PikeResearch
Cleantech Market Intelligence

Research Report

EXECUTIVE SUMMARY:
Renewable Energy for Military Applications

Solar, Wind, Biomass, Geothermal, Hydrokinetic Energy, Biofuels and Synfuels, Fuel Cells, Microgrids, Smart Meters, and Energy Efficiency

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Section 1

EXECUTIVE SUMMARY

1.1 Energy and National Security

This report focuses on the mandates for and development of renewable energy (RE) technologies within the U.S. Department of Defense (DOD) and the military arena in general, with a concentration on those technologies presently competing for incorporation into mainstream DOD activities. In addition, we discuss energy conservation actions, such as the movement toward LEED certification, insulation measures for forward operating bases, retrofits for military installations, and cyber security and other cleantech markets.

The various composite branches of the U.S. DOD combine to form the single largest consumer of energy in the world – more than any other public or private entity and surpassing the consumption totals of more than 100 nations. Energy is the lifeblood of the U.S. military, and of the supporting governmental infrastructure that facilitates and controls it. While recent attention to climate change, global warming, and energy independence is often framed within the context of environmental or ethical concerns, there is no question that energy has become the central most important American national security issue of this century.

The DOD reportedly consumes 3.8 billion kilowatts (kW) of electricity and 120 million barrels of oil per year. This translates to total primary energy consumption of over 1,100 trillion British thermal units (BTU) annually and a per capita consumption, including non-military DOD personnel, of 524 trillion BTU. The DOD currently spends approximately $20 billion per year directly on energy: 75% for fuel and 25% for facilities and infrastructure. The advancement of clean and green technologies into the mainstream of DOD spending is driven by legislation, national and international policy, departmental strategic goals and planning, and as a defense against a perceived threat from hostile entities. Officially, the annual DOD budget is about $800 billion, but Pike Research estimates the actual figure is much higher. A portion of total expenses include the procurement of technology, vehicles, aircraft, vessels equipment, etc. that have RE or cleantech components and at least $75 billion in research and development. As such, the DOD is positioning to be the single most important driver of the cleantech revolution in the United States.

1.2 Current Major Renewable Energy Initiatives

Changes in energy policy have provided countless opportunities throughout all operations of the military and DOD, and there are many examples of renewable energy projects under the DOD umbrella. The most significant recent initiatives include:

The Army, which is under its own internal mandate to convert to a minimum of 25% renewable energy by 2025 and reduce power consumption by 30% by 2015, is moving forward with a $2 billion project to construct a 500 MW solar power installation on military reserves at the National Training Center (NTC), Ft. Irwin, California. This installation is expected to be operational by 2013 and completed by 2022. If all goes well, the project could double in size and scope by 2030. The project is considered a major step, and a working model, toward self-powered, energy-secure capability for all military bases, with the potential to export "green" power to the California grid for domestic usage. The Ft. Irwin project is financed through DOD-private sector partnerships and "Enhanced Use Lease" (EUL) provisions for military property. The private sector contractor is Irwin Energy

Security Partners, a joint venture with the Clark Energy Group, the builder, and ACCIONA Solar Power, a division of the international RE giant ACCIONA. This project will be constructed on 14,000 leased acres at Ft. Irwin Army Base and, if all goes according to plan, will be expanded to 1,000 MW. Ft. Irwin uses from 30 MW to 32 MW for its own operation; thus, a significant amount of electricity would presumably be exported from the project for domestic energy consumption in California. The Army EUL project will be over 10 times larger than the current largest U.S. solar photovoltaic array, which was commissioned in 2007 at Nellis Air Force Base (14 MW). In addition, it will approximately equal or exceed the entire U.S. deployed solar photovoltaic infrastructure in 2009 (477 MW). Pike Research anticipates that many additional solar photovoltaic projects, both large and small in scale, will be initiated on DOD land, buildings, and facilities in the near and long term.

Figure 1.1 The 14 MW Solar Array at Nellis Air Force Base

(Source: U.S. Air Force)

The Navy recently announced its "Great Green Fleet" initiative, whereby it is targeting a biofuels-driven fleet by 2016. Interestingly, the first oil-burning destroyer, the USS Paulding, was commissioned 100 years ago (in September 1910). A year later, the USS Nevada class battleship was burning oil instead of coal, marking a transition for the Navy to a completely different fuel. Today, the Navy is committed to a similarly dramatic shift away from petroleum-based fuels. In addition to biofuels, the Great Green Fleet, which will consist of submarines, ships and planes, will rely on massive hybrid-electric propulsion technology, fuel cells and nuclear power. In October 2009, the Navy commissioned its first "green ship," the USS Makin Island, a Wasp-class amphibious assault vessel built by Northrop Grumman, and the first in the world to be powered by a hybrid-electric propulsion system. The Navy expects to save more than $250 million in fuel costs over the life of the vessel. The greatest challenge to the entire initiative may be the available supply of "green" fuels; the Department of the Navy currently consumes over 1.3 billion gallons of fuel per year. Pike Research believes that successful advances in biofuels technology and production, energy storage technologies, and continued improvements in hybrid-electric technologies will be the key to realizing the Great Green Fleet objective.

Figure 1.2 The First U.S. Navy "Green Ship" – The USS Makin Island

(Sources: U.S. Navy, Northrop Grumman)

Both the Air Force and the Navy have successfully flown unmodified military aircraft – the Air Force A-10 Thunderbolt and the Navy F/A 18 Super Hornet – on a 50/50 mix of biofuels

and petroleum-based JP-8. The demonstration flights followed the pioneering successful transcontinental biofuels-powered flight by Greenflight International and several tests by commercial airlines. The Air Force has set a lofty goal of operating half its fleet on biofuels by 2016. By far the largest DOD consumer of fuel – at 2.4 billion gallons per year – the Air Force is also in the process of certifying all of its airframes for alternative fuels by 2012. The Navy test flight on Earth Day 2010 was powered with Honeywell Green Jet Fuel provided by UOP LLC, a Honeywell subsidiary. This project was sponsored by the U.S. Defense Energy Support Center (DESC), which provides all the fuel to the DOD. Honeywell's UOP is presently producing up to 190,000 gallons of fuel for the Navy and 400,000 gallons for the Air Force from a variety of sustainable, non-food feedstocks, including animal fats, algae, and camelina. The camelina-based portion of the biofuels was domestically produced in Montana by Sustainable Oils. The Navy plans at least 17 additional flights in the certification process and the Air Force will conduct similar additional testing. Several major research and development projects are underway that involve Defense Advanced Research Projects Agency (DARPA) funding and private initiatives. Hundreds of companies, universities, and national laboratories are striving to achieve the goal of abundant and affordable domestically produced biofuels.

Figure 1.3 The U.S. Air Force and U.S. Navy Complete Biofuel-Powered Test Flights: 2010

The Navy F/A 18 Super Hornet

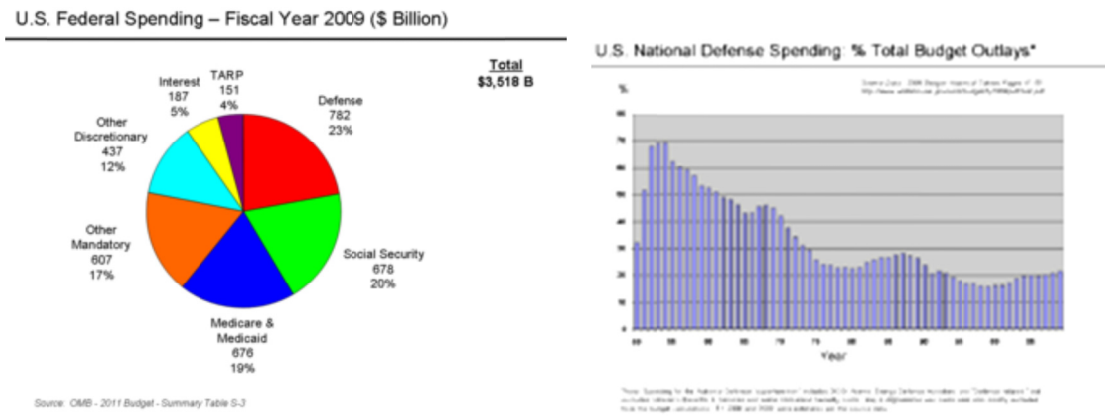
The Air Force A-10 Thunderbolt

(Sources: U.S. Air Force, U.S. Navy)

1.3 DOD Total Spending and Energy Consumption

The Government Accounting Office reported a total DOD budget of $809.14 billion for FY 2009, which represented approximately 23% of total U.S. federal spending. According to most analysts, this figure is lower than actual spending due to "contingency funds" and "operational expenditures" that are used to support military operations overseas. Some analysts prefer estimates of actual total defense-related spending that also include the State Department, Veterans Affairs, and Homeland Security, and defense spending related to the Department of Energy, NASA, federal law enforcement activities, and interest on defense-related debt. All of these expenditures contribute to a total annual "defense-related" spending of about $3 trillion (Figure 1.4). The DOD currently consumes approximately 80% of the U.S. government's total energy annually – with about 75% going to liquid petroleum-based fuels (more than 300,000 barrels of oil per day) to power aircraft, ships, combat vehicles, and generators.

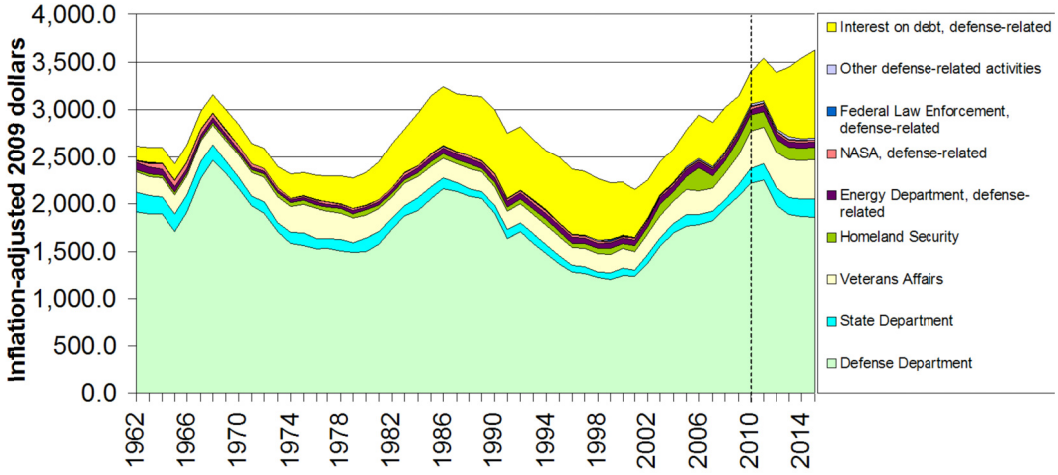
Figure 1.4 U.S. Federal Spending and Proportional DOD Expenditures



Trend Total "Official" DOD Spending: $800 billion

(Sources: OMB, DOD)

Figure 1.5 Upper Estimates for Combined Spending for All "Defense-Related" Activities

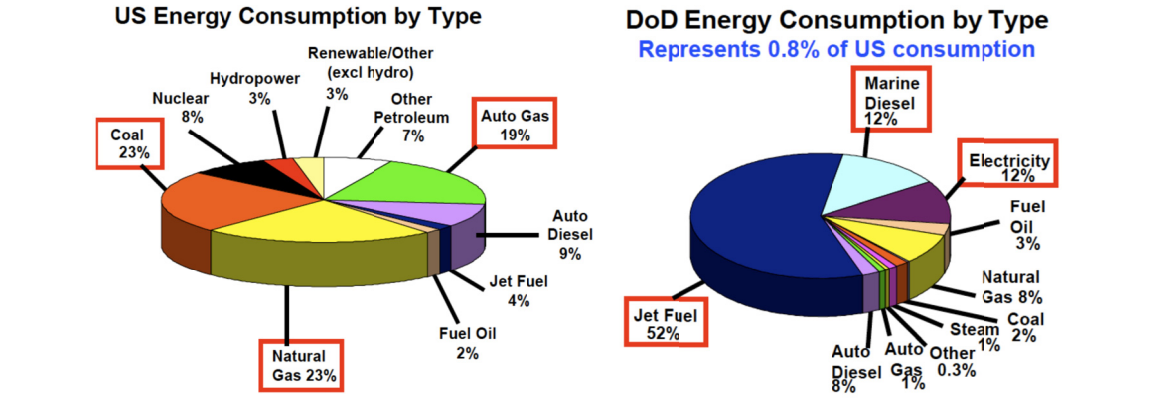


(Source: Wikimedia Commons)

1.4 U.S. and DOD Energy Consumption Patterns and Projections for Renewable Energy

Energy consumption and spending by the DOD differ dramatically from that of the United States in general. According to the general patterns over the last decade, petroleum-based fuels account for approximately 40% of U.S. energy consumption but 75% of DOD energy consumption. Moreover, whereas jet fuel comprises around 4% of the U.S. energy budget, the DOD as a whole consumes over 50% of its total energy in the form of jet fuel. Within the Air Force, this figure increases to over 80% of all energy consumption.

Figure 1.6 Comparison of U.S. Energy Consumption to DOD Energy Consumption by Type



(Sources: EIA 2005 Consumption Data, DOD Annual Energy Report 2006)

1.5 DOD Energy Consumption Patterns

The DOD's overall energy consumption has declined during the last 25 years by more than 60%. DOD energy consumption is divided into the two broad categories of **facilities** and **operations**, which vary dramatically depending on the level of international engagement. Current energy consumption patterns by the DOD reflect of the active status of the U.S. military and contingency operations in Iraq and Afghanistan. During "peacetime" conditions, the relative proportion of energy expenditures for mobility and facilities tends to be balanced. In "wartime," the percentage of total energy expenditures for "mobility" – or primarily liquid fuels consumption – is approximately 75% of the total energy. Of that 75%, the general trend is that more than half of the fuel consumption goes to support activities, primarily the generation of electricity in the field and transportation of supplies.

1.6 Renewable Energy Technologies for Facilities and Infrastructure

1.6.1 Energy Efficiency for DOD Facilities

Under the oversight of the Deputy Undersecretary for Defense and Installations and Environment, an Executive Committee was established in 2008 to oversee, coordinate, and prioritize DOD energy and environmental issues. The American Recovery and Reinvestment Act (ARRA) provided $12.02 billion in 2009 and 2010 to the DOD, funding 45 **energy conservation**-related projects in 17 states. The current initiatives are focused on the following general facility energy improvements:

- Installing wind turbines, solar photovoltaic, and solar thermal systems in buildings and facilities
- Completing energy conservation upgrades
- Upgrading and installing high efficiency lighting and associated controls
- Drilling geothermal test wells
- Installing "air/ventilation" pre-heating systems
- Replacing heat pumps to improve energy efficiency and cost-effectiveness

1.6.2 Direct Investments in RE Initiatives

The DOD has made substantial investments in RE research, projects, and initiatives over the last decade. DARPA is fueling research on multiple RE fronts – from jet fuel derived from algae to nano-batteries, wave energy, solar, and wind technology, and fuel cells from microbes to space-age RE technologies of the future. The numerous research and development components of all the military branches and agencies have a myriad of programs underway that focus heavily on all aspects of RE and include substantial direct DOD investment – on the order of a billion dollars annually.

As of early 2010, the DOD had invested in over 450 RE initiatives related to department facilities. These initiatives emphasize solar energy projects, but also include wind, geothermal, fuel cells, hydrokinetics, wave energy, biomass, waste to energy, microgrids, ocean thermal, and other types of projects.

1.6.3 Net-Zero Plus Initiative

Net-Zero Plus is defined as a military installation that produces as much as or more energy than it consumes. The Army is currently reviewing a list of five initial candidate installations that will be finalized in later 2010. However, Ft. Bliss, Texas and Ft. Irwin, California are already progressing toward Net-Zero. In addition, the Air Force has designated the Air Force Academy as the first Net-Zero facility and the Navy's China Lake facility is already Net-Zero. The long-term goal is to have all U.S. facilities capable of operating, at least partially, off the grid by 2030. This will require a combination of all major sources of renewable energy: solar, geothermal, wind, biomass, hydrokinetic, wave fuel cells, and others that may be developed over the next decade.

1.6.4 Enhanced Use Lease (EUL) and Power Purchase Agreements (PPAs)

The National Defense Authorization Act of FY 2001 (Pub.L.106-398) authorized the DOD to make underutilized, non-excess real property available for long-term lease. In the last decade, each of the major branches of the military has established offices to oversee and administer EUL agreements, and numerous EUL contracts are in place. A formal solicitation, proposal, review, and selection protocol is in place for each of the branches.

Over the course of the last 5 years, much of the attention on EUL engagement has been directed toward energy-related projects. A combination of EUL and power purchase agreements (negotiated separately) has become a standard pathway by which to consummate RE-related projects on DOD property.

1.7 Tactical Energy Consumption and Renewable Energy for Mobility

Liquid petroleum-based fuel represents approximately three-quarters of total DOD annual energy consumption and spending. Based on trends over the last decade, this approaches $20 billion annually. DESC has delivered between 29 million barrels and 33 million barrels of petroleum products to the DOD for the last 5 years. U.S. domestic oil production peaked in the early 1970s, and the United States has since become the largest importer of oil in the world. As the largest consumer of oil in the country, the military is currently completely dependent on foreign oil. Daily military operations around the planet depend on an enormous array of fuel-consuming equipment, including: some 11,000 aircraft and helicopters (and more UAVs, UGVs, missiles, etc.), more than 200 combat and support Navy vessels (and UUVs), 200,000 tactical vehicles (tanks, trucks, and light armored vehicles), and over 190,000 non-combat vehicles, including trucks, cars, buses, etc.

Pike Research estimates that the current horse race to find a technology and commercially viable approach to the production of fuels, and JP-8 in particular, from renewable sources has only started. It is likely that multiple approaches – photosynthetic, heterotrophic, cellulosic, fermentation, etc. – will contribute to the ultimate solution. All of these approaches will take advantage of a range of sources of energy and carbon or carbon dioxide.

1.8 Renewable Energy Technologies in Forward Operating Bases and Tactical Operations

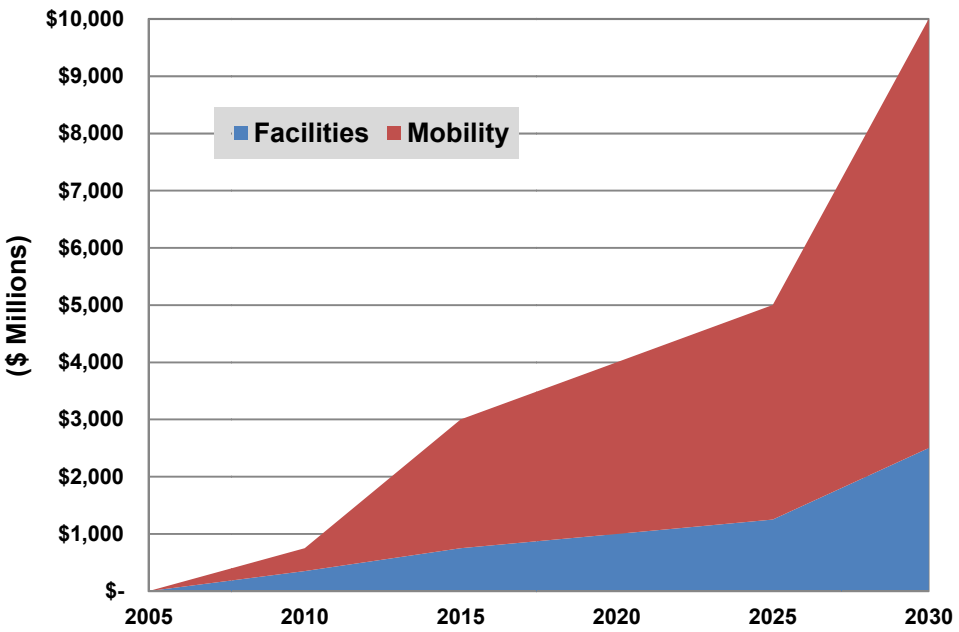
Supplying energy to the tactical battlefield and forward operating facilities remains one of the most urgent challenges for the DOD. Each service is actively engaged in the research, development, and rapid implementation of a diverse range of technologies to reduce energy consumption in the field and transition to renewable and alternative energy sources.

Currently, Generator Sets (GenSets) are the primary power generation technology; aside from improvements in noise and efficiency, this technology has remained essentially unchanged for several decades. The obvious concern with power provided from GenSets is the logistical and practical constraints associated with the transport and storage of fuel (primarily diesel or JP-8). In addition to mobile power generation, current DOD investments in expeditionary energy initiatives include: battery technology, advanced power generation from JP-8, focus on solar photovoltaics for mobile applications, reduced fuel consumption through efficiency, and advanced on-board vehicle power systems.

1.9 Market Forecast for DOD Spending on Procurement and Production of Renewable Energy

The following forecast predicts the annual total market for renewable energy, both production and procurement, for DOD electricity and fuel consumption. Pike Research projects this market will reach approximately $3 billion by 2015 and increase to $5 billion by 2025 and $10 billion by 2030. This forecast is based on the assumption that the DOD targets set forth in the Energy Independence and Security Act of 2007 (EISA 2007) and departmental goals are essentially achieved, and any increased costs are essentially offset by reduced energy consumption – or remain relatively constant compared to 2010 levels (Chart 1.1).

Chart 1.1 Total DOD Renewable Energy Spending: 2005-2030



(Source: Pike Research)

The DOD is effectively fueling the U.S. version of the "Green Revolution," since the military is incapable of operating without sufficient energy resources. Accordingly, the entire perspective of national security has undergone a dramatic paradigm shift, incorporating the more abstract concept of "energy independence" with the traditional tenets of military superiority defined by the sheer might and power of armaments. Pike Research sees the DOD as a key driver in an RE revolution that will directly impact non-military sectors, much the way the Internet and GPS have progressed over the last decade. An undeniable caveat, however, is that the non-petroleum energy must be reliable and meet military standards, which will mandate extensive certification, testing, and assessments to overcome logistic demands and constraints.

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SCOPE OF STUDY

This report focuses on the mandates for and development of renewable energy technologies within the U.S. Department of Defense (DOD) and the military arena in general. Pike Research primarily concentrates on the wide array of emerging renewable energy (RE) technologies that are presently competing for incorporation into mainstream DOD activities. In addition, we discuss energy conservation actions, such as the movement toward LEED certification, insulation measures for forward operating bases, retrofits for military installations, and cyber security and other cleantech markets.

SOURCES AND METHODOLOGY

Pike Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Pike Research's analysis is primary research gained from phone and in-person interviews with industry leaders, including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Pike Research's analysts and the firm's staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Pike Research's reports. Great care is taken in making sure that all analysis is well supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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NOTES

CAGR refers to compound average annual growth rate, using the formula:

CAGR = (End Year Value ÷ Start Year Value)$^{(1/steps)}$ – 1.

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2011 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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