



The Department of Defense: Reducing Its Reliance on Fossil-Based Aviation Fuel— Issues for Congress

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Summary

The Department of Defense (DOD) is a factor in the nation's discussion about national energy security. As the largest single consumer of fuel in the United States, DOD has the potential to make important contributions to the national effort to reduce the use of and reliance on fossil fuel. Aviation fuel makes up the largest portion of fossil fuel consumed by DOD and therefore represents the area of greatest potential energy savings. This report examines DOD's use of aviation fuel and possibilities to reduce that use by examining related issues and presenting options Congress may choose to consider.

Reducing DOD's consumption of aviation fuel could by itself significantly reduce the department's overall reliance on fossil fuel. In Fiscal Year 2005, DOD consumed roughly 125 million barrels of oil—approximately 1.2% of the nation's total. About 74% of that was used to power mobility vehicles—Air Force aircraft, Navy ships, and Army ground vehicles. Over half (roughly 52%) was aviation fuel. (Note: aviation fuel is also used in “non-aircraft” systems such as tanks and generators in order to reduce logistics requirements on the battlefield.

There are several ways in which DOD can reduce its use of fossil-based aviation fuel. Each has advantages and disadvantages and no single option provides the perfect solution. Advanced technologies, such as synthetic fuels, offer potential alternatives but further development and study are required before DOD can employ them on a large scale. DOD can also take measures to decrease its use of fuel. Possible options include upgrading aircraft engines and modifying operational procedures. Many of these measures, however, are costly and must compete for funding with other operational priorities.

Congress also recognizes that DOD has a role to play in the nation's quest for alternative energy sources. Language contained in the FY2007 Defense Authorization and Appropriations Acts requires DOD to report to Congress on their actions to reduce consumption of fossil fuel, increase the energy efficiency of their weapon platforms, and explore the use of synthetic fuel made from coal. Additional proposed legislation would require DOD to further study coal as a fuel source and would remove certain DOD contracting restrictions viewed as a potential obstacle to synthetic fuel development.

DOD has publically expressed its intention to devote resources to this issue; Air Force leadership has stated a goal of using domestically produced synthetic fuel for half of its domestic aviation fuel by 2016. At the present time, however, DOD does not seem to have a comprehensive long-term energy strategy or centralized leadership focused on energy issues for the department. This may affect the department's ability to achieve its long-term energy goals. This report will not be updated.

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Introduction

This report examines the Department of Defense (DOD) use of aviation fuel and possibilities to reduce that use by examining related issues and presenting options Congress may choose to consider.

DOD, the largest single consumer of energy in the United States, recognizes the need to reduce its reliance on fossil fuel. For a number of years, the department has been making steady progress at decreasing their use of fossil fuels on their installations and in their facilities¹ but following the sharp rise in oil prices after Hurricane Katrina in August 2005, DOD stepped-up its examination of fuel use in weapon systems.²

The largest portion of fossil fuel used by DOD is in the form of aviation fuel. Although formulated for use in aircraft, aviation fuel is also used in other, land-based, platforms such as tanks and generators to reduce DOD's logistics requirements. Reducing DOD's consumption of aviation fuel could, by itself, significantly reduce the department's overall use of and reliance on fossil fuel. In Fiscal Year 2005, DOD consumed roughly 125 million barrels of oil—approximately 1.2% of the nation's total. About 74% of DOD's energy powers its mobility vehicles—Air Force aircraft, Navy ships, and Army ground vehicles. Over half—roughly 52%—is aviation fuel.³

There are several options available to DOD for reducing its use of fossil-based aviation fuel. Each has advantages and disadvantages and no single option provides the perfect solution. Advanced technologies such as synthetic fuels offer potential sources of alternate fuel but further development and study are required before DOD can employ them on a large scale. DOD can also take measures to decrease its use of fuel. Possible options include upgrading aircraft engines and modifying operational procedures. Many of these measures, however, are costly and must compete for funding with other operational priorities.

¹ DOD, like other federal agencies, has had to comply with a series of mandates to decrease energy use through efficiencies in facilities and increase the use of renewable forms of energy. President Bush signed the Energy Policy Act in August 2005, and issued Executive Order 13423 in January 2007 both of which update and generally make more stringent existing energy conservation measures for installations and non-tactical vehicles such as passenger sedans. For more information see CRS Report RL33302, *Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions*, by (name redacted) et al.

² Prior to August 2005, there had been some sporadic attention given the topic of reducing fuel use in operational systems, but relatively little action was taken in the area. See U.S. Department of Defense, *More Capable Warfighting Through Reduced Fuel Burden: The Defense Science Board Task Force on Improving Fuel Efficiency of Weapons and Platforms*. Washington, 2001. (January 2001, Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics).

³ Aviation fuel is also used in “non-aircraft” systems such as tanks and generators in order to reduce logistics requirements on the battlefield.

DOD Aviation Fuel Use

The Department of Defense has a unique fuel-use pattern. Approximately 74% of its energy powers its mobility vehicles and over half—roughly 52% of the total—is comprised of aviation fuel.⁴ By comparison, aviation accounts for only about 4% of the energy used in the United States.⁵

Fuel costs, although less than 3% of the total DOD budget, have a significant impact on the department's operating costs. For every \$10 increase in the price of a barrel of oil, DOD's operating costs increase by approximately \$1.3 billion.⁶ DOD budgets for fuel a year or more in advance of its purchase, therefore and sudden large increases in fuel costs must be paid for with emergency funds or by shifting funds from other programs.⁷ The Air Force, which operates most of DOD's fixed-wing aircraft, spends the largest share of DOD's fuel budget. Every \$10 increase in a barrel of oil increases the Air Forces' already sizable annual fuel costs⁸ by \$600 million.⁹

Fuel use varies significantly among the different types of aircraft. For example, the B-52H, one of the oldest aircraft in the service's inventory, has a maximum takeoff weight of 488,000 pounds, runs on eight TF-33 turbine engines, and burns approximately 3500 gallons per flight hour. That is 138 pounds of aircraft for each gallon per hour. By contrast, the C-5B, designed with 1980s technology, is a larger aircraft with four engines, has a maximum takeoff weight of 769,000 pounds, and also burns about 3500 gallons per flight hour. That is 219 pounds of aircraft for each gallon per hour—an increase of 59% over the B-52 capabilities. The T-38, a high-performance jet-engine aircraft used for training, has a maximum takeoff weight of 12,000 pounds and burns only about 395 gallons per flight hour. That is only 30 pounds of aircraft for each gallon per hour—much less than either of the above. The lower fuel efficiency of the T-38 compared to either the B-52H or the C-5B is a reflection of the smaller aircraft's aerodynamic design, afterburning engines, and much shorter sortie length rather than the efficiency of its engines. Fuel consumption rates for a representative selection of Air Force aircraft is provided in **Table 1**.

⁴ Joint Statement [of] Honorable John J. Young, Jr., Director, Defense Research and Engineering [and] Mr. Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), Before the Subcommittees on Terrorism, Unconventional Threats and Capabilities and Readiness of the House Armed Services Committee, September 26, 2006, pp. 4-6.

⁵ JASON, *Reducing DOD Fossil-Fuel Dependence*, JSR-06-135, September 2006, p. iv.

⁶ Joint Statement [of] Honorable John J. Young, Jr., Director, Defense Research and Engineering [and] Mr. Philip W. Grone, Deputy Under Secretary of Defense (Installations and Environment), Before the Subcommittees on Terrorism, Unconventional Threats and Capabilities and Readiness of the House Armed Services Committee, September 26, 2006, p. 5.

⁷ The Defense Energy Support Center (DESC) purchases all of DOD's liquid fuel then sells it to their customers—the military services and other defense and government agencies. DESC offers fuel to its customers at a standard price, set in advance, which allows customers to budget for fuel without having to factor in the risks associated with normal variations in the commercial fuel market.

⁸ The Air Force spends about \$5 billion a year on fuel.

⁹ Statement of Congressman Joel Hefley, Before the Subcommittee on Terrorism, Unconventional Threats and Capabilities Subcommittee and Readiness Subcommittee, September 26, 2006, CQ Transcriptions, p. 4.

Table I. Representative Aircraft Fuel Consumption
(in gallons per flight hour)

Aircraft Type	FY2006
A-10	603
B-1B	3874
B-2A	2181
B-52H	3524
C-130E	742
C-135C/E	1700
C-17A	2781
C-21A	181
C-5A/B	3384
C-5B	3503
E-3B/C	2105
F-15A/B	1715
F-15C/D	1715
F-15E	1879
T-38A/C	395

Source: Headquarter United States Air Force, Office of the Deputy Chief of Staff for Operations, Plans, and Requirements

Delivering fuel to the operational user can add substantially to its cost. The “fully burdened” cost of fuel refers to the price of fuel with the costs of delivery added in. Costs of delivery include the acquisition, maintenance, and operating costs of an aerial refueling tanker and the crew that flies it. The cost of a gallon of fuel delivered to an aircraft on a flight line is a relatively straightforward computation and generally ranges between \$2 and \$3 per gallon. On the other hand, the fully burdened cost of a gallon of fuel delivered to an aircraft in flight is estimated to be around \$20 per gallon.^{10/11} The complexity of measuring fuel use and costs for aircraft is one of the many challenges DOD has to becoming a more efficient user or making other changes in its fuel use, such as using alternative fuels.

Studies on DOD Fuel Use

As fuel costs rose, DOD recognized the need to understand factors that contribute to the department’s heavy usage and examine ways to mitigate them. Consequently, DOD has conducted or sponsored a number of studies in recent years to examine DOD’s fuel use, determine the extent to which that use is problematic, and recommend actions to decrease its

¹⁰ Matthews, William, “DOD Seeks New Energy Sources.” *Defense News*, Vol. 22, No. 1, January 1, 2007.

¹¹ Amory Lovins, founder of the non-profit organization, Rocky Mountain Institute, and advocate for increased energy efficiency in DOD, estimated in 2001 that the cost of a gallon of fuel delivered to a tank on the battlefield can reach \$400 to \$600 per gallon. See Amory B. Lovins, “Battling Fuel Waste in the Military” available on line at <http://www.rmi.org/sitepages/pid939.php>.

use.¹² Two general conclusions seem to emerge from various government studies. The first is that there does not appear to be one ideal alternative fuel with which to replace or augment the fossil fuel already although different technologies are being pursued to varying degrees. The second is that there appears to be several methods currently available to DOD with which it can decrease fuel consumption.

The earliest comprehensive DOD study on fuel use, conducted by the Defense Science Board in 2001, focused on the fuel efficiency of weapon systems and was the first to suggest that the true cost of fuel—the fully burdened rate—was not sufficiently understood by decision-makers.¹³ Two other comprehensive studies were completed more recently, in September 2006. The JASON report, *Reducing DOD Fossil Fuel Dependence*, asserted that an energy shortage was unlikely in the near term to hinder DOD operations and emphasized the value of optimizing the energy efficiency of weapon systems over pursuing alternative fuels at this time.¹⁴ The Defense Task Force on Energy Security was an internal cross-functional group that looked at energy use throughout the department.¹⁵ It presented three recommendations: 1) increase the energy efficiency of weapon systems, 2) accelerate energy-saving initiatives for facilities, and 3) establish an alternative fuels programs. The most recent government sponsored report, completed in April 2007 by LMI Government Consulting, Inc. (LMI), identified areas in which DOD's energy goals are not synchronized with their current practices and recommended actions to address the misalignment.¹⁶ Each of these studies is more fully examined below.

2001 Defense Science Board Task Force

In 2000, the Under Secretary of Defense (Acquisition, Technology and Logistics) directed the Defense Science Board (DSB) to form a task force to examine how DOD could improve the fuel efficiency of their weapons systems. The task force would also identify institutional barriers that impeded the department's understanding of and ability to capture the full advantages of more fuel efficient systems. The task force was not asked to look at possible sources of alternative fuel and they did not address that topic in their report. They reported five significant findings.

Finding #1: Although significant warfighting, logistics and cost benefits occur when weapons systems are more fuel-efficient, these benefits are not valued or emphasized in the DOD requirements and acquisition processes. When buying new weapons, DOD placed performance as its highest priority and seemed to overlook how fuel efficiency could result in

¹² In addition to the studies discussed herein, other DOD sponsored reports on energy and fuel use are:

Air Force Scientific Advisory Board Quick Look, Technology options for improved air vehicle fuel efficiency (2006)

Air Force Studies Board, *Improving the Efficiency of Engines for Large Nonfighter Aircraft* (2007)

Army Corps of Engineers, *Energy Trends and Their Implications for U.S. Army Installations* (2005)

Defense Advanced Research Projects Agency, *Petroleum-Free Military Workshop* (2005)

Naval Research Advisory Council, *Study on Future Fuels* (2005)

¹³ U.S. Department of Defense, *More Capable Warfighting Through Reduced Fuel Burden: The Defense Science Board Task Force on Improving Fuel Efficiency of Weapons and Platforms*. (Washington, D.C.: Office of the Under Secretary of Defense For Acquisition, Technology, and Logistics, January 2001).

¹⁴ JASON, *Reducing DoD Fossil-Fuel Dependence*. (McLean, Virginia: The MITRE Corporation, September 2006).

¹⁵ Department of Defense, *Energy Security Task Force Overview of Findings*, (Washington, D.C.: Department of Defense, March 15, 2007).

¹⁶ Thomas D. Crowley et al, *Transforming the Way DOD Looks at Energy: An Approach To Establishing An Energy Strategy*, FT602T1(McLean, VA: LMI Government Consulting, Inc., April 2007).

improved performance. Furthermore, when developing new systems the department did not seem to take into account how the fuel use of a particular system could have far-reaching effects on the total force (e.g., a system's logistical requirements may create a vulnerable delivery chain).

Finding #2: The DOD currently prices fuel based on the wholesale refinery price and does not include the cost of delivery to its customers. This prevents a comprehensive view of fuel utilization in DOD's decision-making, does not reflect the DOD's true fuel costs, masks energy efficiency benefits, and distorts platform design choices. The DSB pointed out that overlooking the true cost of fuel also masks the real benefits of fuel efficiency. As a consequence, fuel efficiency is not regarded as a relevant factor in the acquisition of weapon systems or in other logistics related decisions. For example, in 1997, using an average fuel price of 97 cents, the Air Force estimated that re-engining the B-52H would generate a savings of just under \$400 million over 40 years. Based on that calculation, the service concluded that retrofitting was not cost-effective. The DSB reworked the equation using an average fuel cost of \$1.50 per gallon (the board estimated that 10% of the fuel would be delivered via aerial refueling at a cost of \$17.50 per gallon) and calculated a savings of \$1.7 billion.¹⁷

Finding #3: DOD resource allocation and accounting processes (the Planning, Programming, and Budgeting System (PPBS), DOD Comptroller) do not reward fuel efficiency or penalize inefficiency. The task force found that DOD interest in fuel efficiency had been mainly limited to meeting goals established by legislation or executive order. Since those goals mainly applied to installations, including their non-warfighting vehicles, there was little incentive to improve the fuel efficiency of weapon systems. Additionally, the department had no way to quantify—and therefore value—the benefits of conserving fuel.

Finding #4: Operational and logistics wargaming¹⁸ involving fuel requirements are not cross-linked to the Service requirements development or acquisition program processes. The task force found that in DOD combat simulation exercises, each military service emphasized mission execution while adequate fuel supplies were considered a constant. DSB asserted that doing so left DOD unaware of the potential effects of fuel efficiency on combat operations and of the vulnerability of the fuel supply chain. Furthermore, with no model of efficient or inefficient fuel use, DOD could not analyze fuel related logistical requirements as part of the acquisition process.

Finding #5: High payoff, fuel-efficient technologies are available now to improve warfighting effectiveness in current weapon systems through retrofit and in new systems acquisition. The task force found that there were existing technologies that could increase weapon systems' fuel efficiency. However, without the tools to analyze the collective benefits of fuel efficiency to warfighting capability, the value of improvements could be misjudged and not fully appreciated.¹⁹

¹⁷ DSB Report, pp. 31-33.

¹⁸ "Wargaming," as defined by DOD is "the simulation, by whatever means, of a military operation involving two or more opposing forces using rules, data, and procedures designed to depict an actual or assumed real life situation."

¹⁹ Winglets, for example, are vertical extensions that can be fitted on wingtips to reduce drag. The Air Force recently sponsored a study to assess the utility of applying winglets to DOD aircraft. See page 22 of this report for further information.

JASON Report

JASON, an independent scientific advisory group for DOD, was asked by the Director, Defense Research and Engineering (DDR&E) to assess ways in which DOD could reduce its demand for fossil fuel using advanced technology, including alternative energy sources. The group was asked specifically not to conduct a detailed analysis of U.S. Air Force fuel use.

The JASON report contained three relevant findings:

Finding #1: DOD fuel costs, though high, represent only about 2.5-3% of the DOD budget and should not be a “primary decision driver at present.” JASON determined that other fuel related issues such as life-cycle costs of weapon systems and the supply chain (in terms of both money and human life) were more significant and compelling factors but that the cost of fuel may become a significant issue in the future. They further noted that the number of Air Force aircraft, the largest source of fuel consumption in DOD, is expected to decline significantly in the next several decades, which should result in a corresponding decrease in fuel use.²⁰

Finding #2: Although revolutionary options in weapon system design exist in their early stages, the technologies that currently promise the most significant fuel savings are light-weighting and modernizing diesel engines. JASON saw little use at the present for most alternative ground vehicle designs such as hybrids, all-electric, or fuel-cell vehicles. In the case of the first two, military use patterns would not allow optimal use of the technologies. In the case of fuel-cells, JASON found that the technology was not sufficiently mature and that there was not a good way to transport hydrogen to theater. JASON suggested light-weighting vehicles by decreasing the weight of manned vehicles and using more unmanned vehicles.

JASON recommended upgrading the gas turbine engine in the Army M-1 Abrams tanks to a modern diesel and that the Army, in particular, install fuel consumption tracking devices in vehicles. The resulting data will allow DOD to gauge use patterns and provide data with which to make informed decisions on engine selections and optimal efficiency.

Finding #3: The Department of Defense uses less than 2% of the oil consumed in the United States and is therefore not a large enough consumer to drive the market for conventional or alternative fuels. JASON and others have suggested that finding substitutes for fossil fuels must be a national endeavor.

According to DOD it uses roughly 340,000 barrels of oil a day whereas the daily consumption rate for the United States is approximately 21 million barrels.²¹ DOD agrees that it plays a significant role in testing, certification, and demonstrating the use of synthetic jet fuel but is not a large enough consumer to drive the market.

JASON contended that in the search for alternative fuels, the most economical and environmentally sound method is to use Fischer-Tropsch technology to produce liquid fuel from “stranded” natural gas.²² They further reported that ethanol was not suitable as a DOD fuel due to its low energy density and high flammability.²³

²⁰ JASON Report, pp. 17, 76, & 81.

²¹ DOD Task Force Overview of Findings, p. 4.

²² “Stranded” natural gas is natural gas that has been discovered but not recovered because it was not economically or (continued...)

DOD Energy Security Task Force

In Spring 2006, former Secretary of Defense Donald Rumsfeld formed a DOD task force with a four-part charter: 1) Examine the issue of energy security; 2) Devise a plan for lowering DOD's fossil fuel requirements; 3) Identify alternate energy sources; and 4) Examine past and ongoing studies to help define DOD's options. The Director of Defense Research and Engineering (DDR&E) led the effort. Task force representation included a cross-section of skills within the military departments, the staff of the Chairman of the Joint Chiefs of Staff, and other defense agencies. Unlike the other studies discussed, the DOD task force did not produce a written report but presented its findings in a slide format that contained little explanation or background. Their three recommendations were:

Recommendation #1: Increase weapon platform fuel efficiency.

- Incorporate the component of energy efficiency into acquisition policy decisions
- Develop more efficient propulsion systems, power generators, and machinery
- Develop more light-weight military vehicles
- Strive for efficient operations and increased use of simulators (primarily affects the aviation community)

Recommendation #2: Accelerate energy efficiency initiatives for military installations.

- Meet or accelerate present energy efficiency goals for military installations.
- Consider and address the energy efficiency of installation-based non-tactical vehicles.
- Expand Energy Conservation Investment Program/Energy Saving Performance Contracts.

Recommendation #3: Establish an alternate fuels program.

- Further develop and test synthetic/alternative fuels for military weapon systems.
- Measure and assess DOD's progress in alternate fuel use.
- Develop incentives programs for alternate fuel industry.

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physically feasible to do so.

²³ JASON Report, p. 87.

LMI Study

The Pentagon's Office of Force Transformation and Resources²⁴ contracted LMI to develop an approach for the creation of a new DOD energy strategy. LMI identified three areas where DOD's current practices were not aligned with its stated energy goals, recommended three main actions that DOD needed to take in order to address the misalignments, and provided other energy related options that could enable DOD to improve their corporate energy related processes.

The three areas of strategic, operational, and fiscal considerations LMI identified where DOD's practices and stated energy goals produced some friction and limitations were as follow.

1. Strategic: DOD's dependence on foreign supplies of fuel limits its flexibility in dealing with certain producer nations;
2. Operational: DOD seeks greater mobility, persistence, and agility for its forces but the energy requirements of its forces limits the department's ability to attain those things; and
3. Fiscal: DOD seeks to reduce the operating costs of its forces and of future procurements but increased energy consumption and increased prices are causing energy associated operating costs to grow.

The three actions LMI recommended DOD take to address the areas noted above were as follow.

1. Incorporate energy considerations (energy use and energy logistics support requirements) in the department's key corporate decision making: strategic planning, analytic agenda, joint concept and joint capability development, acquisition, and planning, programming, budgeting, and execution (PPBE);
2. Establish a corporate governance structure with policy and resource oversight to focus the department's energy efforts; and
3. Apply a new framework to promote energy efficiency, including alternate energy sources, to those areas consuming the most fuel (aviation forces), requiring the most logistics support (forward land forces and mobile electric power), or having the most negative effect on the warfighter (individual warfighter burden).

Other options LMI proposed for DOD to consider included the following.

1. Incorporate energy considerations (energy use and energy logistics support requirements) in all future concept development, capability development, and acquisition actions;
2. Make energy a top research and development priority;

²⁴ The Office of Force Transformation and Resources works within the Office of the Under Secretary of Defense for Policy.

3. Increase global efforts to enhance the stability and security of oil infrastructure, transit lanes, and markets through military-to-military and state-to-state cooperation; and
4. Make reducing energy vulnerability a focus area of the next strategic planning cycle and Quadrennial Defense Review.

Reducing the Use of Petroleum-Based Aviation Fuel

The government sponsored reports seem to indicate, with limited exceptions, that DOD should consider various options for reducing its reliance on fossil fuels. Aviation fuel in particular is viewed as a primary target of that reduction as it accounts for the largest share of fuel consumed by the department. Generally, DOD has several available methods for decreasing its use of petroleum-based aviation fuel. They can be placed in two categories: 1) increasing the use and supply of alternative fuels and 2) decreasing the demand for petroleum-based fuel.

In the first category, options include producing synthetic fuel from coal, natural gas, and biomass, as well as hydrogen fuel cells. In the second category, DOD can use various existing technologies to increase the fuel-efficiency of weapon systems and modify operating procedures and policies to use less fuel. All the options have limitations and none provide a perfect solution.

Whether it is more prudent to aggressively pursue alternative fuels or concentrate resources on decreasing the department's fuel demand is a matter of debate. There are many who suggest that DOD can spur the development of a viable domestic Coal-To-Liquid industry. Others suggest that developing such an industry would contribute to carbon emissions and divert funds from the development of alternative fuels produced from renewable sources as well as from efforts to increase the fuel-efficiency of weapon systems. The following is a discussion of the most frequently cited options.

Increasing Alternative Fuel Use

Alternative fuels are often divided into two categories: "synthetic" fuels derived from non-renewable sources such as coal and natural gas; and "biofuels," produced from renewable feedstocks such as corn, sugar cane, and prairie grasses. Both offer advantages and disadvantages as substitutes for petroleum-based fuel.

An issue that may affect DOD's search for alternative fuels is the department's desire for a "Single Battlespace Fuel." Currently there are seven to nine different types of fuel used in theater.²⁵ Ultimately, DOD would like there to be just one in part to decrease risks associated with the elaborate and vulnerable fuel delivery system now in place. However, that may be several years away. Although DOD has been exploring the use of synthetic fuel for aircraft, there is no indication that DOD is actively pursuing alternative fuels for battlefield ground vehicles. There is speculation that this is due to the difficulty of altering the current logistical system and also to the fact that research and development in alternative ground fuel are still in the early stages.²⁶

²⁵ "The Drivers for Alternative Aviation Fuels" presentation by William Harrison, Senior Advisor, Assured Fuels Initiative, US Department of Defense.

²⁶ "A Cross Force Perspective on the Alternative Energy Sources Available to the Military." 2nd Military Energy (continued...)

Synthetic Fuel

The technology used to produce synthetic liquid fuel from coal, natural gas, or other solid carbon-containing feedstocks has existed since around 1923 when two German researchers, Franz Fischer and Hans Tropsch, found a way to turn carbon-based materials into useable petroleum products. Their discovery—the “Fischer-Tropsch” process—forms the basis of the technology in use today.²⁷ Synthetic fuel can also be extracted from oil shale and tar sands (also referred to as oil sands), forms of organic-rich sedimentary rock abundant in North America.²⁸

Pros

There are many positive qualities associated with Coal-To-Liquid (CTL) and Gas-To-Liquid (GTL) fuels produced via the Fischer-Tropsch (F-T) process. The most frequently cited advantage is that it burns cleaner producing fewer carbon emissions as a result of its consumption in the aircraft. F-T fuels produce approximately 2.4% less carbon dioxide, 50%-90% less particulate matter, and 100% less sulphur than traditional petroleum-based fuels. Other positive attributes of F-T fuels include excellent low temperature properties that improve high altitude operations and low temperature starting; and “superior” thermal stability, which makes possible the development of highly fuel efficient engines.²⁹

Another oft cited advantage of F-T fuel for DOD is that it can be produced using resources available within the United States. Coal and natural gas, two common feedstocks³⁰, are relatively abundant in the United States. The Energy Information Administration³¹ estimated in a 1995 report that the United States has an approximately 250 year supply of coal.³² It should be noted that an increased demand for coal driven by a growing F-T industry may affect that estimate.

The Air Force has already conducted testing of F-T GTL fuel with positive results. In September, 2006, at Edwards Air Force Base in California, the Air Force tested a 50/50 mix of F-T synthetic fuel and Jet Propellant 8 (JP-8) in one engine of a B-52 Stratofortress. No detrimental effects

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Alternatives Conference, Arlington, VA, February 21, 2007.

²⁷ In the Fischer-Tropsch process, a carbon-containing feedstock such as coal or biomass is ‘gasified’ (combined with steam to produce a gas consisting of primarily carbon monoxide and hydrogen), then combined with a catalyst in a chemical process that produces liquid hydrocarbons (e.g., synthetic jet fuel and other usable products such as diesel fuel, alcohol, and lubricants.) Carbon dioxide and water are byproducts of the Fischer-Tropsch process.

²⁸ On April 12, 2005, in testimony before the Senate Energy and Natural Resources Committee, Mr. Mark Maddox, Principal Deputy Assistant Secretary for Fossil Energy, Department of Energy, stated it was estimated in the early 1980s that the United States contains approximately 1.8 trillion barrels worth of oil shale approximately 300 billion of which is readily accessible. The oil shale is concentrated primarily in Utah, Colorado, and Wyoming. In Alberta, Canada, oil is produced from oil sands at a rate of over 1 million barrels per day. The rate of production is expected to exceed 2 million barrels per day within eight years.

²⁹ Department of Defense presentation, “The Drivers for Alternative Aviation Fuels” by William E. Harrison, III, DOD Assured Fuels Initiative.

³⁰ “Feedstock” refers to the main carbon-containing material from which synthetic fuel is manufactured.

³¹ The Energy Information Administration (EIA), the statistical agency of the U.S. Department of Energy, was created by Congress in 1977 to provide unbiased energy data, analysis, and forecasting to policy makers. For further information, see <http://www.eia.doe.gov/neic/aboutEIA/quickfacts.html>.

³² Energy Information Administration, Coal Industry Annual 1995 (DOE/EIA-0584) (Washington, D.C.: U. S. Department of Energy, 1995).

were noted as a result of the flight. In December, 2006, the Air Force tested the synthetic fuel mixture in all eight of the B-52's engines and again, no detrimental effects were noticed. The last set of tests—cold weather engine starting—took place in January, 2007, at Minot Air Force Base in North Dakota. Detailed data analysis and further inspections of the aircraft and its engines are ongoing.

Cons

Challenges involved with the large-scale production of F-T fuel may make its long-term use by DOD problematic. Notwithstanding the low carbon emissions produced by burning F-T fuel in engines, total carbon emissions generated through the fuel's production and use are estimated to be twice that of petroleum-based fuel. Although advocates of F-T argue that the carbon emissions generated during fuel manufacture can be sequestered,³³ U.S. Department of Energy (DOE) officials and other experts have stated that large-scale carbon sequestration is several years away.³⁴

Emissions from F-T fuels seems to be of general concern as examination of the technology continues. The Air Force acknowledges that capturing carbon emissions is the “big issue” as they move ahead with the exploration of F-T fuels.³⁵ According to an Air Force spokesperson, DOD is working with the Department of Energy, the Defense Logistics Agency, and the Task Force on Strategic Unconventional Fuels³⁶ to explore ways to mitigate the problems that may be associated with F-T fuel production.³⁷ Furthermore, legislation proposed in January 2007 (S. 154, S. 155, and H.R. 370. See **Appendix** for relevant legislative language.) calls for the Secretary of Energy, in cooperation with the Administrator of the Environmental Protection Agency, the Administrator of the Federal Aviation Administration, the Secretary of Health and Human Services, and the Secretary of Defense, to report on emissions from F-T products used as transportation fuel.

Although F-T fuel burns cleaner in aircraft engines, the fuel's lack of sulphur presents two problems for the engines. One is that it reduces the fuel's ability to provide lubrication causing stress on the engine's moving parts. The other problem is that less sulphur results in fewer aromatic hydrocarbons, which, in traditional petroleum-based fuels, have the desirous effect of causing engine seals to swell and prevent leakage.³⁸

³³ Carbon sequestration is the practice of capturing carbon emissions at their source, before they are released into the atmosphere, then transporting them to a long-term storage location such as a geological reservoir or the deep ocean. For further information on carbon sequestration see CRS Report RL33801, *Carbon Capture and Sequestration (CCS)*, by (name redacted).

³⁴ In their draft environmental impact statement for a proposed CTL project in Pennsylvania, DOE stated that large-scale carbon sequestration may become “technically practicable with in the next 15 years.” See “DOE Admits CO2 Sequestration Years Away in Coal-To-Fuel Plant Study.” *Defense Environment Alert*, Vol. 15, No. 2, January 23, 2007.

³⁵ “Air Force Seeks Commercial Airlines’ Support in Push for Synfuels.” *Inside the Air Force*, March 23, 2007.

³⁶ The Energy Policy Act of 2005 mandated the creation of a Task Force to “develop a program to coordinate and accelerate the commercial development of strategic unconventional fuels.” Members of the task force are the Secretaries of Energy, Interior, and Defense or their designees, the Governors of affected States, and representatives of local governments in areas affected by the development of unconventional fuels.

³⁷ Testimony of Mr. Michael Aimone before the Senate Finance Committee hearing on The Future of Energy, February 27, 2007.

³⁸ http://www.racq.com.au/cps/rde/xchg/racq/cms_production/hs.xsl/Motoring_Maint_Repairs_Foun_factsheet_low_sulphur_diesel_ENA_HTML.htm

Critics of F-T fuel also point to the potential environmental hazards posed by increased coal mining as an additional drawback. Some fear a “mining boom” that could lead to the strip mining of public lands, degraded water quality in some locations, and additional miners put at risk. They question whether a relatively small dent in oil imports is worth what they predict as a 40% increase of coal production. Instead a need for increased fuel efficiency and cleaner energy alternatives is often cited.³⁹

Recent efforts at constructing F-T plants in the United States have proven challenging. In September 2006, after supplying DOD 100,000 gallons of synthetic fuel to test in the B-52, Syntroleum, a company that produces synthetic fuel, closed its demonstration plant in Tulsa, Oklahoma, its revenue falling after completion of its contracts with DOD and the Department of Transportation.⁴⁰ In a February 2007 hearing before the House Energy and Commerce Committee, Secretary of Energy Samuel W. Bodman, in response to questions about why the Department of Energy proposed halting funding for a CTL diesel fuel plant in Pennsylvania, stated that the “financial viability” of the project was questionable.⁴¹ Cost estimates had grown from an original \$612 million in 2003 to approximately \$800 million. On the other hand, potential developers may be encouraged by DOD’s interest in synthetic fuels. In May 2006, when the Defense Energy Support Center, the agency within the Defense Logistics Agency that purchases fuel for DOD, asked companies to submit proposals for the production of 200,000 gallons of F-T fuels for testing by the Air Force and Navy in 2008 and 2009, it received over 20 responses.⁴²

The Air Force has set a goal of using a domestically produced synthetic fuel blend for 50 percent of its aviation fuel by 2016. At current usage rates, that would require approximately 325 million gallons of mixed fuel a year. The number of plants that would be required to reach this capacity have been reported at five and ten.⁴³ Establishing plants in the United States would reportedly take several years and a significant amount of capital. Estimates for the cost of construction vary between \$1 billion for a plant with a daily output of 10,000 barrels a day⁴⁴ to \$5-10 billion for a plant with a daily output of 80,000 barrels a day.⁴⁵ According to GAO, DOE estimates that a CTL plant would cost up to \$3.5 billion and require 5-6 years to build.⁴⁶

³⁹ See, for example, Margaret Kriz, “Liquid Coal.” *The National Journal*, January 6, 2007.

⁴⁰ “Pentagon May Be Taking More Cautious Approach To Alternative Fuels.” *EnergyWashington Week*, November 15, 2006.

⁴¹ Jeff Tollefson, “Keystone State Lawmakers Upset Over Plan to Eliminate Coal Fuel Project.” *CQ Today*, February 9, 2007.

⁴² “DOD Forges Ahead With Synthetic Jet Fuel Plans.” *Jet Fuel Intelligence*, December 4, 2006.

⁴³ Several media outlets have reported Air Force estimates of five processing plants, each producing 50,000 gallons a day, to meet their needs. See, for example, David Pugliese, “Lean, mean, and going green: The largest buyer of fossil fuel in the world, the Pentagon is racing to kick its habit, and the Canadian military is paying attention,” *Ottawa Citizen*, February 24, 2007. Others report the need for ten plants. See, for example, “Air Force Offers Synfuel Program Roadmap As Inhofe Pushes CTL Bill,” *EnergyWashington Week*, May 9, 2007.

⁴⁴ Coal-To-Liquid Coalition, see <http://www.futurecoalfuels.org/economy.asp>.

⁴⁵ Ed Cameron, Sasol Synfuels International (Pty) Ltd, “Synthetic Fuels—the Sasol Experience,” (presented at The 2nd Annual Military Energy Alternatives Conference, Arlington, VA, February 21, 2007).

⁴⁶ GAO-07-283, p. 60.

Compounding the difficulties posed by the high cost of constructing a F-T plant are restrictions on DOD's ability to enter into long-term contracts for fuel. Currently the department may only enter into contracts for fuel up to five years—not long enough, in the opinion of some, to provide potential suppliers with the economic assurance necessary to justify the up-front costs of building a plant. The five-year limitation is based on language in 10 U.S.C. 2306b, which outlines the circumstances under which the department may sign a “multiyear contract.” The statute defines a multiyear contract as “a contract for the purchase of property for more than one, but not more than five, program years.”⁴⁷

Proposed legislation is intended in part to alleviate this contracting restriction and thus eliminate a perceived barrier to increased F-T synthetic fuel production. The bills—*Coal-To-Liquid Fuel Energy Act of 2007* (S. 154), *Coal-to-Liquid Fuel Act of 2007* (S. 155), and *Coal-To-Liquid Fuel Promotion Act of 2007* (H.R. 370)—propose permitting the Department of Defense to enter into contracts for synthetic fuel for up to 25 years. Critics of the legislation express concern that encouraging increased CTL production before large-scale carbon sequestration is available will significantly increase carbon emissions.⁴⁸

Biofuel

Biofuels are a number of synthetic fuel products that use biological matter as a feedstock: ethanol, produced mainly from corn; cellulosic biofuel, ethanol made from cellulosic plants such as fast-growing trees, prairie grass, and agricultural waste; and biodiesel.^{49/50}

Pros

Many cite as one of the advantages of biofuel that the feedstocks are renewable. Also, unlike synthetic fuel from coal and natural gas, biofuel can theoretically be “carbon neutral.” That is the carbon dioxide emitted during the burning of biofuel is offset by the carbon dioxide consumed during the feedstocks' growth. However, current production methods involve the use of some carbon emitting sources, which detracts from the claim of carbon neutrality.

Cons

In its present state of technological development, the energy density of biofuel is too low to make it a suitable substitute for jet fuel. Ethanol's energy density is approximately 25% lower than that of conventional aviation fuel and is therefore not suitable for jets' turbine engines. Furthermore, ethanol cannot operate at the extreme temperatures—both high and low—at which military aviation fuel is needed to perform. However, in 2006, the Defense Advanced Research Projects

⁴⁷ 10 U.S.C. Armed Forces, Section 2306b. Multiyear contracts: acquisition of property.

⁴⁸ See, for example, “Critics Charge Senate Synfuel Bill Fails to Promote DOD Efficiency.” *Defense Environment Alert*, Vol 15, No. 2, January 23, 2007.

⁴⁹ For more information on biofuels see CRS Report RL33564 *Alternative Fuels and Advanced Technology Vehicles: Issues in Congress* by (name redacted).

⁵⁰ Biodiesel is a synthetic fuel made from vegetable oils or animal fats. B20, the commonly used mix of 20% biodiesel and 80% petroleum-based diesel fuel—works in any diesel engine with few or no modifications. DOD began using biodiesel in 2000 and is now the nation's top purchaser of B20, buying over 15 million gallons annually. All military departments use B20 in a variety of non-tactical vehicles. For more information see the National Biodiesel Board website at <http://www.biodiesel.org> and <http://www.desc.dla.mil/dcm/files/273,13,PresentLimitationsofBiodieselFuel>.

Agency (DARPA) awarded a contract for the development of a synthetic fuel from “oil-rich crops produced by either agriculture or aquaculture (including but not limited to plants, algae, fungi, and bacteria) and which ultimately can be an affordable alternative to petroleum-derived JP-8”⁵¹ Delivery of the product for government testing is expected in 2008.

Hydrogen Fuel Cells

Hydrogen powered fuel cells are a potential alternative power source for DOD and have received considerable attention and study over the past few years.⁵² Fuel cells—thin, flat, and stackable—generate electricity through an electrochemical process that combines hydrogen and oxygen and produces water and heat as waste products. One fuel cell generates a modest amount of energy but several can be stacked together for increased power production.

Pros

Hydrogen fuel cells have many positive attributes. They are more efficient than combustion engines and do not produce carbon emissions.⁵³ They do not run down or need to be recharged but can continue operating with the addition of more fuel. For the military, hydrogen fuel cells provide the added benefits of near silent operation and reduced infrared exposure. Furthermore, for portable applications, hydrogen fuel cells weigh less than batteries and retain power longer. Finally, since hydrogen can be obtained from many sources including water, hydrogen fuel could, theoretically, be manufactured on the battlefield.⁵⁴

Fuel cells are already used on several DOD installations mostly in stationary applications such as back-up generators. At Hickam Air Force Base in Hawaii, a hydrogen station produces enough hydrogen every day to power a 30-foot long, 24-passenger fuel cell shuttle bus with a range of approximately 100 miles.⁵⁵

DOD is also exploring the use of fuel cells for ground vehicles and small portable applications. In September 2006, the Army began testing a fuel cell vehicle manufactured by General Motors, Corp.⁵⁶

Cons

A number of obstacles prohibit the wide-spread use of hydrogen fuel cells by DOD. Cost, durability, and the transport, storage and delivery of hydrogen fuel are the three largest.

⁵¹ See <http://www.fbo.gov/spg/ODA/DARPA/CMO/BAA06%2D43/SynopsisP.html>.

⁵² For background information on hydrogen and fuel cells, see CRS Report RL32196, *A Hydrogen Economy and Fuel Cells: An Overview*, by (name redacted) and Aimee E. Curtright.

⁵³ The amount of emissions produced as a result of using hydrogen fuel cells varies depending on the source of the hydrogen fuel. Hydrogen does not occur naturally by itself and must be extracted from other sources such as water or coal. If hydrogen fuel is obtained by burning a carbon rich resource such as coal, overall emissions increase.

⁵⁴ “Potential Use of Hydrogen as a Defense Logistics Fuel.” LMI Government Consulting, November 2004, p. 1-8.

⁵⁵ Gregg K. Kakesako, “Hydrogen fuel gains ground at Hickam.” *Star Bulletin*, Vol 11, Issue 315, November 12, 2006.

⁵⁶ Ken Thomas, “Army to test hydrogen fuel cell vehicle.” Associated Press, September 22, 2006.

At this stage in their development, fuel cells and hydrogen fuel are quite costly. According to DOE, a fuel cell with a generating capacity of 80 kilowatts lasts approximately 1000 hours and the energy it produces costs approximately \$110 per kilowatt hour.⁵⁷ DOE's goal is to reduce the cost to \$30 per kilowatt hour and extend the fuel cell's life to 5000 hours by 2015.⁵⁸ Finally, neither DOD nor the nation has a comprehensive system at this time to transport, store, or deliver hydrogen fuel.

In 2004, DESC issued a report that assessed hydrogen as a potential future fuel for DOD. The report concluded that hydrogen may be a viable source of fuel for small-scale power generation and portable devices within the next 10-30 years however, based on the current state of its development, employing hydrogen fuel cells in weapons systems will not be feasible for 30-40 years.⁵⁹ The volume of liquid hydrogen required to power a Navy ship, for example, is four times the volume of conventional fuel. Either carrying capacity on the ship for hydrogen fuel would need to be expanded four times—especially difficult on ships that are already space-restricted—or the ship would have to refuel four times as often. Also, since hydrogen is highly flammable, there is no practical way at the present time to carry it aboard a ship. Similar obstacles preclude its use as an aviation fuel.⁶⁰

“Trash to Gas”

Current research indicates a potential way to convert solid waste at deployed DOD locations into a fuel source. Power demands of today's military base-camps have risen sharply over the past several years requiring more fuel deliveries to power generators.⁶¹ Various technologies exist to turn some of the solid waste generated at the camps into fuel. The technologies vary in efficiency rates and range from incineration—the least efficient conversion method—to pyrolysis, which is the chemical decomposition of organic matter and has an efficiency rate of approximately 70-90%.⁶²

Pros

Turning a camp's waste into a source of energy could benefit DOD in two ways: 1) by decreasing the amount of fuel that must be transported to the camp and 2) by reducing the amount of waste that must be taken out. According to a study conducted by the Army, approximately 79% of waste generated in the field is a potential source of energy.⁶³ Meals Ready to Eat (MRE) are a prime source for much of it.

⁵⁷ According to the Energy Information Administration, the average cost of a kilowatt hour of electricity in the United States in 2006 was 8.8 cents.

⁵⁸ Figures provided by Kathi Epping, U.S. Department of Energy Hydrogen Program, Fuel Cell Sub Program, during a presentation at the 2nd Annual Military Energy Alternative Conference, Arlington, VA, February 21, 2007.

⁵⁹ “Potential Use of Hydrogen as a Defense Logistics Fuel.” LMI Government Consulting, November 2004., p. iii.

⁶⁰ *Ibid.*, p. 4-22.

⁶¹ There are many reasons for the increased energy demand including the need for climate control and the increased use of personal electronic devices by today's service members.

⁶² Dr. Rosemary Szostak, LMI Government Consulting, “Reducing Fuel Requirements with Alternative Technologies.” 2nd Annual Military Energy Alternative Conference, Arlington, VA, February 20, 2007, p. 15.

⁶³ Szostak presentation, p. 13.

Cons

One of the challenges of “trash-to-gas” technologies will be making them easy to operate for service members. Additionally, although seven pounds of plastic waste theoretically equates to about one pound of JP-8, there is not enough plastic waste generated in-theater to make on-site production of aviation fuel feasible.⁶⁴ DOD is also looking into other “trash-to-gas” options. In early 2007, DARPA awarded a contract for the further exploration of a technology that produces plastics from plant oils, which can then be broken down into biodiesel in the field.⁶⁵

Solar Power

Solar power has been successfully used to fly unmanned aerial vehicles as well as manned vehicles in a limited capacity. The Helios Prototype, an unmanned drone built by AeroVironment, Inc., under the National Aeronautics and Space Administration’s (NASA) Environmental Research Aircraft and Sensor Technology Program successfully demonstrated high-altitude, long-duration solar-powered flight in August 2001 when it achieved an altitude of over 96,000 feet and stayed airborne for almost 17 hours. Helios was ultra-light at just over 1,300 pounds empty and its wings, which span 247 feet, were covered with over 62,000 solar cells. During daylight, sunlight powered the aircraft while excess energy went into an on-board fuel cell energy storage system for night operations. The aircraft, along with an experimental fuel cell package, was lost in June 2003 when it experienced control difficulties during a checkout flight near the Hawaiian islands.⁶⁶

Since that time, other solar powered aircraft have flown successfully including a manned sailplane that remained in flight for over 48 hours⁶⁷ and another unmanned drone developed by AeroVironment that used a fuel cell fueled with liquid hydrogen.⁶⁸ A group of pilots aided by the European Space Agency is developing a manned solar powered aircraft that they intend to fly around the world by 2010.⁶⁹

⁶⁴ *Ibid.* p. 22

⁶⁵ “Garbage Gas: Polytechnic University Researcher Develops Bioplastic as a Disposable source of Biodiesel.” *PR Newswire US*, March 21, 2007.

⁶⁶ National Aeronautics and Space Administration, “Past Projects—Helios Prototype,” <http://www.nasa.gov/centers/dryden/history/pastprojects/Erast/helios.html> (accessed May 14, 2007).

⁶⁷ Michael A. Dornheim, “Perpetual Motion; SoLong airplane, with lithium-ion batteries to store energy, flies through two nights on solar power. Better batteries are soon to come.” *Aviation Week & Space Technology* 162, no. 26, (June 27, 2005): 48.

⁶⁸ Roy Baybrook, “Better batteries boost drone duration,” *Armada International* 13, no. 2, (April 1, 2007): 29.

⁶⁹ “Solar Aircraft to Fly Around the World.” *Universe Today*, http://www.universetoday.com/am/publish/solar_aircraft_fly_world.html (accessed May 16, 2007).

Figure 1. Helios Prototype



Source: NASA, “Past Projects—Helios Prototype.”

Pros

The advantages of solar powered aircraft include the potential for long-duration flights perhaps lasting months, no emissions, and quiet operation. At their current rate of development, solar powered aircraft may carry relatively small payloads such as cameras or other surveillance equipment. It is possible that solar aircraft may eventually be equipped with armaments as well. Currently, the unmanned MQ-1 Predator and MQ-9 Predator B can carry relatively light-weight armaments: The MQ-1 can carry Air-to-Ground Missile (AGM)-114 Hellfire laser-guided missiles (about 100 pounds each) and the MQ-9 Predator can carry several Guided Bomb Unit (GBU)-12 laser-guided bombs (about 500 pounds each).⁷⁰

Cons

A disadvantage of solar powered aircraft, given the current state of solar technology, is that they must be light-weight with a specialized design that maximizes wing-span and minimizes drag. Their small size and light weight restricts the size of the payload they may carry. Payload capacity for Helios, for example, was only about 700 pounds. Furthermore, both solar cell and the fuel cell technology used to store the sun’s power for night operations are expensive. DARPA is soliciting industry to identify and develop improved technologies for inexpensive, very high efficiency solar cells for high altitude, long-endurance solar aircraft.⁷¹

⁷⁰ “The Air Force Handbook 2006.” The United States Air Force.

⁷¹ “Photovoltaic Cells for Very High Altitude Very Long Endurance Solar Aircraft.” DARPA SBIR 2007.2-Topic SB072-043, <http://www.zyn.com/sbir/sbres/sbir/dod/darpa/darpa072-043.htm> (accessed May 16, 2007).

Decreasing Petroleum-based Demand

Increasing fuel efficiency and eliminating areas of waste are the most expedient ways DOD can reduce its reliance on petroleum-based fuel. Just as military facilities abound with potential ways by which DOD can save energy such as replacing old heating and cooling systems with more energy efficient models, there are ways in which DOD's weapon systems and operations can be made more fuel-efficient. The Air Force, has modified some operational practices and systems to improve energy efficiency and is considering others.

Light-weighting

Light weight composite materials could greatly increase the fuel efficiency of all DOD platforms. Lighter vehicles can travel faster on less fuel. In one effort to light-weight, DOD is striving for a low-cost titanium alloy to replace the heavy steel used in many weapon systems. Titanium is valued for military applications because of its high strength-to-weight ratio and its resistance to corrosion. At approximately \$30 per pound, titanium alloys are too costly for large-scale military applications and are generally reserved for select aviation and space applications. DARPA, is sponsoring a program to develop an environmentally friendly production capability for a titanium alloy under \$4 per pound.⁷²

Another way to reduce fuel consumption is to use more unmanned aerial vehicles (UAV), which are inherently lighter than manned vehicles. The absence of an operator precludes the necessity of including on an aircraft many elements that increase its weight including added protective armor, seating, communications and other life-sustaining equipment.⁷³

Pros

UAVs are becoming increasingly sought after by DOD for surveillance activities since they preclude having to put a service member in danger and are low-cost relative to the manned systems.

Cons

UAV provide DOD with several advanced capabilities; however, they are less than universally applicable as many operations still call for the judgement and flexibility of on-scene human operators.

Increase Landing Weights

DOD policy dictates a maximum take-off and landing weight for all aircraft based on their individual structural limitations. The weight for take-off and landing may be the same or an aircraft's landing weight may be less than that with which it may take off. The KC-135 refueling tanker has one of the most restrictive landing weight requirements in the Air Force fleet. If a

⁷² <http://www.darpa.mil/dso/thrust/matdev/titanium.htm>

⁷³ For more information on UAVs see CRS Report RL31872, *Unmanned Aerial Vehicles: Background and Issues for Congress*, by (name redacted) and (name redacted).

KC-135 approaches a landing too heavy, the crew must rid the aircraft of excess fuel by either continuing to fly or by releasing it from the aircraft while in-flight. The Air Force recently, by changing their policy, increased the safe landing weight of a KC-135 thus allowing it to keep more fuel onboard when it lands. However, changing the landing weight is only an available options for some aircraft. The C-5, for example, one of the heavier fuel users in the Air Force fleet, has the same take off and landing weight negating the need to get rid of excess fuel weight.

Pros

Simply changing a policy to negate the need to discard excess fuel is an expedient way to save. There may be other weapon systems for which a similar re-evaluation can be made.

Cons

By simply changing a policy to allow an aircraft to land with more weight, the Air Force has accepted greater risk to the aircraft and its crew. The service has evidently made the decision that the greater risk is within acceptable limits, however, the long-term affects of the added wear and tear to the aircraft are unknown at this time.

More Direct Flights

Using the most direct routes between points means flying shorter distances and burning less fuel. However, conditions such as military overflight restrictions imposed by some foreign governments may prevent DOD from using the most direct route between destinations. The Air Force is reviewing flight paths and re-evaluating where it may be able to use more direct routes. The service has claimed that by doing so it saved \$46 million in Fiscal Year 2006.⁷⁴

Pros

Saving fuel by eliminating unnecessary miles seems to one of the more simple efficiency measures: it requires no modification to the aircraft and can be put in place wherever applicable, regardless of the weapon system involved. It therefore makes sense to employ this method of cost-saving wherever possible.

Cons

Routing aircraft on more direct flights may seem uncomplicated in theory but in practice other factors may make shortening routes less than optimally efficient. Circuitous routes may use more fuel than direct ones but circuitous flights may take advantage of other efficiencies. For example, a particular route structure, though perhaps circuitous, may exist to transport people and materiel between military locations and thus negate the need for multiple direct routes between points. Furthermore, direct routes may not always be possible due to weather and changes in diplomatic relations between the United States and other governments.

⁷⁴ Headquarters United States Air Force (A3/5) Staff, "AF Aviation Operations," January 22, 2007, 3.

Relocate Aircraft

Aircraft stationed close to the front lines require less fuel to reach the battlefield than those stationed at a distance. With fuel savings as a consideration, the Air Force repositioned B-1 Bombers supporting military operations in Iraq from a base in Diego Garcia to Al Udeid Air Base in Saudi Arabia. Assuming an approximate flying distance saved as 2400 nautical miles, an approximate cruising rate of 450 nautical miles per hour, and a fuel usage rate of 3,874 gallons per flying hour, the move saves over 40,000 gallons of fuel per sortie.⁷⁵

Pros

Moving aircraft closer to the front lines is another way to decrease fuel use without the expense of modifying aircraft and may be applied to a number of weapon systems. Fewer miles flown may also eliminate the need for refueling thus saving the cost of fuel and flying hours involved in the tanker refueling mission.

Cons

In some cases, relocating aircraft may be costly. It may require changes to basing infrastructure and movement of personnel and accompanying support structure. Additionally, the cost to lease space may increase. Other, less tangible factors may also come into play such as the diplomatic and strategic value of maintaining a military installation in a particular country or region despite its distance from the front line.

Decrease Aircraft Rotations

Rotating aircraft between the United States and bases supporting operations overseas takes a great deal of fuel—approximately 150,000-450,000 gallons of fuel per aircraft per rotation.⁷⁶ The Air Force re-assessed the number of times certain Air Force Wings needed to rotate and concluded that fewer rotations would not adversely affect their ability to support combat operations.

Pros

For some Air Force Wings, keeping the aircraft in theater longer while rotating personnel is an expedient way to conserve fuel and aircraft flying hours.

Cons

One of the reasons aircraft get rotated back to the United States is for scheduled maintenance at large logistics centers located here. In a rapidly aging fleet, routine maintenance becomes increasingly important. Furthermore, the climate and environmental factors present in the current theater of operations causes intense wear and tear, increasing their need for upkeep. It is also worth pointing out that for some flying disciplines, flights between the forward bases and the

⁷⁵ Distance flown out and back.

⁷⁶ “AF Aviation Operations,” 3.

permanent bases in the United States is not all wasted time. Those flights may, in some cases, be used to accumulate flight training hours needed by pilots to remain proficient in their aircraft.

Increase Simulator Use

Many gallons of fuel are consumed by the necessary task of training new pilots and maintaining the proficiency of experienced ones. Although simulators have been used to train aviators for many years, actual cockpit training has always been preferred. The DOD Fiscal Year 2007 budget request included funding to study the extent to which flight simulators can and should substitute for training in the actual aircraft. The department estimates that increasing simulator use could save \$1 billion a year.

Language contained in the John Warner National Defense Authorization Act for Fiscal Year 2007 (P.L. 109-364) may limit DOD's ability to aggressively pursue increased use of simulators. A September 2006 GAO study found that DOD use of its simulators fell short of what the department paid for under their service contracts.⁷⁷ Congress subsequently passed legislation prohibiting DOD from entering into a service contract for military flight simulators, which will require DOD to acquire and operate simulators using in-house resources.⁷⁸ DOD contends that contractors' ability to maintain and quickly update simulators results in better training and cautions that department-run simulators may not be as effective.

Pros

Saving fuel and wear and tear on aircraft are the two advantages of using simulators. Simulators are also safer. They also, in theory, provide more flexible scheduling. Naturally factors such as availability of qualified simulator operators or working status of the equipment affect a simulators' availability.

Cons

Air Force leaders have legitimate concerns over how much simulator training is the right amount. Although the quality of simulator software is constantly improving, the experience gained by sitting in a box in a room is significantly different from the experience gained in a real aircraft thousands of feet in the air with real dangers and real consequences. At present, the point at which too much simulator training reduces the operational effectiveness of a pilot is unknown.

⁷⁷ See GAO-06-830, *Contract Management, Service Contract Approach to Aircraft Simulator Training Has Room For Improvement*

⁷⁸ P.L. 109-364 (Section 832.) Limitation on contracts for the Acquisition of Certain Services. 1. (a) Limitation - Except as provided in subsection (b), the Secretary of Defense may not enter into a service contract to acquire a military flight simulator.

(b) Waiver - The Secretary of Defense may waive subsection (a) with respect to a contract if the Secretary—

(1) determines that a waiver is necessary for national security purposes; and

(2) provides to the congressional defense committees an economic analysis as described in subsection (c) at least 30 days before the waiver takes effect.

Install Winglets

Winglets, relatively small vertical extensions attached to the end of an aircraft's wingtips, reduce drag and can increase an aircraft's fuel efficiency.⁷⁹ The House Committee on Armed Services, in their report on the National Defense Authorization Act for Fiscal Year 2007 (H.Rept. 109-452 of May 5, 2006. See **Appendix** for relevant legislative language.), discussed the merits of winglets and directed the Secretary of the Air Force to examine the feasibility of adding them to Air Force aircraft. As a result, the Air Force sponsored a study to assess the feasibility of applying winglets to large aircraft: refuelers, airlift, and intelligence, surveillance, and reconnaissance. The study was intended to determine the price of fuel at which applying winglets becomes cost-effective, their impact on maintenance and flight operations, and a possible investment strategy.⁸⁰

Figure 2. KC-135 Winglet Flight Tests at Dryden Flight Research Center



Source: Chambers, "Winglets."

Pros

Winglets may be a relatively inexpensive way to improve the fuel efficiency of even some of the larger aircraft in the Air Force fleet.

Cons

Any time aircraft are taken out of the fleet for retrofitting, it is an additional expense and takes an aircraft out of commission for a period of time. Furthermore, it is possible that the cost of the research and development of winglets combined with their installation may be more than the actual savings.

⁷⁹ Joseph R. Chambers, *Concept to Reality: Contributions of the NASA Langley Research Center to U.S. Civil Aircraft of the 1990s* (Washington D.C.: NASA, 2003), "Winglets", <http://oea.larc.nasa.gov/PAIS/Concept2Reality/winglets.html>.

⁸⁰ The National Academies, "Current Projects: Assessment of Aircraft Winglets for large Aircraft Fuel Efficiency," The National Academies, <http://www8.nationalacademies.org/cp/projectview.aspx?key=48728>.

Other

Other strategies may further reduce fuel use. One, borrowed from the commercial aviation industry, is to remove extraneous weight such as unnecessary or redundant gear and provisions. Another strategy is to instill awareness in the operational community of the necessity of using fuel smartly. In fall 2006, Air Force leadership communicated to its flying units the importance of adopting a fuel-saving culture and the service's goal of reducing aviation fuel consumption by 10% over the next five years.

Pros

Removing excess items from aircraft and promoting fuel-saving within the department are cost-effective measures that are relatively easy to implement.

Cons

Redundancy in potentially dangerous situations is not by itself negative. Commercial airlines have taken efforts to minimize the weight of their aircraft in order to conserve fuel and increase profits. The military is not concerned with profits but with ensuring the safety of its crew members. Maintaining a healthy supply of safety and other equipment onboard aircraft may reduce risk and increase the survivability of the crew. And although instilling fuel-saving awareness in DOD personnel is a worthy endeavor, the extent to which individual operators will make a difference in DOD fuel consumption remains to be seen and will be difficult to measure.

Issues

DOD's efforts to explore greater use of alternative aviation fuel and to reduce its overall consumption of petroleum-based fuel have been lauded by many. However, the department's ability to follow through with its initiatives may be adversely affected by a number of factors. They include DOD organizational structure, funding, and external expectations for DOD in the nation's search for alternative fuel sources.

DOD Organizational Structure

The perception among many in DOD and others in the federal government seems to be that there are no clear organizational lines of responsibility to lead and manage the department's energy reduction efforts.⁸¹ This may adversely affect its ability to complete long-term projects that are underway and to fund or implement new ones.

⁸¹ In February 2007, during 2nd Annual Defense Energy Alternatives Conference, a representative from the Defense Energy Support Center stated that the lack of a central DOD office that could interact with DESC, the Department of Energy, and other agencies was a "huge problem in DOD." Furthermore, in November 2006, an individual within DOD stated during an interview that there was no single focal point to lead the department's efforts in energy. Also, another individual in DOD, involved with the Energy Security Task Force, related that although DDR&E was at that time acting as the coordinator for the task force, no office or individual had been designated as wholly responsible for coordinating the various energy-related activities within the department.

Many offices within DOD have responsibility for individual energy-related initiatives but the growing number and complexity of activities seem to have grown beyond the current capabilities of the organizational structure. The USD (AT&L) has been directed to ensure the implementation of President's Bush 2007 Executive Order and to "continue efforts of the Energy Security Task Force by implementing the findings and monitoring implementation"⁸² However, there does not appear to be a designated individual in that office to oversee a comprehensive department-wide energy strategy—to prioritize, coordinate, and advocate for the various ongoing projects.

There are a number of other DOD offices that play an energy role to varying degrees. The Office of the Deputy Under Secretary of Defense for Installations & Environment (DUSD (I&E)) has traditionally had oversight of energy issues related to utilities and facilities, but does not have any oversight of fuel savings initiatives in the operational community. The office of DDR&E oversees research and engineering efforts for the department and its director, the Honorable John J. Young, Jr., frequently speaks for DOD's on its fuel reduction efforts. DARPA sponsors active research that turns new discoveries into useful military applications but does not develop policy for the department. And although these offices all fall under USD (AT&L), other relevant agencies that do not, including the individual military services, have ongoing projects that must also compete for a share of the DOD budget.

Funding

Some believe the Air Force seems reluctant to use some additional operational funds for energy-efficiency improvements at this time. Government studies seem to indicate that the most cost-effective way to reduce reliance on petroleum-based fuel—absent leaps in technology that make synthetic fuel abundant and affordable—is to increase the energy-efficiency of current weapon systems. The Defense Science Task Force 2001 study specifically noted that the engines in the B-52H would be profitable candidates for upgrades. The DSB submitted that upgrading its engines would not only reduce fuel usage on the B-52H but that studies suggested it would also reduce tanker force structure requirements.⁸³ However, amid debates over which and how many aircraft the Air Force should retire, the service seems reluctant to spend money upgrading aging aircraft. For example, in March 2007, media sources reported that the Air Force declined a proposal by engine manufacturer Pratt&Whitney to upgrade the B-52H bomber's TF-33 engines, some of the oldest in the service's inventory.⁸⁴ (The B-52H is reportedly expected to remain in service until 2040.⁸⁵)

DOD's funding strategy for energy initiatives likely reflects the department's placement of energy in its priorities. According to DDR&E, \$1.8 billion of DOD's FY2007-FY2011 budget is intended for energy related projects.⁸⁶ Some may argue that \$1.8 billion over five years is a small portion

⁸² The Honorable Gordon England, Deputy Secretary of Defense, to Secretaries of the Military Departments, Chairman of the Joint Chiefs of Staff, Under Secretary of Defense for Acquisition, Technology, and Logistics, 16 February 2007. The memo states in part that USD (AT&L) will "develop and implement necessary policies and guidance to support implementation [of President Bush's Executive Order 13423]."

⁸³ DSB Report, ES-5.

⁸⁴ For more information on long range bombers see CRS Report RS21848, *Air Force FB-22 Bomber Concept*, by (name redacted).

⁸⁵ Michael Sirak, "Pratt & Whitney Offers air Force Upgrades To TF-33 Engines On B-52H Bomber," *Defense Daily*, March 29, 2007.

⁸⁶ The Honorable John J. Young, Jr., DDR&E, and Mr. Philip W. Grone, DUSD (I&E), "Joint Statement before the (continued...)"

of a Research, Development, Test and Evaluation budget that received approximately \$75.5 billion in just the FY2007 Defense Appropriations Act (P.L. 109-289). However, others might contend that in the currently tight defense budget environment, limiting the amount spent on future concepts is a prudent decision. As a result, funding for energy efficiency and alternative fuel initiatives may continue to fall behind other priorities without a department-wide strategy that outlines goals and places energy within a larger set of DOD priorities.

If DOD chooses not to allocate funding to energy-related research, Congress may elect to legislate certain funding strategies. For example, legislation proposed in January 2007 (S. 154, S. 155, and H.R. 370. See **Appendix** for relevant legislative language.) would provide \$10,000,000 to the Air Force Research Laboratory to continue the testing, qualification, and procurement of synthetic jet aviation fuel from coal.

External Expectations

Another issue is the degree to which DOD can take on an energy leadership role in the federal government. Uncertainty regarding DOD's role in a government energy strategy may contribute to the department's seeming reluctance to lay out its own strategy, and committing the necessary resources and organizational structure to carrying it out. Some outside DOD seem to view it as a potential leader in the effort to develop and use alternative forms of energy, particularly synthetic fuel.⁸⁷ Although DOD's fuel purchasing power is small relative to the collective purchasing power of the commercial aviation industry,⁸⁸ the department's tradition of being technologically forward-thinking is frequently cited as a basis for expecting leadership in the energy arena as well.⁸⁹

However, DOD seems to eschew attempts to impose upon it a role beyond facilitator—a catalyst for the development of new technologies; a test-bed and potential market. When questioned by the House Armed Subcommittees on Terrorism, Unconventional Threats, and Capabilities and Readiness regarding DOD's role in developing new technologies for alternative fuels, DOD witnesses consistently responded in language that drew clear boundaries around DOD's role:⁹⁰

Mr. John Young, DDR&E: So, across the board, I think the department is a partner with other agencies in the government and the commercial industry, which is helping to drive this space, and push the technology forward both on revolutionary spaces and then in areas where we see—or evolutionary spaces and then places where we see chances at a revolution...

(...continued)

House Subcommittees on Terrorism, Unconventional Threats and Capabilities; and Readiness of the House Armed Service Committee," September 26, 2006, 8.

⁸⁷ See, for example, the "Opening Statement of Chairman Jim Saxton before the House Committee on Armed Services Subcommittee on Terrorism, Unconventional Threats and Capabilities," September 26, 2006, and "Air Force Offers Synfuel Program Roadmap As Inhofe Pushes CTL Bill," *EnergyWashington Week*, May 9, 2007.

⁸⁸ The Honorable Michael Wynne, Secretary of the Air Force (address, Air Force Energy Forum, Arlington, VA, 8 March 2007). Mr. Wynne stated that the buying power of the commercial airlines "constitutes approximately 85% of the market."

⁸⁹ For example, see, James Bernstein, "A powerful mission; At Congressman's behest, LI defense contractors agree to seek alternative fuels," *Newsday* (New York), October 19, 2006.

⁹⁰ Testimony before the House Armed Services Committee; Terrorism, Unconventional Threats and Capabilities Subcommittee; and Readiness Subcommittee, September 26, 2006.

Mr. Philip Grone, DUSD (I&E): So I do think there's a synergy between activities of the department, activities of the broader federal family and industry, both in research and development and the actual application of the technologies, the vehicles, where we can have an effect on understanding and ultimately of markets in terms of demonstrating the viability of certain technologies.

Mr. Michael Aimone, Deputy Chief of Staff, Air Force Installations, Logistics, and Mission Support: [The Air Force has] the ability to certify fuel for aviation airworthiness.

Mr. Richard Connelly, Director, DESC: ...I think it's the role of the services and the department, DOD, to give us [DESC] the go ahead and the operational supply chain manager, to go ahead and move forward in these markets. You did mention, Mr. Chairman, earlier the percentage of domestic consumption. Internationally, that translates to something less than one-half of one percent of total fuel consumed. So while we are probably the biggest single purchaser of fuel in the world and certainly a voice to be heard in the marketplace, we're not going to move the market, but we can try to exhibit some leadership.

Within DOD, the Air Force is viewed as being on the front-line in the development of alternative aviation fuel. The service has received much attention for its initiative to test and certify a synthetic fuel blend in its B-52 but even as it continues to announce its intention to acquire 50% of its domestically purchased fuel as a synthetic blend by 2016, the service remains steadfast that it needs the support of the commercial aviation industry.⁹¹

It is unclear to what extent the commercial aviation industry is prepared to expand its own role in developing synthetic aviation fuel. In her remarks to the 2007 Air Force Energy Forum, Ms. Marion Blakey, Administrator of the Federal Aviation Administration, stated, "It's clear that the military's energy security mission is something we're all going to have to be a part of." and later, acknowledging DOD's 2016 goal added, "And I want Secretary Wynne and all of you to know that the commercial side will be right there with you."⁹²

Options for Congress

Considering the issues discussed, there appear to be at least six options for Congress. These potential options may be mutually reinforcing and not "either/or" options.

Mandate the Establishment of an DOD Office of Energy Security

DOD's progress in energy security may be enhanced with clearer lines of authority. Currently, different offices within DOD share responsibility for the department's various energy related initiatives. The office of the Director, Defense Research and Engineering seems to have taken on something of a leadership role but, notwithstanding its leadership of the DOD Task Force on Energy Security, DDR&E's mission is to "ensure that the warfighters today and tomorrow have superior and affordable technology to support their missions, and to give them revolutionary war-winning capabilities."⁹³ Its mission does not encompass many other possible aspects of energy

⁹¹ Wynne address to the Air Force Energy Forum, 8 March 2007.

⁹² "'Civil Aviation Gets Green Light,' by Marion C. Blakey." States News Service, March 8, 2007.

⁹³ From DDR&E's website available at <http://www.dod.mil/ddre/mission.htm>.

strategy such as acquisitions, installations, finances, and operations. On the other hand, it may be argued that adding another layer of “bureaucracy” is unnecessary when functions are already in place to handle individual issues.

There are also those who express concern that enthusiasm for recent energy initiatives will wane once a sense of urgency regarding energy availability and prices has subsided. Without a dedicated DOD focal point to ensure consistent progress of the various energy related activities within the department, this concern may have some merit. In light of the financial demands put on DOD by ongoing operations, it is possible that without a dedicated advocate, funding for energy related initiatives may be discontinued or postponed indefinitely. Conversely, others argue that the nature of today’s energy “crisis” is unlike that which faced the nation in the 1970s and 1980s. Information available today regarding the contributions to greenhouse gas emissions made by fossil fuels and concerns about when world oil reserves may “peak,”⁹⁴ may keep attention focused on improving the energy efficiency of weapons and alternative energy.

Mandate Fuel Efficiency in Aircraft

A second option for Congress would be to mandate improvements in energy efficiency for existing DOD aircraft. Precedent for this exists in requirements established for DOD facilities and that have existed for many years and were recently made more stringent with President Bush’s 2005 Energy Policy Act. Furthermore, language in the Senate passed version of the FY2007 defense authorization bill (S. 2766) and conference report (H.Rept. 109-702 of September 29, 2006. See **Appendix** for relevant legislative language.) Calls for a DOD policy to improve the fuel efficiency of weapons systems and established the requirement for a report to Congress on the department’s progress toward that goal. Guidance concerning specific weapon systems was not provided allowing DOD to implement the language at their discretion.

A possible complication to this may be the continual deliberations over the most cost-effective way to spread a finite defense acquisition budget. Some contend that updating the oldest and largest of the Air Force inventory, such as the B-52, would save the most fuel. According to the Rocky Mountain Institute, re-engining one of the bombers would make it 35% more efficient.⁹⁵ Others assert that modernizing more heavily used aircraft such as the C-5 transporters makes more sense. In reality, neither the B-52 nor the C-5 are likely to be upgraded soon. Pratt&Whitney, manufacturer of the B-52H’s TF33 engines, has proposed engine upgrades to the Air Force but the service has thus far declined the offer.⁹⁶ C-5 aircraft are currently the center of a debate over the relative cost-effectiveness of upgrading the large transporter versus purchasing smaller but more versatile C-17s. The Air Force has expressed a desire to retire some older C-5s while others feel that the need for a large transporter compels the service to modernize the aircraft and maintain it in the inventory. Modernization of the C-5 centers on overall aircraft reliability and not specifically energy efficiency.

⁹⁴ Government Accountability Office, *CRUDE OIL: Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production*, GAO Report GAO-07-283 (Washington, D.C.: Government Accountability Office, 2007), ES.

⁹⁵ Amory B. Lovins, “Battling Fuel Waste in the Military,” Rocky Mountain Institute website: http://www.rmi.org/images/PDFs/Security/S01-12_BattlingFuelWaste.pdf, accessed June 14, 2007.

⁹⁶ “Pratt & Whitney Offers Air Force Upgrades to TF-33 Engines On B-52H Bomber.” *Defense Daily*, Vol. 233, Issue 59, March 29, 2007.

Mandate Fuel Efficiency as a Consideration in New DOD Acquisitions

A third option for Congress is to mandate fuel efficiency as a key performance parameter (KPP) in all new DOD acquisitions. As discussed earlier in this report, a review of the contract proposal for DOD's most recent large new aircraft, the KC-X, disclosed a relatively non-specific requirement for "maximum fuel efficiency using current aviation technology."⁹⁷ There are some reports that DOD has already altered its acquisition policies to include energy efficiency. According to DOD officials, a modified policy has not yet been created, but is in the planning stages.⁹⁸

On April 10, 2007, the Honorable Kenneth Krieg, USD (AT&L), signed a memo directing the evaluation of fuel costs in the designs of three new DOD weapon systems: the Air Force's new long-range strike aircraft, the Army and Marine Corps Joint Light Tactical Vehicle, and the Navy's CG-X, its newest cruiser.⁹⁹ In keeping with the recommendations of the Defense Science Board and the department's Energy Security Task Force, DOD will consider the "fully burdened" cost of fuel on the design of these systems figuring the costs of the entire fuel delivery system. This may be a first step to modifying acquisition guidelines. If DOD modifies its acquisition policies in such a manner, future evaluations of aircraft proposals could be based on the "fully burdened" cost of fuel leading to a closer examination of aspects of the aircraft, e.g. maintenance costs, weight, in addition to engine efficiency.

Amend Title 10 to Allow DOD to Enter Into Contracts for Synthetic Fuel Beyond Five Years

A sixth option for Congress is to pass legislation that would grant DOD the authority to enter into a contract for fuel for more than five years. Recent proposed congressional legislation (S. 154, S. 155, and H.R. 370) would allow DOD to enter into contracts for synthetic fuels for up to 25 years. This option may make it possible for DOD, through lengthy contracts, to provide potential synthetic fuel developers an incentive to invest in this capital intensive venture. On the other hand, the proposed legislation would not mandate that DOD use this contracting option and the department may not elect to do so.

⁹⁷ KC-X Solicitation 01, Section J, Attachment 1, System Requirements Document, p. 13. http://fs2.fbo.gov/EPSPData/USAF/Synopses/905/FA8625-07-R-6470/SectionJAttachment1R2_1KC-XSRD-20070125.doc accessed March 16, 2007.

⁹⁸ Discussions with DOD personnel, February 2007.

⁹⁹ Jason Sherman, "Fuel Costs to be Key Factor in Designs for Three Major Weapon Systems." *Inside the Pentagon*, Vol. 23, No. 16, April 19, 2007.

Direct DOD to Devote More Funding to Research and Development of Long-term Alternative Energy Sources for Aviation

Solar powered aircraft are in the early stages of development. DOD through DARPA and the Air Force Research Laboratory at Wright-Patterson Air Force Base, Dayton, OH, has some solar-related research ongoing but, observers note, more could be done. Hydrogen fuel and fuel cells are two other areas where, observers suggest, DOD could fund further research.

Mandate Alternative Fuel Use

And finally, another option for Congress may be to mandate some amount of alternative aviation fuel that DOD will buy and the fuel's origin. The Air Force has already expressed the goal of using 50% synthetic fuel by 2016 but the service has not specified what kind of synthetic fuel it intends to use. Recent tests with Fischer-Tropsch Gas-To-Liquid (GTL) fuel might lead one to believe DOD is targeting coal- or gas-based synthetic fuel for its future purchases, an approach that would likely invite opposition from those who object to CTL and GTL plants because of their carbon emissions. However, DOD has also awarded a contract for the development of a synthetic aviation biofuel, which may eventually prove successful enough to make a mandate for the use of fuel from renewable sources a viable option.

A possible drawback to a synthetic fuel mandate is that domestically produced alternative fuels may not be available for several years. The high cost of constructing the plants and the unresolved issue of how to address carbon emissions from them are two possible limitations. The fact that biofuels are not currently compatible with jet aircraft engines is another issue. Further, it is unclear that sufficient quantities of biofuel could be produced.

Appendix. Legislative Activity in FY2007

The following is a list of provisions in FY2007 DOD authorization and appropriation legislation which contribute to DOD efforts to increase its efficient use of petroleum-based fuels and increases funding for DOD to develop possibilities for using alternative forms of energy.

John Warner National Defense Authorization Act for Fiscal Year 2007 (P.L. 109-364)

Senate

Section 354 of the Senate-passed version of the FY2007 defense authorization bill (S. 2766) stated:

SEC. 354. REPORT ON ACTIONS TO REDUCE DEPARTMENT OF DEFENSE CONSUMPTION OF PETROLEUM-BASED FUEL.

(a) Report Required- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the Committees on Armed Services of the Senate and the House of Representatives a report on the actions taken, and to be taken, by the Department of Defense to reduce the consumption by the Department of petroleum-based fuel.

(b) Elements- The report shall include the status of implementation by the Department of the requirements of the following:

(1) The Energy Policy Act of 2005 (P.L. 109-58).

(2) The Energy Policy Act of 1992. (P.L. 102-486)

(3) Executive Order 13123.

(4) Executive Order 13149.

(5) Any other law, regulation, or directive relating to the consumption by the Department of petroleum-based fuel.

Section 375 of the Senate-passed version of S. 2766 stated:

SEC. 375. ENERGY EFFICIENCY IN WEAPONS PLATFORMS.

(a) Policy- It shall be the policy of the Department of Defense to improve the fuel efficiency of weapons platforms, consistent with mission requirements, in order to—

(1) enhance platform performance;

(2) reduce the size of the fuel logistics systems;

(3) reduce the burden high fuel consumption places on agility;

(4) reduce operating costs; and

(5) dampen the financial impact of volatile oil prices.

(b) Report Required-

(1) IN GENERAL- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report on the progress of the Department of Defense in implementing the policy established by subsection (a).

(2) ELEMENTS- The report shall include the following:

(A) An assessment of the feasibility of designating a senior Department of Defense official to be responsible for implementing the policy established by subsection (a).

(B) A summary of the recommendations made as of the time of the report by

(i) the Energy Security Integrated Product Team established by the Secretary of Defense in April 2006;

(ii) the Defense Science Board Task Force on Department of Defense Energy Strategy established by the Under Secretary of Defense for Acquisition, Technology and Logistics on May 2, 2006; and

(iii) the January 2001 Defense Science Board Task Force report on Improving Fuel Efficiency of Weapons Platforms.

(C) For each recommendation summarized under subparagraph (B)—

(i) the steps that the Department has taken to implement such recommendation;

(ii) any additional steps the Department plans to take to implement such recommendation; and

(iii) for any recommendation that the Department does not plan to implement, the reasons for the decision not to implement such recommendation.

(D) An assessment of the extent to which the research, development, acquisition, and logistics guidance and directives of the Department for weapons platforms are appropriately designed to address the policy established by subsection (a).

(E) An assessment of the extent to which such guidance and directives are being carried out in the research, development, acquisition, and logistics programs of the Department.

(F) A description of any additional actions that, in the view of the Secretary, may be needed to implement the policy established by subsection (a).

Conference Report

Section 358 (P.L. 109-364, conference report of September 29, 2006) states:

SEC. 358. UTILIZATION OF FUEL CELLS AS BACK-UP POWER SYSTEMS IN DEPARTMENT OF DEFENSE OPERATIONS.

The Secretary of Defense shall consider the utilization of fuel cells as replacements for current back-up power systems in a variety of Department of Defense operations and activities, including in telecommunications networks, perimeter security, individual equipment items, and remote facilities, in order to increase the operational longevity of back-up power systems and stand-by power systems in such operations and activities.

Section 360 states:

SEC. 360. ENERGY EFFICIENCY IN WEAPONS PLATFORMS.

(a) Policy- It shall be the policy of the Department of Defense to improve the fuel efficiency of weapons platforms, consistent with mission requirements, in order to—

- (1) enhance platform performance;
- (2) reduce the size of the fuel logistics systems;
- (3) reduce the burden high fuel consumption places on agility;
- (4) reduce operating costs; and
- (5) dampen the financial impact of volatile oil prices.

(b) Report Required-

(1) IN GENERAL- Not later than one year after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report on the progress of the Department of Defense in implementing the policy established by subsection (a).

(2) ELEMENTS- The report shall include the following:

(A) An assessment of the feasibility of designating a senior Department of Defense official to be responsible for implementing the policy established by subsection (a).

(B) A summary of the recommendations made as of the time of the report by

(i) the Energy Security Integrated Product Team established by the Secretary of Defense in April 2006;

(ii) the Defense Science Board Task Force on Department of Defense Energy Strategy established by the Under Secretary of Defense for Acquisition, Technology and Logistics on May 2, 2006; and

(iii) the January 2001 Defense Science Board Task Force report on Improving Fuel Efficiency of Weapons Platforms.

(C) For each recommendation summarized under subparagraph (B)—

(i) the steps that the Department has taken to implement such recommendation;

(ii) any additional steps the Department plans to take to implement such recommendation; and

(iii) for any recommendation that the Department does not plan to implement, the reasons for the decision not to implement such recommendation.

(D) An assessment of the extent to which the research, development, acquisition, and logistics guidance and directives of the Department for weapons platforms are appropriately designed to address the policy established by subsection (a).

(E) An assessment of the extent to which such guidance and directives are being carried out in the research, development, acquisition, and logistics programs of the Department.

(F) A description of any additional actions that, in the view of the Secretary, may be needed to implement the policy established by subsection (a).

The conference report stated:

Report on actions to reduce Department of Defense consumption of petroleum-based fuel

The Senate amendment contained a provision (sec. 354) that would require the Secretary of Defense to report on the actions taken, and to be taken, by the Department of Defense to reduce the consumption of petroleum-based fuels.

The House bill contained no similar provision.

The Senate recedes.

The conferees note that the implementation of current legislation and regulatory guidance should facilitate reduction of petroleum-based fuels by the Department. Therefore, the conferees direct the Secretary to submit a report, not later than September 1, 2007, to the Committees on Armed Services of the Senate and the House of Representatives on the status of implementation by the Department of the requirements contained in the following:

(1) Energy Policy Act of 2005 (Public Law 109—58);

(2) Energy Policy Act of 1992 (Public Law 102—486);

(3) Executive Order 13123;

(4) Executive Order 13149; and

(5) other regulations or directions relating to the Department's consumption of petroleum-based fuels.

Furthermore, the conferees are concerned that although Flexible Fuel Vehicles (FFVs) are being introduced into the Department's vehicle inventory, little reduction in petroleum-based fuel is being realized because operators continue to fuel the FFVs with gasoline rather than E85 (85 percent ethanol with 15 percent gasoline) or M85 (85 percent methanol and 15 percent gasoline). Therefore, the conferees direct the Secretary to include in the report an

analysis of the reduction of petroleum-based fuels since introduction of FFVs into the inventory and an assessment of how the Department might increase the consumption of E85 or M85 in FFVs.

The House Committee on Armed Services, in its report (H.Rept. 109-452 of May 5, 2006) on H.R. 5122 states:

Winglets for in-service aircraft

The committee commends the Air Force in its efforts to increase aircraft fuel efficiency and decrease fuel consumption. The committee notes that initiatives such as re-engining aircraft, modifying in-flight profiles, and revising aircraft ground operations contribute to decreased fuel consumption and increased life-cycle savings.

The committee is aware that winglet technology exists for aircraft to increase fuel efficiency, improve take-off performance, increase cruise altitudes, and increase payload and range capability. The committee notes that winglets are currently used on commercial aircraft and result in a five to seven percent increase in fuel efficiency. On September 16, 1981, the National Aeronautics and Space Administration released the KC-135 Winglet Program Review on the incorporation of winglets for KC-135 aerial refueling aircraft. However, the Air Force concluded that the cost of adding winglets to the KC-135 did not provide sufficient payback in fuel savings or increased range to justify modification. Although the Air Force did conclude that modifying aircraft with winglets could increase fuel efficiency, the Air Force determined that re-engining the KC-135 aircraft produced a greater return on investment. The committee believes that incorporating winglets on military aircraft could increase fuel efficiency on certain platforms and that the Air Force should reexamine incorporating this technology onto its platforms.

Therefore, the committee directs the Secretary of the Air Force to provide a report to the congressional defense committees by March 1, 2007, examining the feasibility of modifying Air Force aircraft with winglets. The report shall include a cost comparison analysis of the cost of winglet modification compared to the return on investment realized over time for each airlift, aerial refueling, and intelligence, surveillance, and reconnaissance aircraft in the Air Force inventory; the market price of aviation fuel at which incorporating winglets would be beneficial for each Air Force platform; all positive and negative impacts to aircraft maintenance and flight operations; and investment strategies the Air Force could implement with commercial partners to minimize Air Force capital investment and maximize investment return.

FY2007 Defense Appropriations Act (H.R. 5631/P.L. 109-289)

The Senate Appropriations Committee, in its report (S.Rept. 109-292 of July 25, 2006) on H.R. 5631 states:

The Committee notes the recent developments relating to the conversion of coal to liquid fuels. Demonstration projects in the United States have produced high-quality, ultra clean synthetic diesel fuels that provide improved efficiency and improved emissions compared to traditionally produced diesel fuel. The Committee encourages the Department of Defense to continue to explore the use of Fischer-Tropsch fuels as alternative sources for DOD's fuel requirements. Further, the Committee requests that the Under Secretary for Acquisition, Technology, and Logistics prepare a report for the congressional defense committees on the Defense Department's assessment, use, and plans to continue to explore the potential of synthetic fuels, to include fuels produced through the Fischer-Tropsch process.

The House Appropriations Committee, in its report (H.Rept. 109-504 of June 16, 2006) on H.R. 5631 states:

C-32 WINGLET MODIFICATION

The Committee recommends \$5,198,000 for C-32 modifications, which is \$5,006,000 more than the amount provided in fiscal year 2006, and \$5,000,000 more than the request for fiscal year 2007. These funds shall be used to install Blended Winglets on the 4 C-32 aircraft operated by the United States Air Force to demonstrate potential fuel savings, and/or increased operating range. Not more than one year after the modification of the first C-32 aircraft, the Secretary of the Air Force shall submit a report to the congressional defense committees assessing the utility of the winglet and making a recommendation if the program should be expanded to other types of aircraft.

Coal-to-Liquid Fuel Energy Act of 2007 (S. 154)

Section 5 of Senate Bill S. 154 of January 4, 2007 states:

SEC. 5. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

Section 7 states:

SEC. 7. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

Section 8 states:

SEC. 8. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended—

(1) in subsection (b)—

(A) by striking ‘The Secretary’ and inserting the following:

(1) IN GENERAL- The Secretary’; and

(B) by adding at the end the following:

(2) COAL-TO-LIQUID PRODUCTION FACILITIES-

(A) IN GENERAL- The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 2 of the Coal-to-Liquid Fuel Energy Act of 2007) on or near military installations.

(B) CONSIDERATIONS- In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.’;

(2) in subsection (d)—

(A) by striking ‘Subject to applicable provisions of law, any’ and inserting Any’; and

(B) by striking ‘1 or more years’ and inserting ‘up to 25 years’; and

(3) by adding at the end the following:

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

Section 9 states:

SEC. 9. REPORT ON EMISSIONS OF FISCHER-TROPSCH PRODUCTS USED AS TRANSPORTATION FUELS.

(a) In General- In cooperation with the Administrator of the Environmental Protection Agency, the Secretary of Defense, the Administrator of the Federal Aviation Administration, and the Secretary of Health and Human Services, the Secretary shall—

(1) carry out a research and demonstration program to evaluate the emissions of the use of Fischer-Tropsch fuel for transportation, including diesel and jet fuel;

(2) evaluate the effect of using Fischer-Tropsch transportation fuel on land and air engine exhaust emissions; and

(3) in accordance with subsection (e), submit to Congress a report on the effect on air quality and public health of using Fischer-Tropsch fuel in the transportation sector.

(b) Guidance and Technical Support- The Secretary shall issue any guidance or technical support documents necessary to facilitate the effective use of Fischer-Tropsch fuel and blends under this section.

(c) Facilities- For the purpose of evaluating the emissions of Fischer-Tropsch transportation fuels, the Secretary shall—

(1) support the use and capital modification of existing facilities and the construction of new facilities at the research centers designated in section 417 of the Energy Policy Act of 2005 (42 U.S.C. 15977); and

(2) engage those research centers in the evaluation and preparation of the report required under subsection (a)(3).

(d) Requirements- The program described in subsection (a)(1) shall consider—

(1) the use of neat (100 percent) Fischer-Tropsch fuel and blends of Fischer-Tropsch fuels with conventional crude oil-derived fuel for heavy-duty and light-duty diesel engines and the aviation sector; and

(2) the production costs associated with domestic production of those fuels and prices for consumers.

(e) Reports- The Secretary shall submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Energy and Commerce of the House of Representatives—

(1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and

(2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

Coal-to-Liquid Fuel Act of 2007 (S. 155)

Section 104 of Senate Bill S. 155 of January 4, 2007 states:

SEC. 104. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

Section 106 states:

SEC. 106. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

Section 107 states:

SEC. 107. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended—

(1) in subsection (b)—

(A) by striking ‘The Secretary’ and inserting the following:

(1) IN GENERAL- The Secretary'; and

(B) by adding at the end the following:

(2) COAL-TO-LIQUID PRODUCTION FACILITIES-

(A) IN GENERAL- The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 101 of the Coal-to-Liquid Fuel Promotion Act of 2007) on or near military installations.

(B) CONSIDERATIONS- In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.';

(2) in subsection (d)—

(A) by striking 'Subject to applicable provisions of law, any' and inserting Any'; and

(B) by striking '1 or more years' and inserting 'up to 25 years'; and

(3) by adding at the end the following:

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.'.

Section 108 states:

SEC. 108. REPORT ON EMISSIONS OF FISCHER-TROPSCH PRODUCTS USED AS TRANSPORTATION FUELS.

(a) In General- In cooperation with the Administrator of the Environmental Protection Agency, the Secretary of Defense, the Administrator of the Federal Aviation Administration, and the Secretary of Health and Human Services, the Secretary shall—

(1) carry out a research and demonstration program to evaluate the emissions of the use of Fischer-Tropsch fuel for transportation, including diesel and jet fuel;

(2) evaluate the effect of using Fischer-Tropsch transportation fuel on land and air engine exhaust emissions; and

(3) in accordance with subsection (e), submit to Congress a report on the effect on air quality and public health of using Fischer-Tropsch fuel in the transportation sector.

(b) Guidance and Technical Support- The Secretary shall issue any guidance or technical support documents necessary to facilitate the effective use of Fischer-Tropsch fuel and blends under this section.

(c) Facilities- For the purpose of evaluating the emissions of Fischer-Tropsch transportation fuels, the Secretary shall—

(1) support the use and capital modification of existing facilities and the construction of new facilities at the research centers designated in section 417 of the Energy Policy Act of 2005 (42 U.S.C. 15977); and

(2) engage those research centers in the evaluation and preparation of the report required under subsection (a)(3).

(d) Requirements- The program described in subsection (a)(1) shall consider—

(1) the use of neat (100 percent) Fischer-Tropsch fuel and blends of Fischer-Tropsch fuels with conventional crude oil-derived fuel for heavy-duty and light-duty diesel engines and the aviation sector; and

(2) the production costs associated with domestic production of those fuels and prices for consumers.

(e) Reports- The Secretary shall submit to the Committee on Energy and Natural Resources of the Senate and the Committee on Energy and Commerce of the House of Representatives—

(1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and

(2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

Coal-to-Liquid Fuel Promotion Act of 2007 (H.R. 370)

Section 104 of House Bill H.R. 370 of January 10, 2007 states:

SEC. 104. LOCATION OF COAL-TO-LIQUID MANUFACTURING FACILITIES.

The Secretary, in coordination with the head of any affected agency, shall promulgate such regulations as the Secretary determines to be necessary to support the development on Federal land (including land of the Department of Energy, military bases, and military installations closed or realigned under the defense base closure and realignment) of coal-to-liquid manufacturing facilities and associated infrastructure, including the capture, transportation, or sequestration of carbon dioxide.

Section 105 states:

Section 106 states:

SEC. 106. AUTHORIZATION TO CONDUCT RESEARCH, DEVELOPMENT, TESTING, AND EVALUATION OF ASSURED DOMESTIC FUELS.

Of the amount authorized to be appropriated for the Air Force for research, development, testing, and evaluation, \$10,000,000 may be made available for the Air Force Research Laboratory to continue support efforts to test, qualify, and procure synthetic fuels developed from coal for aviation jet use.

Section 107 states:

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SEC. 107. COAL-TO-LIQUID LONG-TERM FUEL PROCUREMENT AND DEPARTMENT OF DEFENSE DEVELOPMENT.

Section 2398a of title 10, United States Code is amended—

(1) in subsection (b)—

(A) by striking ‘The Secretary’ and inserting the following:

(1) IN GENERAL- The Secretary’; and

(B) by adding at the end the following:

(2) COAL-TO-LIQUID PRODUCTION FACILITIES-

(A) IN GENERAL- The Secretary of Defense may enter into contracts or other agreements with private companies or other entities to develop and operate coal-to-liquid facilities (as defined in section 101 of the Coal-to-Liquid Fuel Promotion Act of 2007) on or near military installations.

(B) CONSIDERATIONS- In entering into contracts and other agreements under subparagraph (A), the Secretary shall consider land availability, testing opportunities, and proximity to raw materials.’;

(2) in subsection (d)—

(A) by striking ‘Subject to applicable provisions of law, any’ and inserting Any’; and

(B) by striking ‘1 or more years’ and inserting ‘up to 25 years’; and

(3) by adding at the end the following:

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.’.

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(1) not later than 180 days after the date of enactment of this Act, an interim report on actions taken to carry out this section; and

(2) not later than 1 year after the date of enactment of this Act, a final report on actions taken to carry out this section.

(f) Authorization of Appropriations- There are authorized to be appropriated such sums as are necessary to carry out this section.

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