Elsevier Editorial System(tm) for Energy Policy

Manuscript Draft

Manuscript Number: JEPO-D-15-01852R1

Title: Department of Defense energy policy and research: A framework to support strategy

Article Type: Full length article

Section/Category: Energy and Society

Keywords: Energy strategy; knowledge management; energy security; department of defense; military operations management

Corresponding Author: Dr. Joshua K Strakos, Ph.D.

Corresponding Author's Institution: Air Force Institute of Technology

First Author: Joshua K Strakos, Ph.D.

Order of Authors: Joshua K Strakos, Ph.D.; Jose A Quintanilla, M.S.; Joseph R Huscroft, Ph.D.

Abstract: The Department of Defense (DOD) is the major consumer of energy within the Federal government, and it has been directed to implement cost cutting measures related to energy dependence through numerous Executive Orders and Congressional legislation. As a result, the DOD released an Energy Strategy which outlines ways to reduce energy requirements in order to meet both Presidential and Congressional mandates for energy security. With this research, we provide a historical review (1973-2014) of energy policy, legislation, and research. Additionally we identify gaps between strategy and research. The results show that DOD energy research lacks a unifying structure and guiding framework. We propose a knowledge management framework to unify and guide research efforts in direct support of the DOD Energy Strategy.

Title page

Department of Defense energy policy and research: A framework to support strategy[+]

Joshua K. Strakos[a,*], Jose A. Quintanilla[a,b], Joseph R. Huscroft[a]

[a] Air Force Institute of Technology, AFIT/ENS, 2950 Hobson Way, Wright-Patterson AFB, OH, 45433

[b] Present address: PSC 2 Box 7178, APO AE 09012

[+]Disclaimer: The views expressed in this paper are those of the authors and do not reflect the official policy or position of the US government or the Department of Defense.

* Corresponding author. Email address: Joshua.strakos@afit.edu, jmjjstrakos1@gmail.com
Phone: (937) 255-3636 ext. 4318

Abstract

The Department of Defense (DOD) is the major consumer of energy within the Federal government, and it has been directed to implement cost cutting measures related to energy dependence through numerous Executive Orders and Congressional legislation. As a result, the DOD released an Energy Strategy which outlines ways to reduce energy requirements in order to meet both Presidential and Congressional mandates for energy security. With this research, we provide a historical review (1973-2014) of energy policy, legislation, and research. Additionally we identify gaps between strategy and research. The results show that DOD energy research lacks a unifying structure and guiding framework. We propose a knowledge management framework to unify and guide research efforts in direct support of the DOD Energy Strategy.

Keywords: Energy strategy; knowledge management; energy security; department of defense; military operations management

DOD ENERGY POLICY AND RESEARCH: A FRAMEWORK TO SUPPORT STRATEGY

1. Introduction

"Energy security for the Department [of Defense] means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs."

—2010 Quadrennial Defense Review

1.1 Background

The United States Department of Defense (DOD) is the single largest consumer of energy in the country (Gauntlett & Adamson, 2012). This energy is consumed in the form of petroleum products, electricity, and in other forms (Energy Information Administration, 2015a). This consumption coupled with the price volatility and supply vulnerability creates budgetary and security risks for the DOD and the United States. This risk has been addressed through policy throughout the modern era, particularly since the oil embargo and price shock of the early 1970s. US energy policy has repeatedly attempted to address this risk for the past four decades. In the most recent decade, policy has aggressively addressed the risk to the DOD by focusing attention on energy strategy (Department of Defense, 2011a).

The United States and the DOD is reliant upon many sources for its supply of fuel and energy (Energy Information Administration, 2014). These sources vary from domestic producers and refiners to imported sources and alternatives as shown in table 1.4b of the December 2015 Monthly Energy Review (Energy Information Administration, 2015a). The continued dependence of the United States on imported oil and the importance of reducing this dependence is quantified in economic and national security terms (Brown & Huntington, 2015; Geller et al., 1994; Greene, 2010). The cost of the US presence in the Persian Gulf has been evaluated in terms of a national security objective as well as having been linked directly to the oil consumption of the US transportation sector (Delucchi & Murphy, 2008; Stern, 2010). Amidst the growing world demand, price volatility, and supply uncertainty, a new age of increased energy awareness in DOD policy has emerged.

Although the energy policy focus has led to a formal DOD energy strategy within the past 5 years (Department of Defense, 2011a), this strategy is in its infancy, and the means to support this strategy are not fully developed. As the DOD and each of its military services strives to make progress toward energy security, the efforts they expend are largely independent and uncoordinated, resulting in a less than optimal use of resources.

Research addresses how the DOD and the US should deal with specific aspects of fulfilling its energy security goals from different perspectives. Demand reduction is presented as a challenge-ridden objective for the DOD where a gap in policy and implementation is highlighted (Closson, 2013), and studies suggest the need for unification in efficiency efforts by the DOD (Simon, Regnier, & Whitney, 2014; Umstattd, 2009). Although there are suggested maxims to guide research (Sovacool & Brown, 2015) and the notion that DOD efforts need more coordination in this area (Closson, 2013; Simon, Regnier, & Whitney, 2014), there is no big picture in terms of what research has been done, how this research supports the DOD energy strategy, or how future research should be structured and prioritized. In its infancy, the landscape of DOD energy awareness needs a focus and a unifying structure to assure its scarce human capital and monetary resources are used in the most effective way possible.

In this paper, we provide a first look at what DOD energy research has been done within military schools, paint a picture of common issues being addressed, and provide a state of the art in terms of issues and research. We suggest a framework based on the DOD Energy Strategy to illustrate how research supports the strategy. This serves as a guide for future research as well as a basis for unification of effort within the DOD.

Although the US no longer relies primarily on imported sources of petroleum, the DOD still uses petroleum to meet most of its energy needs. In 2014, about 27% of petroleum was imported from foreign countries (Energy Information Administration, 2015b). The DOD cost of petroleum products for fiscal year 2014 was 13.9 billion US dollars (Defense Logistics Agency – Energy, 2015). Compared to an overall DOD energy expenditure of 18.8 billion US dollars in that same year (Department of Energy, 2014), petroleum makes up about 74% of the total. The price volatility of the oil market places huge strains on the US defense budget. It has been estimated that an oil price increase of one dollar per barrel costs the DOD about 130 million dollars (Miles, 2008). And with the price of oil fluctuating between $10.25 and $145.31 since 2008 (WTI Cushing spot price, source: EIA), this makes budgeting for energy use difficult.

Countries like China and India have experienced rapid economic growth and along with this an increased energy demand. A 2007 report, sponsored by the US Department of Energy, found that total global demand for energy is projected to grow by 50-60 percent by 2030, driven by increasing population and the pursuit of improving living standards (Raymond, Deming, &

Nichols, 2007). Although the growth of energy supply is expected to keep pace with this growth in demand for the next 25 years (Dimotakis, Grober, & Lewis, 2006), there remains significant uncertainty related to energy supply due to regional instability (Loechl et al., 2012). The advent of globalization, the war on terrorism, and the need to safeguard the earth's environment are all intertwined with US energy concerns (Wirth, Gray, & Podesta, 2003). Our economy and way of life depend on various sources of energy, the most important of which is oil (Tewksbury, 2006). These circumstances place great strain on the US government as it strives to ensure our continued economic resiliency and national security. CNA, a nonprofit research and analysis organization located in Arlington, VA, notes that US dependence on oil weakens international leverage, undermines foreign policy objectives, and entangles America with unstable or hostile regimes (CNA Military Advisory Board, 2009).

The DOD is the largest single U.S. consumer of energy, consuming 3.8 billion kilowatt hours (kWh) of electricity and over 120 million barrels of oil per year (Gauntlett & Adamson, 2012), having peaked at 145 million barrels in Fiscal Year (FY) 2003. The DOD also relies on foreign supplies of crude oil and the finished transportation fuels that are derived from it (Dimotakis et al., 2006). As a result, the DOD spends billions of dollars per year on fuel, and is pursuing numerous initiatives for reducing its fuel needs and changing the mix of energy sources that it uses (Blakely, 2012).

The DOD Operational Energy Strategy, released in 2011, sets the overall direction for operational energy security for the Office of the Secretary of Defense (OSD), Combatant Commands, Defense Agencies, and Military Departments/Services (Department of Defense, 2011a). The goal of the DOD Operational Energy Strategy is "energy security for the warfighter" - to assure that U.S. forces have a reliable supply of energy for 21st century military missions (Department of Defense, 2011a). Furthermore, the strategy outlines three principle ways to achieve this goal. Additionally, seven targets were introduced to support the goal in the Operational Energy Strategy: Implementation Plan (Department of Defense, 2012). The categories are explained below.

Category one is: "More Fight, Less Fuel…Reduce Demand for Energy in Military Operations." This category focuses on reducing demand and increasing efficiency to enhance combat effectiveness (Department of Defense, 2012). It includes three specific targets which are: Measure Operational Energy Consumption; Improve Energy Performance and Efficiency in Operations and Training; and Promote Operational Energy Innovation.

Category two is: "More Options, Less Risk…Expand and Secure Energy Supplies for Military Operations". This category focuses on diversifying and protecting energy sources (Department of Defense, 2012). It includes two targets which are: Improve Operational Energy Security at Fixed Installations; and Promote the Development of Alternative Fuels.

Category three is: "More Capability, Less Cost…Build Energy Security into the Future Force." This category focuses on integrating energy considerations into planning and policy (Department of Defense, 2012). It includes two targets which are: Incorporate Energy Security Considerations into Requirements and Acquisition; and Adapt Policy, Doctrine, Professional Military Education, and Combatant Command Activities (Change Culture).

1.2 Purpose

Although this strategy signaled a committed focus on energy management by the DOD, a unified effort and means to achieve these goals has not materialized. Policy, strategy, implementation, and research associated with these goals is fragmented and highly parochial among the military service departments. In this paper, we review US DOD energy policy since 1973, analyze the current DOD energy posture, and present a framework to organize and enable unified research to support the DOD Operational Energy Strategy and its goal.

2. Methods

Our systematic approach included a review and analysis of US energy legislation, policy, and DOD-specific energy studies from military schools.

We review US energy policy and legislation since 1973 to frame the evolution and context of the DOD's thought and perspective on energy security. Next, we present a qualitative analysis of the broad spectrum of US DOD energy literature to assess the current posture and issues associated with DOD energy security and provide a basis for a research framework. We confine the scope of the final literature survey and content analysis to include only objective research from military academic institutions. A broader scope is not included at this time for two reasons. First, the graduate military academic institutions provide a well-catalogued and accessible collection of studies from which to base an analysis, and second, our time and resources were not sufficient to cover the potential breadth of areas, outlets, and topics to be covered in a truly exhaustive search of energy literature. This, however, does not detract from the primary contribution of this study, which is to provide a structure and classification schema for connecting research to strategy in the DOD. Finally, we develop a framework and present an initial categorization of the aforementioned military research.

3. Analysis

3.1 The Inception and Evolution of US Energy Policy

Policy makers have been wrestling with the concept of US energy security for decades. The most notable shift of attention toward US energy policy occurred in 1973 as a consequence of the Arab Oil Embargo in reaction to the US support for Israel in the Yom Kippur war (Fehner & Holl, 1994). The Arab oil embargo, sometimes referred to as "Energy Pearl Harbor Day" (Light, 1976) caused the price of oil to triple overnight, which resulted in long gas lines and large price increases at the pump.

A string of executive policy decisions have been made in every administration since this time. During this crisis, President Nixon launched "*Project Independence*," consisting of synthetic fuel programs (Fialka, 2006) and assured, "In the last third of this century, our independence will depend on maintaining and achieving self-sufficiency in energy" (Potter, 2008). President Nixon further asserted this project would "…insure that by the end of this decade, Americans will not have to rely on any source of energy beyond our own" (Fehner & Holl, 1994). On the policy front, the *Federal Energy Administration Act of 1974*, which established the Federal Energy Administration was passed. Since Nixon, every U.S. President has made an effort to free the United States of its dependence on foreign fossil fuels.

President Ford continued this agenda by signing the *Energy Reorganization Act of 1974*, which consolidated the various departments and administrative staffs that dealt with energy under one umbrella (Black, 2009). He later moved the date for achieving American energy independence to 1985 with the signing of the *Energy Policy and Conservation Act of 1975*. It was this Act that required fuel efficiency labeling for new car and major appliances. President Jimmy Carter, in his 1979 "Crisis of Confidence Speech," declared "Beginning this moment, this nation will never use more foreign oil than we did in 1977—never." He proposed an energy plan of 142 billion dollars to establish energy independence by 1990 (Carter, 1979) and gave the management of energy a cabinet-level position with the establishment of the Department of Energy in 1977 (Black, 2009).

In the 1980's, the U.S. government looked to the development of synthetic fuels and to eliminating price controls on oil and natural gas.   Congress, through the passing of the *Energy Security Act of 1980*, sought to reduce dependence on foreign energy resources by producing synthetic fuel. It established a national goal of achieving a synthetic fuel production capability equivalent to at least 500,000 barrels per day of crude oil by 1987 and of at least 2,000,000 barrels per day of crude oil by 1992 from domestic sources (Energy Security Act, 1980). However, this venture never produced the expected results and was terminated in 1986 (Blumberg, 2013). Additionally, President Ronald Reagan signed Executive Order (EO) 12287 – "*Decontrol of Crude Oil and Refined Petroleum Products*" in 1981 which eliminated price controls on oil and natural gas.

In 1991, President George H. W. Bush announced a strategy aimed at "reducing our dependence on foreign oil." He later funded the U.S. Advanced Battery Consortium with a 260 million dollar research project with the goal of developing lightweight battery systems for electric vehicles (Kraemer, 2006). Later, with the *Energy Policy Act of 1992,* we sought to account for the full cost of energy to include accounting for the cost of production, distribution, proper disposal and ensuring access to sources of supply for imported energy resources (Energy Policy Act, 1992).

President Bill Clinton's approach to the energy problem was to propose a large tax on crude oil in order to discourage dependence on foreign sources of oil in 1992. The following year, he launched a billion dollar Partnership for New Generation Vehicles with the Big Three automakers, to produce a prototype car, three times more fuel-efficient than conventional vehicles by 2004 (Fehner & Holl, 1994). Additionally, he issued Executive Order (EO) 13123 – "*Greening the Government through Efficient Energy Management*," directing the Federal Government, as the Nation's largest energy consumer, to significantly improve its energy management to save money and reduce emissions that contribute to air pollution and global climate change (Clinton, 1999). EO 13123 was later revoked by the new and improved EO 13423 – "*Strengthening Federal Environmental, Energy, and Transportation Management,*" in 2007.

President George W. Bush asserted that addressing the nation's "energy crisis" was his most important task as president prior to the terrorist attacks on the World Trade Center and the Pentagon on September 11, 2001 (Klare, 2004). During his first term in office, he declared this, via his 2003 State of the Union address, "to promote energy independence for our country" (Bush, 2003). He announced a 1.2 billion dollar FreedomCAR (Cooperative Automotive Research) proposal to develop hydrogen-fueled vehicles (Kraemer, 2006; Wirth et al., 2003). Additionally, the Bush administration modified the *Energy Policy Act of 2005* and called it the *Energy Independence and Security Act of 2007* as a way to address the country's energy security concerns (Scofield, 2009).

In early 2007, President Obama, who was then just beginning his campaign for the White House, declared that America must break free of the "tyranny of oil" (Bryce, 2009). In his 2011 "*Blueprint for a Secure Energy Future*," he continued the assault on the country's dependency on foreign oil by proposing an ambitious but achievable standard for America. He declared that by 2035, "we will generate 80 percent of our electricity from a diverse set of clean energy sources - including renewable energy sources" (White House, 2011). The Obama administration gave energy security its due share of benefits through the passing of the $800 billion dollar *American Recovery and Reinvestment Act of 2009* (ARRA) also called the *Recovery Act of 2009*. The energy portion alone consisted of approximately $50 billion dollars whereby the largest partition of that money ($11B) was appropriated for development of an electric smart grid to digitize power distribution and improve the grid's efficiency (Scofield, 2009).

Additionally, the DOD is moving aggressively to integrate alternative fuels on its bases, ships, and aircraft from the $7.1 billion in stimulus appropriations by the ARRA to, among other things, modernize DOD's energy infrastructure and conduct targeted energy efficiency research and development projects (Rosen, 2010). The Obama administration is now pushing automakers to hit a 54.5 miles per gallon fleet-wide average by 2025 as a means of increasing vehicle fuel efficiency and thus reducing the consumption of fossil fuels (Krauss & Lipton, 2012). Most recently, an Executive Order was signed on March 19, 2015 on the subject of planning for federal sustainment over the next decade. This policy focuses the government on reducing greenhouse gas emissions while continuing to meet mission requirements.

3.2 Continued Policy and Action in the Department of Defense

In an effort to align the DOD with federal energy policies, the DOD Operational Energy Strategy was released and the position of Assistant Secretary of Defense for Operational Energy Plans and Programs (ASD (OEPP)) was established in 2011 (Department of Defense, 2011a), and an accompanying Energy Strategy Implementation Plan was released in 2012 to guide the department with specific targets to achieve the overall strategic goal of the plan (Department of Defense, 2012).

All military branches have developed their own policies (United States Air Force, 2013, United States Army, 2009, United States Marine Corps, 2009, United States Navy, 2010) with respect to energy and have been actively engaged in energy reduction efforts as well as alternative energy initiatives - a process often referred to as decarbonization (Shinnar & Citro, 2008). As of 14 December 2012, the military service departments had spent approximately 48 million dollars on alternative fuels, and the Navy proposed a 170 million dollar investment in biofuel production capability. By comparison, DOD purchases of petroleum fuels totaled 18.1 billion dollars in FY2011 (Defense Logistics Agency - Energy, 2013).These figures are evidence that progress is being made by each military branch as they strive to meet both Federal and DOD mandates and policies.

3.3 Current Posture and Issues

3.3.1 The DOD is in need of a cultural revolution (reduce demand)

Leadership must begin promoting the message that (fuel) efficiency at the tactical platform and system level is a clear strategic path to improve performance, reduce logistics burden and free resources from modernization and readiness (Defense Science Board, 2008;

Closson, 2013). The CNA Military Advisory Board identified in its May 2009 report that DOD leadership must take an active role in transforming its energy posture and stated, "…leadership must demonstrate the proper focus and attention…" for development, testing, and deploying new technologies (Allen, 2012; CNA Military Advisory Board, 2009).

3.3.2 DOD energy security is threatened by the risk of price fluctuation (reduce demand and ensure supply)

If fuel costs exceed the amount budgeted for them, then they are financed by taking money from the budgets of other programs. This can severely affect other DOD programs, if not cancel them entirely (Fisher & Macheret, 2007). Both a reduction in demand as well as a focus on efforts to expand supply sources lessen this risk.

3.3.3 The DOD's petroleum use contributes to environmental concerns (reduce demand and expand supply)

The United States needs an energy security strategy the entire nation can support in order to cut our dependence on oil and our emissions of greenhouse gases (Center for a New American Security, 2008). Already, the carbon lodged in the atmosphere by the Industrial Revolution over the last 150 years has taken a toll: disappearing glaciers, a thinning Arctic icecap, dying coral reefs, and increasingly violent hurricanes (Kraemer, 2006). Although there has been added pressure for the U.S. to increase its domestic production of fossil fuels as a means of alleviating the dependency of foreign produced energy, critics of domestic oil production argue that fossil fuels are destroying the environment and play a role in global warming by increasing the amount of carbon in the atmosphere (Weidenmier, Davis, & Aliaga-Diaz, 2008).

3.3.4 Political and Security effects (ensure supply)

Since the US still relies to some extent on foreign petroleum imports to meet demand, the potential for reliance on countries that have opposing political and national interests exists. Furthermore, the economic cost of dependence on foreign oil is staggering (Stein, 2011). The high oil prices of 2008 fueled one of the biggest wealth transfers in history (Haigh, 2009). At the time, the U.S. was importing some 60% of its oil from foreign sources resulting in prices adversely affecting our trade balance (Defense Science Board, 2008).

According to Powers (2010), the U.S. at one time had an oil trade deficit of approximately $1 billion dollars per day (Halff, 2008), larger than our trade deficit with China, which in 2010 was approximately $748,000,000 per day (United States Census Bureau, 2011). This outflow of capital not only weakened our national economy by increasing our trade deficit, but has the potential of enriching countries who may wish to harm us. Although our trade deficit has declined (Energy Information Administration, 2015b) any money from the United States to potentially hostile countries enables those nations to purchase the most advanced military technology and the human expertise to further develop and deploy it (Stein, 2011).

Former national security adviser Robert McFarlane and former CIA director James Woolsey once described our dependence on foreign oil as, "the well from which our enemies draw their political strength and financial power: the strategic importance of oil, which provides the wherewithal for a generational war against us" (McFarlane & Woolsey, 2011). Time and again, the U.S. military and national security leaders have warned of the substantial risk this outflow of capital poses to the security of the United States (Stein, 2011). However, due to the increasing demands of petroleum fuels from developing countries like China and India, the offending oil regimes will enrich themselves whether or not America does business with them (Nivola, 2008).

3.3.6 Cost and infrastructure favor oil (build energy into the future force)

By some accounts, the DOD is postured as an instrument of policy to shape the future energy development. The U.S. Congress has codified annual reporting on operational energy management and implementation of operational energy strategy (Duncan Hunter National Defense Authorization Act, 2009). By addressing its own fuel demand, the DOD can serve as a stimulus for new energy efficiency technologies, and mitigate national dependence on foreign oil (Defense Science Board, 2008).

The Defense Science Board, a group of civilian experts appointed to advise the DOD on technical and scientific matters, recommended that, "it is essential that the DOD support fundamental science investments that can lead to revolutionary improvements in the fuel efficiency of tomorrow's weapon platform systems" (Defense Science Board, 2008). The DOD has the capability to explore better technology to reduce fuel consumption and make equipment more fuel efficient. By doing so, the DOD can also stimulate the economy and allow further development of systems the nation can use to reduce our dependence on foreign fuel and increase our national security (Allen, 2012).

However, there are opposing viewpoints which claim the DOD may not have the market power to effect alternative energy development. Furthering the threat to alternative energy are the strict requirements that must be met in order to fully integrate such fuels into the military infrastructure. Each military service must first certify the use of alternative fuel blends with their tactical systems and these fuels must be able to be "dropped in" to current systems and meet standards for energy density, flash point, freezing point, thermal stability, lubricity, and viscosity (Mullen, 2011). However, the use of alternative energy sources must be synchronized with efforts to reduce consumption; otherwise there is no energy savings realized, but merely a shift from one supply source to another (United States Army, 2009). By seeking alternative energy technologies in combination with continued reliance on fossil fuels and conservation policies, the DOD will reduce foreign energy dependence (Holzman, 2006).

The primary consideration in the development and implementation of substantial alternative energy technologies is the cost of oil compared to the cost of alternative sources. Additionally, the current energy infrastructure, built over the last century, was designed to enable the reliable production and delivery of low-cost fuels to consumers (Verrastro et al., 2007). As a result, this infrastructure has been one of the major cost advantages for the continued use of traditional fossil fuel resources over alternative sources of energy (Verrastro & Ladislaw, 2007).

The high oil prices and fears of running out of oil in the 1970s and early 1980s encouraged investments in alternative energy sources, including synthetic fuels made from coal, but when oil prices fell, investments in these alternatives became uneconomical (Government Accountability Office, 2007). A 2006 report, Reducing DOD Fossil Fuel Dependence, asserts that an energy shortage is unlikely in the near term to hinder DOD operations and emphasizes the value of optimizing the energy efficiency of weapon systems over pursuing alternative fuel at this time (Blackwell, 2007; Dimotakis et al., 2006). At present, alternative fuels command a price premium which is expected to decline significantly as the market develops over the next decade. The DOD must send a clear market signal in order to enable the private sector to continue to develop cost-competitive alternative fuels (Parthemore & Nagl, 2010). A 2011 DOD study stated: “Despite the reduced premium, the Services’ renewable fuel goals could still impose $2.2 billion in additional estimated annual fuel costs by 2020.” This would represent a 10 to 15 percent increase over the cost of conventional petroleum fuels (Department of Defense, 2011b). However, 10-year future fuel price predictions are subject to significant fluctuation in most cases and must be considered with a level of caution. Future price uncertainties notwithstanding, some analysts predict that petroleum will remain the primary source of operational energy for the DOD. According to Dimotakis and Grober (2006), barring externalities like subsidies, governmental and departmental directives, etc., non-fossil-derived fuels are not likely to play a significant role in the next 25 years because cost and current infrastructure (refining and distribution networks) favor petroleum.

As long as petroleum-based fuels are less expensive than other fuel or energy sources, this nation will continue to focus on the use of petroleum-based fuels (United States Army, 2009). With their high power density and relative low cost, fossil fuels will be difficult to replace (Blackwell, 2007). A 2011 RAND report found “that a domestic alternative fuel industry could yield large economic profits within the United States. However, RAND further concluded that there was no direct benefit to the DOD from using alternative fuels rather than petroleum-derived fuels (Bartis & Bibber, 2011). Absent a major increase in the relative reliance on alternative energy sources, oil and coal will continue to drive the energy train (United States Joint Force Command, 2010). In essence, oil will leave the economic system when it becomes more expensive than alternative sources or when the end uses it satisfies disappear (Watkins, 2006).

4. Results and Discussion

The issues revealed by the analysis of current DOD energy posture are closely aligned with the "ways" to achieving energy security identified in the DOD energy strategy and implementation plan described in section one. In the final stage of this project, we adapt these strategic categories to develop a framework and perform a content analysis of existing military research to establish theory to guide future research firmly grounded in published strategy and the current issues revealed by the qualitative analysis.

DOD energy research was collected from the Air Force Institute of Technology and the Naval Postgraduate School. These institutions focus on relevant operational problems for their respective services and the DOD, however, the concepts within the energy research they produce are applicable to all branches. They are unique in that they provide high quality academic research for the DOD through graduate education programs in the management sciences, engineering, and other technical fields. Figure 1 below shows the number of studies collected from each source, by year.

Insert Fig. 1 here

--

Fig. 1. Number of studies by source, per year

The analysis revealed that there has been an increase in energy research at these schools in the last decade, but there is no single coordinating structure behind the research.

In total, 350 studies were reviewed, catalogued and classified from AFIT and NPS, as listed in Appendix 1. This research is where the most fruitful and detailed results have been harvested. For example, the result of a single aircraft refueling logistics study has yielded the Air Force and the DOD $111 million per year in savings via cost reduction (Air Force Institute of Technology, 2012). This type of research is where the DOD should place its largest investment. In addition to using the human capital resource available to conduct valuable research toward strategic goals, the research at these military schools also serves as an enabler for educating the force and driving culture change, a part of building energy into the future force. The students and faculty conducting this research receive educational benefit from conducting the research, and then return to the operational force with an enhanced understanding of energy matters and analytical tools to be agents of change. So, the second and third order benefits accrue to the DOD through investing in this type of research. However, the lack of a guiding framework or institutional coordination for this research means that this valuable resource is not being fully utilized.

4.1 Conceptual Development

Although the DOD has established a clear strategy, goals, and implementation plan, the research is guided only by DOD and service department mandates, sponsor encouragement, and individually established researcher and student interest. This is not to say that these are unimportant factors, but to suggest the need for a structure such as a single research center to categorize and prioritize what the combined efforts should be focused on, and to enable long-term projects in pursuit of a single body of knowledge. Additionally, other than this project, there is no consolidation and categorization of the research to date.

4.2 A knowledge management framework

Knowledge has been viewed as a resource in strategic decision making and discussed in the context of achieving the performance-oriented goals of an organization (Holsapple & Singh, 2001; Hoopes & Postrel, 1999; Yang, 2010). In the context of energy security, knowledge management is a way of converting knowledge gathered through existing and ongoing research into a strategic asset – something the DOD has not taken advantage of to this point. One way to do this is through information technology, however, this is not always the necessary or sufficient ingredient for transforming existing knowledge into a strategic asset (Teece, 2000).

Foundationally, knowledge management resides in underlying structures used to gather, store and disseminate knowledge throughout an organization, and involves not only content but context (Teece, 2000). Knowledge management may enable organizational elements such as structure, culture, and strategy to positively influence organizational effectiveness (Zheng, Yang, & McLean, 2010). Knowledge transfer in and of itself may require a particular strategy to exploit the creation and transfer of new and existing knowledge (Von Krogh, Nonaka, & Aben, 2001).

A framework consisting of elements to not only assemble, but to contextualize DOD energy research will have a better chance of translating existing knowledge (research) into a strategic asset for the DOD as well as guide knowledge creation (future research) toward the attainment of the overall goal of energy security for the warfighter, which is our goal for the framework presented here.

Energy is fungible, therefore, the structure must recognize that all energy research is a joint endeavor. There is no “color” for energy. The Air Force, Army, and Navy all use the same energy from the same sources. Uncoordinated parochial efforts to improve energy efficiency, supply management, and culture are sub-optimal. Not all such efforts will overlap, however, there is ample opportunity for complementary efforts within a unifying schema which establishes coordinated priorities and allows for knowledge transfer and resource-sharing, which does not exist. A joint DOD center for energy research would enable the strategic exploitation of knowledge creation and transfer amongst the military services.

Previous taxonomies are sparse and either address the categorization of energy research without respect to the specific concerns of the DOD or focus on only one particular focus area of research. For example, a general set of maxims was introduced by Sovacool and Brown (2015) to guide energy researchers. The maxims presented are information, inclusivity, symmetry, reflexivity, prudence, and technological agnosticism. These maxims when taken as a whole point to the importance of having the “big picture” when conducting research. The framework presented herein theoretically organizes these general doctrinal ideals for DOD energy research. A very specific set of categories for improving energy efficiency within the DOD is presented by Umstattd (2009). These categories suggest that efficiency efforts need focus and can be grouped into three solution categories: develop renewable sources, reduce and conserve, and improve efficiency. These categories are very specific to the implementation of overall efficiency improvements in the DOD and are too narrow to capture the breadth of research topics currently being researched. Finally, Simon, Regnier, and Whitney (2014) rightfully point out that a “lack of precision and consistency in DOD guidance limits practical usefulness” of policy in analyzing decisions. They present a value focused thinking approach to identify common objectives of semi-overlapping policy. The results include a comprehensive set of common objectives taken from current policy. These objectives include the ideas of demand reduction, supply assurance, and maximizing motivation to improve the DOD energy profile.

Since the goal of all DOD energy research is ensuring energy security, the research to support such a goal should fit within the strategy which aims to achieve the goal. The DOD Operational Energy Strategy addresses energy security through three ways: Reducing demand, expanding and securing supply, and building energy into the future force. Our framework translates the ways into research categories. These three ways form the foundational categories of our framework. A common categorization of research will enable knowledge transfer and coordination between services and within the DOD energy research community, while a joint energy research center will practically drive the strategy.

A total of 350 studies are included in these categories. The three framework categories are adapted from the three principle ways outlined in the DOD Operational Energy Strategy. Using these categories as a basis for the framework connects and focuses past and future research efforts on the overarching goal of energy security for the warfighter. The categories are broad enough to encompass the spectrum of research being conducted to support the goal, but focused enough to allow researchers and consumers of research to identify the knowledge base that exists for a particular topic. Additionally, we found that the categories need not be limited to operational energy topics. The scope of the categories allows for inclusion of installation energy topics as well as operational topics, as the goal of energy security for the warfighter certainly encompasses both realms. The categories are described next.

The first category is "reduce demand." This category includes research that contributes to measuring consumption, improving performance and efficiency, elimination of non-value-added activities, and promoting energy innovation. This is the most straightforward of the categories as it deals primarily with energy efficiency studies and the immediate temporal benefits that accrue from energy savings. Interest in this category has been lower than the other two areas. This can be due to the focus on supply assurance and alternative energy sources found in policy since the 1970's. The psychological link between demand reduction and energy security must be strengthened, as it is just as important a factor as supply expansion and assurance.

The second category is "expand and secure supply." This includes research that contributes to improved energy security at installations. This category covers both current and future temporal bounds, which include the development and use of alternative fuels, physical security, grid security, broadening supplier base, etc. It may also include the development of technology or operations management techniques for the use of alternative fuels. Our analysis shows that the interest in this category has been greater than the other categories, partly because of the policy focus on alternative energy and the linkage between energy security and supply assurance.

The third category is "build energy into the future force." This category has an exclusive forward looking temporal focus and includes literature that encompasses strategic decision making, planning, policy development, legislation, the role of geopolitics in energy strategy, and the incorporation of energy security into requirements and acquisitions. More broadly, this category includes research that promotes overall culture change in the DOD with regard to energy. This is a particularly broad category in that it encompasses more than the typical supply chain management considerations of supply and demand. It includes factors that typically fall into the realms of public policy, political science, strategic policy, and acquisitions and requirements. A breakout of these categories and examples of topics within each is found in table 1 below.

Table 1
Categories and topics of DOD energy research

Insert Table. 1 here

Although the scope of this review does not include the general category of independent peer-reviewed research, more strategically-focused DOD sponsorship of civilian research, guided by a singular structure would benefit the DOD as well as all energy consumers.

Finally, the framework categories inherently include classification of research by either a near or long term focus. For example, many conflicting views exist on the importance of alternative energy research and application. Some believe the DOD will be a driver to the rest of society and a change agent for this type of energy implementation and research (Defense Science Board, 2008). However, some believe that the DOD simply does not constitute a large enough demand on the system to be such an agent of change (Dimotakis et al., 2006). In short, the use of alternative energy sources such as biofuels (a chief implementation goal for the DOD) is too expensive to be economically viable while the price of fossil fuels remains relatively low. It is important to deconflict these views by recognizing the temporal element in each category. For example, a given alternative energy source may become a source of security and economically feasible in the long-term, so while research in this area is extremely important to the long-term strategic outlook of our energy security future, immediate implementation may be short-sighted and extremely costly. Therefore, it should be classified as such and recommendations should not hinge on immediate implementation given the economic consequences. The three categories fall along a temporal continuum. Reducing demand encompasses current implementation, whereas building energy into the future force looks to future considerations. Assurance of supply takes both a current and long-term outlook.

Figure 2 below depicts such a framework which support the main goal of energy security for the warfighter.

Insert Fig. 2 here

--

Fig. 2. A framework for research to support DOD energy strategy

A preliminary classification of existing research in the categories of this framework is represented in figure 3 below.

Insert Fig. 3 here

Fig. 3. Initial categorization of DOD research by framework categories (2000-2015).

This initial classification should be refined and maintained to reflect the state of the art in the field of DOD energy research. Although it is beyond the scope and resources of this study, the classification should be expanded to include non-DOD sources of research. Further detail should be added to classify and refine the research within each broad category.

5. Conclusions and Policy Implications

The number of DOD energy studies shows a spike in interest in the most recent decade. As a result of the DOD's thrust to attain energy security, this is no real surprise. The result of this study is that most research produced is based only on a single, short-term topical research question. Additionally, much of the work done outside the DOD is of a very high level policy-oriented nature. In the DOD, policy must precede efforts to attain specific goals, however, it is important to bring more balance to the policy efforts with actionable research.

The absence of a unifying construct for DOD energy research is partially to blame for the lack of focus on specific goals and topics. Although we see a fairly wide spread of topical coverage in the research reviewed, the motivations are often driven solely by researcher interest, sponsor guidance, or parochial budgetary reasons. There is no central mechanism in-place to ensure that research efforts are directly supporting strategic goals and that efforts are not duplicated. The proposed framework will serve as a theoretical focal point and enabling mechanism for guiding energy research. The ideals of such a framework should be put into practice by a research center operating as a single unifying structure within the DOD. This will provide coordination, guidance, focus, and knowledge management functions which ultimately support the goal of the DOD energy strategy, and do not currently exist. A unifying effort is needed to maximize the research potential – particularly from the most abundant source of thought leadership available to the DOD – its military schools, students, and faculty. Such a unifying effort will ensure that research supports strategy. Additionally, research by traditional academic institutions should be encouraged and sponsored by the DOD when possible.

Next, we have to realize that education, research, and culture change go hand in hand. The research being conducted by faculty and students at military schools fuels education efforts. This happens through direct learning of those involved in the research, the secondary benefits of taking the research findings into the classroom, and finally the third order effect of having well-informed energy change agents reintegrated into the operational environment. In short, education will spur culture change and the ability to build energy into a future force.

These observations drive three recommendations. First, a formal, joint, and permanent structure is needed to ensure the unified effort. In order to unify the research and education efforts of the DOD, a joint center or academic group is needed. This structure will ensure multi-way communication between policy makers, operational customers, and academic institutions. Next, education and research must be integrated with strategic goals of the DOD. Although the services currently have some educational opportunities in energy management, they focus almost entirely on specific jobs or career paths. With the exception of the Navy, no formal plan for energy education exists (United States Navy, 2015). Fostering an energy aware culture should have intentional education built into multiple career paths and professional military education in order to reach the widest audience and permeate the organizational culture to educate the total force. Finally, the terms, definitions, and goals of an energy aware culture must be standardized. A common language, established by a guiding framework, will enable clear communication to occur across service boundaries and within the DOD.

5.1 Limitations and Future Research

Although the content analysis presented in this paper provides the first summary of DOD energy research to date, it is not all-inclusive. The broad nature of this survey provides the "big picture" of where we are with respect to DOD energy research, however, its breadth and our limited resources prevent a deep exploration of topics by specific category at this time. Additionally, there is some overlap in the categories presented. No one set of categories will be able to capture the richness or complexity of the subject of energy security. This does provide, however, a unifying direction for future research.

What is the next step in DOD energy research? Suggestions for future research include the revising of topical categories within the framework as research evolves and technological advances are made in the areas of alternative fuel sources. Additionally, the changing budgetary posture of the DOD and the highly volatile price of oil will no doubt continue to shift focus and interest in terms of economic feasibility.

As with any large organization, culture change within the DOD is difficult and slow. Such a rigid and segmented structure changes only as senior leadership guides and codifies expected changes in policy. Communication is key to cultural shifts, and so a steady stream of information and education is needed to initiate real change. Finally, culture change and the priority placed on it will only be as effective as the budget and resources allocated to the topic. As more research is conducted and education and training programs are developed, the “spend” will reveal what the true priorities are.

Where does environmental research fit into the energy picture? More research is needed to align the complementary priorities of environmental sustainment and energy efficiency. Although the two go hand in hand, the DOD has not yet captured how to integrate the topics, and it is outside the intended scope of the framework presented in this paper.

Are there other categories to be considered? Although the DOD primarily divides its energy use by whether it supports a fixed installation or an operational force, the two are not mutually exclusive, nor are they all encompassing. A combined effort with more detailed breakouts of energy use may be helpful in guiding and focusing future research efforts.

Finally, the mission of the DOD is to focus on effectiveness. Although efficiency is part of overall effectiveness, in the end, the DOD has a charge to provide security of a nation, which comes at a high cost. In short, we have to win wars. In the end, efficiency takes second place to meeting mission requirements.

Energy security is an overwhelmingly broad topic. Without a guiding framework to focus the future efforts and a unifying structure to make the best use of resources available for research, the time and effort needed to cover this topic will be enormous. In order to keep pace with the economic and budgetary pressures being exerted by changing technology, environmental concerns, and the ever volatile price of oil, the DOD must move forward with a combined and unified focus to address its goal of energy security.

Acknowledgements

The authors wish to thank the office of the Office of the Secretary of the Air Force for Installations, Environment, and Energy for sponsorship of the original thesis work represented in this paper; The faculty and staff of the Air Force Institute of Technology and the Naval Postgraduate School for providing historical energy research; Ryan Crean for cataloguing of source documents; James Cotton and George Lafiguera for their review and comments on this paper; and Ken Schultz and Adam Reiman for their comments and conversations concerning DOD energy strategy.

References

Air Force Institute of Technology. Center for Operational Analysis (COA) Significant Research. Retrieved September 15, 2015, from http://www.afit.edu/coa/page.cfm?page=166

Allen, S., 2012. Cultural Change and the Operational Energy Strategy. Army War College. Carlisle Barracks, PA.

Bartis, J.T., Bibber, L.V., 2011. Alternative Fuels for Military Applications. RAND Corporation.

Black, C., 2009. Post Oil America and a Renewable Energy Policy Leads to the Abrogation of the Middle East to China. National Defense University. Norfolk, VA. Joint Advanced Warfighting School.

Blackwell, K. E., 2007. Department of Defense and Energy Independence: Optimism Meets Reality. Air University. Maxwell AFB, AL.

Blakely, K., 2012. DoD Alternative Fuels Policy, Initiatives and Legislative Activity. Library of Congress. Washington, DC. Congressional Research Service.

Blumberg, G., 2013. The Origin of the Department of the Navy's Biofuel Initiative and the Volatility Problem for Defense Energy. Naval Postgraduate School. Monterey, CA.

Brown, S. P., Huntington, H. G., 2015. Evaluating US Oil Security and Import Reliance. Energy Policy, 79, 9-22.

Bryce, R., 2009. Energy Security Means Energy Interdependence. National Defense University. Washington, DC. Institute for National Strategic Studies.

Bush, G. W., 2003. State of the Union Address, 28 January.

Carter, J., 1979. Crisis of Confidence Speech, 15 July.

Center for a New American Security, 2008. A Strategy for American Power: Energy, Climate and National Security.

Clinton, W.J., 1999. Executive Order 13123, Greening the Government through Efficient Energy Management, 3 June.

Closson, S., 2013. The military and energy: Moving the United States beyond oil. Energy Policy, 61, 306-316.

CNA Military Advisory Board, 2009. Powering America's Defense: Energy and the Risks to National Security.

Defense Logistics Agency – Energy, 2013. Fact Book Fiscal Year 2012.

Defense Logistics Agency - Energy, 2015. Fact Book Fiscal Year 2014.

Defense Science Board, 2008. More Fight - Less Fuel: Report of the Defense Science Board Task Force on DOD Energy Strategy, February.

Delucchi, M. A., Murphy, J. J., 2008. US Military Expenditures to Protect the Use of Persian Gulf Oil for Motor Vehicles. Energy Policy, 36(6), 2253-2264.

Department of Defense, 2011a. Energy for the Warfighter: Operational Energy Strategy.

Department of Defense, 2011b. Opportunities for DOD use of Alternative and Renewable Fuels. 18 July.

Department of Defense, 2012. Operational Energy Strategy: Implementation Plan.

Department of Energy, 2014. Site-Delivered Energy Use and Costs by End-Use Sector and Energy Type, by Federal Agency. Retrieved from http://ctsedwweb.ee.doe.gov/Annual/Report/BEAReport.aspx?ef=Excel&fy=1&yo=&ag=6&au=false

Dimotakis, P., Grober, R., Lewis, N., 2006. Reducing DOD Fossil-Fuel Dependence (No. JSR-06-135). Mitre Corp., Mclean, VA. JASON Program Office.

Duncan Hunter National Defense Authorization Act, 2009. Public law 110-417, 110th Congress, 14 October.

Energy Information Administration, 2014. Primary Energy Consumption by Source and Sector 2014. Department of Energy. Retrieved from http://www.eia.gov/totalenergy/data/monthly/

Energy Information Administration, 2015a. Monthly Energy Review, 23 December. Retrieved from http://www.eia.gov/totalenergy/data/monthly/#summary

Energy Information Administration, 2015b. How Much Oil Consumed by the United States comes from Foreign Sources? Department of Energy. Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=32&t=6

Energy Security Act, 1980. Public law 96-294, 96th Congress, 30 June.

Energy Policy Act, 1992. Public law 102-486, 102nd Congress, 3 January.

Fehner, T. R., Holl, J. M., 1994. Department of Energy, 1977-1994: A Summary History. US Department of Energy.

Fialka, J. J., 2006. Energy Independence: A Dry Hole?. The Wall Street Journal, 5 July.

Fisher, B., Macheret, Y., 2007. Should DOD be Concerned with Potential Petroleum Supply Shortage and What Could It Do to Stimulate Alternative Fuels Development? (No. IDA-P-4255). Institute for Defense Analyses. Alexandria, VA.

Geller, H., DeCicco, J., Laitner, S., Dyson, C., 1994. Twenty Years after the Embargo US Oil Import Dependence and how it can be Reduced. Energy policy, 22(6), 471-485.

Greene, D. L., 2010. Measuring Energy Security: Can the United States Achieve Oil Independence?. Energy policy, 38(4), 1614-1621.

Government Accountability Office, 2007. Uncertainty about Future Oil Supply Makes It Important to Develop a Strategy for Addressing a Peak and Decline in Oil Production, 28 February.

Gauntlett, D., Adamson, K.A., 2012. Renewable Energy for Military Applications. Pike Research.

Haigh, C. S., 2009. Getting Over the Barrel: Achieving Independence from Foreign Oil in 2018. Army War College. Carlisle Barracks, PA.

Halff, A., 2008. Energy Nationalism, Consumer Style: How the Quest for Energy Independence Undermines US Ethanol Policy and Energy Security. Stan. L. & Pol'y Rev., 19, 402.

Holsapple, C. W., Singh, M., 2001. The Knowledge Chain Model: Activities for Competitiveness. Expert systems with applications, 20(1), 77-98.

Holzman, S. L., 2006. A Need for Change: The Looming Energy Crisis. Army War College. Carlisle Barracks, PA.

Hoopes, D. G., Postrel, S., 1999. Shared Knowledge, “Glitches,” and Product Development Performance. Strategic Management Journal, 20(9), 837-865.

Klare, M., 2004. Bush-Cheney Energy Strategy: Procuring the Rest of the World’s Oil. Foreign Policy in Focus, 0113-01.

Kraemer, T. D., 2006. Addicted to Oil: Strategic Implications of American Oil Policy. Strategic Studies Institute.

Krauss, C., Lipton, E., 2012. US Inches Toward Goal of Energy Independence. New York Times, 22 March.

Light, A.R., 1976. Federalism and the Energy Crisis: A View from the States. Publius, 81-96.

Loechl, P. M., Kemme, M. R., Shah, P. S., Goran, W. D., 2012. Resource Efficiency in the US Army Corps of Engineers: Examination of Strategies to Reduce Energy Use and Greenhouse Gas Emissions (No. ERDC/CERL-TR-12-17). Engineer Research and Development Center. Champaign, IL. Construction Engineering Research Lab.

McFarlane, R., Woolsey, R. J., 2011. How to Weaken the Power of Foreign Oil. New York Times, 20 September.

Miles, D., 2008. Military Looks to Synthetics, Conservation to Cut Fuel Bills. American Forces Press Service, 6 June.

Mullen, M. G., 2011. The National Military Strategy of the United States of America, 2011: Redefining America's Military Leadership. Joint Chiefs of Staff, 8 February.

Nivola, P. S., 2008. Rethinking Energy Independence. Brookings institution. Governance Studies at Brookings.

Parthemore, C., Nagl, J., 2010. Fueling the Future Force. Center for a New American Security, September.

Potter, N., 2008. How Brazil Achieved Energy Independence and the Lessons the United States Should Learn from Brazil's Experience. Washington University Global Studies Law Review, 7(2), 331-351.

Powers, J., 2010. Oil Addiction: Fueling Our Enemies. Truman National Security Project.

Raymond, L. R., Deming, C. P., and Nichols, M. W., 2007. Hard Truths—Facing the Hard Truths about Energy. National Petroleum Council report, July.

Rosen, M. E., 2010. Energy Independence and Climate Change: The Economic and National Security Consequences of Failing to Act. U. Rich. L. Rev., 44, 977.

Scofield, J. P., 2009. Energy Security through 2030: Some Considerations. Marine Corps Command and Staff College. Quantico, VA.

Shinnar, R., Citro, F., 2008. Decarbonization: Achieving Near-Total Energy Independence and Near-Total Elimination of Greenhouse Emissions with Available Technologies. Technology in Society, 30, 1-16.

Simon, J., Regnier, E., Whitney, L., 2014. A Value-focused Approach to Energy Transformation in the United States Department of Defense. Decision Analysis, 11(2), 117-132.

Sovacool, B. K., Brown, M. A., 2015. Deconstructing Facts and Frames in Energy Research: Maxims for Evaluating Contentious Problems. Energy Policy, 86, 36-42.

Stein, F., 2011. Ending America's Energy Insecurity: How Electric Vehicles Can Drive the Solution to Energy Independence. Naval Postgraduate School, Monterey CA.

Stern, R. J., 2010. United States Cost of Military Force Projection in the Persian Gulf, 1976–2007. Energy Policy, 38(6), 2816-2825.

Teece, D. J., 2000. Strategies for Managing Knowledge Assets: The Role of Firm Structure and Industrial Context. Long range planning, 33(1), 35-54.

Tewksbury, D. D., 2006. Preemptive Energy Security: An Aggressive Approach to Meeting America's Requirements. Army War College. Carlisle Barracks, PA.

Umstattd, R. J., 2009. Future Energy Efficiency Improvements within the US Department of Defense: Incentives and Barriers. Energy Policy, 37(8), 2870-2880.

United States Air Force, 2013. US Air Force Energy Strategic Plan. Office of the Secretary of the Air Force, March.

United States Army, 2009. Army Energy Security Implementation Strategy. Office of the Deputy Assistant Secretary of the Army for Energy and Partnerships, January.

United States Marine Corps, 2009. Marine Corps Expeditionary Energy Strategy and Implementation Plan. Marine Corps Expeditionary Office.

United States Navy, 2010. Department of the Navy's Energy Program for Security and Independence. Deputy Assistant Secretary of the navy Energy Office. October.

United States Navy, 2015. Navy Energy Training and Education Plan. Assistant Secretary of the Navy for Energy, Installations, and Environment. 2 July.

United States Census Bureau, 2011. Trade in Goods with China.

United States Joint Force Command, 2010. Joint Operating Environment. Joint Futures Group (J59), 18 February.

Verrastro, F., Ladislaw, S., 2007. Providing Energy Security in an Interdependent World. Washington Quarterly, 30(4), 95-104.

Von Krogh, G., Nonaka, I., Aben, M., 2001. Making the most of your company's knowledge: a strategic framework. Long range planning, 34(4), 421-439.

Watkins, G. C., 2006. Oil Scarcity: What Have The Past Three Decades Revealed? Energy Policy, 34(5), 508-514.

Weidenmier, M. D., Davis, J. H., Aliaga-Diaz, R., 2008. Is Sugar Sweeter at the Pump? The Macroeconomic Impact of Brazil's Alternative Energy Program (No. w14362). National Bureau of Economic Research.

White House, 2011. Blueprint for a Secure Energy Future, 30 March.

Wirth, T. E., Gray, C. B., Podesta, J. D., 2003. The Future of Energy Policy. Foreign Affairs, 132-155.

Yang, J., 2010. The Knowledge Management Strategy and its Effect on Firm Performance: A Contingency Analysis. International Journal of Production Economics, 125(2), 215-223.

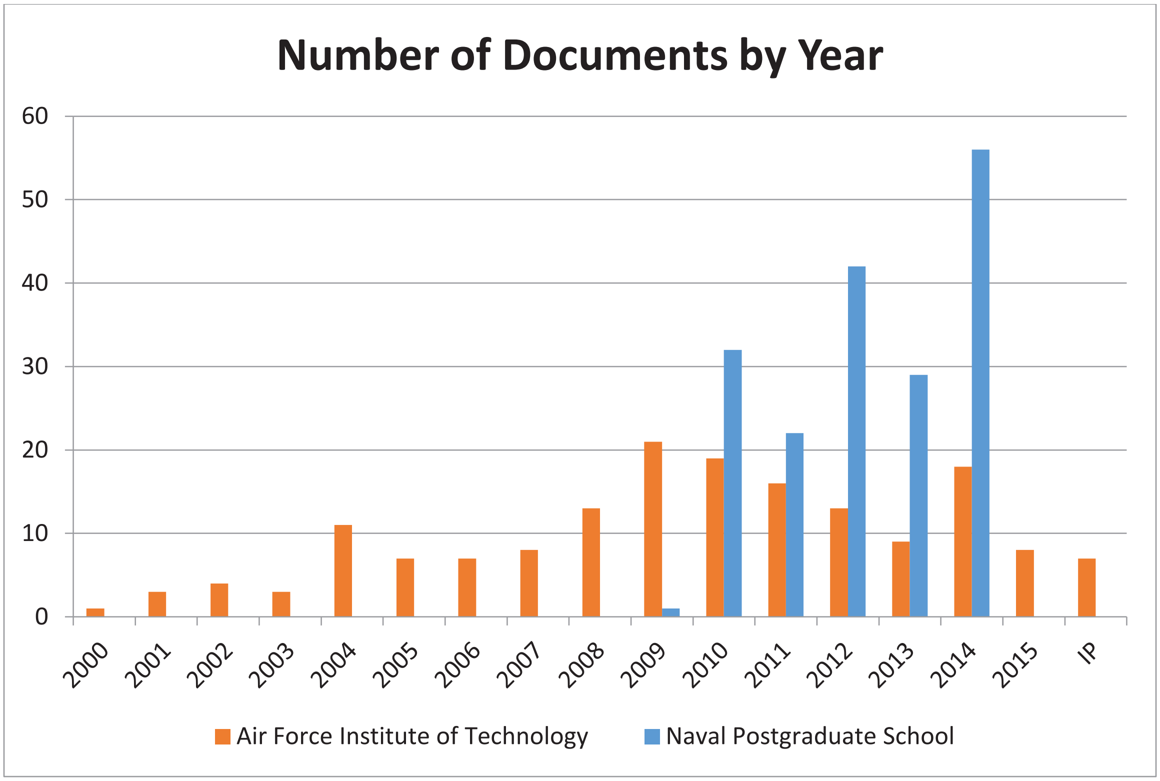
Zheng, W., Yang, B., McLean, G. N., 2010. Linking Organizational Culture, Structure, Strategy, and Organizational Effectiveness: Mediating Role of Knowledge Management. Journal of Business Research, 63(7), 763-771.

Table 1

Table 1
Categories and topics of DOD energy research

Category 1	Category 2	Category 3
Reduce Demand	Expand and Secure Supply	Build Energy into the Future Force
Measure consumption Improve performance and efficiency Promote innovation	Improve energy security at installations Develop and use alternative fuels Physical security Grid security Broaden supplier base Develop technology or operations management techniques for the use of alternative fuels	Strategic decision making Planning Policy development Legislation Geopolitics Incorporation of energy security into requirements and acquisitions Culture change Education and Training

Figure 1



Number of Documents by Year
60
50
40
30
20
10
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
IP
Air Force Institute of Technology
Naval Postgraduate School

Figure 2

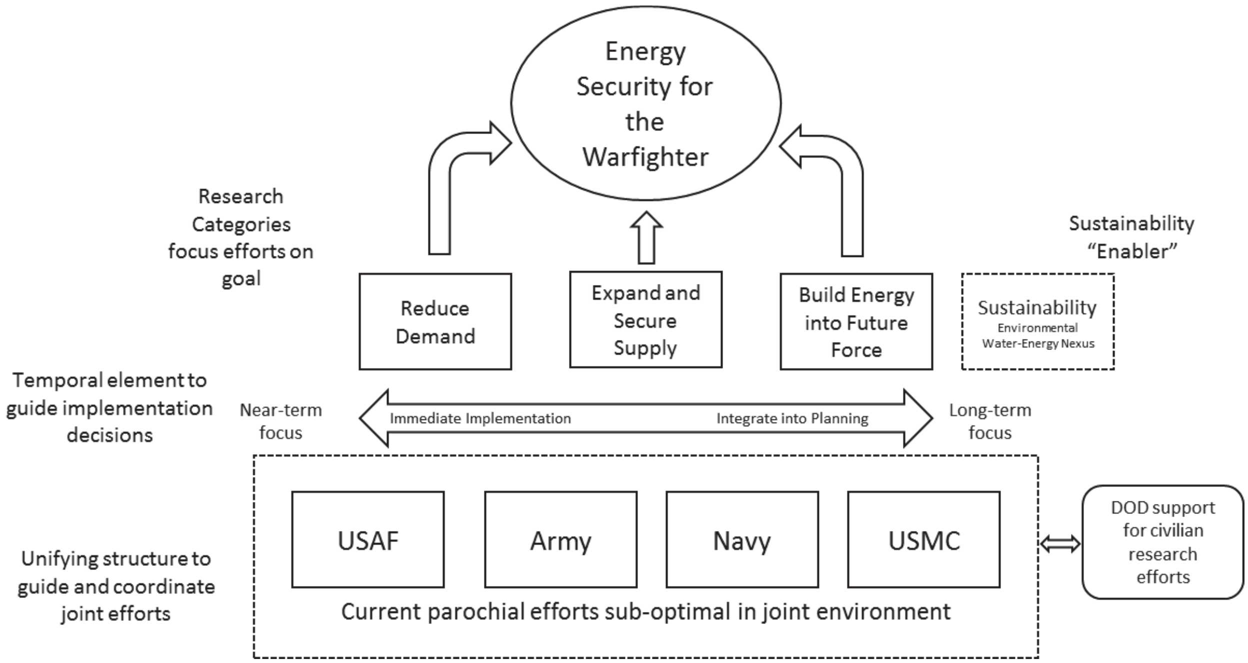
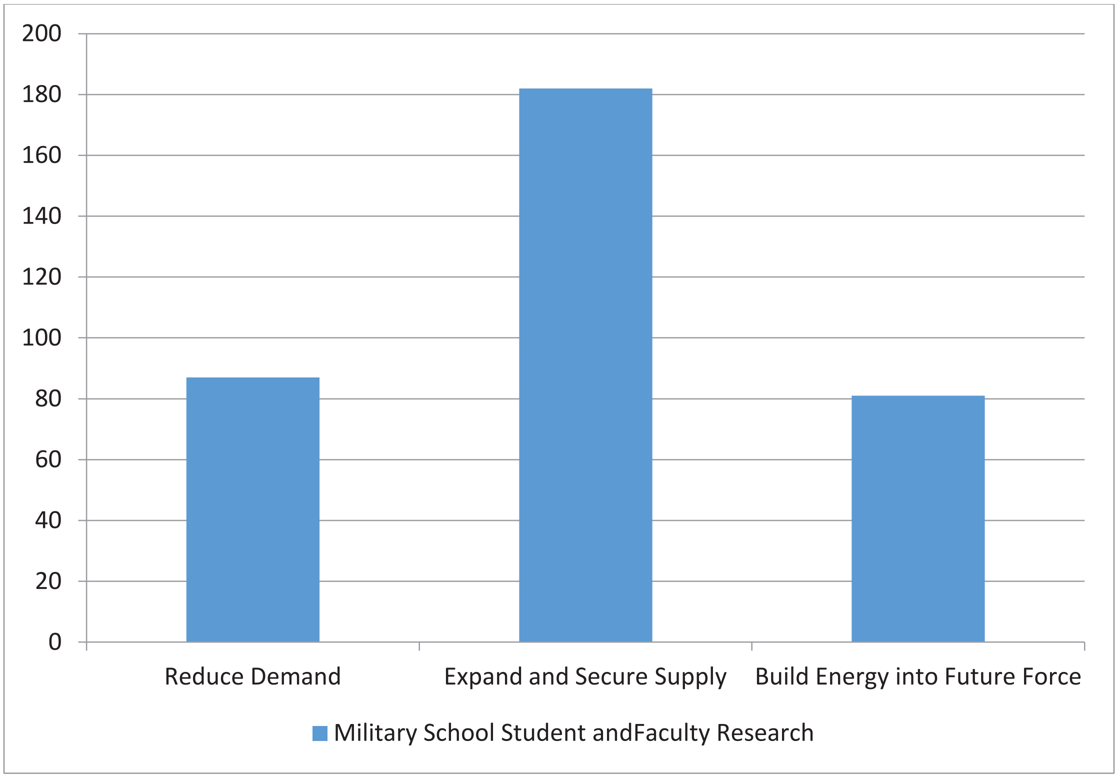

Energy Security for the Warfighter
Research Categories focus efforts on goal
Reduce Demand
Expand and Secure Supply
Build Energy into Future Force
Sustainability "Enabler"
Sustainability
Environmental
Water-Energy Nexus
Temporal element to guide implementation decisions
Near-term focus
Immediate Implementation
Integrate into Planning
Long-term focus
Unifying structure to guide and coordinate joint efforts
USAF
Army
Navy
USMC
Current parochial efforts sub-optimal in joint environment
DOD support for civilian research efforts

Figure 3


200
180
160
140
120
100
80
60
40
20
0
Reduce Demand
Expand and Secure Supply
Build Energy into Future Force
Military School Student andFaculty Research