Energy Security
America’s Best Defense

A study of increasing dependence on fossil fuels in wartime, and its contribution to ever higher casualty rates
Deloitte conducted a study of energy use in wartime from World War II (WW II) through the current Middle East wars, and found that there has been a 175% increase in gallons of fuel consumed per U.S. soldier per day since the Vietnam conflict. In today’s conflicts, fuel consumption is 22 gallons used, per soldier, per day, for an average annual increase of 2.6% in the last 40 years, with an expected 1.5% annual growth rate through 2017. This has been driven by several factors: the increasing mechanization of technologies used in wartime, the expeditionary nature of conflict requiring mobility over long distances, and the rugged terrain and the irregular warfare nature of operations.

This increase has occurred despite the significant increase in fuel efficiency in internal combustion and jet engines used with armored vehicles, tanks, ships and jet aircraft, and the use of nuclear-powered aircraft carriers and submarines. However, these significant improvements in efficiency are vastly overshadowed by the higher number of vehicles and increasing rate of use. Furthermore, the increasing number of convoys required to transport an ever increasing requirement for fossil fuels is itself a root cause of casualties, both wounded and killed in action. The use of IEDs and roadside bombs has been an especially effective means to disable friendly fighting forces by disrupting their supply of energy. The Deloitte study found that absent game-changing shifts, the current Afghan conflict may result in a 124% (17.5% annually) increase in U.S. casualties through 2014, should the war be prosecuted with a similar profile to Operation Iraqi Freedom (OIF).

Game-changing strategies for reducing this casualty rate rests on several means for reducing fossil fuel dependence, thus reducing the need for fuel convoys. These include widespread and aggressive conservation techniques; the use of renewable resources, in particular, solar and wind energy within the theater; renewable carbon-based fuels generated in theater, such as algae, biomass, and other alternative fuels; the use of highly efficient electric vehicles; nuclear fission; hot/cold fusion; fuel cell technology, and other innovations currently being experimented within labs around the world.

The business case for alternative energy development has rested first on the concept of a more sustainable planet, resulting in reductions in hydrocarbons and other harmful emissions in the creation and use of fossil fuels. With the dramatic rise in the price of oil seen in 2008, and increased recognition that the oil supply may be limited, the business case has shifted emphasis to the economic benefit for developing and using renewable energy sources.

Beyond sustainability and economics, this study demonstrates that the development and use of alternative energy can be a direct cause for reductions in wartime casualties, and may rank on par with the business cases for development of ever more effective offensive weapons, sophisticated fuel transport tankers, mine resistant armored vehicles, and net centric sensing technologies. Aerospace and Defense firms, their government customers, and research labs around the world are well positioned to accelerate the development and deployment of such technologies.
The use of stored energy in warfare can be traced back to the use of bow and arrow, catapults, and crossbows in the Middle Ages, where kinetic energy in the spring action of the launcher was used to hurl weapons to create damage. “Resupply” required cranking of the spring or drawing back of the bow, after each use — a primitive form of stored energy. With the invention, then application of gunpowder-based weapons, guns, cannons, and bombs became the common technology of warfare. “Energy” was produced upon immediate need by igniting the stored energy — gunpowder — with a fuse or a lighter. Travel was still on horse or by foot for advancing armies, or by sail power for navies.

With the invention of the steam and the internal combustion engine, warfare became significantly more efficient because armies and navies could travel great distances and use engine powered warships, armored personnel carriers, tanks, and fighter aircraft. With the discovery of oil and its application as a fuel, the mechanization of armed forces increased dramatically, especially between World War I and World War II, to power the engines of the tanks, transports, and other drivable vehicles, as well as ships that could travel great distances carrying the expeditionary armies and navies to carry out missions.

During the modern age of warfare, the use of fossil fuels to power these vehicles has increased exponentially and dependence has itself created casualty risk. With the advent of jet-powered aircraft, another leap in fossil fuel energy use took place, especially from the Korean War through today. This increasing use of fossil fuels to power the implements of warfare technologies has created the need for sophisticated logistics and supply lines in the form of aerial refueling tankers, fuel tanker trucks, and other fuel supply mechanisms.

This Deloitte study has found that there has been a steady increase in the dependence on fossil fuels since World War II. The following chart shows the progression from the early 1940’s through the current Middle East wars, and the increasing numbers of gallons required per U.S. soldier per day. The study found that there is a high correlation between the gallons of fuel consumed per U.S. soldier per day from World War II, to the Korean conflict, to Vietnam, the Gulf War, to Operation Enduring Freedom (OEF), and OIF.

It is estimated that as of 2007, the average gallons of consumption in OIF/OEF per U.S. soldier per day was 22 gallons. Using a least squares regression forecasting methodology, it is predicted that there will be a 15.6% increase in gallons consumed per U.S. soldier per day by 2017, for a 1.5% compounded annual growth rate (CAGR) increase.

With the level of consumption rising dramatically over time, there is concern about the dependence on oil derived from foreign sources as well as the economics of acquisition. Later in this study, we will link this increasing use and dependence on oil, to the increasing vulnerability and risk to human lives.
Today, U.S. economic power and national security are more reliant than ever on imported oil. As that dependency grows, the fundamental stability of the global oil market is being stressed by inadequate investment in expanded oil production capacity, persistent geopolitical instability, and rapidly growing demand in emerging market economies.

Oil is the world’s single most important energy source, alone providing 35% of primary energy consumption.\(^1\) In 2008, global oil demand averaged about 85 million barrels per day (mb/d). The International Energy Agency (IEA) predicts that those numbers will rise to 94.4 mb/d by 2015 and 106.4 mb/d by 2030. Moreover, 100% of that growth is forecast to occur in emerging market economies.\(^2\) The following chart illustrates global demand for oil exceeding 100 mb/d by 2030.

“The relationship between America’s national security and its dependence on foreign oil has been clear since President Franklin Roosevelt hosted Saudi King Abdul Aziz ibn Saud aboard the U.S.S. Quincy in the Suez in 1945.”


\(^1\)BP plc, Statistical Review of World Energy 2009, Primary energy consumption by fuel, available at www.bp.com

It is increasingly difficult technically and financially to locate and extract oil out of new sites. Proven reserves are now being depleted at three times the rate of new discoveries. Since 2000, the cost of finding and developing new oil sources has risen at an annual rate of 15%.

With rapid economic growth and industrialization in developing nations predicted to continue, and global oil production capacity struggling to increase, the global oil market is expected to operate with little room for error. Between 2003 and 2008, effective spare production capacity within the Organization of Petroleum Exporting Countries (OPEC) averaged just 1.5 mb/d. This razor thin margin helped to create the environment for substantial oil price volatility, culminating in $150 oil in July of 2008.

The 2008-2009 global economic recession and subsequent OPEC lower than capacity production, i.e., shut-ins, have temporarily increased spare capacity, which currently rests at more than 4.3 mb/d. That amount equates to more than 5% of daily demand, a healthy buffer. At the same time, falling demand in industrialized countries has outpaced changes in crude oil deliveries, and industry stocks have swelled. U.S. crude oil stocks now sit at 343 million barrels, almost 15% higher than August 2008 levels.

This respite, however, represents only a brief pause and potentially a serious situation. The return of pre-crisis economic growth rates in China, India, the Middle East, and Latin America are expected to be accompanied by renewed oil demand growth. At the same time, the impact of the financial crisis on supply-side investment remains a concern. Industry observers note that decline rates at existing fields tend to accelerate in the absence of consistent maintenance and technological innovation. To the extent that such capital intensive efforts have been postponed over the past 12 months, supply-side challenges may increase faster than expected postcrisis.

In the face of rapidly escalating demand and a sluggish increase in global production capacity, OPEC spare capacity will quickly dwindle, industry stocks are likely to fall back toward normal levels, and the return of tight oil markets could once again create an environment for price volatility. Experts disagree about the timing for this cycle. Goldman Sachs recently predicted the per barrel price of oil to remain at $60+ a barrel mark through 2010. Other analysts expect a more expeditious return to high prices. Regardless of timing, the basic oil market fundamentals provide cause for concern over the mid-term. In its June 2009 Medium Term Market Report, the IEA discussed two global Gross Domestic Product (GDP) scenarios and their impact on spare capacity. In its higher GDP scenario—in which global growth averages 1.8% in 2010 and above 4% through 2014—spare capacity falls below 4% of world demand by 2014. The analysis assumed OPEC production capacity would expand by 1.2 mb/d over the same timeframe.
In 2008, U.S. oil consumption averaged 19.5 mb/d, almost one quarter of the world’s total oil consumption. Of that total, roughly 69% was used for transportation. Driving this high level of consumption is the fact that almost no substitutes are available: the cars and trucks that power the U.S. economy use petroleum for as much as 95% of their fuel needs.

After the energy crises of the early 1970s, the Carter administration came to power and promised to invest in researching alternative fuels and wean America from its addiction to fossil fuels. Three decades later, despite efforts by the U.S. government, industry, and academia, America’s oil addiction has only grown. Despite gains made in the 70s and early 80s, the plentiful availability of inexpensive fuel between 1986 and 2004 mitigated the imperative for research into new alternatives and efficiencies. However, during the past 30 years, Americans have increased their fuel consumption by a third and imports have doubled.

The following chart depicts oil consumption in the U.S., and illustrates the significant growth from 1985 through today. It also shows the impact of oil price spikes and shortages.

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5BP plc, Statistical Review of World Energy 2009
6U.S. Department of Energy, Energy Information Administration, Annual Energy Outlook 2009, Table A7; author calculations
Today, net imports provide 57% of U.S. daily petroleum demand. Most other major economic powers also depend on imported oil to meet their energy needs. China imports 44% of its oil (a number that is likely to increase as its demand rises along with its economic power). Imports for Germany are at 93%, and Japan, South Korea, and France import virtually all of their oil. Among the major consumers of oil in the world, only Russia, Canada, and Brazil are self-sufficient.

Saudi Arabia and other OPEC countries control more than two thirds of known conventional world oil reserves. Saudi Arabia itself has reserves of 264 billion barrels and the rest of OPEC has an additional 688 billion barrels of oil. The next largest block of oil is held by Russia, Kazakhstan and Canada, which together account for 11.7% of the world’s oil reserves. The U.S., on the other hand, possesses only 3% of world proved conventional oil reserves.

As the following charts demonstrate, the global proven reserves of oil are located in countries that, generally speaking, do not have the highest demand, with Middle Eastern countries having the highest reserves.

*OPEC members.
The majority — about three quarters — of the world’s known oil reserves are owned by government-controlled national oil companies (NOCs), many in countries that are unstable or prone to conflict. Unlike publicly held companies, NOCs are not necessarily responsive to the natural force of open competitive markets. Out of the major countries that export oil to the U.S., only Mexico and Canada are considered strategically reliable sources of energy for America.

The following chart illustrates the top oil and gas companies ranked by proven reserves with data as of 2005. As can be seen, most of the top companies are government controlled NOCs.

**Chart 6: Top Oil and Gas Firms by Proven Reserves (2005)**

Source: PFC Energy
The U.S. Department of Defense (DoD) is the single largest institutional consumer of oil in the United States of America. The majority of the DoD’s expenditures on energy are for petroleum-based fuels. In 2008, the DoD spent more than $16 billion to buy roughly 120 million barrels of petroleum. That figure amounted to approximately 1.7% of total U.S. consumption. Said another way, every 3 days, the DoD consumes about 1 million barrels of petroleum.

Among the services, the USAF stands out as particularly reliant on petroleum. The USAF alone accounts for more than half the consumption of oil by all government agencies, primarily due to its heavy use of jet fuel. This underscores the point made earlier that advancing technology and innovative weapons technologies are requiring ever more energy to operate. For example, a modern F-16 fighter jet burns up to 2,000 gallons per flight hour in normal flight conditions, and much more if using after burners.

More importantly, the use of fuel to power the weapons and implements of warfare represent an increasingly higher consumer of energy itself. Mobility fuel drives DoD energy spending: just 25% of DoD fuel today is used for buildings and installations; the rest of the spending — about $12 billion per year — is for combat and combat-related systems. The following chart illustrates where in the U.S. government fossil fuel is consumed, noting that the USAF is the largest consumer of oil of any institutional entity within the entire federal government.

**Chart 7: Fuel Consumption by U.S. Government Agencies**

Source: “Energy Efficiency for Tactical Systems,” by Mr. Chris DiPetto, Deputy Director, SSBE, DoD, 2006
Fuels used for mobility, such as jet fuel and marine diesel, account for almost 71% of the fuel used by the DoD. Electricity generation for military bases represents another major consumer of oil and increasing cost. In 2008, a Defense Science Board (DSB) task force report stated that U.S. Army generators alone consume over 26 million gallons of fuel annually during peacetime and 357 million gallons of fuel every year during wartime. The following chart illustrates the use of oil by consumption source in the DoD in 2006, showing that jet fuel accounts for a vast majority of fuel.

Warfare and combat operations increase DoD fuel consumption due to the necessity for long range transport of equipment and personnel, as well as operations of the technologies and implements of warfare. In 2008, the DoD supplied at least 90 million gallons of fuel each month (approximately 2.1 million barrels) to support U.S. forces operating in Iraq and Afghanistan, representing some 20% of the department’s total fuel purchases.

Chart 8: Fuel Consumption by the U.S. DoD

![Chart 8: Fuel Consumption by the U.S. DoD](image_url)

Source: “Energy Efficiency for Tactical Systems,” by Mr. Chris DiPietto, Deputy Director, SS&E, DoD, 2006
Warfare and combat operations are not the only variables driving DoD fuel usage and costs. It is estimated that a $10 cost increase for a barrel of oil, costs the DoD over $1 billion. The Defense Energy Support Center (DESC) purchases energy resources from the private sector and then sells to the DoD. The DESC maintains a robust network of supply sources and strategic contracts to procure petroleum products from refineries around the world. It also sets the price for procurement of fuel for government purchases.

From 2004 through 2008, the cost of DESC purchases from its supply network increased from $5.9 billion to $18.1 billion, a significant jump due almost entirely to increases in fuel prices. Over the same period, DESC sales to its customers increased from $6.9 billion to $18.7 billion. The DoD is overwhelmingly the DESC’s largest customer, although the DESC sells a small amount of energy resources to non-DoD governmental agencies, as well as to foreign governments.

Price increases experienced in 2008 may not represent a one-time event. Most experts predict that over time, oil prices will rise. Today, the DoD is looking ahead to additional cost burdens based on carbon emissions. Whether through a carbon tax or some version of a cap and trade system, like all consumers, the DoD will likely be paying an added charge for every gallon of fuel it consumes.

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Source: DESC, Deloitte Analysis
Implications of Dependence — Dependence on Foreign Oil Affects U.S. Foreign Policy

China is adjusting its relationships in the Middle East (with Iran and Saudi Arabia, for example) and Africa (most notably with Nigeria and Sudan) in an attempt to secure assured oil supplies. France and Germany are viewed by many as reluctant to address difficult issues with Russia and Iran due in part to their dependence on imported fossil fuels from those countries. Concerns about losing Iran’s 2.5 million barrels per day of world oil exports is making it difficult to find consensus on international action in response to that nation’s nuclear program.

The following chart illustrates who supplies the U.S. fossil fuel based energy requirements.

Global Oil Infrastructure — Potential Threats

Energy security and national security are closely interrelated: threats to the former are likely to translate as threats to the latter. The U.S. military, in its planning for the future, recognizes the ability of an adversary (or adversaries) to use the “oil weapon.” The control over enormous oil supplies gives exporting countries the flexibility to adopt policies that oppose democratic interests and values — and the United States and its allies. Case in point — Russia has withheld natural gas supplies to both Ukraine and Georgia in the last few years alone, demonstrating that, as the Economist wrote in 2006, “when it comes to hydrocarbons, geopolitics, and geology are inextricable.”

The global oil market is highly vulnerable to potential supply disruptions. Global energy reserves are heavily concentrated among a handful of major producers and the largest consuming centers are often far from producing basins. Chokepoints are narrow channels along widely used global sea routes. These “lines of communication” (LOCs) represent a critical part of the global energy security infrastructure due to the high percentage of the world’s daily energy supply that passes through their narrow straits.

The Straits of Hormuz, Strait of Malacca, Suez Canal, Panama Canal, Bab el-Mandeb, and Bosphorus/Turkish Straits are all extremely critical and vulnerable LOCs. Disruptions at any one of these chokepoints could interrupt a significant percentage of the world’s daily requirement for fuel.

The Straits of Hormuz is the world’s most important oil chokepoint, with over 17 million barrels of oil passing through it every day. That equates to roughly 40% of all seaborne traded oil and more than 20% of oil traded worldwide. At its narrowest point, the straits are 21 miles wide, and the shipping lanes consist of two-mile wide channels for inbound and outbound tanker traffic, as well as a two-mile wide buffer zone.

Chart 11: World’s key chokepoints for oil transportation

Source: Energy Information Administration
The Fully “Burdened” Cost of Fuel, in Blood and Money

In early 2009, the U.S. DoD Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), Dr. Ashton Carter, testified to Congress that “protecting large fuel convoys imposes a huge burden on the combat forces.” He went on to say that “reducing the fuel demand would move the department more towards efficient force structure by enabling more combat forces supported by fewer logistics assets, reducing operating costs, and mitigating budget effects caused by fuel price volatility.”

At the U.S. Marines Corps’ (USMC) 2009 Energy Summit, Commandant General James Conway identified fuel convoy security in Afghanistan as one of his most pressing problems related to risk of casualties. General Conway said he was in the process of reorganizing the USMC/Headquarters (HQ) staff to better address energy problems and to more clearly focus on energy efficiency. During that conference, the U.S. Secretary of the Navy, the Honorable Ray Mabus, made the same comment regarding his U.S. Navy HQ staff.

On any given day, the U.S. military hosts a substantial forward contingent abroad, serving in strategically critical support missions. Since the conflicts in Afghanistan and Iraq began in 2001 and 2003, respectively, the amount of oil consumption at forward bases has increased tenfold. Every forward operating base (FOB) in Afghanistan requires a minimum of 300 gallons of diesel daily to satisfy its requirements. A typical USMC combat brigade alone requires over 500,000 gallons of fuel per day. High fuel requirements in forward deployed locations present the military with a significant logistical burden.

More importantly, the transport of this fuel via truck convoy represents casualty risks, not only from IEDs and enemy attacks, but also rough weather, traffic accidents, and pilferage. DoD officials reported that in June 2008 alone, a combination of these factors caused the loss of some 44 trucks and 220,000 gallons of fuel. The following pictures illustrate the logistical difficulty in fuel transport and distribution in theaters of war. They dramatically illustrate the magnitude, vulnerability, and conditions that the operation consists of in the type of expeditionary warfare experienced in the last 20 years.
According to a 2001 Defense Science Board (DSB) report, over 70% of the tonnage required to position today’s U.S. Army into battle is fuel. With the logistics, fuel convoys and distribution requirements to transport fuel into battle, it is not surprising that U.S. adversaries are targeting one of its most vulnerable assets. In addition, the number of fuel convoys — trucks traveling over unimproved roads in remote areas — has skyrocketed in the Iraq and Afghanistan conflicts, in order to supply the engines of the personnel carriers, camp generators, jeeps, tanks and other equipment requiring a continuous oil supply to operate.

Between July 2003 and May 2009, IEDs accounted for some 43% of U.S. fatalities in Iraq. For many months between 2005 and 2008, the IED-related fatality rate exceeded 50% (as seen in the chart below). Convoys, whose primary tonnage is fuel, represent a substantial target of IED-related assaults.

Chart 12: U.S. Fatalities in Iraq by IED

Source:icasualties.org, Deloitte Analysis
Over the past five fiscal years (FY 2005 through FY 2009), IEDs accounted for about 38% of U.S. fatalities in Afghanistan. In contrast to the situation in Iraq where IED related U.S. casualties declined both in absolute numbers and as a percentage of total U.S. casualties beginning in the second half of 2007, the situation in Afghanistan has only worsened, both in absolute numbers and as a percentage of total U.S. fatalities, as seen in the chart below. Indeed, the total U.S. IED-related fatalities in Afghanistan for just the two months of July and August 2009 were 50% higher than they were for the entirety of FY 2007. For FY 2009, IEDs will likely have accounted for slightly more than half of all U.S. fatalities in Afghanistan.

**Chart 13: U.S. Fatalities in Afghanistan by IED**

Source: icasualties.org, Deloitte Analysis
Note: FY 2009 data are projections based on first eleven months (October 2008 – August 2009).
Furthermore, the following chart correlates the number of total U.S. casualties in Afghanistan — killed in action and wounded — from 2002 through the present, to the increasing consumption of fuel by U.S. forces. This demonstrates that the number of convoys required to transport an ever increasing requirement for fossil fuels is itself a root cause of casualties, both wounded and killed in action.

As mentioned, the use of improvised explosive devices (IEDs) and roadside bombs by U.S. adversaries has been an especially effective means to disable friendly fighting forces by disrupting their supply of energy. The chart shows that the current Afghan conflict may result in a 124% increase in U.S. casualties through 2014 (17.5% CAGR), should the war be prosecuted with a similar profile to Operation Iraqi Freedom.

**Chart 14: U.S. Total Annual Casualties in OEF versus U.S. Fuel Consumed**

Source: icasualties.org, DoD, CRS, Deloitte Analysis

Y=50.502X-105.21. R-squared: 0.8966

Note: Between FY 2009 and FY 2014, a presumed doubling in U.S. troops will lead to a 116% increase in average monthly fuel consumption, as per capita consumption increases annually by 0.31 gal/soldier/day—some 1.55 gal/soldier/day over the five year period.
Beyond the danger to lives — the most important issue raised here — there is the issue of cost. Beyond the basic purchase cost of fuel are other ‘hidden’ costs, including maintaining fuel transport equipment, training personnel, and maintaining and protecting the oil supply chain. The military currently pays between $2 and $3 per gallon for fuel depending on market conditions. The process of getting the fuel to its intended destination, even assuming that no protection is provided to the convoys during transport, increases the cost to nearly $15 a gallon. Protection of fuel convoys in combat zones requires an enormous show of force in the form of armored vehicles, helicopters, and fixed wing aircraft, forcing costs even higher.

Protecting fuel convoys from the ground and air costs the DoD upward of 15 times the actual purchase cost of fuel, depending on the level of protection required by the convoy and the current market prices of the fuel commodity. Fuel costs grow exponentially as the delivery distance increases or when force protection is provided from air.

The following chart illustrates the fully burdened costs of fuel and shows how high the cost is to protect and transport this fuel to its final destination, bringing the cost per gallon to almost $45 per gallon, compared to the average cost at the retail gas pump of approximately $3 per gallon in 2009.

The business case for alternative energy development has rested first on the concept of a sustainable planet, resulting in reductions in hydrocarbons and other harmful emissions in the creation and use of fossil fuels. With the dramatic rise in the price of oil seen in 2008, and increased recognition that the oil supply may be limited, the business case has shifted emphasis to the economic benefit for developing and using renewable energy sources.

This study demonstrates that the development and use of alternative energy can be a direct cause for reductions in wartime casualties and may rank on par with the business cases for development of ever more effective offensive weapons, sophisticated fuel transport tankers, mine resistant armored vehicles, and net-centric sensing technologies.

Aerospace and Defense firms, their government customers, and research labs around the world are well positioned to accelerate the development and deployment of such technologies.
DoD Strategic Options and Initiatives

The DoD recognizes the threats of increasing dependence on oil, specifically the threats to troops in the transport of fuel to forward bases that power implements of warfare. The strategic pathway for the DoD to decrease energy consumption begins with a basic premise: the DoD is but one, albeit large, customer in the global energy market. The DoD purchases and distributes energy just as any large institutional consumer would.

Although a huge consumer of energy, the DoD energy challenge is part of a much larger national energy challenge that, broadly speaking, must address fundamental questions:

- How can the U.S. break its oil dependence?
- How can U.S. address energy security and environmental sustainability while safeguarding economic growth?
- What is the role of government in the transformative process?

Such policy choices form a national imperative that transcends the strictly limited purview of the DoD, as it is captive to the success or failure of a national energy strategy. However, as both the largest single consumer of energy and the single most critical component of national defense, the DoD should consider its role and the level of its involvement in defining a comprehensive national energy strategy.

In a 2008 DSB study, “More Fight, Less Fuel,” former Defense Secretary, James Schlesinger and General (ret) Mike Cains identified the issues that the DoD is faced with as it moves toward alternative energy sources. They stated that the DoD did not have a single clearly articulated energy strategy in place or even a single focal point for energy related department-wide policy such as that which might exist at the Assistant Secretary of Defense level. In point of fact, Section 902 of the 2009 Defense Authorization Act directed DoD to create and fill a Presidentially-nominated position to oversee the DoD energy transformation.

Despite the absence of a single leadership role, strategy, and focus, a number of energy-related policy groups reside within the DoD that are making progress. They along with several research and think tank organizations have defined elements of a DoD energy security plan. In particular, the DoD’s Energy Security Task Force, chaired by the Director, Defense Research and Engineering, has drafted an “Energy Security Strategic Plan,” which has four overarching goals:

- Maintain or enhance operational effectiveness while reducing total force energy demands by reducing: systemic demand for energy from DoD platforms and weapons systems, net energy use at fixed and tactical installations, risk to deployed forces due to availability and distribution demands of energy, and risk of loss of critical functions due to extended commercial grid power disruptions at fixed installations.
• Increase strategic energy resilience by developing alternative/assured fuels and energy by: increasing use of renewable energy sources/microgrids, developing and maturing protocols to use alternative fuels, and investing in science and technology to develop and test alternative and renewable fuel and energy systems.

• Enhance operational and business effectiveness by institutionalizing energy considerations and solutions in DoD planning and business processes through the following steps: make energy a selective key performance parameter (KPP), fully burden the cost of energy in trade-off analyses, ensure that energy is included in life cycle sustainment metrics for major defense acquisition programs (MDAPs), and develop individual component energy security plans.

• Establish and monitor Department-wide energy metrics to include: entering building metering data into benchmarking database; establishing electricity metering by 2012; and establishing natural gas and steam metering by 2016.

In a parallel fashion, the Under Secretary of Defense for AT&L asked the DSB to formulate recommendations for the DoD to address its “primary energy challenges.” The “Report of the Defense Science Board Task Force on DoD Energy Strategy” was issued in early 2008 and cited five recommendations:

• Accelerate efforts to implement energy efficiency KPPs and use the fully burdened cost of fuel to inform all acquisition trades and analyses

• Reduce the risk to critical missions at fixed installations from loss of commercial power and other critical national infrastructure

• Establish a Department-wide strategic plan that establishes measurable goals

• Invest in energy efficient and alternative energy technologies to a level commensurate with their operational and financial value

• Identify and exploit near-term opportunities to reduce energy use through policies and incentives that change operational procedures

Evidence suggests that the DoD has undertaken a number of initiatives to advance the cause of energy security. However, significant progress is still required in consolidating its energy-related bureaucracy and formulating an all inclusive energy policy.
Fuel Optimization for Mobility Platforms
Technologies that the DoD is pursuing that would increase fuel efficiency for its platforms and systems include the following:

• **Turbine engine efficiencies** — The Highly Efficient Embedded Turbine Engine initiative, part of the Versatile Affordable Advanced Turbine Engine program, is developing a high-pressure ratio, high-temperature core technology, with the potential to reduce specific fuel consumption up to 25% over today’s systems.

• **Unmanned Aerial Vehicle (UAV)/generator engine efficiencies** — The Small Heavy Fueled Engine demonstration is a three-year program, initiated in FY 2008, that is anticipated to increase fuel efficiency and power density by 20% for UAVs and generators.

• **Ground vehicles engine efficiencies** — The Fuel Efficient Demonstrator is testing the feasibility and affordability of achieving significant decreases in fuel consumption in tactical vehicles without sacrificing performance or capability.

Facility Energy Initiatives
The DoD reports a reduction in facility energy usage of more than 10% between FY 2003 and FY 2007. More than 12% of facility energy usage now derives from alternative sources, including the following:

• **Solar power** — Solar power is considered the largest contributor to the USAF’s renewable energy development program. In late 2007, the USAF commissioned what is currently the largest photovoltaic solar array (14.2 megawatts) at the Nellis Air Force Base (AFB). This is expected to support some one quarter of Nellis’ daily energy requirements, saving the USAF $1 million annually.

• **Geothermal power** — The U.S. Navy recently awarded a 30+ megawatt geothermal plant at Fallon Naval Air Station, Nevada. More generally, ground source heat pumps are increasingly being used by the DoD, especially at housing units.

• **Other potential energy generation technologies** — The U.S. Navy has been active in testing other energy generation technologies. Such alternatives include buoy technology, tidal energy harvesting, and a barge-mounted off-shore Ocean Thermal Energy Conversion plant for electrical and water requirement at Diego Garcia.
Alternative Fuels, Power Generation, and Energy Storage

There are several alternative fuel initiatives and methods of power generation that are being researched and experimented with. The DoD and private sector research labs have undertaken a number of alternative fuel initiatives, including the following:

• **Synthetic fuels (synfuels)** — The DoD has several synfuel projects underway. In August 2007, the USAF certified the B-52 to use a 50/50 coal to liquid synfuel blend. Tests leading to synfuel certification are underway for the F-15, C-17, B-1, and F-22. The USAF intends to derive half of its fuel requirements from synfuels by 2016. The Energy Independence and Security Act of 2007, however, does limit federal agencies from purchasing synfuels whose life cycle greenhouse gas (GHG) emissions exceed those from conventional crude oil, thus limiting the use of coal to liquid fuels for example.

• **Biofuels** — Defense Advances Research Project Agency (DARPA) is exploring technologies that could enable affordable production of jet fuel alternatives using agricultural or aquacultural crops.

• **Algae-based diesel** — In 2007, the USAF and the Office of Secretary of Defense collaborated with the Department of Energy to develop an algae-based CO2 absorption system, which produces oils that can further be developed into jet fuel. The U.S. Navy is in the early stages of testing algae-based fuels in the fleet.

• **Tactical Power Systems and Generators** — The DoD is exploring several energy research projects for tactical, in-theater applications, including hybrid power generation for Forward Operating Bases as well as solid oxide fuel cells for critical support equipment (such as GPS, radios, and infrared vision systems). There is also interest in the efficacy of commercial hybrid power stations — using a variety of energy sources — in meeting military needs in isolated, but fixed, locations, such as Iraqi border crossings.

• **Fuel cell technologies** — Private industry and public research labs are experimenting with this promising technology. Fuel cells have had a poor track record of development and performance, but are of particular interest since they have the potential to double the energy efficiency of current power systems. The initiation of a hydrogen fuel cell demonstration pilot program by the U.S. Army would provide an opportunity to become a unique laboratory for the nation to learn how to make the move to a substitute fuel.

• **Nuclear fission technologies** — Nuclear reactors to produce electricity represent a widely adopted technology that is clean and does not depend on oil. Its drawbacks, of course, are related to nuclear contamination and spent fuel disposal, as well as the safety and quality standards that are required. However, promising research into safer, smaller, and more efficient reactors is making the nuclear option more appealing. The application of nuclear technology to power aircraft carriers and submarines has been a game changer, and if it could be applied to portable power generators, armored personnel carriers, jeeps, cars, and even aircraft in a way that is safe and secure, dependence on oil to power defense would shrink dramatically. Of course, there are significant hurdles to overcome related to pilferage and theft, contamination risk related to accidents and casualties by enemy fire, maintenance, cost, and technology miniaturization.

• **Energy storage** — The use of alkaline batteries to start engines using gas has been a long standing technology. Recent innovations in electric energy storage has resulted in longer lasting, lower weight and more durable storage devices; e.g., lithium ion batteries. Technology innovations in electric energy storage resulting in ever more lightweight, more powerful and reliable energy is needed and could reduce the requirements for traditional sources significantly.
Regulatory and Legislative

The DoD is subject to the full array of energy-related regulatory regimes that affect any federal agency. The following is a brief, not all inclusive, list of relevant energy-related regulatory and legislative initiatives that will impact the transformation of the U.S.’s energy dependence:

• **American Clean Energy and Security Act (ACES)** — ACES, also known as the Waxman-Markey climate and energy bill was passed by the U.S. House of Representatives on June 26, 2009.

This Act would create a national cap-and-trade scheme, to which President Obama referred in his FY 2010 budget speech. Under the plan, the government would establish a market for carbon dioxide by selling credits to companies that emit GHG. Companies could then invest in technologies to reduce emissions to reach a certain target or buy credits from other companies that already have met their emission reduction goals. The Act also includes a renewable electricity standard, which requires each electricity provider that supplies over 4 million megawatt hours (MWh) to produce 20% of its electricity from renewable sources by 2020.

If it becomes a law—and the legislation is awaiting action by the Senate—ACES could provide business opportunities for the clean technology sector by increasing investments in alternative energy and energy efficient technologies. This legislation promotes energy generation from renewable sources, energy efficiency, clean transportation projects, smart grid technology, and sustainable buildings.

DoD is deploying various measures to align with ACES, such as: the use of life cycle cost analysis in finalizing investment in projects; sourcing components that are Energy Star® certified; undertaking energy audits of its facilities to incorporate energy savings measures; and creating opportunities to install renewable energy technologies.

• **American Recovery and Reinvestment Act of 2009 (ARRA)** — ARRA, popularly known as the ‘stimulus bill,’ was enacted in February 2009. It is largely based on President Obama’s proposals to provide a stimulus to the U.S. economy amid the severe economic downturn that began in 2008. ARRA made supplemental appropriations for job preservation and creation, infrastructure investment, energy efficiency and science, assistance to the unemployed, and state and local fiscal stabilization. The allocations — worth $787 billion — are to be disbursed by September 2010, out of which 5.5% is allocated to the energy sector. ARRA also provides a thrust to the energy sector by guaranteeing loans related to investments in sustainable energy technologies. The act provides $11 billion funding for an electric smart grid, $6.3 billion for state and local governments to make investments in energy efficiency, $2.5 billion for energy efficiency research, $400 million for electric vehicle technologies, and other similar allocations to encourage energy efficiency.

The chart at left illustrates where the DoD is targeting its $7.4 billion of ARRA funding.

The DoD has allocated its stimulus funding towards:
upgrading department buildings, including upgrades
to military medical facilities; new military construction;
improving the energy efficiency of existing facilities; develop-
ing energy-efficient technologies; and providing assis-
tance to military and DoD civilian personnel who suffered
financial loss on the sale of their primary residence.

Chart 17: DoD Projects Completed or Underway by August 2009

$1.9 B through 2,307 projects in 49 states, DC and Guam

Source: Department of Defense
• **National Defense Authorization Acts** — As mentioned previously, Section 902 of the National Defense Authorization Act (NDAA) for FY 2009 calls for the appointment of a Director to “provide leadership and facilitate communication regarding, and conduct oversight to manage and be accountable for, operational energy plans and programs within the Department of Defense and the U.S. Army, U.S. Navy, USAF, and Marine Corps.”

Section 333 of the FY 2009 NDAA requires the DoD conduct a feasibility study on solar and wind energy use for expeditionary forces. In a similar fashion, Section 334 directs the DoD to conduct a feasibility study on alternatives to reduce the life cycle emissions of alternative and synthetic fuels (including coal-to-liquid fuels).

The NDAA of 2008 required the DoD to establish a goal in which it produces or procures at least 25% of its electric energy consumption from renewable sources by the year 2025.

• **Others** — The Energy Policy Act of 2005 (EPACT ’05) mandates a 30% reduction in energy consumption in new federal buildings as compared to earlier standards. It also requires that the federal government offset its electric energy consumption with an increasing percentage of “renewable energy” (from 3% starting in 2005 to not less than 7.5% by 2013 and each fiscal year thereafter).

The Energy Independence and Security Act of 2007 requires 55% reduced fossil energy use in new federal buildings and major renovations by 2010 relative to a 2003 baseline, with 100% reductions by 2030. It also prohibits federal agencies from leasing buildings that have not earned an EPA Energy Star label.

Executive Order 13423, signed by former President Bush in 2007, directs all federal agencies, including DoD, to improve energy efficiency and reduce GHG emissions through reduction of energy intensity (3% annually through the end of FY 2015, and 30% by the end of FY 2015, relative to each agency’s baseline energy use in FY 2003).
Today, national security, energy security, and environmental security are inextricably related. This study demonstrates that energy security may be one of the most effective defenses for the U.S. war-fighter. Finding and implementing a solution for one of the challenges will most certainly have to be done by addressing the other two. Just as importantly, any such solution will require significant new systems across the military.

At the USMC energy summit, General Conway made clear the challenges and changes facing the Marine Corps — and the entirety of the Department of Defense — as U.S. armed forces adapt to new energy realities. General Conway called for improved, aggressive research and development, acquisition, and fielding. He also called for sustainment of equipment that has inherent force protection capability, is lighter and easier to maintain, and promotes efficiency and ensures interoperability with and between Naval platforms and joint systems. Fuel efficiency, availability, and affordability will all be necessities in new systems and technologies.

Aerospace and Defense industry organizations are well placed to take leadership in the development of alternative energy through public-private partnerships, in order to increase America's defense, through the reduction of the fossil fuel based energy supply requirements in war theaters. In partnership of research labs, commercial companies and government, this imperative, well-executed, can result in a reduction in human casualties in Afghanistan and future expeditionary conflicts. With a history of game-changing innovations, the industry companies have the skills, capacity, process discipline, and overall capability to provide the program management, applied research, product development, systems integration, subcontractor management, and technology introduction and aftermarket support.

The DoD will not be able to fill it without help from its many partners both inside and outside of government. What will be required is a sophisticated interagency process, as well as a variety of public-private partnerships. Only such cooperative action can maximize available research and development funds, provide the scale necessary to fulfill the demand of both the private and military requirement, share technology and development tools and centers, and combine the government and industry talent pool and intellectual capital.

The DoD will necessarily become a test bed for large-scale trials and validation for new alternative energies, due to the significant usage of fossil fuel energy requirements. The following DoD energy security initiatives are among the possibilities for accelerated deployment, as relates to partnerships:

- **Common biofuels** — for aircraft and large horsepower engines. FedEx and Virgin Airways are committed to a significant portion of their air and ground fleets (FedEx 30%/Virgin Air/Ground 100%) being powered by biofuels by 2020. The U.S. Navy and USAF are looking at similar programs. The USAF has tested liquid coal fuel in their aircraft, and the U.S. Navy is in the process of conducting a large scale ship test using fuel derived from algae.

- **Hybrid/electrical/biofuel** — technology for the next generation of ground vehicles (which will also include built-in, multiuse generators as a common feature).

- **Solar requirements** — Affordable, durable, and lightweight solar technology on permanent as well as temporary structures (tents) should be commonplace.

- **Engine/propulsion technology** — Innovation and invention at the high end of the technology spectrum is necessary. R&D cost requirements will demand creative funding sources and demand more cooperation between industry and government.

As has been the case throughout history, all of these technologies will be applicable far beyond military use. The entire nation is on course for a new energy future, and the DoD is committed to working with existing and new partners to lead the way.

First and foremost, energy security is essential to reduce wartime casualties. With the significant numbers of U.S. soldiers supporting the transport, logistics, and deployment of fossil fuel to the front lines, there is a call to action to reduce dependence on oil in war. Energy security is America’s best defense.
Chart 1: Historic U.S. DoD Fuel Consumption
Deloitte LLP (Deloitte) based its estimates of historical daily per U.S. soldier fuel consumption for five previous military conflicts on estimates from several sources, including those of the U.S. Defense Energy Support Center, Rand Corporation, U.S. Army Materiel Systems Analysis Activity, among others. Deloitte also applied its own analysis to this estimation process based on a number of factors, including the unique characteristics of each U.S. military conflict.

The value for OIF/OEF is a composite figure for the conflicts in Iraq and Afghanistan as of 2007.

Deloitte used its estimates of historical daily per U.S. soldier fuel consumption to derive a historical trend by way of a simple linear regression technique. Based on this trend Deloitte projected 10- and 20-year growth, both in terms of absolute beginning-to-end change and a CAGR.

Chart 14: U.S. Total Annual Casualties in OEF versus U.S. Fuel Consumed
U.S. total casualties reflect both killed and wounded in Afghanistan and are based primarily on data from the DoD andicasualties.org.

In calculating monthly fuel consumption in Afghanistan, a proxy value of daily fuel consumption per U.S. soldier was applied to an estimated average number of U.S. soldiers in Afghanistan for each fiscal year. The proxy value of daily fuel consumption per U.S. soldier derived from Deloitte’s estimate of fuel consumption by U.S. soldiers in Afghanistan over the entirety of OEF (FY 2002-FY 2009) and, as such, should not be confused with the composite value for OIF/OEF for 2007 in Chart 1: Historic U.S. DoD Fuel Consumption.

Deloitte estimated the average number of U.S. soldiers in Afghanistan for each fiscal year from publicly available sources, including and primarily the Congressional Research Service. To derive total daily U.S. soldier fuel consumption in Afghanistan, the daily fuel consumption per U.S. soldier proxy was multiplied by the estimated average number of U.S. soldiers in Afghanistan. To derive the total monthly U.S. soldier fuel consumption in Afghanistan, the daily figure was multiplied by 30.

Deloitte used estimates of each fiscal year’s combination of total U.S. casualties and monthly fuel consumption to derive a historical trend by way of a simple linear regression technique. In projecting this historical trend to FY 2014, the proxy value of daily fuel consumption per U.S. soldier described above was adjusted by adding to it the value of 0.31 gallons/day/soldier for each year through FY 2014 (1.55 gallons/day/soldier over the 5-year period). The value of 0.31 gallons/day/soldier corresponds to the slope of the regression line in Chart 1: Historic U.S. DoD Fuel Consumption.

Deloitte then multiplied this adjusted proxy by its estimate of the number of U.S. soldiers in Afghanistan in FY 2014 in order to derive its estimate of total daily U.S. soldier fuel consumption. (For purposes of this calculation, Deloitte assumed that the number of U.S. soldiers in Afghanistan in FY 2014 would be twice that of FY 2009). Deloitte then multiplied this daily figure by 30 in order to calculate the monthly figure. Deloitte based projections of FY 2014 U.S. total casualties on the point on the projected regression line that corresponded to the projected FY 2014 monthly fuel consumption.
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