/fuel technology and fund their long term development	(3)-1. thru 6. Revolutionizing military fuel technology will be a pre-requisite for military dominance given the DoD's transformational goals for the 21st century
	(4) Chance to leverage knowledge of conflict to protect against fuel prices	(4)-1. When possible, use knowledge of imminent conflict to hedge against fuel prices in financial markets and protect the DoD fuel budget	(4)-2. Financially hedge against fuel prices to protect expenditures, especially when new conflict is imminent
	Threats	**Quadrant (3): ST Implicates**	**Quadrant (4): WT Implications**
	(1) Operational Risk: Supply chains in dangerous and unstable areas such as Pakistan (2) Operational Risk: Need to execute several contingency operations in varied locations	(1)-1.,2.,3., (2)-1.,2.,3. Focus defense research agencies on fuel/energy technology needed to reduce supply chain and fuel requirements in order to expand capabilities to successfully operate in multiple theatres (1)-4., (2)-4. Leverage any applicable energy technology applications from permanent facility energy reductions into portable applications for deployed and forward operating bases.	(1)-1. thru 6., (2)-1. thru 6. The U.S. military is exposed to a great amount of operational risk and needs to develop technologies and efficiencies to address these areas as show in the other 3 quadrants of the implication matrix
	(3) Uncertain geo-political future, shifting allies	(3)-3. Focus on development of technologies that make us less reliant on unstable regions	(3)-1. thru 6., (4)-1. thru 6. The U.S. military is: A) still dependent on cheap and available fuel in all areas of operations, especially unstable ones, B) is at the mercy of resource rich adversaries which might want to manipulate the energy markets, and C) lacks the ability to provide key allies energy efficiency technology to help free them from the influence of regional powers who provide them traditional energy such as gas, oil, and coal
	(4) Adversaries ability to manipulate energy and prices	(4)-3. Develop energy efficiency technologies and offer them to key allies to free them from regional influences where applicable	

Overall, the implications that emerge on the SWOT implication matrix form three general areas of consideration/courses of action. The first would be action items to consider immediately, including financially hedging against fuel prices before a major operation starts, and also making it a priority to hurry the widespread adoption of technologies that reduce deployed fuel consumption, such as those being tested at Fort Irwin and mentioned in Section E. The second area of consideration would be action items to consider over the medium term. These action items consist of re-adjusting budgeting priorities and research goals. If the DoD is serious about fulfilling its 21st century version, it must make the design of new energy and fuel efficiency technologies a priority as important as new weapons systems. It may be one of the few organizations in the world that has the resources, scientific knowledge, and industrial partnerships to maintain long term fuel efficiency research projects that might eventually produce truly revolutionary results. This requires the DoD to recognize the importance of this opportunity and to pursue it relentlessly as a top level goal, rather than haphazardly and coincidentally.

The third area of consideration is not as defined, but it could be seen as the ability to maintain a focus on the strategic and operational opportunities of becoming a truly fuel-efficient organization. Pursuing and developing fuel technology could put the DoD in position of national and international power. New and effective solutions would have huge impacts both inside the country and abroad. As mentioned earlier, America's excessive oil importation threatens the building blocks of national power as it contributes to financial decay. If the DoD were to produce technology that could significantly alter this dependency, it would make a huge impact on the stability and well being of the country. Looking abroad for another example, the ability to provide European or Baltic allies new and proprietary fuel efficiency technology could free them from Russia's or Iran's sphere of influence and alter the balance of power in the region. This is because those regions rely upon Russian and Iran for energy and oil. This is not to say that these tasks could be accomplished easily. The above possibilities do however demonstrate the potential lucrative opportunities that could arise from the DoD altering its research priorities to become a world class leader in fuel efficiency technology.

3. Consequences of Not Changing

The above arguments and recommended courses of action may sound far-fetched to some, but it is important to realize that the world is changing, and that in the past, nations that were unable to recognize a changing world, quickly lost their positions of power. The French were rapidly and decisively defeated by the Germans in World War II as the French defensive strategy was outdated and did not reflect new technologies. The Maginot Line, the pinnacle of defensive capability based upon experiences in World War I, was quickly defeated by the Germans through new tactics and technologies.

The world of technology is changing rapidly. Right now, "inside a hangar at a Swiss airfield is the prototype of an aircraft that does not use any fuel at all. The wings of this aircraft are almost as big as those of an airliner, but they are covered in a film of solar cells that convert sunlight into electricity to drive its engines" ("Flying for ever" 2009). This is noteworthy because on long flights, "fuel can account for 40% of a plane's take-off weight, so that around 20% of the fuel is used to carry the rest of the fuel" ("Flying for ever" 2009). Innovative possibilities, previously considered to be fictional, are becoming more likely all the time. Even some of the difficulties of using hydrogen to power fuel cells or vehicles are being overcome. Hydrogen is difficult to store due to the fact it is the lightest element. Without compressing the gas, a typical gas tank filled with hydrogen will only take a car a kilometer or so (“Plumage Power” 2009). However, compressing the hydrogen can be dangerous and uses up energy that could be used to otherwise power the vehicle (“Plumage Power” 2009). There is another way to store hydrogen, though. There has been some progress with materials like carbon nanotubes that can be put inside the gas tank, increasing the total internal surface area to which the gas molecules can cling, allowing more hydrogen to be packed into a smaller area” (“Plumage Power” 2009). Unfortunately, it is currently estimated that it would cost $5.5 million to fit a car gas tank with carbon nanotubes (“Plummage Power” 2009). However, due to the properties of keratin found in chicken feathers, researchers now think they can use them in place of carbon nanotubes, at a cost of only $200 to outfit a car to run on hydrogen and have a 300 mile range (“Plumage Power” 2009). This is a 99.9 percent decrease in the cost of outfitting a hydrogen powered vehicle, using chicken feathers nonetheless. Whether or not the military is paying attention, the assumptions around the implementation of fuel technology are changing every day.

The winner in the future might not be the competitor who accomplishes the mission the fastest, but the competitor who can maintain the mission for long periods of time at virtually no cost. It should be noted that while the American forces often win individual battles in Iraq and Afghanistan, the wars could be said to have dealt a terrible blow to the country economically. The Congressional Budget Office estimates that the wars have already cost nearly $1 trillion in spending by the government and could easily cost an additional trillion over the next decade (Belasco 2009). This is extremely relevant as “[a] careful study of Osama bin Laden's videos, letters and Internet statements makes clear that Al Qaeda's goal is more than to terrorize Americans or to drive us out of the

Middle East. Bin Laden believes that Al Qaeda can bring about the economic collapse of the United States" (Thiessen 2009). The great expense of American military operations is being used against the country itself. The idea of economically bleeding an adversary who is overpowering in the traditional sense is not a new one. In *The Evolution of a Revolt,* T.E. Lawrence (Lawrence of Arabia) (1920) wrote about the Arabs protracted war against the Turkish army and said:

> [o]ur aim was to seek its weakest link, and bear only on that till time made the mass of it fall. Our largest available resources were the tribesmen, men quite unused to formal warfare, whose assets were movement, endurance, individual intelligence, knowledge of the country, courage. We must impose the longest possible passive defence on the Turks (this being the most materially passive form of war) by extending our own front to its maximum. Tactically we must develop a highly mobile, highly equipped type of army, of the smallest size, and use it successively at distributed points of the Turkish line, to make the Turks reinforce their occupying posts beyond the economic minimum of twenty men. The power of this striking force of ours would not be reckoned merely by its strength. The ratio between number and area determined the character of the war, and by having five times the mobility of the Turks we could be on terms with them with one-fifth their number.

In this manner, the Arabs tribesmen were able to impose a costly war upon the Turkish army. By keeping the Arab tribesmen mobile and on the move, it forced the Turks to tie up their soldiers in city garrisons to protect them. The Arabs then were free to carry out attacks against the Turks' weakest point: the Hejaz railroad which brought them their supplies. In this manner, a smaller and more efficient force was able to tie up and threaten a better-equipped force due to the vulnerability of their supply chain. This should not sound unfamiliar to the ears of the American military today.

Beyond a tactical disadvantage from burdensome supply requirements, history is replete with tragic examples of crushing military defeat caused by the inability of societies or militaries to foster the relevant technology innovations needed for superiority. Technology, through its intrinsic changes, can often change the calculations for warfare itself. In *A Distant Mirror,* the historian Barbara Tuchman analyzes the 14th century in Europe, a time of tumultuous change. During the mid part of the century, Edward III of England and Philip VI of France were engaged in a struggle for dominance in the region. Tuchman (1978) notes that "[p]reparing for a challenge to France, Edward had to make up for the disparity in numbers by some superiority in weaponry or tactics. In 1337 he had prohibited on pain of death all sport except archery and canceled the debts of all workmen who manufactured the bows of yew and their arrows" (70). This societal shift in resources and attention resulted in the development of the longbow. A weapon [w]ith a range reaching 300 yards and a rapidity, in skilled hands, of ten to twelve arrows a minute in comparison to the crossbow's two, the longbow represented a revolutionary delivery of military force" (Tuchman p. 70 1978). This single innovation tilted the balance of military power to the English even though France had superior numbers and resources. In 1340, "the French had assembled 200 ships from as far away as Genoa and the Levant for a projected invasion of England. The outcome of the battle was an English victory that destroyed the French fleet and for a time being gave England command of the Channel" (Tuchman p. 70 1978). Tuchman goes on to say one specific technological innovation, the longbow, won the day for the English. The battle "was won by the virtue of a military innovation that was to become the nemesis of France" (Tuchman p. 70 1978). In this era it was not naval power but the strength of soldiers and archers on board the ships which determined sea battles and this case the English longbowmen dominated and destroyed the French fleet (Tuchman p. 71 1978). Tuchman (1978) reports that:

> [n]o one dared tell the outcome of the battle to Philip VI until his jester was thrust forward and said, 'Oh, the cowardly English, the cowardly English!' and on being asked why, replied, 'They did not jump overboard like our brave Frenchmen.' The King evidently got the point. The fish drank so much French blood, it was said afterward, that if God had given them the power of speech they would have spoken in French (71).

The ability of societies and militaries to sacrifice resources in the short term to develop innovative technologies can serve to increase long term dominance, especially in times of great change. If the DoD truly wants to fulfill its vision for the 21st century, it cannot just have a vague realization that the world is changing around it, it must step up and lead the changes, especially in terms of fuel efficiency.

Conclusion

The Department of Defense is the largest single consumer of energy within United States. It consumes 80% of the energy used by the federal government (DSB “More Fight Less Fuel” p. 11 2008). In 2006, it consumed .8% of all energy consumed in the United States and produced 85.4 billion pounds of carbon emissions (OUSDATL “Fiscal Year 2006 Energy Management Data Report” 2006). The DoD must reduce its facility energy consumption 30 percent by 2015 as required by Executive Order 13423. It is evident that the DoD is taking strong measures to reduce consumption, or at least offset it, via renewables its as shown by the initial summary of DoD efforts and the case study of Offutt Air Force Base. However, of all the energy consumed by the DoD, approximately 75% of it is fuel for airplanes, vehicles, and ships. The Pentagon has developed a true Achilles’ heel regarding vehicle fuel consumption and fuel consumption to power forward bases such as those in Afghanistan. These current fuel consumption practices are a true problem and it is here that DoD energy and innovation policy needs to be focused.

There are eight overall reasons the Department of Defense must completely revamp its relationship with fuel consumption. Firstly, America’s oil importation practices threaten to destroy the building blocks of national power and undermine the country’s financial well-being. The second and perhaps most ignored reason is that when the DoD needs fuel the most, it is likely to cost it the most, as shown by the regression analysis of oil prices and conflict. The third reason is that the DoD has no good recourse when fuel prices surge, and not even the Strategic Petroleum Reserve (SPR) will help in a true crisis situation. Fourthly, the DoD’s current relationship with fuel causes unwieldy supply chains that greatly increase operational risk. Fifthly, these increased operational risks coming from long supply chains often weaken America's strategic position. Sixthly, given all these other legitimate reasons, the DoD can now seize upon an opportunity to lead a green revolution that could be one of the most successful military public relations campaigns in U.S. history. The seventh reason is that the DoD's own vision for the 21st century demands a complete overhaul of its relationship with fuel consumption, even if this is not explicitly recognized. Lastly, the DoD's methods and processes are becoming obsolete relative to new and innovative fuel technologies. For all of the above reasons, it is imperative that the DoD re-examine its posture toward fuel consumption, both for vehicles and for powering deployed bases.

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