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The origin of the Department of the Navy's biofuel initiative and the volatility problem for defense energy

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

THE ORIGIN OF THE DEPARTMENT OF THE NAVY'S BIOFUEL INITIATIVE AND THE VOLATILITY PROBLEM FOR DEFENSE ENERGY

by

Gary A. Blumberg

June 2013

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This thesis presents three catalysts for the origins of the Department of the Navy's biofuel initiative: (1) Section 526 of the Energy Independence and Security Act of 2007 effectively ended the Department of Defense's (DoD's) research program into synthetic fuels derived from fossil fuels; (2) the crude oil spot price reached a maximum daily price of $145.16 on July 14, 2008; and (3) the American Recovery and Reinvestment Act of 2009 appropriated over one billion dollars for biomass research and development. Although cost volatility has impacted the DoD's budget, the DoD already has used the Defense Working Capital Fund to make perceived oil prices less volatile to DoD users. Drop-in replaceable biofuels would not remove petroleum price volatility because biofuels act as close substitutes. The governments of other countries reduce cost volatility by managing fuel price risk using futures contracts; opinions differ on whether the DoD should pursue this option. To mitigate cost volatility, the Defense Business Board recommended exploring intragovernmental transfers between the DoD and Department of the Interior on two occasions. Long-term contracts could reduce volatility, but the DoD risks losing competitors in supply.

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THE ORIGIN OF THE DEPARTMENT OF THE NAVY'S BIOFUEL INITIATIVE AND THE VOLATILITY PROBLEM FOR DEFENSE ENERGY

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ABSTRACT

This thesis presents three catalysts for the origins of the Department of the Navy’s biofuel initiative: (1) Section 526 of the Energy Independence and Security Act of 2007 effectively ended the Department of Defense’s (DoD’s) research program into synthetic fuels derived from fossil fuels; (2) the crude oil spot price reached a maximum daily price of $145.16 on July 14, 2008; and (3) the American Recovery and Reinvestment Act of 2009 appropriated over one billion dollars for biomass research and development. Although cost volatility has impacted the DoD’s budget, the DoD already has used the Defense Working Capital Fund to make perceived oil prices less volatile to DoD users. Drop-in replaceable biofuels would not remove petroleum price volatility because biofuels act as close substitutes. The governments of other countries reduce cost volatility by managing fuel price risk using futures contracts; opinions differ on whether the DoD should pursue this option. To mitigate cost volatility, the Defense Business Board recommended exploring intragovernmental transfers between the DoD and Department of the Interior on two occasions. Long-term contracts could reduce volatility, but the DoD risks losing competitors in supply.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFOSR	Air Force Office of Scientific Research
ARRA	American Recovery and Reinvestment Act
[ASD(OEPP)]	Assistant Secretary of Defense for Operational Energy Plans and Programs
ASP	Aquatic Species Program
Blueprint	Blueprint for a Secure Energy Future
BOEM	Bureau of Ocean Energy Management
BOEMRE	Bureau of Ocean Energy Management, Regulation and Enforcement
CAAFI	Commercial Aviation Alternative Fuels Initiative
CBO	Congressional Budget Office
CNO	Chief of Naval Operations
CONUS	Continental United States
CRS	Congressional Research Service
CTL	Coal-To-Liquid
DAF	Department of the Air Force
DOI	Department of the Interior
DESC	Defense Energy Support Center
DLA	Defense Logistics Agency
DLA–E	DLA–Energy
DoD	Department of Defense
DOE	Department of Energy
DON	Department of the Navy
DPA	Defense Production Act
DWCF	Defense Working Capital Fund
EIA	Energy Information Administration
EISA	Energy Independence and Security Act
EPA	Environmental Protection Agency
FT	Fischer–Tropsch
FY	Fiscal Year

GGF	Great Green Fleet
GHG	Greenhouse Gas
HASC	House Armed Services Committee
HECO	Hawaiian Electric Company
HEFA	Hydroprocessed Esters and Fatty Acids
HRD	Hydrotreated Renewable Diesel
HRJ	Hydrotreated Renewable Jet
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JP	Jet Propellant
LLNL	Lawrence Livermore National Laboratory
MOU	Memorandum of Understanding
NDAA	National Defense Authorization Act
NPSRO	Naval Petroleum and Oil Shale Reserves Office
NSS	National Security Strategy
OCONUS	Outside Continental United States
OMB	Office of Management and Budget
PPA	Power Purchase Agreement
QDR	Quadrennial Defense Review
RDT&E	Research, Development, Testing, and Evaluation
RFS	Renewable Fuel Standard
SBIR	Small Business Innovative Research
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SFC	Synthetic Fuels Corporation
SPK	Synthetic Paraffinic Kerosene
UNFCCC	United Nations Framework Convention on Climate Change

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Finally, we should not forget where biomass came from: "And out of the ground made the LORD God to grow every tree that is pleasant to the sight, and good for food" (Genesis 2:9, KJV).

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I. INTRODUCTION

The Secretary of the Navy, the Honorable Ray Mabus, established five energy goals in his speech at the Naval Energy Forum in October 2009. Two out of five goals from his speech focused on biofuels as an operational energy source:

> Second: The Navy will demonstrate in local operations by 2012 a Green Strike Group composed of nuclear vessels and ships powered by biofuel. And by 2016, we will sail that Strike Group as a Great Green Fleet composed of nuclear ships, surface combatants equipped with hybrid electric alternative power systems running biofuel, and aircraft flying only biofuels—and we will deploy it…
>
> Lastly, and maybe most importantly, I am asking all of us to meet a very ambitious goal. Today, about 17 percent of our total energy consumption comes from alternative sources. By 2020, half of our total energy consumption for ships, aircraft, tanks, vehicles, and shore installations will come from alternative sources. Right now I'm told 40 percent is a more realistic goal and even that remains difficult because of the cost and logistics. (Mabus, 2009, pp. 8–9)

This research focuses on biofuels as an alternative operational energy source and does not focus on efficiency, conservation, and shore energy. The objective of this research is to answer the question, what is the origin of the Department of the Navy's (DON's) biofuel initiative? Secretary Mabus' speech at the Naval Energy Forum was the beginning of the DON's biofuel initiative. What were some of the factors that influenced the DON to arrive at the decision to start the biofuels initiative? In Chapter II, I present three catalysts for the DON's biofuel initiative. Additionally, in Chapter II, I present a number of fuel-related definitions from multiple organizations. However, the list of definitions is not all-inclusive. The conclusion in Chapter II is that organizations differ in the ways that they define energy security as well as drop-in replaceable biofuels.

In Chapter II, two options to accomplish Secretary Mabus' goals are presented for the DON to obtain biofuels: Build biofuel refineries using the Defense Production Act (DPA), or rely on the commercial market with the Commercial Aviation Alternative Fuels Initiative (CAAFI). Chapter II includes an explanation of the DON's strategy using the DPA to build or retrofit multiple biofuel refineries as a part of its biofuel initiative.

To obtain biofuel, the Departments of the Navy, Energy, and Agriculture signed a joint memorandum of understanding (MOU) in June 2011. The DON's contribution as a signatory to this MOU is $170 million over three years, with the funds transferred in accordance with the DPA ("Memorandum of Understanding [MOU]," 2011, pp. 2–3). The following is the stated objective of the joint DON, Department of Energy (DOE), and U.S. Department of Agriculture (USDA) joint initiative:

> the construction or retrofit of multiple domestic commercial or pre-commercial scale advanced drop-in biofuel plants and refineries with the following characteristics: [c]apability to produce ready drop-in replacement advanced biofuels meeting military specifications at a price competitive with petroleum; [g]eographically diverse locations for ready market access; and [n]o significant impact on the supply of agricultural commodities for the production of food. (MOU, 2011, p. 2)

Finally, Chapter II includes a summary of previous attempts to develop synthetic fuels from fossil fuel sources as well as fuels from aquatic species to provide a historical perspective for the current debate on the Navy's biofuel initiative.

Approximately three years after the 2009 Naval Energy Forum speech, Secretary Mabus testified regarding the impacts that oil price and volatility had on the DON:

> The Department [of the Navy] is also exposed to price shocks in the global market because too much fuel comes from volatile regions, places that are vulnerable to instability and ruled by regimes that do not support our interests. Every time the cost of a barrel of oil goes up a dollar, it costs the Department $30 million in extra fuel costs. In FY12 alone, in large part due to political unrest in oil producing regions, the price per barrel of oil is $38 more than was budgeted increasing the Navy's fuel bill by over $1 billion. These price spikes must be paid for out of our operations funds. That means that our Sailors and Marines are forced to steam less, fly less, and train less. (Statement of the Honorable Ray Mabus, 2012, p. 30)

From January 2007 to July 2008, the West Texas Intermediate crude oil spot price approximately tripled in 18 months as the spot price of oil went from $50 to its peak of $145. Secretary Mabus' 2012 testimony reflects the budgetary and operational impacts of both price and volatility of oil to the naval service. This research in Chapter II includes how the price of oil influenced Secretary Mabus' decision to pursue biofuels. In Chapter III, this research focuses on price volatility.

In Chapter III, I present another objective of this research. In Chapter III, I analyze whether biofuels—as an alternative operational fuel—will remove fuel cost volatility as a direct substitute for petroleum, and I examine options to mitigate cost volatility. The following research questions are answered: Will biofuels remove fuel cost volatility for the DON, and what options are available to mitigate petroleum price volatility? In Chapter III, I show the historical volatility of petroleum prices and explain how price volatility affects the Department of Defense (DoD) and the DON. I then summarize how the DoD currently avoids petroleum cost volatility using the Defense Working Capital Fund (DWCF). Chapter III includes further evaluation of whether biofuels, as an alternative operational fuel, will dampen the effects of fuel cost volatility. Five options to potentially reduce price volatility are then examined: futures contracts, intragovernmental transfers, long-term contracts, off-take agreements, and the status quo.

In the final chapter of this research, I present a brief summary, recommendations, and discussion of future research in this area.

Archived data from open sources were used to conduct this research. In Chapter III, I use comparative analysis to examine options to mitigate fuel cost volatility as well as examine options to provide a diversity of fuel options. Due to financial and practical constraints, I did not conduct interviews to attempt to answer the research questions.

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II. ORIGIN OF THE DEPARTMENT OF THE NAVY'S BIOFUEL INITIATIVE

In this chapter, I examine the origins of the biofuels initiative undertaken by the DON. The chapter begins with a definition of biofuels and drop-in replaceable biofuels. I then explain how biofuels fit into the energy security strategy by examining the organization and policies from the perspective of the federal government. I examine two options to provide to provide biofuels: building biofuel refineries using the DPA or relying on the commercial market with the CAAFI. I summarize the historical attempts to develop non-petroleum–based fuels and then demonstrate how section 526 of the Energy Independence and Security Act (EISA) of 2007 effectively ended the DoD's research into synthetic fuels derived from fossil fuels. I analyze the external environment in terms of the price of crude oil to show how costs played a role in the DON's biofuel initiative. I then summarize historical attempts to develop petroleum from aquatic species and conclude this chapter by showing how the enactment of the American Recovery and Reinvestment Act (ARRA) of 2009 appropriated over one billion dollars for biomass research and development and was another catalyst for the DON's biofuel initiative.

A. WHAT ARE BIOFUELS?

Biomass fuel is defined as "any gaseous, liquid, or solid fuel produced by conversion of biomass" (Energy Security Act of 1980, § 203(3)). *Biomass* is then defined as "any organic matter which is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes, and aquatic plants" (Energy Security Act of 1980, § 203(2)(A)). *Renewable energy*[1] is "any energy resource[2] that has recently originated in the sun, including direct and indirect solar radiation and intermediate solar energy forms such as wind, ocean thermal gradients, ocean currents and waves,

[1] Section 9001 of the Food, Conservation, and Energy Act of 2008 (Pub. L. 110-246) also defined "renewable energy."

[2] Energy is a source, not a resource.

hydropower, photovoltaic energy, products of photosynthetic processes, organic wastes, and others” (Energy Security Act of 1980, § 403(2)). Fossil fuels are not considered to be a biofuel because fossil fuels are not renewable, are not a recent product from the sun, and are “material[s] [of biological origin] embedded in geological formations” (Intergovernmental Panel on Climate Change [IPCC], 2012, p. 955).

The EISA of 2007 amended the Clean Air Act, which places the authority to regulate fuels and fuel additives under the Environmental Protection Agency (EPA), to include three biofuel definitions: *conventional biofuel* means “renewable fuel that is ethanol derived from corn starch” (Energy Independence and Security Act [EISA] of 2007, § 201(1)(F)); *advanced biofuel* is “renewable fuel, other than ethanol derived from corn starch, that has lifecycle greenhouse gas emissions … that are at least 50 percent less than baseline lifecycle greenhouse gas emissions” (EISA of 2007, § 201(1)(B)); and *cellulosic biofuel* means “renewable fuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass and that has lifecycle greenhouse gas emissions … that are at least 60 percent less than the baseline lifecycle greenhouse gas emissions” (EISA of 2007, § 201(1)(E)). The Intergovernmental Panel on Climate Change (IPCC) divides biofuel into three generations: first-generation, second-generation, and third-generation (IPCC, 2012, p. 955). The EPA (2012) refers to *conventional biofuels* as first-generation biofuels, *cellulosic biofuels* as second-generation biofuels, and *advanced biofuels* as third-generation biofuels. Section 9001 of the Food, Conservation, and Energy Act of 2008 (Pub. L. 110-246) also defined the terms *advanced biofuel*, *biofuel*, *renewable biomass*, and *renewable energy*.

The EPA defines *greenhouse gas* (GHG) as “any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include carbon dioxide [CO2], methane [CH4], nitrous oxide [N2O], ozone [O3], chlorofluorocarbons, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, [and] sulfur hexafluoride [SF6]” (Environmental Protection Agency [EPA], 2013). The EPA derived its GHG definition from the United Nations Framework Convention on Climate Change (UNFCCC), which includes water vapor as a GHG (United Nations Framework Convention on Climate Change [UNFCC], n.d.). The IPPC also defines water vapor as a GHG (IPCC, 2012, p. 960). The phrase *baseline lifecycle greenhouse gas emissions* means the average lifecycle greenhouse gas emissions based on the 2005 baseline average levels for the gasoline or diesel fuel being replaced (EISA of 2007, § 201). Lifecycle greenhouse gas emissions mean

> the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator [of the Environmental Protection Agency], related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential. (EISA of 2007, § 201(1)(H))

A *feedstock* "means the raw material supplied for use in manufacturing, chemical, and biological processes" (EISA of 2007, § 452(a)(3)).

First-generation biofuels degrade in storage. Because this led to plugged filters, these fuels were unacceptable for naval systems (Bartis & Van Bibber, 2011, p. 12; J. Brown, 2011, p. 7; Pearlson, 2011, pp. 28–29). The DoD is seeking alternative fuels that must be "drop-in replaceable," which the DoD's Operational Energy Strategy and Bhargava defined as compatible with current infrastructure (Bhargava, 2011, p. 34; Department of Defense [DoD], 2011a, p. 8). However, this definition of drop-in replaceable is inadequate, because it ignores the chemical properties of a drop-in replaceable fuel. There is also a chemical compatibility issue that needs to be included when defining a drop-in replaceable fuel. Callahan limited his definition to second-generation jet fuels, but this definition ignores diesel and third-generation biofuels (Callahan, 2011, p. 4).

As of this writing, the DON has not yet formally defined "drop-in replaceable" (B. Boughey, Office of the Deputy Assistant Secretary of the Navy for Energy, personal communication, March 7, 2013). One description comes from a combination of the Department of the Air Force (DAF) and *Currents*, the official environmental magazine of the DON, which states that drop-in replaceable fuel for military operational applications

- must meet or exceed the performance requirements of petroleum-based fuel (i.e., there must be no notable operational differences; Kamin & Abbotts, 2012, p. 8; Kamin & Rudy, 2011, p. 8);

- must be equivalent to military specifications (JP-5, JP-8, and/or F-76);
- require no change in engine architecture, fuel infrastructure, or fuel handling;
- must be fully blended with conventional petroleum and biofuel, up to a maximum blend ratio of 50/50; and
- must be ready for use (Department of the Air Force [DAF], 2012a, pp. 1–2).

Two biofuels that are possible as a drop-in replaceable fuel are hydrotreated renewable jet (HRJ) fuel for aircraft and hydrotreated renewable diesel (HRD) fuel for ships. Jet Propellant (JP)-5 is military aviation jet fuel ("MIL-DTL-5624U," 2004), JP-8 is commercial Jet A fuel plus additives ("MIL-DTL-83133H," 2012), and F-76 is naval distillate fuel ("MIL-DTL-16884M," 2012).

Based on my literature review, sources differ on the definition of the letter H in HRJ and HRD. Bhargava and Pearlson define H as hydroprocessed (Bhargava, 2011, p. 12; Pearlson, 2011, p. 15). The majority of the government literature I reviewed defines H as hydrotreated, which is what I will use as well. Hydrotreating is a subset of hydroprocessing (Mochida & Choi, 2006, p. 257). HRJ and HRD are also referred to as Hydroprocessed Esters and Fatty Acids (HEFA) fuels (Blakeley, 2012, p. 5). HRJ is also called renewable synthetic paraffinic kerosene (SPK), sometimes called bio-SPK, to differentiate it from the SPK produced from non-renewable sources (DoD, 2011b, p. 7-1). I now turn to show how biofuels fit into the energy security strategy.

B. USING BIOFUELS AS PART OF THE ENERGY SECURITY STRATEGY

The Office of the Chief of Naval Operations (CNO) stated, in October 2010, that "energy security is a critical component of national security" (Office of the Chief of Naval Operations [CNO], 2010, p. 4). The military requires energy in the form of fuel to provide for the nation's defense and security. President Barack H. Obama's May 2010 National Security Strategy (NSS) stated,

> We must transform the way that we use energy—diversifying supplies, investing in innovation, and deploying clean energy technologies. By doing so, we will enhance energy security. (The White House, 2010, p. 10)

> The United States has a window of opportunity to lead in the development of clean energy technology. If successful, the United States will lead in this new Industrial Revolution in clean energy that will be a major contributor to our economic prosperity. If we do not develop the policies that encourage the private sector to seize the opportunity, the United States will fall behind and increasingly become an importer of these new energy technologies.
>
> We have already made the largest investment in clean energy in history, but there is much more to do to build on this foundation. We must continue to transform our energy economy, leveraging private capital to accelerate deployment of clean energy technologies that will cut greenhouse gas emissions, improve energy efficiency, increase use of renewable and nuclear power, reduce the dependence of vehicles on oil, and diversify energy sources and suppliers. We will invest in research and next-generation technology, modernize the way we distribute electricity, and encourage the usage of transitional fuels, while moving towards clean energy produced at home. (The White House, 2010, p. 30)

Notice that the statement quoted above says "if successful" and connects energy security to developing clean energy technologies. *Energy security* was defined in the Quadrennial Defense Review (QDR) on February 1, 2010, as "having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs" (Quadrennial Defense Review [QDR], 2010, p. 87). The CNO used the QDR's definition for energy security (CNO, 2010, pp. ii, 4, 17). Congress defined energy security in a similar fashion on December 31, 2011, but changed "operational needs" to "mission essential requirements" (National Defense Authorization Act [NDAA] for Fiscal Year [FY] 2012, § 2821). The strategic approach of energy security for Congress, the 2010 QDR, and the Office of the CNO is a future with petroleum.

The Secretary of the Navy (SECNAV) released the "Energy Roadmap" on January 5, 2011, with a different energy security definition: It states that energy security can be achieved only with sustainable sources, asserting, "[E]nergy security is achieved by utilizing sustainable sources that meet tactical, expeditionary, and shore operational requirements and force sustainment functions, and having the ability to protect and deliver sufficient energy to meet operational needs" (Office of the Secretary of the Navy [SECNAV], 2010, p. 2). Although "sustainable sources" is not defined, in this context it appears that the commitment to sustainable sources means that the DON "will increase its energy security … by increasing its use of alternative energy, including biofuels, solar, wind, hydro, geothermal, and nuclear; and aggressively pursuing conservation, energy efficient technologies, and energy supply management innovations" (Office of the SECNAV, 2010, p. 3). Per the SECNAV, energy security can be increased only with sustainable sources like biofuels. The strategic approach of energy security for the SECNAV is limited to sustainable sources and the strategic approach is in the distant future when petroleum is no longer available. According to the SECNAV's energy security definition, the DON cannot be secure with petroleum because petroleum is not sustainable. As a result, the SECNAV's strategy requires infrastructure investments so the DON has sustainable sources to rely on. Kiefer claimed biofuels may reduce energy security: "Energy security is reduced by choosing a primary energy source that has no proved reserves, but rather is created from scratch annually and is subject to floods, freezes, droughts, and blight" (Kiefer, 2013, p. 27).

These documents indicate that the SECNAV's and CNO's offices do not agree on the definition of energy security and the SECNAV's definition needs to be updated to be in accordance with section 2821 of the NDAA for FY 2012. The SECNAV, similar to the NSS, ties energy security to sustainable sources.

The SECNAV's strategic approach to energy security is shown in Figure 1, released in October 2009 (Office of the SECNAV, 2009, p. 5). The DON states that in order to build an energy-secure "house," it must first reduce the DON's carbon footprint. To accomplish the goal of reducing the carbon footprint, the DON plans to "replace energy from fossil fuels with energy from alternative and renewable sources" (Office of the SECNAV, 2009, p. 3). As previously mentioned, biofuels are a portion of this strategy. To build the tactical or operational wall of the house, the DON would start by increasing the use of alternative fuels and building an alternative energy infrastructure. Then, the DON would raise energy efficiency, and, finally, reduce energy consumption. The DON claims that after these steps have been completed, it will have increased the energy security for the DON (Office of the SECNAV, 2009, p. 5).

This research shows the origin of the DON's biofuels initiative. This research further analyzes whether biofuels will remove fuel cost volatility as a direct substitute for petroleum and examines options to mitigate cost volatility.

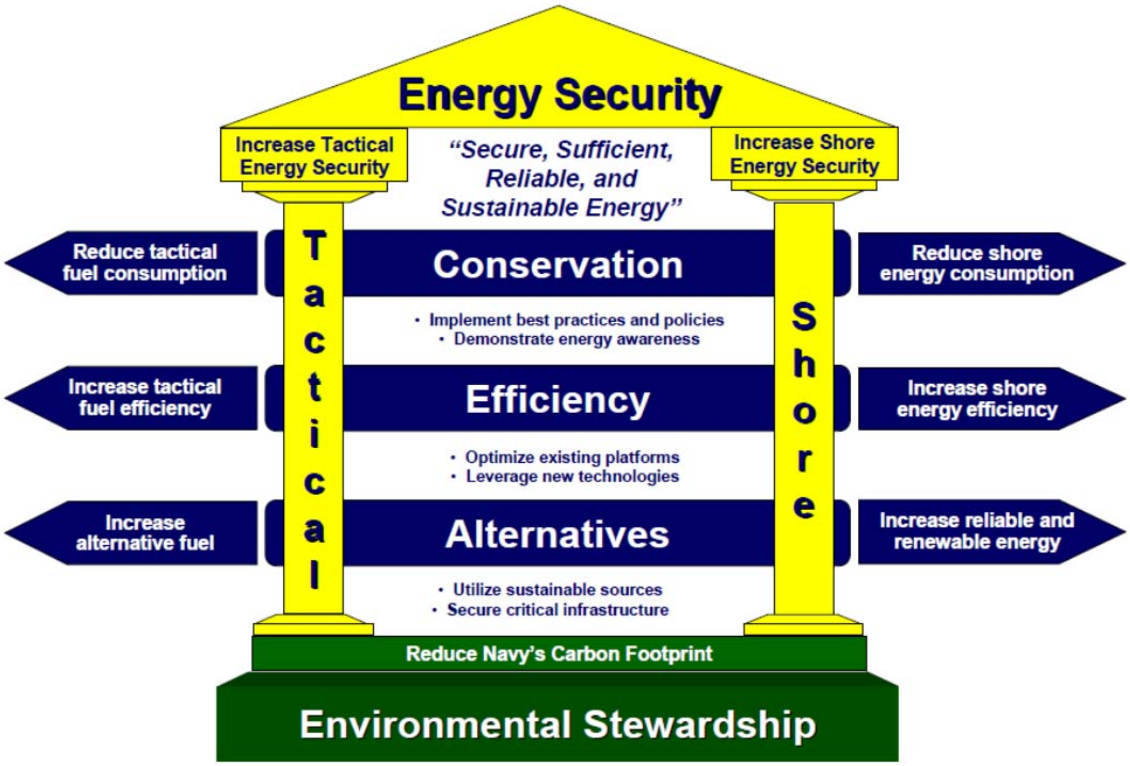

Figure 1. The SECNAV's Strategic Approach to Energy Security (From Office of the SECNAV, 2009, p. 5[3])

Kerner and Thomas (2012) argued that the DON should add another floor to Figure 1 and call it "energy resilience." *Resilience* can be defined as "being able to perform the intended mission despite energy supply perturbations" (Kerner & Thomas, 2012, p. 30). The previous levels in the house—efficiency and conservation—still assume a continual supply of energy to either the shore or operational forces. Energy resilience would shift the DON from focusing on supply to preparedness when supply disruptions occur. The Navy's energy vision is an energy resilient Navy (CNO, 2010, pp. 1, 17). Bartis, Camm, and Ortiz (2008) also discussed resiliency. They noted that as a

[3] No page numbers are used in the document, so I assumed the cover page as page 1 and so forth.

substitute for petroleum, developing domestic coal-to-liquid (CTL) refineries would increase the energy resilience (Bartis, Camm, & Ortiz, 2008, p. 67). This chapter includes a discussion of the CTL history.

Secretary Mabus established five energy goals in his speech at the Naval Energy Forum on October 14, 2009, and later published them in the "Energy Roadmap." This was the beginning of the DON's biofuel initiative. Two out of five goals focus on biofuels: (1) "By 2016, the DON will sail the Great Green Fleet (GGF), a carrier strike group composed of nuclear ships, hybrid electric ships running on biofuel, and aircraft flying on biofuel," and (2) "supply 50 percent of DON energy demand with alternative sources, such as solar, wind, biofuels, and geothermal energy by 2020" (Office of the SECNAV, 2010, p. 4) His plan to accomplish the latter goal in a three-fold manner is shown in Figure 2: (1) a continued decrease in petroleum use through increased efficiencies and decreased use; (2) an increased use of liquid alternative fuels, such as biofuels; and (3) a continued use of nuclear power. As part of his plan, the GGF was demonstrated during the 2012 Rim of the Pacific exercise, with the goal of deploying the GGF in 2016 (U.S. Navy, 2012).

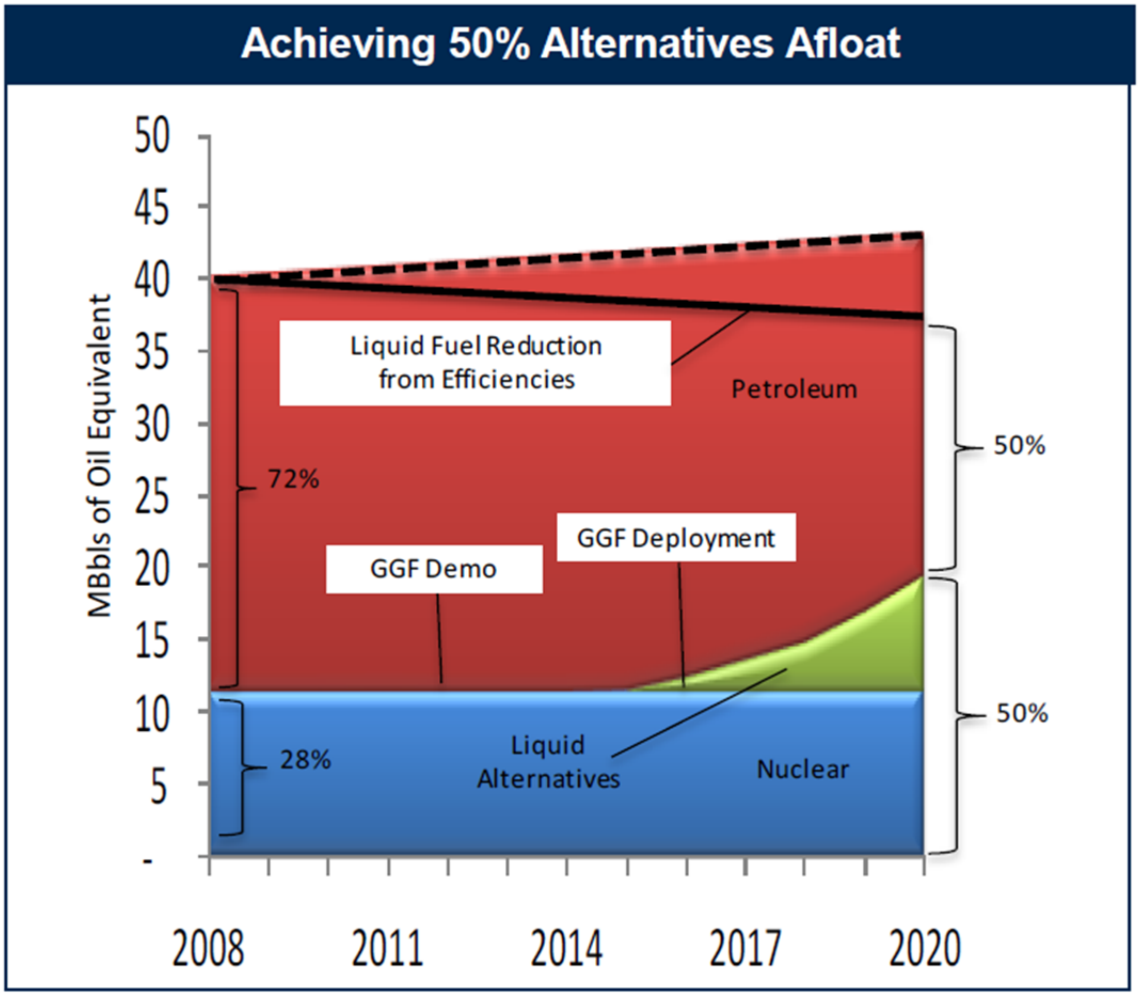

Figure 2. DON Energy Plan to Supply 50 Percent of Demand With Alternative Sources by 2020 (From J. Brown, 2011, p. 4)

The White House followed the release of the NSS with the *Blueprint for a Secure Energy Future* (*Blueprint*) on March 30, 2011. The current administration maintains that a domestic biofuel industry is necessary for energy security and has included biofuel in its energy strategy for new technologies, as outlined below:

> **Commercializing New Technologies**: Corn ethanol is already making a significant contribution to reducing our oil dependence, but going a lot further will depend on taking promising cellulosic and advanced biofuels technologies to scale. To help advance the commercialization process, the Administration has set a goal of breaking ground on at least four commercial-scale cellulosic or advanced bio-refineries over the next two years. In addition, the President has challenged his Secretaries of

> Agriculture, Energy and the Navy to investigate how they can work together to speed the development of "drop-in" biofuels substitutes for diesel and jet fuel. Competitively-priced drop-in biofuels could help meet the fuel needs of the Navy, as well as the commercial aviation and shipping sectors. (The White House, 2011, p. 23; bold in original)

Consistent with the NSS and the *Blueprint*, the 2010 QDR stated, "The [Defense] Department is increasing its use of renewable energy supplies and reducing energy demand to improve operational effectiveness, reduce greenhouse gas emissions in support of U.S. climate change initiatives, and protect the Department from energy price fluctuations" (QDR, 2010, p. 87). The 2010 QDR also incorporated a more robust discussion on energy than the 2006 QDR. While the 2006 QDR focused on energy sources, the 2010 QDR included a number of energy topics such as energy security, energy efficiency, operational energy, and renewable energy.

The DoD released its first-ever Operational Energy Strategy in May 2011, and it aligned with the 2010 QDR and resulted from congressional interpretation of the 2006 QDR. Congress instituted the requirement for the Operational Energy Strategy on October 14, 2008 (Duncan Hunter NDAA for Fiscal Year [FY] 2009, § 902). The House Armed Services Committee (HASC) was concerned that "the heavy logistical burden imposed by fuel [would] … impede realization of the more-distributed 'new global posture' called for in the 2005 National Defense Strategy and 2006 Quadrennial Defense Review" (U.S. House, Committee on Armed Services, 2008, p. 409). Three-quarters of the DoD's energy consumption was for operational purposes, which had previously lacked congressional oversight until Congress mandated an operational energy strategy and an annual report (U.S. House, Committee on Armed Services, 2008, p. 345). Operational energy is defined as the "the energy required for training, moving, and sustaining military forces and weapons platforms for military operations. The term includes energy used by tactical power systems and generators and weapons platforms" (Duncan Hunter NDAA for FY 2009, § 331).

The DoD's Operational Energy Strategy continued to support alternative fuels with limitations, but the publication came after the DON biofuel initiative had started:

> In the long term, alternative fuels have the potential to be an important part of the Nation's energy landscape, and the Department should be prepared to leverage this development through continued investments in Research, Development, Testing, and Evaluation (RDT&E) of alternative fuels. These investments must be supported by analysis on economic and technical feasibility and meet the following conditions:
>
> - The fuels must be "drop-in" (i.e., compatible with current equipment, platforms, and infrastructure);
> - The fuels must be able to support an expeditionary, globally deployed force;
> - There must be consideration of potential upstream and downstream consequences, such as higher food prices; and
> - Lifecycle greenhouse gas emissions must be less than or equal to such emissions from conventional fuel. (DoD, 2011a, p. 8)

In a letter to members of the Defense Operational Energy Board, the Assistant Secretary of Defense for Operational Energy Plans and Programs listed alternative fuel investment considerations as "increased resilience against strategic supply disruptions; dampened effect of petroleum price volatility; increased fuel options for operational commanders; and ultimately increased expeditionary effectiveness of our joint force" (Burke, 2012, p. 1). In Chapter III of this thesis, I evaluate whether biofuels, as an alternative operational fuel, will dampen the effects of fuel cost volatility.

Along with the issuance of the aforementioned policies and strategies by the White House, the DoD, and the DON, congressionally mandated civilian leadership changes occurred to assist the DoD in managing its operational energy use. A "Director of Operational Energy Plans and Programs in the Department of Defense" was created, along with a subordinate director in each service (Duncan Hunter NDAA for FY 2009, § 902). The HASC created the additional oversight because "the [Defense] Department has failed to establish and meet operational energy goals, and that lack of leadership is a root cause. Similarly, the U.S. Comptroller General issued a March 2008 report recommending that the Department establish an overarching organizational framework to guide and oversee mobility energy initiatives" (U.S. House, Committee on Armed Services, 2008, p. 409). On January 7, 2011, the "Director of Operational Energy Plans and Programs [was] redesignated as the Assistant Secretary of Defense for Operational

Energy Plans and Programs [ASD(OEPP)]" (Ike Skelton NDAA for FY 2011, § 901). The mission of the ASD(OEPP) is to "promote the energy security of military operations through guidance for and oversight of Departmental activities and investments" (DoD, 2011a, introduction).

The previous sections are the organizations and policies pertaining to biofuels from a perspective internal to the federal government. Next I summarize two options for the DON to obtain biofuels: build biofuel refineries using the DPA, or rely on the commercial market with the assistance of the CAAFI.

1. Defense Production Act (DPA)

The DPA is the legal authority to build the previously discussed biofuel refineries. The DPA "declaration of policy" states,

> (4) this Act … provides the President with an array of authorities to shape national defense preparedness programs and to take appropriate steps to maintain and enhance the domestic industrial base;
>
> (5) in order to ensure national defense preparedness, it is necessary and appropriate to assure the availability of domestic energy supplies for national defense needs;
>
> (6) to further assure the adequate maintenance of the domestic industrial base, to the maximum extent possible, domestic energy supplies should be augmented through reliance on renewable energy sources (including solar, geothermal, wind, and biomass sources), more efficient energy storage and distribution technologies, and energy conservation measures. (50 U.S.C. § 2062(a)(4)–(6))

Additionally, 50 U.S.C. § 2152(14) defines *national defense* as "programs for military and energy production" and applies to the DPA.

Pursuant to the DPA, President Obama announced on August 16, 2011, an expenditure of up to $510 million during the following three years through a DON, DOE, and USDA joint MOU in partnership with the private sector to build or retrofit refineries that can produce drop-in biofuels for military applications (The White House: Office of the Press Secretary, 2011). The DON's contribution to the MOU is $170 million over 3 years (MOU, 2011, p. 2). The following is the stated objective of the joint DON, DOE, and USDA joint initiative:

> the construction or retrofit of multiple domestic commercial or pre-commercial scale advanced drop-in biofuel plants and refineries with the following characteristics: [c]apability to produce ready drop-in replacement advanced biofuels meeting military specifications at a price competitive with petroleum; [g]eographically diverse locations for ready market access; and [n]o significant impact on the supply of agricultural commodities for the production of food. (MOU, 2011, p. 2)

The DON, DOE, and USDA joint initiative recognizes the lack of U.S. manufacturing capability for advanced biofuels. The President's budget for the DPA requested $70 million in FY 2013 for this initiative, as follows:

> [The] Advanced Drop-In Biofuel Production project funds in FY 2013 enable the Department [of Defense] to execute a DPA Title III project, building upon previous efforts and investments by the Navy and other agencies, with the principal objective being a government-industry partnership for the construction or retrofit of multiple domestic commercial or pre-commercial scale advanced drop-in biofuel plants and refineries. These plants will have the capability to produce ready, drop-in replacement advanced biofuels meeting military specifications at a price competitive with petroleum in geographically diverse locations for ready market access, while having no significant impact on the supply of agricultural commodities for the production of food. (Office of the Secretary of Defense [SECDEF], 2012, p. 2)

Through the joint MOU, the DON is using the DPA to subsidize the construction or modification of biofuel refineries as a national defense need, which could further diversify the DON's fuel supply.

The DPA contract limits the biofuel produced from the available biomass with seven requirements, but the first three requirements are the most relevant: "Requirement 1: Biofuels must be produced domestically" (DAF, 2012c, p. 17); "Requirement 2: Biofuels Must Comply with EISA Section 526" (DAF, 2012c, p. 18); and finally, "Requirement 3: Biofuels must come from an acceptable feedstock" (DAF, 2012c, p. 18). All other biofuels produced from biomass are excluded. To further reduce the available biomass feedstocks, requirement 3 initially allows feedstock that is used in food production[4], but the offeror must include a plan to transition away from a feedstock used in food production (DAF, 2012c, p. 19).

2. Commercial Aviation Alternative Fuels Initiative

The CAAFI is a "cooperative effort among interested stakeholders to bring commercially viable, environmentally friendly alternative aviation fuels to market" (Commercial Aviation Alternative Fuels Initiative [CAAFI], n.d.b) to diversify the fuel supply. The CAAFI shares many of the same goals as the DoD, and the DoD is a participant. The CAAFI seeks

> to enhance energy security and environmental sustainability for aviation by exploring the use of alternative jet fuels. … CAAFI's goal is to promote the development of alternative jet fuel options that offer equivalent levels of safety and compare favorably on cost with petroleum based jet fuel, while also offering environmental improvement and security of energy supply for aviation. The recent volatility in petroleum prices caused fuel to become the single largest component of U.S. airline operating cost for the first time in history in 2006. (CAAFI, n.d.a)

In August 2009, with CAAFI assistance, ASTM International, a private certifying agency, approved a new fuel standard for certifying different types of biofuels. The standard is entitled "ASTM D7566 Aviation Turbine Fuel Containing Synthesized Hydrocarbons." ASTM approval of D7566 "means a broader range of fuel producers, using a broader range of feedstock, can now supply jet fuel to users with confidence that it can be used and purchased" (CAAFI, 2009). Using the D7566 standard, Fischer–Tropsch (FT) and HRJ fuels have already been certified for operational use in civilian aviation, with alcohol to jet, direct sugar to hydrocarbons, hydrotreated depolymerized cellulosic jet, catalytic hydrothermolysis, and catalytic conversion of sugar biofuels scheduled in the future (N. Brown, 2012, p. 4). These additional biofuels diversify the civilian aviation supply chain. On the one hand, the DON could rely on this diversified biofuel supply chain instead of subsidizing the construction or modification of its own biofuel refineries. This shifts the cost and risk of developing biofuels from the DON onto

[4] Section 9001(12) of the Food, Conservation, and Energy Act of 2008 (Pub. L. 110-246) was the basis for requirement 3.

the civilian-owned enterprise. On the other hand, one could argue that by subsidizing the building or modification of biofuel refineries, the DON can further diversify the available suppliers by creating another supplier. Additionally, the CAAFI is investigating only jet biofuel. If the DON wants a different form of biofuel, then it would have to look elsewhere.

This section presented the current DON initiative to obtain biofuels using the DPA. The current biofuel initiative is not the first attempt to develop liquid fuels. I turn now to past government attempts to diversify the nation's energy supplies because this will lead us to a catalyst for the DON's biofuel initiative.

C. SUMMARY OF PAST ATTEMPTS TO DEVELOP SYNTHETIC FUELS.

In the early 1990s, Franz Fischer and Hans Tropsch developed the technological breakthrough of coal liquefaction, which converts coal to liquid (CTL) through the Fischer–Tropsch (FT) process to produce a synthetic fuel from coal. The German company I. G. Farben expanded the technology during World War II and supplied approximately "ninety percent of the aviation fuel required for the German war effort" (General Accounting Office [GAO], 1980, p. 2).

The U.S. government has a history of developing synthetic fuels derived from fossil fuels, originating with the FT process. The Synthetic Liquid Fuels Act of 1944 authorized "the Secretary of the Interior … to construct, maintain, and operate one or more demonstration plants to produce synthetic liquid fuels from coal, oil shale, and other substances, and one or more demonstration plants to produce liquid fuels from agricultural and forestry products" (Synthetic Liquid Fuels Act of 1944, § 1). The Senate Committee on Public Lands and Surveys (1943) reported the following justifications for passing this legislation: to "assure the United States a continuous supply of domestically produced motor fuel and aviation gasoline" (p. 1); "the demand for American [oil] supplies is likely to continue at a tremendously high rate" (p. 1); "[m]ore and larger planes of longer flying radius are under construction and the demand for these planes will not be appreciably diminished" (pp. 1–2); "[t]he consumption of oil in the United States is now proceeding annually at a rate much greater than the discovery of new supplies" (p.

2); "the demand for liquid fuel is likely to continue at such a high rate that the Nation's interest can be conserved only by immediate action to bring about the manufacture of synthetic liquid fuel from the unlimited supplies of coal which this country possesses and from the vast deposits of oil shale" (p. 2); "[i]f … the country is to maintain its leadership in the air it must take steps now to guarantee a sure and certain supply of liquid fuel; and this occurred during a time of war" (p. 2).

The Bureau of Mines within the Department of the Interior (DOI), later transferred to the Office of Coal Research, funded the development of two small refineries that tested the CTL liquefaction processes developed by Germany. These plants closed in 1954 because they were not economically viable. The Department of Interior's Office of Coal Research was eventually transferred to the DOE (GAO, 1980, p. 2)

The DOE's objective for the liquefaction research, development, and demonstration program plan was to "facilitate the establishment of a synthetic liquid fuels industry. Specifically for direct liquefaction, the program goal is to demonstrate the technical capability to commercially produce clean liquid and solid fuels from coal by the late 1980s" (GAO, 1980, p. 5). In FY 1981, the DOE requested $524 million "in order to begin construction of two demonstration plants and operation of two pilot plants" (GAO, 1980, pp. 5–6). The estimated cost for the two demonstration plants was $1.4 billion. The cost of the plants was shared among the governments of Germany and Japan, Pittsburg and Midway Coal Mining Company, the State of Kentucky, International Coal Refining Company, and the DOE (GAO, 1980, p. 11). DOE requested an additional $27 million in FY 1981 for research in developing liquids from synthesis gas (GAO, 1980, p. 24).

The Naval Petroleum and Oil Shale Reserves Office (NPSRO) tested oil shale distillates to determine their suitability as a synthetic fuel for the military. Development Engineering, which later formed the Paraho Development Corporation from a consortium of 17 energy companies, produced oil shale distillates for DON testing in the 1970s (Andrews, Bracmort, Brown, & Else, 2012, p. 5). The DAF also evaluated oil shale distillates under Project River Shale. In 1979, contracts were awarded to Ashland

Research and Development, Suntech, and UOP for research and development of the production of oil shale–derived JP-4 jet fuel. From 1985 to 1990, the Parachute Creek oil shale plant produced 4.6 million barrels of oil shale distillates for DAF testing and certification under Project River Shale (Andrews et al., 2012, p. 5). The DAF continued its synthetic fuel program until September 2006, after Syntroleum had supplied 100,000 gallons of synthetic fuel, and then closed after completing its government contracts (Blackwell, 2007, p. CRS-13).

The Synthetic Fuels Corporation (SFC) managed the federal funds appropriated by the Energy Security Act of 1980 to produce synthetic fuels with the goal of "500,000 barrels of crude oil per day of synthetic fuel by 1987 and of at least 2,000,000 barrels of crude oil per day of synthetic fuel by 1992" (Energy Security Act of 1980, § 100). *Synthetic fuels* are fuels "produced by chemical or physical transformation … of domestic sources of coal, … shale, … tar sands, … [and] hydrogen only through electrolysis" (Energy Security Act of 1980, § 112(17)). When Congress repealed the funding for the SFC in 1986 (Continuing Appropriations for Fiscal Year 1986, pp. 1249–1250[5]), the contracts under review by the SFC proposed a synthetic fuel production level of "about 116,000 BOED [Barrels of Oil Equivalent per Day], or less than one percent of U.S. petroleum consumption in 1983" (Gilbert, 1984, p. 3). As a result, the SFC never achieved the synthetic fuel production goals mandated by Congress. Instead of funding the SFC, the House Energy and Commerce Committee viewed "purchasing oil for the Strategic Petroleum Reserve as a far more cost effective defense against another oil embargo than subsidizing synthetic fuels" (Andrews et al., 2012, p. 6). Congressional disapproval of the SFC "also focused on conflicts of interest among the [Synthetic Fuels] Corporation board members, high salaries for staff, lack of interest on the part of private industry, and the possibility of huge subsidies going to profitable oil companies" (Andrews et al., 2012, p. 6). The DOE continued CTL research until February 2007, when funding was halted for a CTL diesel fuel plant located in Pennsylvania because

[5] The Continuing Appropriations for Fiscal Year 1986 has no sections, so the page numbers of the U.S. Statutes at Large are provided instead.

"cost estimates had grown from an original $612 million in 2003 to approximately $800 million" (Blackwell, 2007, p. CRS-13).

D. ALTERNATIVE AND STRATEGIC UNCONVENTIONAL FUELS

Alternative fuels mean "methanol, denatured ethanol … natural gas; liquefied petroleum gas; hydrogen; coal-derived liquid fuels; fuels (other than alcohol) derived from biological materials; electricity … and any other fuel the Secretary [of Energy] determines, by rule, is substantially not petroleum" (Energy Policy Act of 1992, § 301). Section 369 of the Energy Policy Act of 2005 (Pub. L. 109-58) created the Task Force on Strategic Unconventional Fuels, which defined *strategic unconventional fuels* as "oil shale, coal-derived liquids, heavy oil, tar sands, and candidate oil resources for CO2 enhanced oil recovery" (Task Force on Strategic Unconventional Fuels, 2006, p. 2). The SECDEF was required to develop a strategy to use unconventional fuels (Energy Policy Act of 2005, § 369(q)). The U.S. Energy Information Administration (EIA) defines *unconventional fuel* as "[a]n umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production" (Energy Information Administration [EIA], n.d.). *Conventional production* means "[c]rude oil and natural gas that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore" (EIA, n.d.). Understanding the definitions of alternative and unconventional fuels is important for the next section.

E. SECTION 526 OF THE ENERGY INDEPENDENCE AND SECURITY ACT OF 2007 AND THE MAXIMUM CRUDE OIL SPOT PRICE

The first catalyst for the DON developing its biofuel initiative was section 526 of the EISA of 2007, enacted on December 19, 2007. Section 526 effectively ended the DoD's research program in developing non-petroleum–based fuels because of immature GHG capturing technology and the increased cost for the additional equipment. This event was a catalyst for the DON's biofuel initiative. The production and combustion of synthetic or nonconventional fuels usually release more GHG emissions than burning the equivalent conventional fuel unless the GHG emissions are captured and sequestered.

However, lifecycle GHG emissions associated with the production and combustion of alternative fuels may or may not release more GHG emissions compared to burning the equivalent conventional petroleum sources. As a result, biofuel production could potentially be limited by section 526 of the EISA 2007 as well. Although federal agencies are still allowed to purchase synthetic, alternative, or nonconventional fuel for research and testing, the statute puts a serious limit on such purchases:

> No Federal agency shall enter into a contract for procurement of an alternative or synthetic fuel, including a fuel produced from nonconventional petroleum sources, for any mobility-related use, other than for research or testing, unless the contract specifies that the lifecycle greenhouse gas emissions associated with the production and combustion of the fuel supplied under the contract must, on an ongoing basis, be less than or equal to such emissions from the equivalent conventional fuel produced from conventional petroleum sources. (EISA of 2007, § 526)

The Southern Alliance for Clean Energy and the Sierra Club filed a complaint against the DoD and other non-federal organizations for violating section 526 of the EISA of 2007 by purchasing oil derived from tar sands because the production of this oil produces more greenhouse gases than conventional oil (Sierra Club, n.d.). The case was dismissed because the plaintiffs lacked standing (Bouboushian, 2011). The Defense Energy Support Center (DESC) concluded "that its contracts for petroleum were not covered by section 526 because DESC is purchasing commercially available fuels, consistent with acquisition policy" (Defense Energy Support Center, 2009, p. ii).

The previous section described the SECDEF's mandated strategy to use unconventional fuels, from section 369 of the Energy Policy Act of 2005. Section 526 limits this strategy to those fuels commercially available. There have been attempts to modify or repeal section 526. Section 30310 in the National and Commercial Space Programs Act of 2010 (Pub. L. 111-314) created an exception from section 526 for the National Aeronautics and Space Administration. Congress has tried unsuccessfully to either repeal section 526 (A bill to repeal a requirement with respect to the procurement and acquisition of alternative fuels [S. 2827], § 1; A bill to repeal a requirement with respect to the procurement and acquisition of alternative fuels [S. 290] § 1; A Roadmap for America's Energy Future, § 153), modify section 526 (NDAA for FY 2010, § 335), or exempt the DoD from section 526 (NDAA for FY 2012 [H.R. 1540], § 844; NDAA for FY 2013, § 313). The Department of Defense Energy Security Act of 2011 attempted to limit section 526 to natural gas or liquid fuels ([H.R. 2266], § 104; [S. 1204], § 104). The DoD's acting General Counsel Dell'Orto[6] (2008) endorsed the repeal of section 526. However, as of this writing, section 526 remains unchanged.

Ten months after the enactment of section 526, the SECDEF was required to "conduct a study on alternatives to reduce the life cycle emissions of alternative and synthetic fuels (including coal-to-liquid fuels)" (Duncan Hunter NDAA for FY 2009, § 334). The study concluded that "Fischer–Tropsch fuels are the most promising near-term options for meeting the Department of Defense's needs cleanly and affordably. … But if FT fuel production is to occur without compromising national goals to control greenhouse gas emissions, the following must hold: For biomass-derived FT fuels, … its production should not be based on practices that lead to sizable emissions due to direct or indirect changes in land use" (Bartis & Van Bibber, 2011, p. xi). Fuels from aquatic species may not affect crop land production, as is explained in the next section.

The second catalyst for the DON's biofuel initiative was when the West Texas Intermediate crude oil spot price reached a maximum daily price of $145.16 on July 14, 2008, as depicted in Figure 3. From January 2007 to July 2008, the price of oil approximately tripled in eighteen months as the spot price of oil went from $50 to its peak of $145. Secretary Mabus noted the high price of oil in his speech at the Naval Energy Forum, stating, "oil, just last year, approached $150 a barrel" (Mabus, 2009, p. 2). The high price of oil affects energy policy. The pressure from the high cost of fuel on the DON's budget, coupled with the pressure from Congress to develop an operational energy strategy, resulted in the DON developing an alternative to petroleum fuel energy strategy. This event was an additional catalyst for the DON's biofuel initiative.

[6] Daniel J. Dell'Orto is printed on the document. However, an unknown individual signed for him.

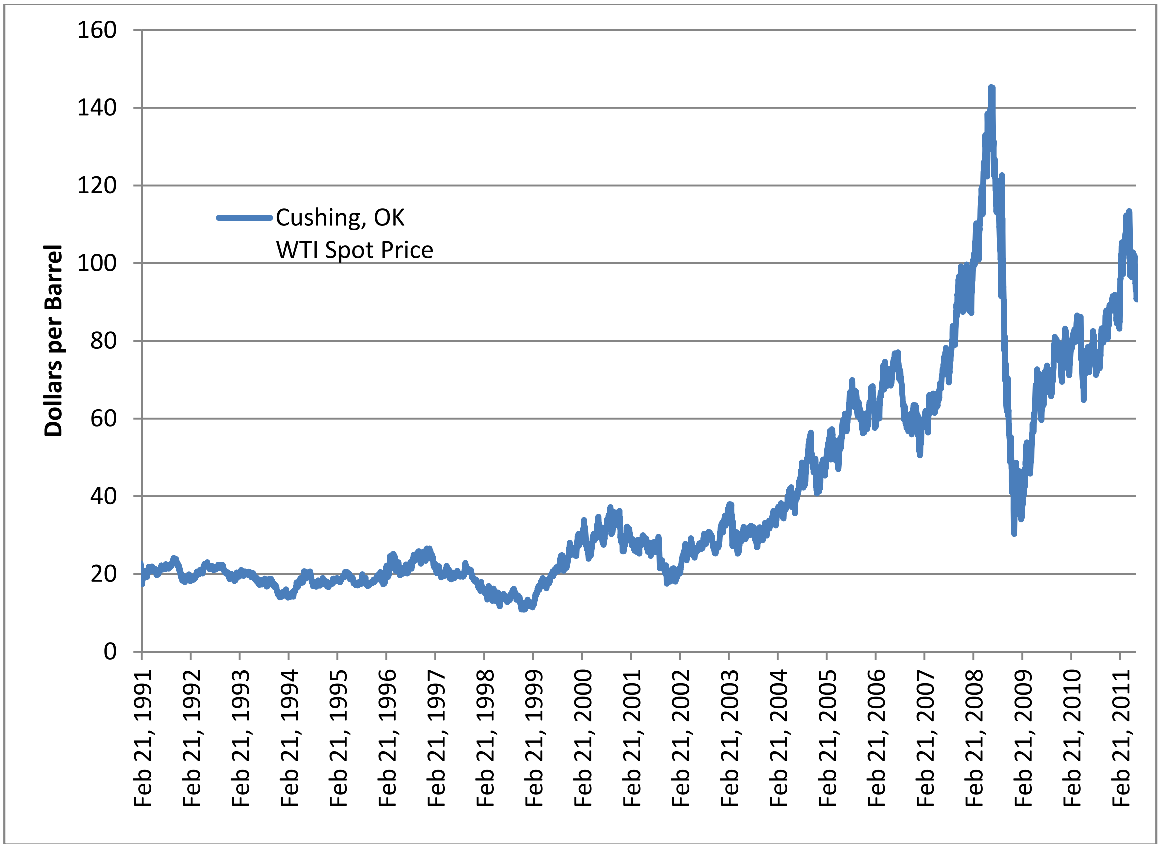

Figure 3. Daily Crude Oil Prices From 1986–2013 in U.S. Dollars per Barrel (After EIA, 2013)

F. FUEL FROM AQUATIC SPECIES

The DOE researched not only fuels derived from non-petroleum sources, but also fuels derived from aquatic species. The Office of Fuels Development within the DOE funded the Aquatic Species Program (ASP) from 1978 to 1996. The main effort of the program was "the production of biodiesel from high lipid-content algae grown in ponds, utilizing waste CO2 from coal fired power plants" (Sheehan, Dunahay, Benemann, Roessler, & Weissman, 1998, p. i). The DOE eliminated ASP funding in 1995 to instead focus on the development of bioethanol (Sheehan et al., 1998, p. 1). Over the approximately 20-year period, the DOE spent $25.05 million on the ASP (Sheehan et al., 1998, p. 20).

Between 1996 and 2009, algal research was funded from organizations such as the "DOE, the Department of Defense, the National Science Foundation, and the

Department of Agriculture" (Department of Energy [DOE], 2010, p. 5). Some of the recent initiatives in these organizations include the "Defense Advanced Research Projects Agency solicitation, the Air Force Office of Scientific Research (AFOSR) algal bio-jet program, and several DOE Small Business Innovative Research (SBIR) request for proposals" (DOE, 2010, p. 5) When the ARRA of 2009 was enacted on February 17, 2009, the DOE received $36 billion, of which $1.03 billion was used to support "innovative work to advance biomass research, development, demonstration, and deployment" (DOE, n.d., p. 1). Figure 4 shows the congressionally directed and annual appropriations and the impact the ARRA had on the DOE's Office of Biomass.

The enactment of the ARRA was another catalyst for the DON's biofuel initiative. Six months after the ARRA's passage, the SECNAV released *Naval Energy: A Strategic Approach* in October 2009 and gave his aforementioned remarks to the Naval Energy Forum on October 14, 2009. Four months later, the DoD released the 2010 QDR, followed by the 2010 NSS, which laid out the strategies for pursuing biofuels. The DON has recently purchased biofuel from two companies receiving ARRA funds. Using funds from the ARRA, DOE established a cost-sharing agreement with Solazyme and Amyris at a cost to the DOE of $21,765,738 and $25,000,000, respectively (DOE, n.d., p. 3). The DON then purchased 1,500 gallons of biofuel from Solazyme at a cost of $149 per gallon for a total of $223,500 and 15,000 gallons of biofuel from Amyris at a cost of $25.73 per gallon, for a total of $385,950. The DON has two additional options remaining on the contract with Amyris to purchase 25,000 gallons of biofuel at a cost of $25.73 per gallon for a cost of $643,250 for each option (Blakeley, 2012, p. CRS-13).

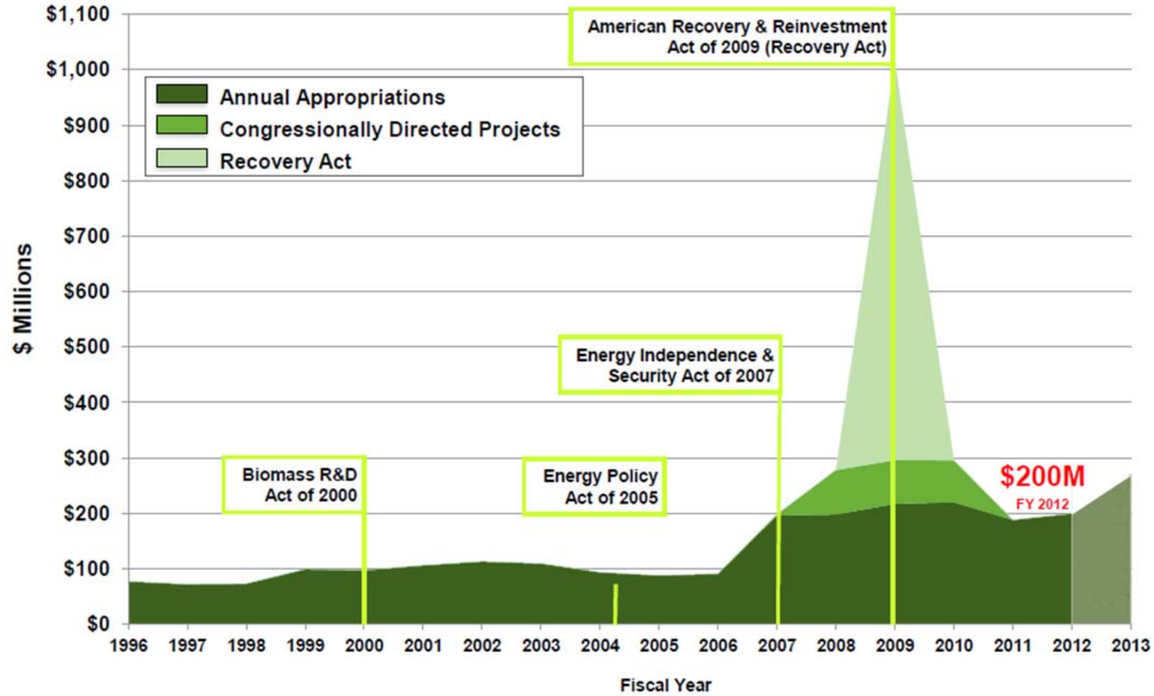

Figure 4. DOE's Office of Biomass Congressionally Directed and Annual Appropriations and the ARRA
(From Reed, 2012, p. 3)

G. BIOMASS WAS THE ONLY OPTION FOR DIVERSIFICATION

This section answers the same research goal of determining the origin of the DON's biofuel initiative, but approaches the analysis from a different angle.

Figure 5 is a Sankey[7] diagram and was developed by Lawrence Livermore National Laboratory (LLNL). Figure 5 shows the petroleum and biofuel used by the DoD in 2008, measured in thousands of barrels, and it also shows whether the fuel was purchased by the Defense Logistics Agency–Energy (DLA–E) from the Continental United States (CONUS) or outside Continental United States (OCONUS). The middle boxes depict the type of petroleum and biofuel while the boxes on the right depict which military service used the petroleum. Although the DON uses nuclear energy (as shown in Figure 2 above), this energy source is not displayed in Figure 5.

[7] A Sankey diagram is named after Matthew Henry Phineas Riall Sankey. A Sankey diagram displays a type of flow, where the width of the flow on the diagram is proportional to the quantity of flow.

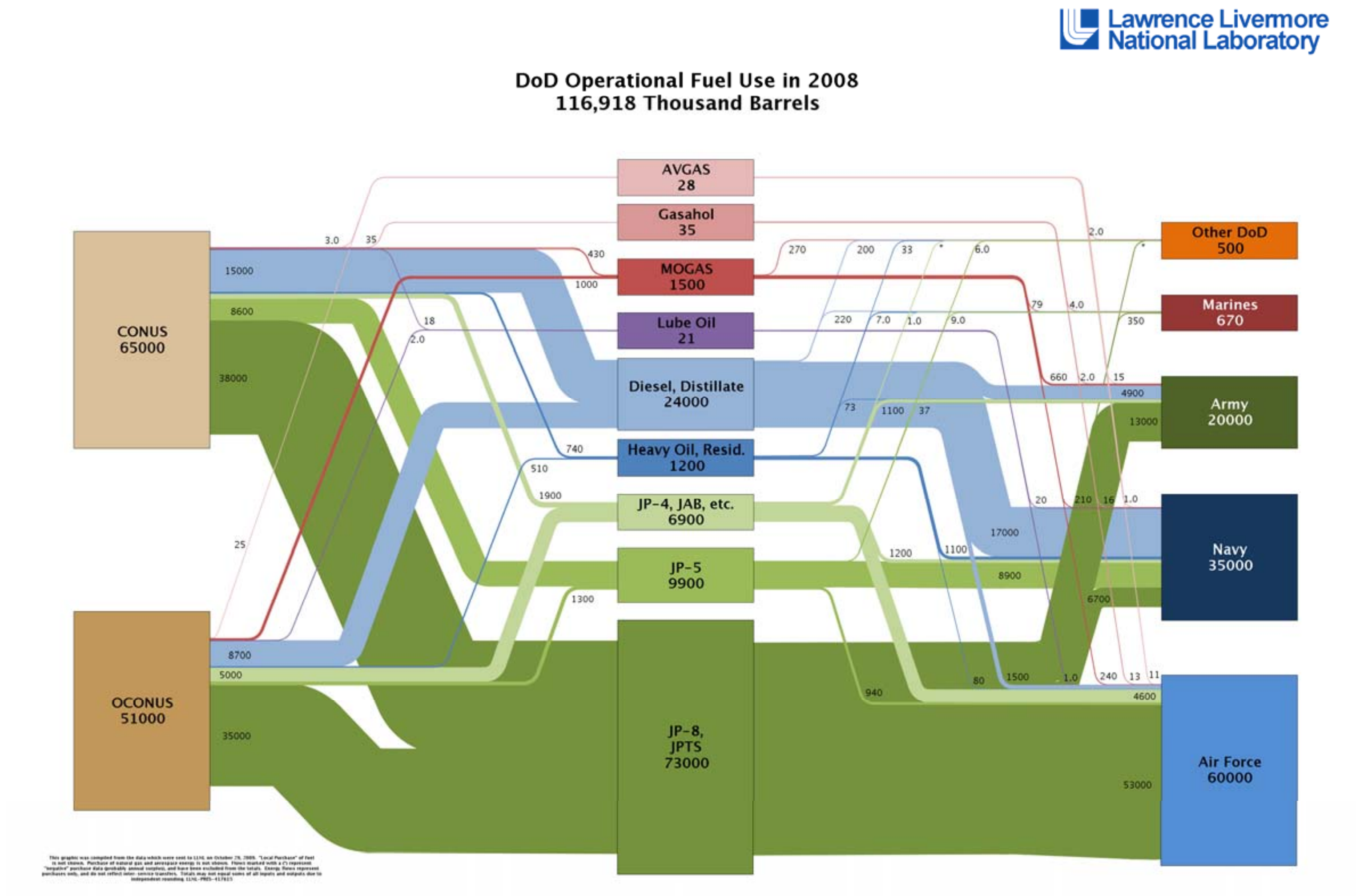

Figure 5. DoD Petroleum Use in 2008, Shown in Thousands of Barrels (From Kaahaaina, 2013, p. 2)
Notes. Image created by LLNL from data provided by DLA–E. AVGAS is aviation gasoline; gasahol is gasoline blended with ethanol; MOGAS is motor gasoline; and distillate is F-76.

Figure 5 shows that the DoD is not diversified in terms of liquid, operational energy fuels and mostly relies on petroleum. As I mentioned above, the NSS called for "diversifying [energy] supplies" (The White House, 2010, p. 10) and the *Blueprint's* goal "of breaking ground on at least four commercial-scale cellulosic or advanced bio-refineries over the next two years" (The White House, 2011, p. 23). In a letter to members of the Defense Operational Energy Board, the Assistant Secretary of Defense for Operational Energy Plans and Programs listed "increased fuel options for operational commanders" (Burke, 2012, p. 1) as an alternative fuel investment consideration. The DoD's Operational Energy Strategy continued this reasoning, stating,

> **More options, less risk: Expand and secure the supply of energy to military operations.** The Department [of Defense] needs to diversify its energy sources and protect access to energy supplies in order to have a more reliable and assured supply of energy for military missions. (DoD, 2011a, p. 1; bold in original)

Assuming that the DON wants to look for an alternative energy source for operational military applications, I will examine what is already available in the United States. Figure 6 is another Sankey diagram developed by LLNL. The multi-colored boxes on the left-hand side of Figure 6 depict the energy produced by source for the United States in 2008 and the orange, pink, and grey boxes on the right show the energy consumed by sector. As depicted in Figure 6, the transportation sector is heavily dependent upon petroleum, indicated by the dark-green band, which was shown true for the DoD as well in Figure 5. The transportation sector as well as the DoD reacts to the price volatility of petroleum because it cannot easily substitute for petroleum. Solar, hydropower, wind, and geothermal energy sources are not effective for modern operational military applications based on current technology and are not discussed further in this thesis.

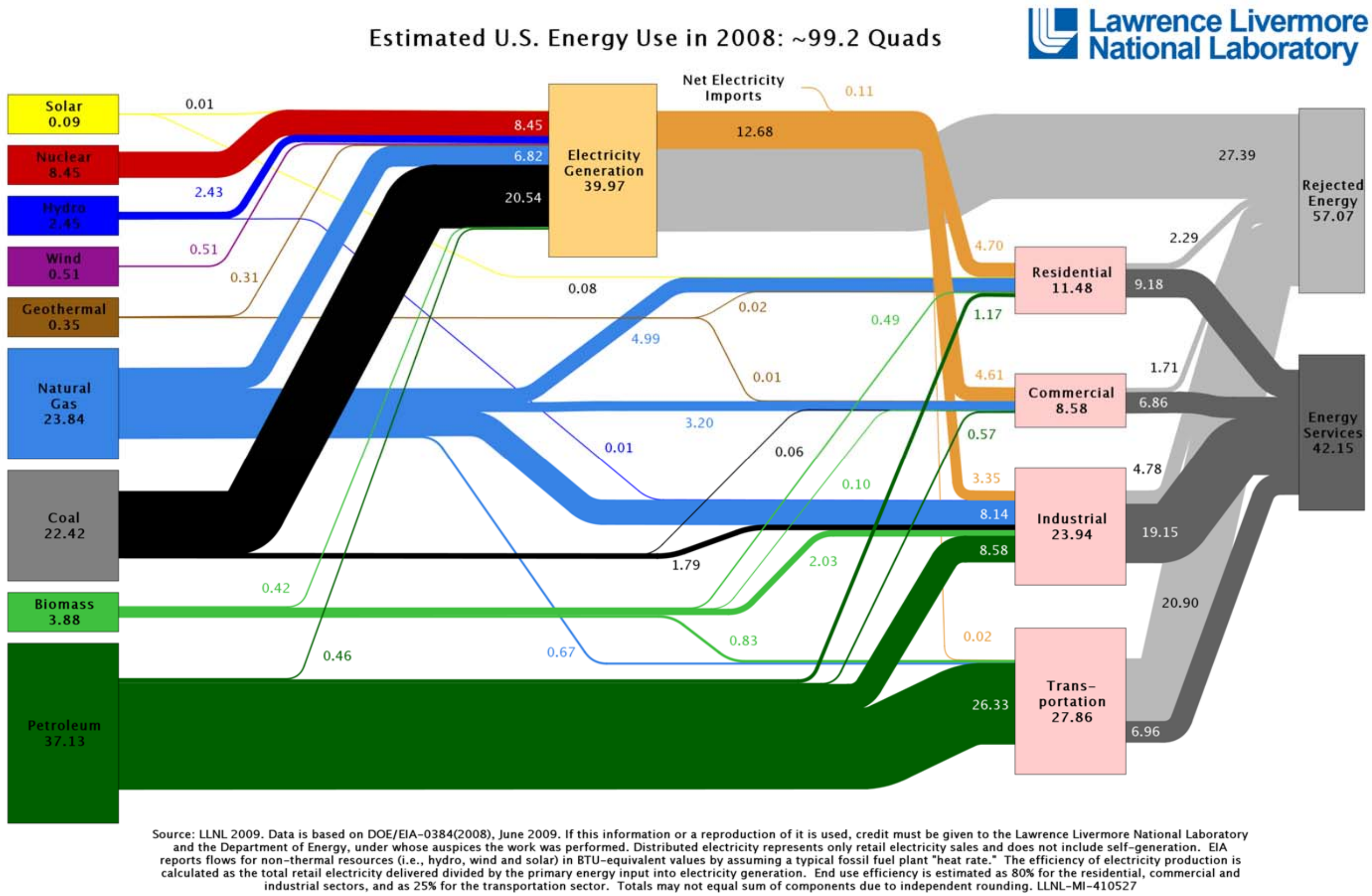

Figure 6. Estimated Energy Use in 2008 for the United States, Numbers Shown in Quads (From Lawrence Livermore National Laboratory [LLNL], 2009)

Previously, I summarized previous attempts at diversifying energy sources by developing synthetic fuels derived from fossil fuels. However, section 526 of EISA of 2007 limits the DoD's ability to acquire fuels from natural gas and coal for operational uses. This further substantiates why section 526 of the EISA of 2007 was a catalyst for the DON developing its biofuel initiative. Repealing or creating an exception for the DoD from section 526 of the EISA of 2007 could allow the DoD to further diversify its operational energy sources with coal- and natural gas–derived operational fuels. From Figure 6, therefore, only three energy sources at the national level can help the DoD diversify its operational energy portfolio: petroleum, biomass, and nuclear.

Nuclear energy is an option to further diversify the DoD's operational energy portfolio beyond the current usage. The Congressional Budget Office's (2011) study found the following break-even points based on the price of a barrel of oil in 2011 dollars for fleets of three classes of Navy ships: nuclear-powered destroyers, $223; nuclear-powered LH(X) amphibious assault ships, $140; and nuclear-powered LSD(X) amphibious dock landing ships, $323 (p. 7). Since the current price of oil is lower than the Congressional Budget Office's projections, it appears cheaper to continue to use conventional power for those classes of Navy ships.

Of the three energy sources available for operational military applications, a portion of the available biomass was the only option available to appropriate research and development dollars to develop an alternative operational energy source. This further substantiates why the enactment of the ARRA was another catalyst for the DON's biofuel initiative.

H. SUMMARY AND CONCLUSIONS

In this chapter, I examined the biofuels initiative undertaken by the DON and explained the origin of the current DON biofuel initiative. I began with defining biofuels and drop-in replaceable biofuels. I then explained how biofuels fit into the energy security strategy by examining the organization and policies from the perspective of the federal government. The SECNAV, as in the NSS, ties energy security to sustainable sources. I detailed the importance of the price of crude oil as well as its role in the DON pursuit of the current biofuel initiative. Two options to provide biofuels were examined: build biofuel refineries using the DPA, or rely on the commercial market with the assistance of the CAAFI. Through the joint MOU, the DON is using the DPA to subsidize the construction or modification of biofuel refineries as a national defense need, which could further diversify the DON's fuel supply. If the DON did not want to accept the cost and risk of subsidizing the construction or modification of biofuel refineries, the DON could rely on the diversified biofuel supply chain being developed for civilian aviation with the assistance of the CAAFI. In this chapter, I summarized historical attempts to develop non-petroleum–based fuels and then demonstrated how section 526 of the EISA of 2007 effectively ended the DoD's research program into developing synthetic fuels derived from fossil fuels. I then summarized historical attempts to develop petroleum from aquatic species. The federal government has a history of developing petroleum from fossil fuels, starting from 1944, as well as petroleum from aquatic species. I concluded the chapter by depicting how the enactment of ARRA of 2009 made available a large amount of money for biofuel research and development and was another catalyst for the DON's biofuel initiative.

In this chapter, I presented three catalysts for the DON's biofuel initiative: (1) Section 526 of the EISA of 2007 effectively ended the DoD's research program into synthetic fuels derived from fossil fuels; (2) the West Texas Intermediate crude oil spot price reached a maximum daily price of $145.16 on July 14, 2008; and (3) the ARRA of 2009 appropriated over a billion dollars for biomass research and development.

III. THE VOLATILITY PROBLEM FOR DEFENSE ENERGY

I begin this chapter by showing the DON's plan to invest in biofuels as a way to mitigate volatility. Next, I show the historical volatility of oil prices and demonstrate how price volatility affects the DoD and the DON. I then summarize how the DoD currently avoids petroleum cost volatility using the DWCF and evaluate whether biofuels, as an alternative operational fuel, will dampen the effects of fuel cost volatility. I examine other options to mitigate cost volatility, such as futures contracts, intragovernmental transfers, long-term contracts, off-take agreements, and the status quo.

A. BACKGROUND

Volatility is defined as "characterized by or subject to rapid or unexpected change" ("Volatility," n.d.). Petroleum volatility is "one of the top challenges for both our Nation and Department of Defense" ("Task Force Energy Charter," n.d., p. 1). The QDR ties renewable energy investments to reducing cost volatility, stating, "[t]he Department [of Defense] is increasing its use of renewable energy supplies and reducing energy demand to … protect the Department from energy price fluctuations" (QDR, 2010, p. 87). The DoD included "dampened effect of petroleum price volatility" (Burke, 2012, p. 1) as a consideration for investing in alternative fuels. The DON connects energy security and investing in biofuels as a way to "shield ourselves from a volatile fuel supply" (Office of the SECNAV, 2009, p. 3).

Dvir and Rogoff (2009) calculated the mean volatility of crude oil from 1861–2008 during four different periods, shown in Table 1. Dvir and Rogoff defined *mean volatility* "as the mean absolute residual from a regression of oil price growth on its lagged value" (Dvir & Rogoff, 2009, p. 8).

Table 1. Mean Volatility of Crude Oil Prices From 1861–2008 (Dvir & Rogoff, 2009, p. 49)

Period	**Timespan**	**Mean volatility**
I	1861–1878	0.381
II	1878–1934	0.195
III	1934–1972	0.061
IV	1972–2008	0.221

Figure 7 shows the mean volatility of oil prices from 1861 to 2008. The highest mean volatility occurred during period I from 1861 to 1878, followed by significantly lower levels until 1972. During period IV, the mean volatility stepped back up to a similar level previously experienced in period II. The mean volatility of period IV was lower than the mean volatility experienced in period I and about equal to the mean volatility experienced in period II. In the next section, I describe the budgetary impacts of fuel cost volatility on the DoD and DON.

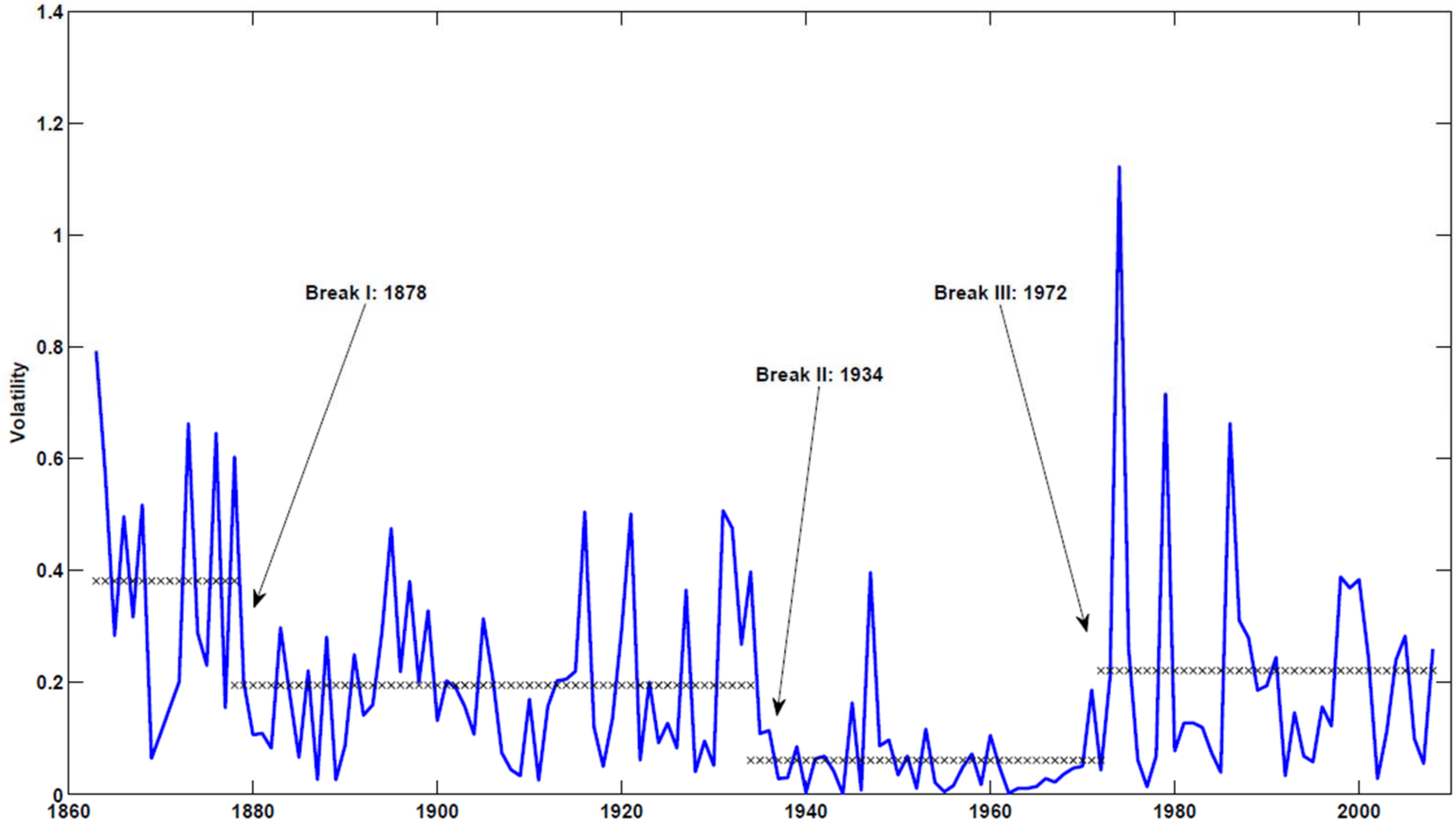

Figure 7. The Volatility of Oil Prices During 1861–2008 (From Dvir & Rogoff, 2009, p. 50)
Notes. Real volatility is depicted with the blue line and mean volatility is shown as the horizontal line with black Xs. The mean volatility has three distinct breaks.

B. BUDGETARY IMPACTS TO THE DOD AND THE DON

The DoD uses the Operations and Maintenance accounts to procure fuel. From FY 2000 to FY 2008, DoD fuel expenditures rose from approximately $3.6 billion to $18 billion—a 400 percent increase. Fuel volumes increased by only 30 percent during the same time frame (Andrews, 2009, p. 2). Since more money is spent on fuel, this translates into less money spent on military operations, maintenance, and personnel. In 2011, the Honorable Robert Gates, then-SECDEF, testified "that unbudgeted fuel costs could force cuts in Air Force flying hours, Navy steaming days, and training for homestationed Army troops" (Schwartz, Blakeley, & O'Rourke, 2013, p. 10). The SECNAV, the Honorable Ray Mabus, testified before Congress in 2012 that "in FY12 alone, in large part due to political unrest in oil producing regions, the price per barrel of oil is $38 more than was budgeted [*sic*] increasing the Navy's fuel bill by over $1 billion. These price spikes must be paid for out of our operations funds. That means that our Sailors and Marines are forced to steam less, fly less, and train less" (Statement of the Honorable Ray Mabus, 2012, p. 30). Secretary Mabus' testimony reflected the budgetary and operational impacts of both price and volatility of oil to the Naval service. As shown, crude oil cost volatility continues to have budgetary impacts to the DoD and the DON (DoD, 2011a, p. 8). The DoD already has a mechanism in place to mitigate the petroleum price volatility, which is the DWCF.

C. HOW THE DOD PURCHASES FUEL

The Defense Logistics Agency (DLA) "sources and provides nearly 100 percent of the consumable items America's military forces need to operate … [including] fuel and energy" (DLA, n.d.). DLA–Energy (DLA–E) has the responsibility for "purchasing fuel for all of DOD's services and agencies, both in the continental United States (CONUS) and outside (OCONUS)" (Andrews, 2009, p. 1). DLA–E purchases fuel in the following categories: "bulk petroleum products (JP-8, JP-5, and diesel fuel), ships' bunker fuel, into-plane (refueling at commercial airports), and post-camp-and-station" (Andrews, p. 1). DLA–E usually awards fuel contacts for a duration of one year for the lowest point-of-delivery cost (Andrews, p. 1). The contracts are "fixed-price contracts with an economic price adjustment that provides for upward and downward revision of the stated contract price upon the occurrence of specified contingencies" (Andrews, p. 18).

DLA–E uses the DWCF as the initial funding to purchase fuel products. A working capital fund is a "type of revolving fund … [in which] all income is received from the activity's operations and is available to finance continuing operations without a fiscal year limitation" (Jones, Candreva, & DeVore, 2012, p. 265). The DWCF is reimbursed when fuel is purchased from the DLA–E by the DoD services and agencies at a reimbursable price that is static for the duration of the FY. The static reimbursable price for fuel is determined by the Office of Management and Budget (OMB) projections of the cost of petroleum and incorporates the cost of the fuel price as well as DLA–E's worldwide operating expenses, such as handling, storage, distribution, and overhead. The static reimbursable price is also independent of location (Schwartz et al., 2013, p. 6). OMB projections are based on New York Mercantile Exchange market futures data ("Defense Working Capital Fund: Defense-Wide Fiscal Year 2010 [DWCF FY 2010]," 2009, p. 154).

Using the DWCF for bulk fuel purchases benefits the DoD because it allows DLA–E to purchase large quantities at the lowest market price on a competitive market. Individual commands do not need to buy small quantities for their own use. Transportation costs are minimized by having the fuel delivered to large military concentration areas. From a budgetary point of view, the DWCF continues to operate across FYs and appropriation bills, unlike individual command accounts. Lastly, the DLA–E customer desires a constant fuel price throughout the FY, which the DoD services and agencies can then use to plan their respective operations for the FY (Bowman & Wright, 2009, pp. 5–6; Knapp, 2008, p. 3). DLA–E absorbs the daily cost volatility of petroleum with the DWCF. Through the use of the DWCF and the static fuel price, the DoD has an established way of doing business to mitigate the perceived volatility in petroleum prices for DoD users. Individual commands do not have to compete on the volatile petroleum world market, whose daily volatility is shown in Figure 3 in Chapter II.

Figure 8 compares the West Texas Intermediate Crude Oil Price to the OMB budget projection from February 1991 through February 2011. OMB fuel projections, which set the reimbursable rate for the DWCF, have to be accurate for the entire FY. It is obvious from Figure 8 that the OMB projections are usually lower than the actual petroleum price. When the petroleum price was greater than OMB projections, the following options were employed: (1) static reimbursable prices were adjusted during the FY, (2) additional dollars were transferred into the DWCF to maintain solvency of the DWCF through a congressional appropriation, (3) the DoD services and agencies reduced operational and maintenance requirements, and (4) a combination of the above. As a result of the recent high petroleum price volatility, DLA–E instituted a policy of adjusting the static fuel price whenever required within a FY, starting in FY 2005. This was in contrast to the previous policy of maintaining a reimbursable price constant throughout the FY (Schwartz et al., p. 10). However, when the petroleum price was less than OMB projections, Congress removed money from the DWCF if the cash balance was excessive. This occurred in FY 2008 when Congress implemented a $40 million reduction for an excessive DWCF cash balance ("DWCF FY 2010," 2009, p. 3[8]) As a result of congressional intervention, the DWCF cannot accumulate funds as a cushion to protect against price volatility, so the OMB petroleum price projections have to be accurate for the entire FY. Starting in FY 2014, the days of cash available in the DWCF will be increased to 7–10 days ("DWCF FY 2013," 2012, p. 3[9]). For a detailed analysis of Figure 8, see Defense Business Board (2011, p. 43[10]).

[8] Multiple page numbers are used throughout the document, so I assumed the cover page as page one and so forth.

[9] Multiple page numbers are used throughout the document, so I assumed the cover page as page one and so forth.

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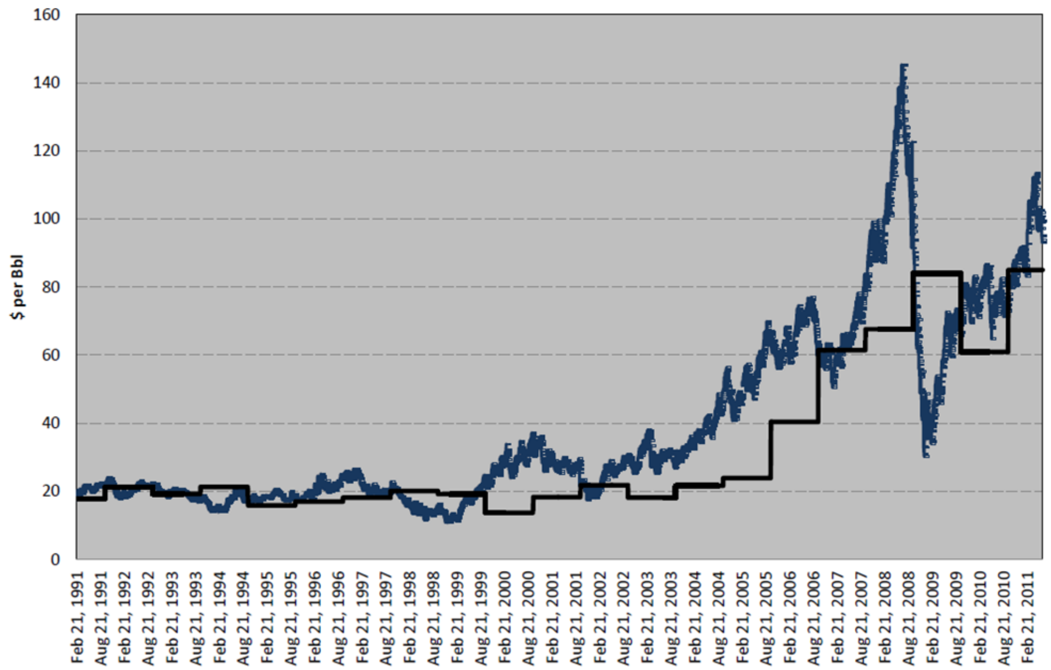

Figure 8. West Texas Intermediate Crude Oil Spot Price Versus OMB Budget Projection From February 21, 1991 Through February 21, 2011 (From Defense Business Board, 2011, p. 42)
Note. The jagged dark blue line is the spot price, and the black line is the OMB budget projection price.

Thus the DoD already has a mechanism in place that results in a perceived lower cost volatility to DLA–E customers, although it has demonstrated it cannot handle extreme volatility within a single year.

D. WILL BIOFUELS REMOVE THE COST VOLATILITY ASSOCIATED WITH PETROLEUM?

Chapter II previously demonstrated that the DoD is seeking biofuels as a drop-in replaceable fuel. Biofuels would become a substitute for petroleum if the price was advantageous to the consumer. The drop-in replaceable biofuel prices are not currently cost competitive with petroleum (Blakeley, 2012, pp. CRS-13–CRS-14). The following analysis is valid only when drop-in replaceable biofuel prices eventually become cost competitive with petroleum and remains cost competitive with the petroleum's volatile price. If the prices of drop-in replaceable biofuels remain above petroleum's prices, it is obvious that drop-in replaceable biofuels would not remove volatility.

Will biofuels remove the price volatility associated with petroleum? If drop-in replaceable biofuel can substitute for petroleum, the answer is no. Two goods for which an increase in the price of one leads to an increase in the demand for the other are called "substitutes" (Mankiw, 2009, p. 70). If one product—for example, petroleum—increased in price, consumers would switch to the lower-priced product—in this example, biofuels. As consumers switch to biofuels, the demand for biofuels rises. With a given supply of biofuels (that is, a supply schedule relating the quantity supplied to the price), an increase in the demand for biofuels will cause their price to rise. The price volatility would remain because biofuel prices would follow in-step along with petroleum prices on the open market. Biofuels would be close substitutes as drop-in replacements. Chapter II previously demonstrated the DON is seeking to obtain biofuels by building or retrofitting refineries to produce biofuels using the DPA. I next explore, using gasoline as an example, whether domestically produced biofuels will remove price volatility.

In Chapter II, I summarized previous attempts to domestically produce synthetic fuels derived from fossil fuels. Since the petroleum market is a world market, no country can be independent. Figure 9 shows the volatility of the average retail price of gasoline for Japan, Canada, and the United Sates. In 2010, Japan imported 100 percent of its petroleum, compared to Canada, which is a net exporter of oil. All three countries experienced the same volatility in the price of gasoline. Even if the United States produced all of its fuel domestically, the United States would probably still experience the same price volatility as Canada does (Congressional Budget Office [CBO], 2012a, p. 6). Oil is sold in a global market that is controlled by international market forces. For that reason, the United States would be affected by world prices. Increasing domestic fuel production would not shield the United States from fuel price volatility. Consequently, domestically producing biofuels and selling the biofuels on the open market would not remove price volatility.

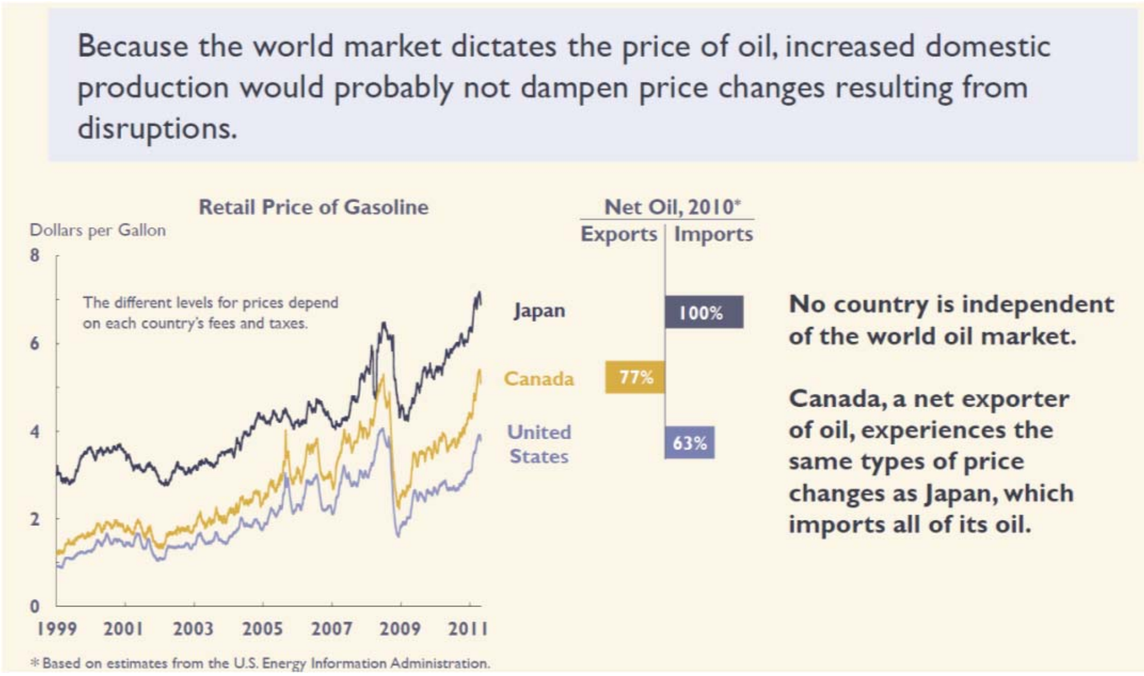

Figure 9. Average Retail Price of Gasoline in Dollars per Gallon for Japan, Canada, and the United Sates 1999–2011
(From CBO, 2012b, p. 8)

Additionally, Kiefer claims biofuels may increase price volatility: "Deriving fuel from farming does not liberate it [the fuel] from petroleum dependence or oil market price volatility, but rather increases price volatility by adding an additional linkage to global agricultural commodities markets" (Kiefer, 2013, p. 27).

E. OPTIONS TO REDUCE COST VOLATILITY

Options available to potentially reduce price volatility include futures contracts, intragovernmental transfers, long-term contracts, off-take agreements, and the status quo. Each of these options is briefly examined below.

1. Futures Contracts

Since petroleum is sold on the world market, one option that could mitigate cost volatility to the DoD is the use of futures contracts. A *futures contract* is an "agreement to buy or sell a commodity, financial instrument, or security, on a stated future date, at a specified price" ("Futures contract," n.d.). The governments of the United Kingdom, France, and Israel reduce cost volatility by actively managing fuel price risk using futures contracts (Defense Business Board, 2011, p. 3). However, the Defense Business Board did not recommend that the DoD use the futures market to mitigate volatility. The Board's concern was senior DoD officials' lack of experience (Defense Business Board, 2011, p. 5). Bowman and Wright (2009) came to a different conclusion and recommended that the DoD adopt a "70 percent futures and 30 percent spot, 12-month, futures hedging program" (p. 68).

2. Intragovernmental Transfers

Instead of using the futures market, the Defense Business Board (2004) recommended pursuing a "non-market hedging" opportunity as a way to mitigate fuel cost volatility. This opportunity is a proposed intragovernmental transfer between the DoD and the Bureau of Ocean Energy Management (BOEM), an agency within the U.S. DOI. The BOEM was previously called the Minerals Management Service and the Bureau of Ocean Energy Management, Regulation and Enforcement (Bureau of Ocean Energy Management, Regulation and Enforcement [BOEMRE], n.d.). BOEM receives revenue by leasing off-shore federal lands. When oil prices rise, revenues for the BOEM increase, while the costs for the DoD simultaneously increase. The Defense Business Board concluded the following:

> DoD should recommend that OMB seek legislative authority to transfer funds from Interior to Defense or vice versa depending on which Department benefits from unanticipated [oil] price changes. This could offset, at least partially, the growth in DoD [oil] costs. Such an approach would allow DoD to realize some of the benefits of fuel hedging while avoiding many of the potential adverse effects associated with hedging in commercial markets. (Defense Business Board, 2004, p. 4[11])

Later, the Defense Business Board (2011, p. 6) reaffirmed this recommendation. However, this recommendation could face resistance from Congress because "Congress has already statutorily allocated those revenues [from off-shore federal leases] among various government accounts, including coastal states" (Andrews, 2009, p. 18).

[11] Multiple page numbers are used throughout the document, so I assumed the cover page as page one and so forth.

3. Long-Term Contracts

Long-term contracts could reduce volatility, but the DoD risks losing competitors in supply. Long-term contracts are currently limited to five years, pursuant to 10 U.S.C. 2304a (Kendall, 2012, p. 1). Bartis, Camm, and Ortiz (2008) cited 10 U.S.C. 2306b as the long-term contracting authority, which is for the acquisition of property (p. 114). Bartis and Van Bibber (2011) recommended that long-term contracts allow adjustments to market prices (pp. 69–70). If the agreed upon price differs from the market price, the parties locked in a fixed-price agreement do not share a continued interest in continuing the agreement. There is less of an incentive to maintain or continue the long-term fixed-price agreement when the market price and fixed-price differ because one party is losing (Bartis & Van Bibber, pp. 69–70). If the contracted price departs largely from the market price, this incentivizes one party to seek to terminate the long-term contract prematurely. If the government is a signatory of the fixed-price agreement, and the price goes against the private contractor, this could result in a publicly perceived forced bankruptcy by the government. If the market price turns out to be lower than the agreed upon price this could be perceived as a waste of government funds (Camm, Bartis, & Bushman, 2008, p. 7). If the goal of the long-term contract is to maintain the relationship for longevity, then there should be incentives to continue the relationship. When the fixed-price agreement adjusts periodically to the market price, the parties locked in a fixed-price agreement are incentivized to continue the agreement. As discussed above, DLA–E's one-year contracts already include an economic price adjustment, which results in a perceived lower volatility for DLA–E's customers.

If DLA–E pursues long-term contracts, the DoD risks losing competitors in supply. Not all refineries produce DoD-specification fuels. Signing a long-term contract with a single refinery could force other refineries to leave the DoD fuel-making business.

Section 863 of the NDAA for FY 2012 focused on long-term contracts for alternative fuel sources. The recent congressional interest in long-term contracting is mainly for financing the building of biofuel refineries. Petroleum price volatility affects investment opportunities in the biofuel industry, which could limit the development of the industry. If the biofuels market price followed the volatile petroleum market, "such price volatility could create uncertainty in revenue projections for the biofuel projects, and discourage investment in the industry” (State of Hawaii, 2012, p. i).

In response to section 863 of the NDAA for FY 2012, the DoD stated,

> Potential alternative fuels suppliers have indicated to the Department [of Defense] that purchase contracts of at least 10 years in duration could potentially stimulate additional capital investment in alternative fuels production beyond the small volumes currently planned in response to commercial demand. Renewable fuel projects are capital investment intensive, involving construction of production facilities, and long-term contracts enhance the ability of developers to secure critical financing and recoup capital investments. (Kendall, 2012, p. 1)

The DoD has not yet requested legislative authority to enter into long-term contracts beyond five years (Kendall, 2012, p. 1).

4. Off-Take Agreements

The potential biofuel refinery producers not only desire a 10-year (or longer) firm, fixed-price contract, but also desire off-take agreements (B. Boughey, Office of the Deputy Assistant SECNAV for Energy, personal communication, January 18, 2013). An off-take agreement is “[a]n agreement that takes place between a producer and a buyer before the construction of a facility that guarantees a market for the future production of a facility” (“Offtake agreement,” n.d.). An off-take agreement may also be referred to as a purchase agreement.

Off-take agreements may reduce volatility, but long-term off-take agreements would be expected, so the aforementioned paragraphs on long-term contracts apply. The off-take agreements should allow for adjustments to market prices, which would mitigate volatility until the next adjustment. DLA–E uses the DWCF to execute contracts in a similar manner.

Off-take agreements are already in place within the military and commercial enterprises. The Pew Project on National Security, Energy and Climate (2011) highlighted DoD usage of electrical power purchase agreements (PPAs). PPAs are “long-term contracts between DoD and electricity providers, which incur the cost of developing power supply and are remunerated at an agreed price over the length of the agreement" (The Pew Project, 2011, p. 24). Hawaiian Electric Company (HECO) has also used off-take agreements "to supply up to 200 million gallons of sustainably produced, renewable biofuel per year to fuel power generation stations starting as early as July 2014" (Solecki, Richey, & Epstein, 2011, p. 11).

It is inadvisable to extrapolate the experience with these off-take agreements to biofuels, because the PPAs and HECO off-take agreements are used for electrical energy production. The electricity price index has a lower price volatility than the gasoline index (CBO, 2012b, p. 4). In the area of transportation fuels, "KiOR signed offtake agreements with Hunt Refining, Catchlight Energy (a joint venture between Chevron Corporation and Weyerhaeuser Company), and FedEx Corporate Services" (KiOR, n.d.). The KiOR off-take agreements supply renewable gasoline, diesel, and fuel oil. KiOR and Catchlight Energy also signed a feedstock supply agreement to guarantee a constant source of raw materials in order to produce the renewable transportation fuels (KiOR, n.d.).

5. Status Quo

Through the aforementioned DWCF, the DoD already has made perceived oil prices less volatile to the DoD users. In Chapter II, I summarized previous failed attempts to domestically produce synthetic fuels derived from fossil fuels. How is the current biofuels initiative different from previous attempts to produce cost-competitive fuels? In order to make drop-in replaceable biofuels cost-competitive with petroleum, the commercial industry needs to overcome numerous technical challenges. An organization that strongly advocates biofuels, the American Security Project, concluded, "The technology for advanced biofuels is advancing rapidly, but much of the industry is still largely immature" (Holland, 2013, p. 8). The National Research Council (2012) further discussed some of the technical challenges involved in commercializing advanced biofuels, summarized below:

- large quantity of water and nutrients required for algae cultivation;
- algae cultivation would have to produce more energy than required for cultivation and fuel conversion for an energy return on investment greater than one; and

- lifecycle GHG emissions to produce advanced biofuels would have to be lower than fossil fuels. (p. 3)

In the 2012 edition of the International Energy Agency (IEA) World Energy Outlook, the United States "is projected to become the largest global oil producer" by approximately 2020 (IEA, 2012, p. 23). With this projection, the DoD, coupled with the DWCF, could achieve the DoD's goal of domestically produced petroleum without the investment in building biofuel refineries. If the DoD is seeking an option that does not require infrastructure investments in biofuel refineries, then the status quo may be an answer.

F. SUMMARY

In this chapter, I explained the DON's plan to invest in biofuels to mitigate volatility. I defined volatility and presented the historical volatility of oil prices. Although cost volatility has demonstrated a negative effect on the DoD, it is using the DWCF to make perceived oil prices less volatile to DoD users. Purchasing drop-in replaceable biofuels at the market price would not remove the price volatility associated with petroleum. Increasing domestic biofuel production would not shield the United States from fuel price volatility. I examined other options to mitigate cost volatility, with the results shown in Table 2.

Table 2. Summary of the Options Examined to Mitigate Cost Volatility

Options to mitigate cost volatility	**Summary of conclusions**
Futures contracts	The governments of other countries reduce cost volatility by actively managing fuel price risk using futures contracts. This option was not recommended by the Defense Business Board (2011, p. 5) and Knapp (2008). Bowman and Wright (2009) came to a different conclusion and recommended that the DoD adopt a "70 percent futures and 30 percent spot, 12-month, futures hedging program" (p. 68).
Intragovernmental transfers	Intragovernmental transfers are proposed transfers between the DoD and DOI. This option was recommended by Defense Business Board (2004) and Defense Business Board (2011). However, the petroleum revenues from DOI are already allocated to other government accounts.
Long-term contracts	Long-term contracts could reduce volatility, but the DoD risks losing competitors in supply. The DoD has not yet requested legislative authority to enter into long-term contracts beyond five years (Kendall, 2012, p. 1).
Off-take agreements	Off-take agreements may reduce volatility, but could result in a higher product cost. The off-take agreements should allow for adjustments to market prices, which would mitigate volatility until the next adjustment. DLA–E uses the DWCF to execute contracts in a similar manner. Off-take agreements would be expected to be long-term. Therefore, the long-term contract conclusions apply as well. KiOR used off-take agreements for the production of renewable gasoline, diesel, and fuel oil.
Status quo	Through the DWCF, the DoD already has made perceived oil prices less volatile to the DoD users. However, extreme price volatility is an issue for the DWCF. Numerous technical challenges need to be overcome in developing drop-in replaceable biofuels that are cost competitive with petroleum. Oil production in the United States is expected to increase significantly by 2020. If the DoD is seeking an option that does not require infrastructure investments in biofuel refineries, then the status quo may be an answer.

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IV. SUMMARY, RECOMMENDATIONS, AND FURTHER STUDY

A. SUMMARY

One of the objectives of this research was to answer the question: What is the origin of the Department of the Navy's (DON's) biofuel initiative? Secretary Mabus' speech at the Naval Energy Forum was the beginning of the DON's biofuel initiative. In Chapter II, I presented three catalysts for the DON's biofuel initiative: (1) Section 526 of the Energy Independence and Security Act of 2007 effectively ended the DoD's research program into synthetic fuels derived from fossil fuels; (2) the West Texas Intermediate crude oil spot price reached a maximum daily price of $145.16 on July 14, 2008; and (3) the American Recovery and Reinvestment Act of 2009 funded over one billion dollars for biomass research and development.

Two options to provide biofuels were examined: building biofuel refineries using the DPA or relying on the commercial market with the assistance of the CAAFI. To obtain biofuel, the Departments of the Navy, Energy, and Agriculture signed a joint MOU in June 2011. The DON's contribution as a signatory to this MOU is $170 million over three years, with the funds transferred in accordance with the DPA (MOU, 2011, pp. 2–3). The DON is using the DPA to subsidize the construction or modification of biofuel refineries as a national defense need. If the DON did not want to accept the cost and risk of subsidizing the construction of biofuel refineries, the DON could rely on the diversified biofuel supply chain being developed for civilian aviation with the assistance of the CAAFI. In Chapter II, I also found that organizations differ in the definitions of both energy security and drop-in replaceable biofuels, which is expounded upon in the recommendation section below.

In Chapter III, I analyzed whether biofuels—as an alternative operational fuel—will remove fuel cost volatility as a direct substitute for petroleum, and I also examined options to mitigate cost volatility. The following research questions were answered: Will biofuels remove fuel cost volatility for the DON, and what options are available to mitigate petroleum price volatility? Secretary Mabus testified before Congress in 2012 that "in FY12 alone, in large part due to political unrest in oil producing regions, the price per barrel of oil is $38 more than was budgeted [*sic*] increasing the Navy's fuel bill by over $1 billion. These price spikes must be paid for out of our operations funds. That means that our Sailors and Marines are forced to steam less, fly less, and train less" (Statement of the Honorable Ray Mabus, 2012, p. 30). Secretary Mabus' testimony reflected the budgetary and operational impacts of both price and volatility of oil to the Naval service. In Chapter III, I examined the DON's plan to invest in biofuels as a way to mitigate price volatility. Although cost volatility has affected the DoD's budget, the DoD has routinely used the DWCF to make perceived oil prices to DoD users less volatile. DLA–E, as the responsible agency for purchasing fuels, absorbs the daily cost volatility of petroleum with the DWCF. The DWCF is then reimbursed at a static reimbursable price when fuel is purchased from the DLA–E by DoD customers. Purchasing drop-in replaceable biofuels at the market price would not remove the price volatility associated with petroleum because biofuels would act as close substitutes. Increasing domestic biofuel production would not shield the United States from fuel price volatility.

In Chapter III, I explored other options to mitigate cost volatility. These options include futures contracts, intragovernmental transfers, long-term contracts, off-take agreements, and the status quo. Although the governments of other countries reduce cost volatility by actively managing fuel price risk using futures contracts, opinions differ on whether the DoD should pursue this option. The Defense Business Board (2011, p. 5) and Knapp (2008) recommended against DoD use of futures contracts. Bowman and Wright (2009) came to a different conclusion and recommended that the DoD adopt a "70 percent futures and 30 percent spot, 12-month, futures hedging program" (p. 68). Intragovernmental transfers are proposed transfers between the DoD and the DOI. Although the Defense Business Board recommended exploring this option on two separate occasions, (2004, p. 4; 2011, p. 6) the petroleum revenues are already allocated to other government accounts (Andrews, 2009, p. 18).

Contracts greater than five years could reduce volatility, but if DLA–E pursued long-term contracts, the DoD risks losing competitors in supply. Military specification fuels are not produced by all refineries. Signing a long-term contract with a single refinery could force other refineries to leave the DoD fuel–making business. The recent interest in long-term contracting is mainly for financing the building of biofuel refineries (NDAA for FY 2012, § 863). The interest in biofuel development follows the increase in global petroleum prices. Petroleum price volatility affects the investment opportunities in the biofuel industry, which could limit the development of the industry (State of Hawaii, 2012, p. i). The DoD has not yet requested legislative authority to enter into long-term contracts beyond five years (Kendall, 2012, p. 1).

Off-take agreements, an agreement to purchase the output before the facility is built, may reduce volatility. The off-take agreements should allow for adjustments to market prices, which would mitigate volatility until the next adjustment. Currently, DLA–E uses the DWCF to execute contracts in a similar manner.

As for the status quo option, the DoD already has made perceived oil prices to DoD users less volatile through the DWCF. However, the DWCF cannot handle extreme price volatility. In order to have drop-in replaceable biofuels cost competitive with petroleum, industry needs to overcome numerous technical challenges (National Research Council, 2012; Holland, 2013, p. 8). Once the biofuels are produced, purchasing biofuels at the market price would not remove volatility. The drop-in replaceable biofuels would be a part of the global fuels market, so the market values of biofuels and petroleum would be nearly identical. The International Energy Agency (IEA) projects the United States to become the world's leading oil-producing nation by 2020 (IEA, 2012, p. 23). If the DoD is seeking an option that domestically produces petroleum and does not require infrastructure investments in biofuel refineries, then the status quo might be an answer.

B. RECOMMENDATIONS

The various agencies and departments within the federal government should agree on the same definition as well as the same strategic approach to energy security. Congress, the 2010 QDR, and the Office of the CNO define energy security similarly, but Congress shifts the focus from "operational needs" to "mission essential requirements"

(QDR, 2010, p. 87; CNO, 2010, pp. ii, 4, 17; NDAA for FY 2012, § 2821). The strategic approach of energy security for Congress, the 2010 QDR, and the Office of the CNO is a future with petroleum. The Secretary of the Navy's (SECNAV's) energy security definition is different from the CNO's (2010) and the QDR's (2010) definitions because it asserts that energy security can be achieved only with sustainable sources: "[E]nergy security is achieved by utilizing sustainable sources that meet tactical, expeditionary, and shore operational requirements and force sustainment functions, and having the ability to protect and deliver sufficient energy to meet operational needs" (Office of the SECNAV, 2010, p. 2). The strategic approach of energy security for the SECNAV is limited to sustainable sources and the time horizon is in the distant future when petroleum is no longer available. This research finding goes beyond a simple definition. The SECNAV's energy security definition means the DON cannot be secure with petroleum because petroleum is not sustainable. Per the SECNAV, energy security can be obtained only with sustainable sources like biofuels, which is a much longer time horizon than Congress, the 2010 QDR, and the CNO. As a result, the SECNAV's strategy requires infrastructure investments so the DON has sustainable sources to rely on.

During my research I looked for a precise definition of *drop-in replaceable* in a Navy policy document, but I could not find one. I recommend that a specific drop-in replaceable definition be published so policy makers know what "drop-in replaceable" precisely means. My research found a very specific definition of "drop-in replaceable" by combining two sources: the DAF and *Currents*, the official environmental magazine of the DON, which states that drop-in replaceable fuel for military operational applications

- must meet or exceed the performance requirements of petroleum-based fuel (i.e., there must be no notable operational differences; Kamin & Rudy, 2011, p. 8; Kamin & Abbotts, 2012, p. 8);
- must be equivalent to military specifications (JP-5, JP-8, and/or F-76);
- requires no change in engine architecture, fuel infrastructure, or fuel handling;
- must be fully blended with conventional petroleum and biofuel, up to a maximum blend ratio of 50/50; and

- must be ready for use (DAF, 2012a, p. 1–2).

LLNL should update the DoD’s operational energy flow, shown in Figure 10, to reflect the contribution from all energy sources. Figure 10 shows the operational fuel used by the DoD in 2008, but does not account for the nuclear energy used for operational purposes. Since the DoD is required to diversify its energy sources, updating the DoD operational energy flow diagram to include all energy sources would present decision makers with a picture of all operational energy used in one convenient diagram. This diagram could be submitted with the DoD’s annual report on operational energy to Congress. Furthermore, Secretary Mabus’ energy goals assume a continued use of nuclear power (as shown in Figure 2 of Chapter II). If the assumption is continued use of nuclear power, then the operational energy contribution from the nuclear energy source should be emphasized. Figure 10 is identical to Figure 5 and is included here for easy reference.

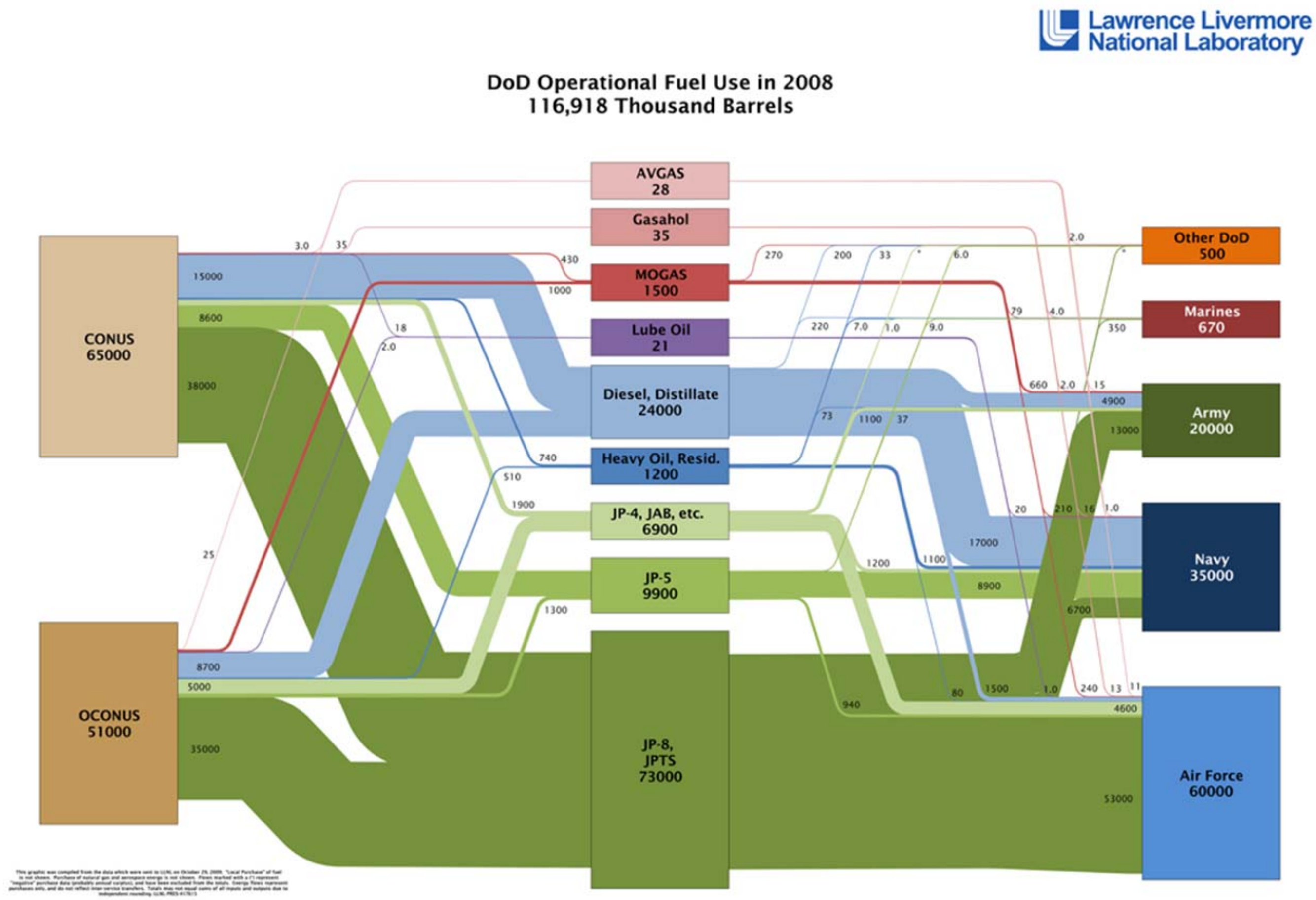

Figure 10. DoD Petroleum Use in 2008, Shown in Thousands of Barrels (From Kaahaaina, 2013, p. 2)

Notes. Image created by LLNL from data provided by DLA–E. AVGAS is aviation gasoline; gasahol is gasoline blended with ethanol; MOGAS is motor gasoline; and distillate is F-76.

C. AREAS FOR FURTHER RESEARCH

Further research might explore energy independence as it applies to the SECNAV's biofuel initiative. The SECNAV's two naval energy reform priorities are energy security and energy independence (Office of the SECNAV, 2010, p. 2). Further research could determine whether investments in biofuels contribute to energy independence or whether energy independence is achievable with biofuels. Energy independence, as a goal, is not present in the QDR (2010), DoD (2011a), and CNO (2010). Additional research could determine whether the goal of energy independence aligns with other DoD energy goals.

Further work needs to be done to establish whether taking action to mitigate the cost volatility of petroleum will have an unintended consequence in another area, for example, causing the costs to procure the fuel to rise or fall.

Additional research could determine whether biofuels would create some of the same problems that boutique fuels create (e.g., higher costs, logistical problems, etc.).

Further calculations are needed to determine the volume of biofuel as a percent of the global market that would need to be produced to have a perceptible impact on price volatility.

Further research could analyze the impact that Renewable Fuel Standard (RFS) tax credits have on the perceived costs of biofuels to consumers. The following question and answer from the advanced drop-in biofuel production project is an attempt to take advantage of tax credits in the production of biofuels:

> Q31. While the Biofuels FOA [Funding Opportunity Announcement] asks applicants to address RFS-2 [Renewable Fuel Standard] compliance, I don't see a way to interject a discussion of how RFS-2 impacts project economics. For instance, if we build our IBPE [Integrated Biofuels Production Enterprise] and sell renewable F-76 directly to the government, which is not an obligated party, there is not a method provided for in the regulations for the producer to monetize the RINS [Renewable Identification Numbers]. Feedstock demand (and thus pricing) is significantly impacted by RFS-2 and mandated production. Can the IBPE sell through an obligated party intermediary to the government in order to monetize the RINS generated by it?

> A31. If an offeror proposes to utilize RIN credits under the RFS2 in their [*sic*] business model, information in the technical and business sections of the proposal should support the credibility of this plan. One way to monetize RINS would be to have an "obligated party" as a partner in the proposed IBPE. (DAF, 2012b, p. 6)

The DoD has procured several lots of biofuel (Blakeley, 2012, pp. CRS-13–CRS-14). With this data, one could compare the biofuel price learning curves to previous price learning curves estimated from synthetic fuels derived from fossil fuels.

It would be interesting to assess how close substitutes affect DPA-sponsored projects. As an example, Kutner (1999) discussed a DPA-sponsored project that had a close substitute.

Further work could compare the costs of relying on the DWCF compared to the costs of previous attempts to develop alternative liquid fuels.

Future work could determine whether the DoD should consider procuring cost-competitive biofuels based on energy density. For instance, E85, a blend of 15 percent gasoline and 85 percent ethanol, has 28 percent less energy than gasoline (DoD, 2011b, p. 5-22). Consequently, the E85 price should also be 28 percent less compared to gasoline. Statistics show the price spread between the gasoline and E85 is usually less than 25 percent; therefore, E85 is more expensive relative to the alternate fuel (E85 Prices, n.d.).

More broadly, work should be done to review the historical justifications for the Energy and Fuel Acts enacted by Congress. Additional work could examine how the justifications for federal expenditures have changed since the passage of the Synthetic Liquid Fuels Act of 1944.

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