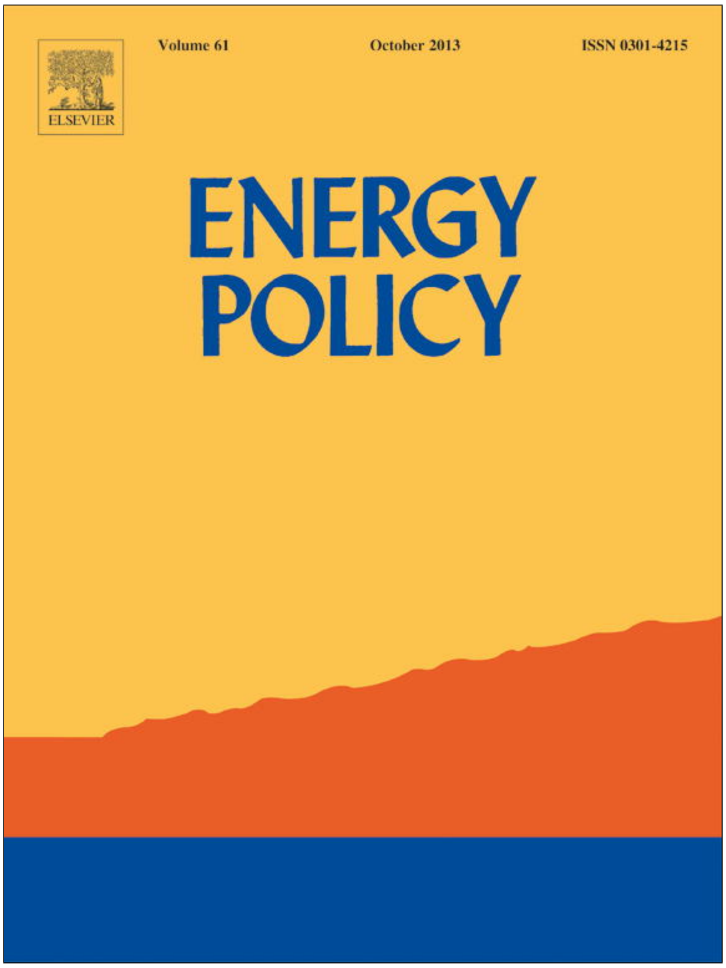
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# The military and energy: Moving the United States beyond oil

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## HIGHLIGHTS

- The drive for less oil is about cost, combat maneuverability, and climate change.
- Culture of oil, lagging research and development, and lack of leadership pose challenges.
- Ultimately, the US Congress questioning the necessity to replace oil could derail the effort.
- Lessening operational oil use could take several decades of sustained leadership.

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ABSTRACT

Energized by service members wounded and killed protecting fuel convoys in Iraq in the mid-2000s and stunned by the oil price spike in 2008, the Department of Defense (DOD) had already started to seriously address energy challenges when the Obama Administration took steps to accelerate these actions. Real-world events, a growing military realization of threats and opportunities, and an Administration intent on fostering American leadership in clean-energy innovation have coalesced to promote change across the military services in the energy domain. This has been particularly evident in the Department's efforts to lessen its oil consumption. However, the ability to turn policy into practice has met numerous challenges from within and without the defense establishment. The question remains whether the DOD will be able to move beyond oil in a significant way. By examining a series of US government policy documents and programs, this article seeks to analyze the motivations behind the drive by the DOD to reduce oil consumption, to identify the challenges in meeting this objective, and to analyze efforts underway by the Department. Given that replacing oil for the largest transport fleet in the world will take several decades, it will require a sustained leadership from senior military officials.



## 1. Introduction

Energized by service members wounded and killed protecting fuel convoys in Iraq in the mid-2000s and stunned by the oil price spike in 2008, the Department of Defense (DOD) had already started to seriously address energy challenges when the Obama Administration took steps to accelerate these actions. Real-world events, a growing military realization of threats and opportunities, and an Administration intent on fostering American leadership in clean energy have coalesced to promote change across the military services in the energy domain. This has been particularly evident in the Department's efforts to lessen its consumption of fuel, or oil derived products (gasoline for light vehicles, diesel for trucks, jet aviation fuel, and fuel oil in ships) through efficiency and alternative energy sources. However, the ability to turn policy into practice has met numerous challenges from within and without the defense establishment. The Department understands that its efforts are tied to a broader set of issues that will require the support of the US Congress and the research and development community.

The question remains whether the DOD will be able to move beyond oil in a significant way. By examining a series of US government (USG) policy documents and programs, this article seeks to analyze the motivations behind the drive by the DOD to reduce oil consumption, to identify the challenges in meeting this objective, and to analyze efforts underway by the Department.

Earlier authors recognized that the US military's oil dependence weakened US national security (Hall, 1992) and offered US Navy jet fuel production strategies for a Persian Gulf crisis (Hadder et al., 1989). Articles have advocated for new battlefield energy technology (Adams et al., 2010), metrics for measuring operational energy use (Bochman, 2009), and metrics for measuring operational energy cost (Lovins, 2010). Roege (2011) discussed the need to create a single logistical network for all sources of energy to better match future demand in different terrains. Kiefer (2013) argued

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that using liquid biofuels for military transport was a ‘false promise’ due to an inadequate supply and an energy intensive production process. Beyond this, none of the Service's leading journals – the US Army War College's *Military Review,* the US Air Force's *Aerospace Power Journal, and* the Navy War College's *Review* – have articles covering energy. And, absent is a journal article analyzing the US government's energy policy as it relates to the military.

This article seeks to redress this by first providing an overview of the US military's dependence on oil and reduction targets. The next section suggests three reasons for the military to reduce the amount of petroleum-based fuels: keeping costs under control, improving combat maneuverability, and adapting to the effects of climate change. Following this, three challenges are identified that may hamper reducing oil consumption, including a culture of cheap oil in the military, lagging research and development in alternative fuels, and lack of sustained leadership. Ultimately, even as the first two challenges are gradually being overcome, factions within the US Congress questioning the necessity to replace oil could derail the effort. The article concludes that replacing oil derived products for the largest transport fleet in the world could well take several decades, and will therefore require a sustained leadership from senior military officials.

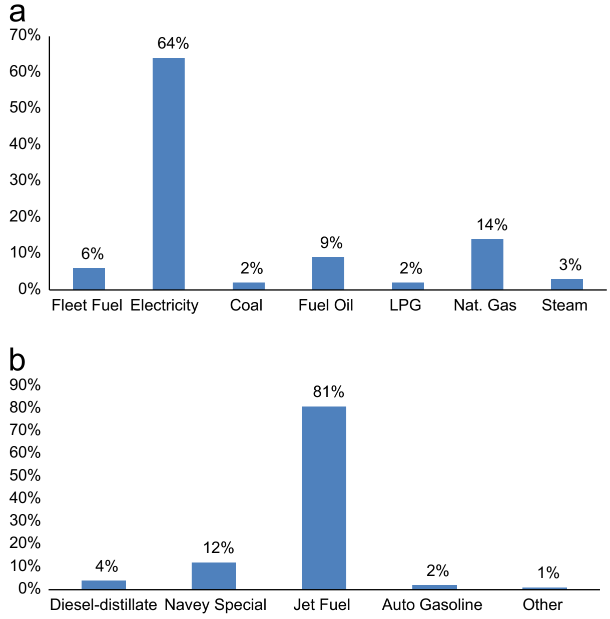


**Fig. 1.** DOD energy costs FY2010.
*Source*: Department of Defense, 2011a. Data from FY2010 Federal Energy Management Report.

## 2. The US military's oil dependence and reduction goals

The US military's oil dependence reflects that of the United States as a whole. The United States is 4% of the world's population, but consumes a quarter of its oil. US consumption of oil rose an average of 2% annually up until the global financial crisis of 2008, then dipped through 2010, but climbed once again (Energy Information Agency, 2012). The country has remained heavily dependent on oil for energy, particularly for transportation. The United State's energy consumption by end-use has varied according to sector, with transportation consuming almost 30% of total energy demand, 94% of this derived from fossil fuels (Energy Information Agency, 2012).

Within the United States, the DOD is the single largest purchaser of energy and DOD's energy use in FY2010 constituted about 80% of the federal government's use of energy (Schwartz et al., 2012, p. 2). Oil derived products are used in transport (tactical and non-tactical), 500 domestic installations, and battlefield generators to supply electricity for powering communications equipment, heat and air units, charging batteries, and preparing meals (Assistant Secretary of Energy, 2006). An estimated 75% of oil products purchased by the military are used for operational energy required for training, moving, and sustaining military forces and weapons platforms (Burke, 2012) (see Fig. 1(a) and (b)). The remaining 25% of energy use is used for installation energy, primarily in the United States. The Air Force is the largest consumer of fuel out of all military branches, accounting for 53% of petroleum use. By comparison, the Navy makes up 28%, the Army 18%, and the Marines and Coast Guard less than 1% of total DOD fuel consumption. Aircraft are by far the main consumers of DOD's petroleum use (over 70% in 2003), followed by ground vehicles at 15%, ships at 8% and installations at 4% (Andrews et al., 2006, p. 19).

DOD energy consumption and cost has varied over the 2000s. From 2000, when the Department began to publish detailed data of its energy consumption and cost (see Fig. 2), operational energy consumption, which is all oil derived products, rose over a decade 100 trillion of BTUs (British Thermal Units) in equivalent usage. Operational energy costs, meanwhile, increased eight-fold, from US$ 2 to 16 billion. Facilities energy consumption, on the other hand, remained fairly steady, and the costs for this energy, which has increasingly included a mix of renewable energy sources and far less fuel oil, rose US$ 2 billion. A great part of decreased facilities costs was due to the closure of older buildings and the retrofitting and new construction of more energy efficient facilities. Overall, fuel costs increased substantially from the early 2000s until 2012, reaching $17 billion for about 117 million barrels of oil in FY 2011, or 2.5% of DOD's total outlays (Schwartz et al., 2012).[2]

Throughout the 1970s and into the 1980s a series of congressional legislation was passed, setting goals and providing incentives for greater efficiency, including fuel use. However, while Congress set specific energy-reduction targets for DOD installation energy, it did not for operational energy. The Federal Energy Management Program was established in 1973. In 1992, the program mandated a 10% energy reduction goal be established for federal buildings measured against a 1985 baseline. When budgetary constraints hit the DOD in the 1990s, the Clinton Administration made addressing high energy usage and rising costs of fuel a major policy priority. Executive Order (13031) “Federal Alternative Fueled Vehicle Leadership,” (Clinton, 1996) propelled an effort underway to acquire non-oil use vehicles and to create the refueling infrastructure to accommodate them. Executive Order 13123, “Greening the Government Through Efficient Energy Management” (Department of Energy, 2000) put to paper a practice for federal agencies that the DOD had adopted in the mid-1990s to better track energy usage in its facilities. A third Executive Order 13123 implementation plan led the DOD to set three goals: reduce energy and water consumption, take advantage of deregulated energy commodity markets, and privatize the utilities infrastructure on military installations (Department of Defense, 1999).

The Defense Science Board (2001) subsequently issued a report on energy, however, that detailed the Department's shortfalls in its approach to energy use. The report recommended that the Department make energy a factor in key Departmental decisions

[2] Data provided to the Congressional Research Service from the Defense Logistics Agency-Energy (DLA-E). See Schwartz et al, 2012, p. 1, fn 6 and p. 2, fn 9 for data sources and calculations.

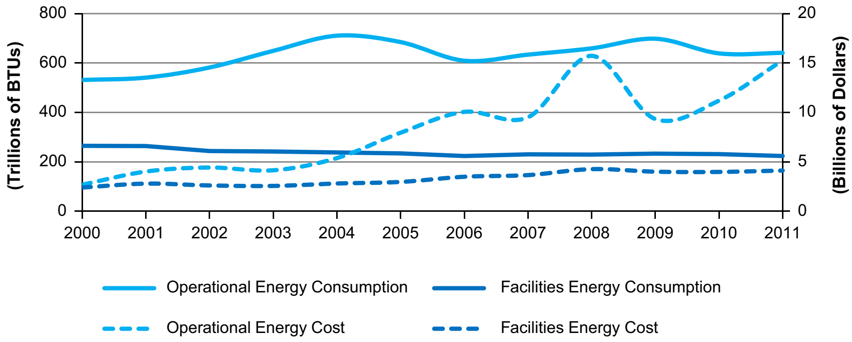


**Fig. 2.** DOD energy consumption and cost.
*Source*: Office of the Undersecretary of Defense, Acquisition, Technology & Logistics, Assistant Secretary of Defense for Operational Energy Plans and Programs. Data from the DOD Annual Energy Management Reports (FY1999 to FY 2010).

**Table 1**
Recent federal requirements relating to fuel.
*Source*: Author compiled from Department of Defense (2011a, p. 4), Pew Project on National Security, Energy and Climate (Pew) (2011), p. 74–5.

| Legislation/order | Requirement | Metric | DOD-wide actual | DOD-wide Target |
|---|---|---|---|---|
| Executive Order 13423 (2007) | Vehicle fleets' total consumption reduced by 2% annually through end of FY2015 relative to FY2005 baseline | Unknown | | |
| Executive Order 13514 (2009) | Reduce petroleum consumption in non-tactical vehicles relative to FY2005 baseline | Gasoline-equivalent gallons fuel used | −5.3% | −10.0% |
| Energy Act 2005 | Consume more electric energy from renewable resources | Total renewable electricity as a fraction of total facility electricity consumption | +4.1% | +5.0% |
| Energy Independence and Security Act 2007 | Section 141 purchase only low GHG-emitting vehicles<br>Section 142 20% reduction in petroleum use, 10% increase in non-petroleum use, annually by FY2015 relative to FY2005<br>Section 246 renewable fuel pump for every fleet by 1/1/10. Section 526 alternative fuels cannot be used if GHG emissions are greater than petroleum sources<br>Section 433, 55% reduction in fossil energy use in new buildings, 100% by 2030 | Unknown (applies to all Sections) | 11.4% | |

that established requirements, shaped acquisition programs, and set funding priorities. This included fossil fuels used for transport, as well as the electricity supplied to US military installations. Nevertheless, specific DOD mandates for the military services to replace oil derived products were not forthcoming. Rather, DOD drew requirements from federal initiatives; treating the Energy Policy Act (2005), the Energy Independence and Security Act (EISA) (2007), and Executive Order 13423 (Bush, 2007), which directed departments to decrease fossil fuel consumption 30% by 2015 at Federal facilities, as mandatory.

Energy Independence and Security (2007) was the most comprehensive of fuel mandates (see Table 1). Section 246 required modification of large fueling sites to provide alternative fuels (of 137 DOD sites, 63% were modified by 2010). Section 141 authorized the purchasing of only low greenhouse gas (GHG) emitting vehicles. Section 142 mandated a 20% reduction in petroleum use coupled with a 10% increase in non-petroleum use, annually by FY2015 relative to FY2005. Section 246 mandated a renewable fuel pump for every fleet by January 2010 and Section 526 stated that alternative fuels could not be used if GHG emissions were greater than petroleum sources. Despite the acceptance of federal mandates, however, the follow-up report of the Defense Science Board (2008) concluded that the Department had not significantly changed its way of doing business concerning energy usage.

A principle advisor to the Secretary of Defense on energy was congressionally mandated for the first time in 2009 as the Assistant Secretary of Defense for Operational Energy Plans and Programs. This office released the first “Operational Energy Strategy” (Department of Defense, 2011b); a plan to transform the way fuel was used in the theater of war. The Chairman of the Joint Chiefs of Staff designated the Director of Logistics (J-4) as his lead on operational energy to work with the new Assistant Secretary of Defense to establish a Defense Operational Energy Board, an advisory council charged with overseeing the Department's execution of the Operational Energy Strategy and Implementation Plan. The three goals of the strategy were to use less fuel through efficiency, diversify energy sources, and to enhance capability while spending less.

Subsequently, several plans were devised to encourage the military to meet specific targets. This included an implementation plan circulated internally with seven targets: measure operational energy consumption; improve energy performance and efficiency; promote innovation; improve operational energy security at fixed installations; promote the development of alternative fuels; incorporate energy into requirements and acquisitions; and, adopt energy policy in military education and combatant command activities (Burke, 2012). Related to this was the implementation of Executive Order 13514 (Obama, 2009) requiring that federal agencies, among other things, provide metrics on fuel use, with the Office of Management and Budget (OMB) scoring progress annually The focus concerning fuel use was on efficiency measures (Table 2). Concerning oil, the focus was on the reducing the use of petroleum product in non-tactical vehicle fleets by 30% from FY2005 by FY2020.

During 2010–11, all four of the military services set budgets, targets, and programs to replace oil derived products (see Table 3). The United States Air Force (2010) planned to burn 50% of its aviation fuels from domestic alternative blends by 2016 and to reduce its fuel consumption 10% by 2015. They also wanted 25% of their facilities to use renewable energy by 2025. The United States Navy (2010) planned 50% less petroleum use by 2015 and 50% of

**Table 2**
DOD Strategic sustainability performance plan goals and sub-goals: FY2010 results and targets for FY2011 through FY2020.
*Source*: (Department of Defense, 2010c).

| | Sub-goal | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Objective #1: The continued availability of resources critical to the DOD mission is ensured | | | | | | | | | | | | |
| Goal #1: The use of fossil fuels reduced (in percentages) | | | | | | | | | | | | |
| 1.1 | Energy Intensity of Facilities Reduced by 30% from FY2003 by FY2015 and 37.5% by 2020 | 11.4 | 18 | 21 | 24 | 27 | 30 | 31.5 | 33 | 34.5 | 36 | 37.5 |
| 1.2 | By FY2020, Produce or Procure energy from Renewable Sources in an Amount that Represents at Least 20% of Electricity Consumed by Facilities | 9.6 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1.3 | Use of Petroleum Products by Vehicle Fleets Reduced 30% from FY2005 by FY2020 | 5.3 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |

**Table 3**
Energy reforms by military service.
*Source*: (Pew Project on National Security, Energy and Climate (Pew), 2011), pp. 59–71.

| | Army | Air force | Marine corps | Navy |
|---|---|---|---|---|
| Energy Use 2010 (percent total energy cost) | Operations: 68%<br>Installations 32% | Operations: 84%<br>Installations: 16% | Operations: 68%<br>Installations: 32% | Operations: 76%<br>Installations: 24% |
| Total energy cost (FY 2010) | $4 billion | $6.83 billion | $651 million | $3.17 billion |
| Clean energy goals | 25% renewable energy by 2025<br>4,000 electric vehicles<br>Net-zero energy use installations | 25% renewable energy by 2025<br>50% aviation fuels with alternative blends by 2016<br>Reduce energy intensity 30% by 2015<br>Reduce fuel burn 20% by 2030 in existing aircraft<br>Increase lift-to-drag ration 20% by 2016 | 50% installations energy from alternative sources by 2020<br>Reduce battlefield fuel demand 25% by 2015 and 50% by 2025<br>Reduce installation energy intensity 30% by 2015<br>50% reduction in fuel use in non-tactical vehicles by 2015 | 50% alternative sources by 2020<br>50% facilities "net zero" by 2020<br>Demonstrate "Great Green Fleet" on biofuels by 2016<br>Reduce installation energy intensity 30% by 2015<br>50% reduction in fuel use in non-tactical vehicles by 2015 |
| Budget for FY2012 for operational energy initiatives | $212 million | $261 million | $42 million | $389 million |
| Transport related major initiative | Hybrid vehicles with energy storage systems | Certify all aircraft and systems for a 50–50 biofuel blend<br>Increase use of flight simulators<br>R&D of Highly Efficient Embedded Turbine Engine and Adaptive Versatile Engine Technology program<br>Material initiatives to optimize aircraft efficiency | Expeditionary energy initiatives<br>Advanced power distribution/generation technology<br>R&D on advanced power distribution/generation technology | Increase R&D of advanced biofuels<br>Buy more alternative jet and maritime fuels<br>Increase efficiency of shops and aircraft |

total energy from alternative sources by 2020. The United States Army (2009) planned for reductions in energy consumption, increased efficiency across platforms and facilities, and an increased use of renewable energy. The United States Marine Corps (2011) wanted a 50% reduction in gallons per marine on the battlefield and a 50% of installation energy from renewable by 2020. Subsequent 2012 DOD strategy documents discussed the need to decrease logistic footprints and to reduce energy demand, including the Defense Strategic Guidance, Joint Operational Access Concept, Army-Marine Corps Access Concept, and the National Military Strategy.

## 3. Cost, combat and climate

There appear to be three reasons for the US military to identify a reduction in fuel consumption as a necessary measure at this time. These include keeping costs under control, improving combat maneuverability, and adapting to the effects of climate change. All three reasons were captured in the Quadrennial Defense Review (Department of Defense, 2010a):

> The Department is increasing its use of renewable energy supplies and reducing energy demand to improve operational effectiveness, reduce greenhouse gas emissions in support of US climate change initiatives, and protect the Department from energy price fluctuations.

Concerning cost, the fuel requirement for the battlefield has increased over time, thereby raising the overall expenditures on fuel. Deloitte (2009) conducted a study of energy use in wartime, including WWII, Korea, Vietnam, the Gulf War, Operation Enduring Freedom/Operation Iraqi Freedom, and Afghanistan, and found that there had been a 175% increase in gallons of fuel consumed per US solider per day since the Vietnam conflict. This was driven by greater mechanization of warfare, the mobility of the armed forces over long distances, and the rugged terrain and the irregular warfare nature of operations. Mechanized warfare, especially aircraft, but also tanks and other fighting vehicles, consumed greater amounts of energy related to speeds, efficiency, and mass of these objects. During peacetime the use of oil was 26 million gallons of fuel annually, and this jumped to 357 million gallons during wartime (Defense Science Board, 2008).

While oil has not comprised a large part of the Defense Department's budget, the cost of oil in dollars to the Department is best understood as a severe lost opportunity. On the one hand, DOD's share of total US energy consumption is small; in FY2010 DOD accounted for about 1% of all US energy consumption (Schwartz et al., 2012, p. 1, fn. 6). Moreover, the amount of money that DOD has spent on petroleum-based fuels was relatively small as a percentage of DOD's overall budget (less than 3%). This said, DOD has used thousands of contractors and the fuel they have used has not been reflected in DOD data (Schwartz et al., 2012, p. 6).

On the other hand, the larger issue has been cost rises over the past decade combined with price volatility. At the same time that the military's demand for oil derived products increased in the 2000s for operations in Afghanistan and Iraq, so too did the price of oil. Starting in 2003 the price went from under $25 to above $30 per barrel, reached $60 by August 2005, and peaked at just over $147 in July 2008. As a result, between 2000 and 2008, DOD's oil related expenditures increased by almost 500%, peaking at nearly $18 billion (Andrews, 2009, p. 2). Every $10 increase in the price of a barrel of oil cost the US military $1.3 billion (Montgomery, 2007). This is equivalent to a loss of almost the entire US Marine Corps' procurement budget or a new naval destroyer. And this makes it difficult for services and combatant commands to plan budgets. In FY2012 US Pacific Command faced a $200 million budget gap due to unexpected fuel costs, shorting resources to train, equip, and supply the force (Holland and Cunningham, 2013).

In reality, a full appreciation of the true expense of fueling operations has been absent. As first suggested by the 2008 Defense Science Board and mandated by the National Defense Authorization Act of 2009, DOD began to factor in the logistics tail of fuel by implementing energy metrics for operational systems. In calculating the real or Fully Burdened Cost of Full (FBCF), they understood that the true cost of all personnel and assets required to move and protect fuel from point to point was much more costly than realized. Moving a gallon of fuel down the supply line into the gas tank of a deployed Humvee or helicopter could easily run over $400 a gallon for diesel (Bochman, 2009). Likewise, a fuel powered 10 kilowatt (kW) generator, providing the majority of electricity in the field, burned roughly a gallon per hour. At $14 a gallon delivered, electricity cost $1.40 per kW hour (kW h) in 2011 (Siegel, 2011). Compare this to the national average for electricity of $.09 per kW h in the same year. According to Lovins (2010, p. 35), however, the FBCF calculations initially in use still did not account for the true opportunity cost of the entire logistical chain. Rather, they established a baseline, such that saved fuel could be more highly valued than previously.

Protecting seaways for transit of oil tankers is an additional undercounted aspect of cost. Oil for civilian and military use must pass some of the most contentious thoroughfares in the world, prone to regional rivalries and pirates. These include the Straits of Malacca and Hormuz, Bab el-Mandeb Strait, the Suez Canal, the Turkish Straits, and the Panama Canal, as well as open oceans where pirates have captured tankers. One estimate of the economic impact of securing maritime oil chokepoints by the Center for Naval Analysis was $74 billion per year to the DOD (Komiss and Huntzinger, 2010). Retired Army Colonel Nolan noted that the US Navy spent US$ 3.5 million per day to keep battle groups in the Straits of Malacca and Hormuz, through which the majority of the world's oil travels (Lane, 2012). A RAND study estimated that removing the mission to defend oil supplies and sea routes from the Persian Gulf alone would save between 12 and 15% of the entire defense budget, or more than US$ 90 billion annually (Crane et al., 2009). Granted, a decrease in oil consumption by the United States would not necessarily translate in the short-term to a reduced naval presence at maritime oil chokepoints. But it may in the longer-term reduce geo-strategic leverage some suppliers have over the United States, such as the Persian Gulf oil states.

Less documented and understood have been the contracts that DOD must conclude along the logistics chain, often with corrupt governments. The graft in procuring oil derived products for the mission in Afghanistan has been particularly high, both at the transit center in Manas, Kyrgyzstan, as well as along the Northern Distribution Network (NDN)—a series of sea, railway, and air routes crossing Central Asia into Afghanistan. Transparency International (1999–2011) has consistently ranked Central Asian countries in the top 20% of their index for most corrupted countries. In the case of Manas, two of Kyrgyzstan's Presidents' sons in 2005 and again in 2009 were caught operating through a network of opaque contracts to supply the US military with fuel, embezzling tens of millions of dollars (United States House of Representatives, 2010). In Uzbekistan the US military spent $15 million for base-related costs in the early 2000s and supplied weapons to the Army and security services.

In both accounts, rather than generate economic growth and stabilize the country, the incomes from oil sales to the US strengthened the regime and ended up in offshore accounts (United States House of Representatives, 2010). Moreover, in 2005 the government of Uzbekistan evicted US personnel from the Karshi-Khanabad air base, which Washington had used as a staging ground for combat, reconnaissance, and humanitarian missions in Afghanistan, following a disagreement with the Uzbek government over alleged human rights abuses (Cooley, 2009). Five years later the US military returned and was once again paying large sums to use base facilities and to transit the country by railroad as part of the NDN. And, NDN proved to be more expensive; DOD's costs for transporting fuel and supplies to Afghanistan rose 20% when they shifted from the alternative route through Pakistan, which was periodically blocked (Baldor and Burns, 2012).

Tied to concerns of cost has been the impact oil dependence has on combat effectiveness. For fuel used in the theater of war, the real cost has been higher combat deaths. The 2000 deadly attack on the USS Cole in the Yemeni Port of Aden just over a decade ago, resulting in the death of 17 sailors and 39 injured, underscored how ship refueling is vulnerable. Likewise, getting a gallon of gasoline to a front unit in Afghanistan has been one of the most critical, yet deadly, missions in the war. The Deloitte (2009) study argued that as the demand for fuel increased from FY02 in Afghanistan, so too did the number of casualties from IEDs through FY09. Fuel convoys accounted for nearly half of American deaths in Iraq (from 2003 to 2009) and Afghanistan (through 2009). The study concluded that the increasing demand for fuel on the battlefield was responsible for increasing numbers of deaths from the military's mission to protect fuel tank convoys.

Oil dependence also affected how the military fought in Iraq. The frequency and amount of time it took to refuel hampered a commander's maneuverability, as well as took soldiers away from fighting (Mabus, 2010). During the Persian Gulf War in Iraq (August 1990–February 1991), General Paul Kern, commander of the Second Brigade, 24th Infantry Division, recounted having spent the entirety of his time designing battle plans focused on how to keep the inefficient Abrams tanks from running out of fuel (CNA Analysis & Solutions, 2009, p. 14). The battle plan included stops every two and a half hours to refuel. The vulnerability of this slow-moving, fuel-intense supply line made the General a strong advocate for more efficiency, as fuel drove tactical planning, rather than the other way around.

Not much had changed in the Iraq War (March 2003–December 2011). Captain Kunkel (2012), who served in the Marine Corps as an adviser to the Iraqi Army in 2007–8, described his experience:

> Our tactical capabilities were often restricted due to the risk of obtaining fuel. At any given time my fellow advisers and I were

60 or more kilometers away from friendly forces. Our small forward operating base required a great deal of fuel to maintain a generator and several vehicles. Any time I received a fuel shipment, anywhere from 20 to 50 fellow service members were put in harm's way across some of the most dangerous highways in the Anbar Province.

Thus, transporting fuel across Iraq not only took people away from the mission to fight, but also stretched the capabilities of the units. US Army Captain Maddox (2012) estimated that his oil protective services employed at its peak 1.5 of his 4 combat enabled company sized elements to secure the K3 oil refinery and a pipeline from Bayji's K2 oil refinery. US Army Captain Scott (2012) explained that maintenance companies, while not combat arms units, had to train personnel to become infantry men to convoy oil and other supplies. With minimal training, supply clerks manned weapons for convoys that were often slow moving targets. Sometimes, troops on the convoy lacked the basic knowledge of the rules of engagement and necessary tactics, techniques and procedures to avoid the enemy. In Afghanistan, the fuel convoys were referred to as "Taliban targets,"—they were a high-payoff target for insurgents using homemade bombs (Anderson, 2011). If targeted, they were to leave immediately and not to engage the enemy, making them not only a softer target, but shorting the war fighters much needed fuel. Alternatively, Sergeant Miller (2012) explained if the troops manning the fuel convoys were highly trained in combat, the military lost their skills to guarding trucks.

The role of oil, oil pricing, and smuggling of oil ultimately undermined the US operation in Iraq. American opposition to letting Iraqi refined oil products rise to market prices after 2003 was a major factor in the large numbers of troops used to guard convoys for refined oil products. The United States was importing large amounts of refined oil products from Kuwait in 2004 through 2005, most of which were sold on the domestic market for a nickel a gallon, and then promptly smuggled into Turkey and Jordan for resale at $3 per gallon (Crane, 2012). The insurgents took a cut of the profits from smuggling and resale to finance their operations against the US soldiers. Because so much was being smuggled outside of the country, the Iraqi government imported gasoline with government funds, which diminished official funds towards security (Oliker, 2007, p. 47). As proof of this connection between oil, oil prices, smuggling, and American combat lives spent guarding oil transport, once the prices were increased to whole sale prices in the Gulf, imports and the associated convoys to protect them dropped sharply (Crane, 2012).

As with cost and combat effectiveness, there is concern among senior military strategists that climate change could act as a threat multiplier in critical parts of the world. A group of retired military generals and admirals with a collective 400 years of service in uniform issued a report, "National Security and the Threat of Climate Change" (CNA Analysis & Solutions, 2007). General Charles Boyd, US Air Force, former Deputy Commander-in-chief, Headquarters USEUCOM wrote in that report:

> When you add in some of the effect of climate change – the disruption of agricultural production patterns, the disruption of water availability – it's a formula for aggravating, in a dramatic way, the problem and consequences of large scale dislocation. The more I think about it, the more I believe it's one of the major threats of climate change. And it's not well understood (CNA Analysis & Solutions, 2007, p. 5).

The QDR (2010) reported on assessments conducted by the intelligence community indicating that climate change could have significant geopolitical impacts around the world, contributing to poverty, environmental degradation, and the further weakening of fragile governments. Climate change would not cause wars, but fault lines along religious, ethnic, economic and political lines would be compounded by severe weather events adding pressures that could cause governments and societies to fail. In this chaos, paramilitaries, organized crime, and extreme terrorist organizations could take advantage of the misery of crumbled societies unaided by governments.

Chairman of the Joint Chiefs of Staff Mullen (2011) penned an article in which he opined that regardless of the cause of changes to the climate, the impacts of opening waterways, rising sea levels, reduced arable lands, and the loss of critical water supplies would have far-reaching impacts for the US military. Likewise, the Defense Science Board authored a study dedicated to climate change (Defense Science Board, 2012) highlighting how changes in climate patterns and their impact on the physical environment required more information about the implications for combatant commands and a coordinated inter-agency response to climate change threats. "Failure to anticipate and mitigate these changes increases the threat of more failed states with the instabilities and potential for conflict inherent in such failures" (Defense Science Board, 2012, p. 4).

A related concern has been whether instability caused by climate change could hamper gaining access to fuel supplies. The National Security Strategy (White House, 2010) stated that without significant and timely adjustments, energy dependence would continue to undermine security and prosperity and leave the United States vulnerable to energy supply disruptions and manipulation. Most critically, the highest potential for instability, the aforementioned Defense Science Board (2012) report judged, would be in places where the United States obtained vital fuel and strategic minerals, such as in Africa. After the report's release, General Carter F. (Ham, 2012), Commander of the United States Africa Command (AFRICOM), testified before the US Senate Armed Services Committee on the security challenges the United States faces in Africa. He agreed with the report's findings that there needed to be greater focus by the USG on preparing for crises posed by climate change, and that his forces were conducting joint military exercises with African forces to this end. Likewise, the commander of US Pacific Command, Admiral Samuel Locklear, opined that as the United States turned its attention to the vast potential of the Asia Pacific region, significant upheaval related to the warming planet was likely to be the single biggest challenge. The US Navy has been working with Asian nations, he said, to stockpile supplies in strategic locations and planning exercises that address environmental catastrophes (Bender, 2013).

While senior defense leaders have not directly engaged in the debate as to the causes of climate change, there have been admissions that DOD is a greenhouse gas (GHG) emitter. Fossil fuel combustion is the largest contributor of GHG emissions in the United States (Department of State, 2010). As DOD is the largest purchaser of fuel in the United States, much of it used in transport, then DOD is a significant GHG emitter. That said, the percentage of Department of Defense GHG emissions as a proportion of overall US federal agencies, or the United States as a whole, is unpublished. The DOD by its own admission accounts for more than half of all USG emissions (Department of Defense, 2011c). What is published is an Environmental Protection Agency (2012) figure of 6821.8 million metric tons of carbon dioxide ($CO_2$) for the United States in 2010. Of that, OMB reports that the Federal Government is responsible for 66.4 million metric tons of $CO_2$ or about 1% of total US $CO_2$. (Although EPA is on a calendar year and OMB is on a fiscal year basis, the months are close enough for an order of magnitude estimate).

That said, at least half of DOD energy use has been exempted from calculations as battlefield operations (Lopez et al., 2008). As with the FBCF, the Defense Science Board (2008) determined that DOD emissions were undervalued, as the cost of transporting the fuel and running military machinery, were not counted. While it is clear that DOD alone will not be able to alter climate change effects nationally or globally, its acknowledgement of the need to adapt to the effect of climate change in operations provides a platform for addressing national security implications of oil use in an otherwise highly politicized domestic and global arena.

## 4. Challenges to moving beyond oil

Cost control, combat effectiveness, and climate change have served as impetuses for DOD to reduce the consumption of oil refined products. Nevertheless, there remain challenges to meeting these goals, including culture of cheap oil in the military, research and development lagging behind the Department's targets, and lack of sustained leadership. The Department is addressing each of these challenges to varying degrees with policy and programmatic changes. That said, these challenges preceded the identification of the need to lessen fuel use. It was through addressing fuel consumption that these challenges became more evident. And, it is unclear if the DOD's desire to lessen oil use will be the catalyst that can overcome these challenges.

On the culture of energy use, there has been a divide in the Department between the strategists and those engaged in operations. The strategic level has focused on ensuring a long-term supply of oil at an affordable cost, including the stability of oil producers and supply routes. Their prescription is a multi-year correctional path of lessening oil dependency. DOD strategists wrote, “Reducing the demand for energy must be the most immediate operational energy priority for the Department of Defense (2011b).” The operational level has been concerned with logistics of supply, particularly to the battlefield, and the running of tactical weapons systems. The risk of sacrificing the mission for energy savings has not been viewed as a win–win situation (Siegel, 2011). And, while the military services revised their operating concepts to reflect the realities of fueling the extensive constellation of bases and logistics nodes, DOD's lack of metrics to measure military effectiveness per unit of input energy and the absence of clear goals to measure progress hampered implementation of new plans and programs (Umstattd, 2009).

Thus, for the most part, the US military was waging a highly fuel intensive war in Afghanistan and Iraq. Aside from the leadership of the US Marines of India Company, 3rd Battalion, 5th Marine Regiment in Afghanistan demonstrating increased energy efficiency and renewable energy sources, and the Army's $108 million investment in more efficient power production and distribution across its Afghan bases, the joint force did not recognize the overall value that battlefield renewable energy would bring to the fight. As journalist Shachtman (2010) commented during his visit to Afghanistan, ‘Because of waste, poor insulation, inefficiency, and redundancy, fully 89% of the electricity they produce for the base is wasted. It's one of the reasons why the US military is burning 22 gallons of diesel per soldier per day in Afghanistan, at a cost of more than $100,000 a person annually.’ DOD had not managed to systematically embed the use of renewable energy into the culture of the military (Adams et al., 2010).

After a decade in conflict, General David Petraeus (2011) sent a memo to the troops stating that, “a force that makes better use of fuel will have increased agility, improved resilience against disruption and more capacity for engaging Afghan partners, particularly at the tactical edge.” However, no detailed guidance was forthcoming. An Army brigadier general opined in the New York Times, “until the Defense Department develops battlefield policies recognizing that energy efficiency contributes to military effectiveness, more blood will be shed, billions of dollars will be wasted, our enemies will have thousands of vulnerable fuel trucks for targets and our commanders will continue to be distracted by the task of overseeing fuel convoys” (Anderson, 2011). The cultural change, Siegel (2011) assessed, would come with a command to increase efficiency across facilities and platforms.

Another aspect of culture was the efficiency of weapons systems. Weapons systems in the design phase last several decades; a jet fighter in production in 2010 will require fuel out to 2060. Morin (2010) recommended implementing energy efficiency key performance parameters as broadly as possible, while offering incentives to contracts and suppliers to improve energy efficiency. There have been some positive developments: the Navy demonstrated a hybrid electric drive system in a ship that saved $2 million in fuel; and, DOD is partnering with major engine producers to develop more fuel efficient aircraft engines (Pew Project on National Security, Energy and Climate (Pew), 2011). Recent large-scale purchases, however, do not appear to reflect a ‘less oil’ culture in DOD. The Navy announced 17 March 2011 that it will buy more Littoral Combat Ships (Department of the Navy, 2011). They use more fuel than the guided missile frigates they are replacing (Siegel, 2011). The Navy is also buying more of the P8-A Poseidon to replace the P-3 Orion (the Navy's frontline, land-based maritime patrol aircraft since the 1960s) (Naval Air Systems Command, 2012). The Poseidon burns more fuel, carries less, and cannot last as long as its predecessor before refueling (Siegel, 2011). Finally, in February 2012, the Obama Administration supported the purchase of the Boeing tanker – the Air Force's next generation of mid-air refueling tankers – over the EADS's plane, which is smaller, but delivers more fuel to the war fighter and burns less fuel per hour getting it there (Siegel, 2011).

The Department has made more progress in changing the culture of energy use at stationary installations, including replacing fuel combustion engines in non-tactical vehicles. Mandated under the aforementioned legislation (Table 1) and funded with $7.4 billion through the American Recovery and Reinvestment Act of 2009, energy efficiency and the use of alternative energy sources on installations are improving. The Energy Conservation Investment Program (ECIP) has become a critical element of DOD's strategy to improve the energy performance of its permanent installations. On bases across the United States, the services are creating councils and signing charters in a multi-disciplinary participatory approach to energy savings (Department of Defense, 2010b). Energy efficiency measures have included increasing the number of hydrogen-powered electric, hybrids, plug-in hybrids, and flex fuel non-tactical vehicles on all US military installations (see Department of Defense, 2010b, p. 23–31). The US Air Force has led on a project in which DOD plans to spend $20 million on a fleet of electric vehicles unique in their ability to export their own power and offset their cost at six installations for non-tactical vehicles around the United States. The dual bi-directional charging model funded by DOD research and development is a power management system that performs charging and discharging of various power devices, including batteries, sending power back to the power grid for sale (Detjen, 2013; Simeone, 2013).

The second challenge has been to spur research and development in decreasing oil use. Under the Defense Production Act of 1950, the DOD has used its long-term procurement process to drive the improvement of new technologies, many of which later made it to the commercial market including the personal computer, GPS, satellite communications, aviation, and the flat screen TV (Hayward et al., 2010). To do the same for energy, DOD's energy research and development budget has gone from $400 million to $1.2 billion in five years (Department of Defense, 2010a). In the first phase starting in the mid-2000s, DOD concentrated on buying off-the-shelf technologies that were readily available. For example, a new Power Surety Task Force acted as a liaison between the

Army and the private sector and managed to insulate more than 6 million square feet of tents in Iraq and Afghanistan with spray-on foam, saving $1.5 million a day in fuel savings.

The focus shifted to research and development of non-commercialized energy technology. This process, however, has sometimes led to good ideas falling into the 'Valley of Death' between the lab and market. That is, technology development often needs experts who can identify the best projects. Significant resource and time must be spent before a technology becomes cost-effective on a large scale (Hourihand and Stepp, 2011). Companies complained that it was hard to find a champion within the government for renewable energies, get the product demonstration to the customer, identify funding, and find the appropriate contractor. The pre-market phase needed a customer that guided the research and development to get the best possible application of an innovation. An example would be the Central Intelligence Agency's establishment of In-Q-Tel in 1999, a strategic investment fund allowing the agency to scale up potential solutions to its technology needs in a timely manner (Morin, 2010). In response, policy makers in DOD provided $17.4 million in FY2012 to support the military in developing or demonstrating and rapidly transitioning into the force energy technologies and practices to improve capabilities and reduce costs (Assistant Secretary of Defense, 2011).

DOD is also investing in technology through public-private partnerships that could enhance commercial market penetration. In particular, to spur innovation of transport energy, DOD leaders have identified the need for substantial partnerships with the Department of Energy (DOE), the Department of Agriculture (DOA), and the private sector. The US Navy worked with DOE's Advanced Research Projects Agency—Energy (ARPA-E) on a $30 million research competition to improve the capability in energy storage devices. In spring 2012, the US Army opened a lab in Michigan bringing together leading scientists, engineers and technicians to develop energy technologies such as fuel cells, hybrid systems, battery technologies, and alternative fuels for the next generation of combat vehicles named the 'Army Green Warrior Convoy' (White House, 2012). The Navy also teamed with the DOE and DOA to dedicate $510 million over three years to collaborate with private companies in producing advanced 'drop in' biofuels not requiring current systems to be retrofitted (Mabus, 2011). Spearheaded by the Secretary of the Navy Ray Mabus, the Navy operated its 'Great Green Fleet' of planes and ships on a 50–50 blend of biofuels and fuel in large scale exercises in summer 2012, purchasing 400,000 gallons of biofuel at US$26 per gallon (Platts, 2012). Shortly after, the US Navy and the Royal Australian Navy signed a Statement of Cooperation to develop and use next-generation alternative fuels (Department of Agriculture, 2012). It is hoped that a thriving biofuels industry in East Asian countries would provide fuel for forces deployed in the region in the short-term, since operational fuel is purchased from sources close to where it is to be used (Burke, 2012).

Efforts to develop biofuels on a large scale have not been without controversy. The Navy has several requirements for biofuels development: they must cost be less than oil in the long-term, be compatible with tactical weapons systems, versatile in every region and climate of the world, be scaled to deploy large volumes, and not pose a challenge to climate goals (Pew 2011, 25). However, it is not clear if the logistics tail, the price, and the accessibility of drop-in advance biofuels will meet these requirements. A RAND study concluded that the military would be better off to focus on efficiency from an environmental and economic perspective, rather than biofuels (Bartis and Bibber, 2011). The authors' opined that the benefit of replacing oil with biofuels and the costs that would be incurred to meet the goal could be more than the benefits of reaching the goal. Moreover, the environmental and economic benefits of biofuels were highly uncertain; seed fuels could cause GHG emissions well above those of conventional fuels and could potentially compete with food production. Conversely, according to Baron (2011), Chairman and CEO or Sweetwater Energy Inc. who is working with the DOD on biofuels development, new crop sciences in major US research universities yield is three to five times the amount per acre as opposed to conventional dry corn. The RAND study suggested instead that the military adopt the Fischer-Tropsch fuels process of converting biomass and coal-to-synthetic liquids as the most promising option for affordability and cleanliness. This would require carbon capture and sequestration technology to eliminate emissions, which is likely several decades away from realization. It would also require tens of billions of dollars in capital investment to build multiple plants across the United States so as to avoid an attack taking out the military's fuel supply (Vallentin, 2008).

In the end, the third challenge – the need for sustained leadership in lessening oil use – may be the most difficult one to overcome. Justifying up-front DOD development costs, advocating for the benefits of alternative fuels over petroleum products, and coordinating public-private efforts entail long-term commitments. A growing dissent from the majority in the US Congress for DOD funding of alternative fuels could derail the process in the future. Recent legislation in the US Congress appears to pit DOD in the middle of the fossil fuels versus clean energy debate. Although Congress has in the past given bipartisan and bicameral support for the Department's efforts to reduce oil consumption, two House bills proposed in spring 2011 incentivized a turn towards coal-to-liquids, a dirtier fuel than oil. The 2012 House Armed Service Committee's National Defense Authorization Act, H.R. 1540 passed in July 2011 included an amendment that prevented the use of the bill's funds to enforce Section 526 of the 2007 Energy Independent and Security Act, which prohibited the government from buying fuels that had a lifecycle GHG content greater than petroleum. This basically removed restrictions on the military from using dirtier fuels, such as converting Canadian tar sands to liquid or purchasing coal-based liquid in the future. The DOD circulated a memo to congressional offices that sought to stop the amendment stating their concern that the exemption could further increase America's reliance on non-renewable fuel, degrading US national security and negatively impacting on the economy.

Nevertheless, in the next appropriations cycle, the US Senate Armed Services Committee included similar language in the 2012 National Defense Authorization Act. Two criticisms of DOD from members of Congress were that it should not be experimenting in alternative fuels and that biofuels current cost is higher than refined oil products. In a show of bipartisan support, Senators Shaheen (D-New Hampshire) and Collins (R-Maine) (2012) from the Armed Services Committee published an article rebutting these claims, arguing that DOE was funding half of the biofuels development, and that the price the Navy paid for biofuels had plummeted 90% in the previous two years. Moreover, they reminded the American public that in the past, Congress promoted DOD efforts in next-generation investments in materials, including encouraging domestic production of steel in the 1880s at three times the market price, which greatly secured the United States in the lead up to World War I (Shaheen and Collins, 2012). Indeed, blanket subsidies to a range of energy options, from oil to biofuels, remain in the legislation. In the end, during full Senate consideration in November 2012, amendments sponsored by Senators Mark Udall and Kay Hagen removed these provisions from the bill. When signed into law by President Barak Obama on January 2, 2013, DOD retained the ability, at least for a year, to develop alternative sources of energy.

Sustaining military leadership in the face of congressional skepticism on addressing climate change has also proven precarious. The two dominant political parties – the Democrats and Republicans – differ on whether human activity is quickening global warming, on whether climate patterns are the result of a warming planet, and whether worsening weather patterns will continue. As a result, policy changes with elections. During the Clinton Administration, the civilian leadership in the Pentagon complied with executive orders on energy, including the need to decrease the use of fuel oil in order to reduce greenhouse gas emissions (GHG) harmful to the environment (Department of Defense, 1999). President George H.W. Bush issued Executive Order 13423 in 2007 directing the Department to lower GHG emissions by decreasing energy intensity 3% per year to FY2015 relative to FY2003. At the same time, the order revoked promotion of renewable energy, did not set goals for decreasing GHG emissions, and took the emphasis off of replacing oil and placed it instead on efficiency of fuel use.

The Obama Administration made decreasing GHG emissions a security priority. The QDR, 2010; pp. 84–88) discussed the importance of the Department's use of renewable energy supplies and reducing energy demand to decrease GHG emissions in support of US climate change initiatives. As of FY2011, the OMB under Strategic Sustainability Performance Plan (SSPP) requirements tracked progress in GHG emissions targets per Executive Order 13514 (Obama, 2009). The Department of Defense (2011c), among 34 other federal agencies, was obliged to report its emissions targets to the OMB to be scored. The White House goal was to decrease emissions 28% by 2020 compared to 2008 levels. Similar legislation supported by the Obama Administration that would have set a target of reducing US GHG emissions 17% compared with 2005 levels by 2020 stalled in the US Senate in 2009. The Defense Department pledged at the start of 2010 to reduce GHG emissions 34% in noncombat areas by 2020 at stationary facilities including energy generation plants and vehicles owned by the Department, and 13% from sources that support DOD activity. However, the pledge did not include combat operations, which account for 62% of the Department's carbon footprint. The inventory showed that from 2008 to 2010, the Department reduced its targeted GHG emissions by a modest amount: 3.6% in noncombat areas and 4.8% from support activity (Office of Management and Budget, 2011).

Leadership from commercial airlines and private investors in harvesting and delivering the feedstock and building biorefineries could aid DOD's efforts substantially. There is an increasing coalition of members from commercial airlines, trade groups, national security organizations, farmers unions, and biofuels proponents advocating for legislation supporting alternative fuel development by DOD. The commercial transportation sector in the United States is expected to consume 40 times the amount of energy consumed by the military by 2020 (Energy Information Agency, 2012). Whereas about 5 to 6% of the defense budget is towards oil products, commercial airlines spend 30–40% of their annual expenditures (Bartis and Bibber, 2011). Boeing Commercial Airlines Vice President has advocated for the commercial sector to develop regional supply chains of biofuels, taking advantage of supporting government policies that encourages early investment in this emerging sector (Alaska Air, 2011). Lufthansa is flying the Airbus between Hamburg and Frankfurt on 50% biofuel. Carbon dioxide emissions have declined about 60%, gallon for gallon, with biofuel, Lufthansa reported (Wald, 2012)

Likewise, more active duty flag officers advocating for alternative fuels in light of cost, combat and climate could support longer-term lessening of oil use. Indeed, a few officers with firm convictions on the need to move beyond oil have begun to project DOD's energy transformation into the mainstream debate. History has proven that through leadership, the military has been able to surmount the seemingly insurmountable, such as integrating units between races. President Harry S Truman's Executive Order 9981 in 1948 ordered the integration of the armed forces shortly after World War II, a major advance in civil rights well before desegregation. This took place within a heated partisan debate over the merits of change and Truman's Executive Order was issued to bypass a disapproving majority in Congress. The military has also recently reversed its 1994 policy of 'Don't Ask, Don't Tell,' despite an initial lack of support from key congress members. After the Chairman of the Joint Chiefs of Staff Admiral Mike (Mullen, 2010) testified before the US Congress to change the policy of keeping secret the sexuality of US service men and women, a majority in the House and Senate voted to overturn the policy.

## 5. Conclusion

A combination of concerns over cost, combat, and climate has combined to propel DOD to design policies and programs to move beyond oil in a significant way. A new generation of military officers, influenced by combat tours in Iraq and Afghanistan, is coming of age with different perspectives on energy use and DOD has instituted incentives for the research and development community to meet new operational fuel requirements through innovation. The question remains whether DOD will be able to bridge the gap between the will to move beyond oil and accomplishing this goal through sustained leadership. At this point, it would appear that there is momentum to gradually replace oil derived products at stationary installations and in non-tactical vehicles. This is the result of increasing efficiency standards, the upgrading of the electricity grid, and the procurement of vehicles. Given that these efforts began during the Clinton Administration and have continued gradually throughout, there is reason to believe that this will continue.

Operations fuel, however, will be more difficult to replace. Caught in a partisan battle of oil versus alternative fuels and the merits of climate change, it will be a challenge for DOD to sustain this effort. Moreover, a change in political leadership in the United States could result in different directives for such efforts. Sustaining funding could also be a problem; DOD's five year (FY2013-FY2017) Future Year's Defense Plan includes a total of about $8.6 billion for operational energy initiatives. With US troops gone from Iraq and a scheduled draw down from Afghanistan in 2014, the drive by military services to replace operational fuel may also wane. Moreover, should oil prices stabilize at moderate rates along with a sustained US exploration drive, alternative fuels could remain too expensive to develop without subsidies, particularly if the private sector does not invest in production and refineries of biofuels. Finally, it is still unclear how the logistical tail of biofuels would improve the current challenges related to moving oil around the globe, whether weapons systems will be compatible over the long-run, and whether production will be sustainable at affordable prices.

Ultimately, reducing the amount of oil consumed through more efficient systems, or replacing oil with an alternative fuels will not be enough. These efforts must be accompanied by a re-evaluation of the way wars are fought. It was envisioned in the 2011 Operational Energy Strategy released by DOD that new notions of operational energy security could mean new equipment, new doctrine, new concepts of operation, or other changes in military operations. DOD leaders could make a much stronger case for its efforts if they discussed in more detail how replacing oil is related to a broader strategic concept. They could also detail the benefits of new more efficient systems and alternative biofuels much more, as it relates to improving combat capabilities, reducing costs over the longer-run, and improving national security—the opposite of oil. Finally, DOD could make a much stronger case of its accomplishments on stationary installations by facilitating greater civilian exposure to its innovations in renewable energies and non-tactical vehicles. In the end, given that replacing oil derived products for the largest transport fleet in the world will take several decades, it will require a sustained leadership from senior military officials.

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