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Fueling the Future Force

Preparing the Department of Defense for a Post-Petroleum Era

By Christine Parthemore and John Nagl

Center for a New American Security

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Cover Image
Staff Sgt. Rusty Jones prepares to fuel an A-10C Thunderbolt II March 25, 2010, with a 50/50 blend of Hydrotreated Renewable Jet and JP-8. The A-10 then flew what was the first flight of an aircraft powered solely by a biomass-derived jet fuel blend.
(SAMUEL KING JR./U.S. Air Force)

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I. INTRODUCTION

The U.S. Department of Defense (DOD) must prepare now to transition smoothly to a future in which it does not depend on petroleum. This is no small task: up to 77 percent of DOD's massive energy needs – and most of the aircraft, ground vehicles, ships and weapons systems that DOD is purchasing today – depend on petroleum for fuel.[1] Yet, while many of today's weapons and transportation systems are unlikely to change dramatically or be replaced for decades, the petroleum needed to operate DOD assets may not remain affordable, or even reliably available, for the lifespans of these systems.

To ready America's armed forces for tomorrow's challenges, DOD should ensure that it can operate all of its systems on non-petroleum fuels by 2040. This 30-year timeframe reflects market indicators pointing toward both higher demand for petroleum and increasing international competition to acquire it. Moreover, the geology and economics of producing petroleum will ensure that the market grows tight long before petroleum reserves are depleted. Some estimates indicate that the current global reserve-to-production (R/P) ratio – how fast the world will produce all currently known recoverable petroleum reserves at the current rate of production – is less than 50 years.[2] Thus, given projected supply and demand, we cannot assume that oil will remain affordable or that supplies will be available to the United States reliably three decades hence. Ensuring that DOD can operate on non-petroleum fuels 30 years from today is a conservative hedge against prevailing economic, political and environmental trends, conditions and constraints.

It will take decades to complete this transition away from petroleum. However, DOD has already laid important groundwork. The development, testing and evaluation of renewable fuel conducted by the armed services to date mark the first steps in guaranteeing DOD's long-term ability to meet its energy needs. DOD should build on this work and develop a strategy that guarantees its ability to operate worldwide in the event of petroleum scarcity or unavailability.

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The Center for a New American Security (CNAS) launched a project in September 2009 to examine DOD's energy challenges and recommend a path forward. We convened DOD leaders and non-governmental experts; researched current laws, requirements and projects; and visited military bases around the country to discuss DOD's energy challenges and opportunities. From this research, we concluded that DOD needs a long-term strategy to adopt alternative fuels based on our reading of current trends in petroleum availability and use, as well as our identification of petroleum dependence as a long-term vulnerability for DOD.

DOD officials increasingly understand this vulnerability. During the course of our project, the Navy appointed two-star officers to lead two task forces on energy and climate change. Their activities, which began quietly within the bureaucracy, are now well-known examples of leadership by the U.S. armed forces. The Air Force and Navy flight-tested camelina-based biofuel blends in the past year.[3] The Air Force's Air Mobility Command and the Office of the Secretary of Defense (OSD) are working to increase energy efficiency and maximize fuel savings in existing platforms and new acquisitions. The Quadrennial Defense Review (QDR) presented instructions for integrating energy considerations into how DOD does business. Bases around the country are investing in solar, wind and geothermal projects. DOD is working to comply with federal energy mandates, and in particular those found in the Energy Independence and Security Act (EISA) of 2007, President Barack Obama's October 2009 Executive Order on resource conservation by federal agencies and defense authorization acts.

Though each of the services has admirably developed its own energy strategy to improve its near-term energy management, DOD must also develop a comprehensive long-term energy strategy. The strategies developed by individual services focus heavily on electricity usage at domestic installations, which accounts for a relatively small fraction of DOD's energy needs, and most goals within these strategies do not look beyond 2015 or 2020 – a timeline that is too short to ensure DOD's long-term energy security. Moreover, there is no single official who oversees DOD's entire energy portfolio; authority within DOD is currently divided, which is likely to complicate implementation of the strategy. This report lays out the strategic necessity for DOD to find alternatives to petroleum over the next 30 years and then presents important steps in achieving that long-term goal.

Transitioning away from petroleum dependence by 2040 will be enormously difficult, but fortunately the U.S. defense sector has made several energy transitions successfully in its history. In particular, it moved from coal to petroleum to nuclear power in its ships. In a similarly seismic shift, DOD rapidly increased its reliance on electronics, space assets and computer systems in modern warfare in ways that enhanced mission effectiveness. These experiences may offer lessons for DOD as it leverages an energy transition to maximize its strategic flexibility and freedom of maneuver.

Now is an opportune time to make this transition. As the services redeploy from current wars, the Army (and to a lesser extent the other services) have years of reset ahead of them. Acquisition reforms and personnel restructuring initiatives launched by Secretary Robert Gates in 2009 and

TABLE 1: DOD ENERGY CONSUMPTION BY FUEL, 2009

2009 DOD ENERGY CONSUMPTION BY FUEL SOURCE, IN TRILLION BRITISH THERMAL UNITS (BTU)		
Fuel Source	Energy Use	Percentage of total
Petroleum	679.7	77.2
Natural Gas	74.2	8.4
Coal	16.2	1.8
Chilled water, renewable energy, and other fuels reported as used in facilities	9.1	1.0
Other electric	101.1	11.4
Total	**880.3**	**99.8**

Source: Department of Energy, "U.S. Government Energy Consumption by Agency and Source, Fiscal Years 2003, 2008 and 2009." Totals may not equal 100 percent due to rounding.

2010 will continue through the Obama administration and likely beyond. Together, these developments will present opportunities to procure new, more energy-efficient systems.

A successful transition away from petroleum will produce financial, operational and strategic gains. Reducing dependence on petroleum will help ensure the long-term ability of the military to carry out its assigned missions — and help ensure the security of the nation. Though adopting non-petroleum fuels will require an initial investment, it will likely be recouped in budget savings over the long term. Finally, moving beyond petroleum will allow DOD to lead in the development of innovative technologies that can benefit the nation more broadly, while signaling to the world that the United States has as innovative and adaptable force.

This transition should not compromise readiness and, indeed, DOD must always put mission first. However, DOD need not choose between accomplishing its mission and minimizing the strategic risks, price fluctuations and negative environmental effects of petroleum consumption. By providing the private sector with stable market signals and incentives to invest in scaling up the fuels that meet its unique energy needs, DOD will never need to sacrifice performance or national security for energy security. Rather, reducing reliance on petroleum will only help the armed services to accomplish their missions in the years and decades to come.

II. WHY DOD SHOULD ADOPT ALTERNATIVE FUELS

Several factors challenge DOD's continued reliance on its existing petroleum-dominant energy strategy over the long term: direct risks to U.S. security; troubling supply and demand trends; the often-hidden external costs of fuel consumption; and a changing domestic political and regulatory environment.

The Risks of Petroleum Dependence

The growing world demand for petroleum presents major geostrategic risks. High prices and rising demand are a boon to major suppliers and reserve holders such as Iran and Venezuela, which are unfriendly to the United States. It also affects the international behavior of rising powers such as China, which is on a quest to secure access to natural resources that is in turn expanding its influence around the globe. In Mexico, one of the top suppliers of petroleum to the United States, pipelines serve as an increasingly attractive target for dangerous cartels to fund activities that could undermine the Mexican government, destabilize the region and decrease U.S. homeland security.[4] American foreign policy itself has been colored by its growing petroleum demands since the 1970s oil crises and subsequent declaration of the Carter doctrine, which stipulated that the United States would consider threats to the Persian Gulf region threats to its "vital interests" due to the strategic importance of its petroleum reserves.[5]

Dependence on petroleum for 94 percent of transportation fuel is also a dangerous strategic risk for the United States given the leverage oil can provide to supplier countries. Many European allies have experienced such leverage in action with Russia periodically threatening to reduce or cut off natural gas exports to countries highly reliant on their supplies (and in some cases carrying through with these threats). Similarly, national oil companies and OPEC can choose to increase or decrease their production rates to drive changes in the market. The more the United States reduces its dependence on petroleum, the better it can hedge against petroleum suppliers exerting political leverage over U.S. interests, including in times of crisis.

At the operational level, heavy reliance on liquid fuels also constitutes a force protection challenge for DOD. Fuel supply convoys have been vulnerable to attack in both Iraq and Afghanistan, where the services have struggled to adapt to the challenges of terrorism, insurgency and violent extremism. In addition to minimizing these risks in the current wars, DOD must also conceptualize and plan for what the future will likely hold for America's security. The Navy's battle against pirates off the coast of the Horn of Africa foreshadows the littoral and unconventional challenges that await the United States in the coming decades, as populations continue to migrate toward the world's coastal area. These types of problems often manifest at major shipping chokepoints (including petroleum transit chokepoints), and addressing them will include distinctive fueling requirements. The Air Force, likewise, confronts dramatic changes in manned and unmanned flight, in addition to the proliferation of space technologies, all of which could dramatically alter fuel needs. In another example, one recently published AirSea battle concept focused on China notes that the type of conflict it outlines could require hardening fueling infrastructure, improving aerial refueling, "stockpiling petrol, oil, and lubricants" and potentially "running undersea fuel pipelines between Guam, Tinian and Saipan."[6] As the character of warfare changes, DOD will have to continue to consider the attraction of fuel supply lines to opponents.

Changing Supply and Demand

DOD cannot be assured of continued access to the energy it needs at costs it can afford to pay over the long term. Today DOD meets its energy needs primarily through petroleum, which accounts for more than 77 percent of DOD's total energy use.[7] However, both demand and supply trends are likely

COSTS OF PETROLEUM DEPENDENCE

- Heavy dependence on large fuel supplies can increase operational vulnerabilities and make fuel supply infrastructure a more valuable target.
- Every dollar increase in the price of petroleum costs DOD up to 130 million additional dollars.
- Rising global demand, for instance in China, is increasing the strategic importance of petroleum in ways that could be detrimental to U.S. interests.
- Countries such as Iran and Venezuela could have the largest remaining reserves in a few decades if current production rates hold – and will gain leverage as a result.
- High levels of petroleum consumption are contributing to the changing climate, which can bring destabilizing effects and trigger new security challenges.

to raise the price and perhaps even limit the availability of petroleum.

The U.S. Energy Information Administration projects that world energy demand will grow from its 2007 level of 495.2 quadrillion British thermal units (Btu) to 738.7 quadrillion Btu by 2035 – a steep increase. If current trends continue, energy demand in non-OECD countries will grow more than four times faster than in OECD countries.[8] Global petroleum demand has increased steadily from about 63 million barrels of oil per day in 1980 to more than 85 million barrels today, and will grow to 110.6 million barrels per day by 2035 if current trends hold.[9]

While global oil demand increases, the supply side of the equation is equally worrisome. At current production rates, the global R/P ratio is about 46 years (see *Appendix I*). Proved reserves (those recoverable under current conditions[10]) increasingly lie in the hands of national oil companies that are often hostile to U.S. interests. Venezuela, for example, holds over 100 years' equivalent of reserves at its current production rates. Thus, the U.S. reliance on countries such as Venezuela as a supplier could increase beyond the roughly 1 million barrels of petroleum it already imports from there every day.[11] The reserve part of this ratio may increase, but we can also be certain that the demand half of the ratio will increase, and likely at a faster pace.

The United States is already moving past the era of nearly complete reliance on petroleum for transportation fuel. Though it will take several decades to make this transition, the country should take every opportunity to hasten progress given projections of tight markets and a heightened potential for competition. This transition will require careful investments that account for the potential economic, environmental and geopolitical tradeoffs involved with all energy sources.

There is an array of reliable, renewable fuels that should be considered as alternative supplies to petroleum, including multiple generations of biofuels. Biotechnicians have long proven the technical ability to produce hydrocarbon equivalents to fossil fuels, including the jet fuel blends that DOD requires. Efforts by the National Laboratories, academia and the private sector are focusing on basic science that will enable more efficient use of second-generation biological fuel sources (made from non-food crops) by increasing efficiency in processing plant materials while retaining net energy gains, and by overcoming other technical hurdles. Others are leap-frogging beyond second-generation biofuels to fuels derived from algae. Still other options include displacing petroleum by using electricity or natural gas to power transportation, and using distributed renewable energy at overseas and forward operating bases to displace petroleum in powering generators. It is encouraging that growth in renewable energy supply availability frequently outpaces expectations. Ethanol production grew 164 percent between 2002 and 2006, and biodiesel

The United States is already moving past the era of nearly complete reliance on petroleum for transportation fuel.

production expanded from 1 trillion Btu to 32 trillion Btu over the same period. Wind, solar and geothermal supplies also have expanded faster than most analysts predicted over the past decade.[12] These supply-side changes show how technical, economic and policy decisions, such as tax regimes that Congress has enacted to even the playing field with fossil fuels, can affect energy trends.

Any effective DOD energy strategy must also be flexible enough to account for the fact that its leaders will have to make energy decisions based on imperfect information. Specific projections regarding how rapidly fuel alternatives could achieve large-scale production and consumption are often treated as proprietary. This uncertainty is particularly problematic for DOD, which has limited manpower and funds to invest in fuel research and development.

The Indirect Costs of Petroleum Dependence

The Department of Defense accounts for about 80 percent of the federal government's energy consumption, and its high dependence on petroleum-based fuels – the Defense Energy Support Center reported 132.5 million barrels in petroleum sales in fiscal year 2008, totaling nearly 18 billion dollars[13] – means that its budget is subject to major oil price fluctuations.[14] Petroleum price spikes negatively affect DOD's budget and divert funds that could be used for more important purposes. As Secretary Gates said in 2008, "Every time the price of oil goes up by 1 dollar per barrel, it costs us about 130 million dollars."[15] In an era of constrained budgets, American security is best served by trying to hedge against future price fluctuations of this scale.

In addition to the security and financial costs, petroleum dependence creates environmental costs that are causing increasing concern among security analysts. Emissions from fossil fuel use contribute to changes in the global climate, which risk altering geopolitical relations, destabilizing regions of high strategic importance to the United States, increasing erosion and storm surges at coastal installations, and altering disease patterns.[16] Melting summer ice in the Arctic is an early example; its geopolitical importance has risen sharply in the past five years as Arctic countries (and their potential shipping and natural resource customers) prepare to exploit newly navigable waterways and seabed resource deposits. Federal leaders from both major political parties, DOD's civilian and military leaders, and security analysts of all stripes regularly reiterate concerns over the national security implications of the changing climate caused by high-carbon fuel consumption.[17] Other environmental costs of fuel production can include heavy water use and diverting arable land to fuel production, both of which can trigger negative side effects if not managed properly. Factors such as greenhouse gas emissions (including from burning high-carbon fuels and from land use change) and the effects of fuel production on food prices should therefore constrain DOD's energy investments in high-carbon fossil fuels or first-generation biofuels derived from food crops.

The Changing Political, Legal and Regulatory Environment

Signs indicate that federal and state governments will continue to push for greater adoption of domestic and/or lower-carbon energy technologies. As a result, DOD will face a changing legal, regulatory and political environment in the coming decades. Congress has consistently

passed legislation since 2005 to support investments and set federal requirements supporting energy efficiency and renewable energy production. The Obama administration strongly supports this approach as well. Obama issued an October 2009 Executive Order committing federal agencies to calculate and reduce their greenhouse gas emissions, which spurred energy-focused DOD officials to begin complying with this requirement. Likewise, 27 states have instituted renewable energy portfolio standards, and nine others have renewable or alternative energy goals or requirements.[18] Legal and regulatory changes can also constrain energy choices. For instance, the U.S. Supreme Court ruled in 2007 that greenhouse gas emissions constitute a pollutant and therefore can be regulated at the federal level, and the Obama administration has signaled its intent to move forward with such regulation unless the Congress mandates emissions reductions through legislation.

While the U.S. government sets domestic regulations and laws, and can exempt combat-related activities, it does not exercise the same control internationally. Indeed, there is growing concern that foreign countries may not always exempt military activities within their territory from environmental standards. For example, the Canadian government recently decided to upgrade one of its vessels that was not equipped to meet the environmental standards of several European countries, for fear that the vessel could be denied port access.[19] The Department of Defense must consider emerging international trends in regulating emissions and adopting less carbon-intensive energy sources as it considers how to guarantee its freedom of access to foreign ports and territories.

III. ELEMENTS OF A DOD ENERGY STRATEGY

In response to these factors, DOD should map a path forward that relies on technological innovation and efficiency to hedge against price spikes and scarcities and to accommodate America's economic, political and environmental needs. By planning now around these likely future conditions, DOD can weather change, protect its own interests, reduce its vulnerability to extreme price spikes and – most importantly – ensure that it can meet its mandate to protect the nation's security. The logical next step is to develop a strategy that adheres to 12 specific guiding principles.

1. Set a Common Energy Goal

In order to address security risks, costs, domestic constraints and changing energy supply and demand trends, DOD should set an overarching energy goal of *managing a smooth transition beyond petroleum over the next 30 years.* This goal is significantly broader than the array of goals and objectives that the services have set to guide their own energy decisions to date. Those more near-term goals move in the right direction, but remain insufficient given the broad scope and extended timeline of DOD's energy challenges.

The 2010 QDR stated, "Energy security for the Department means having assured access to reliable supplies of energy and the ability to protect and deliver sufficient energy to meet operational needs."[20] This leaves much room for interpretation and is not precise enough to ensure that everyone within DOD is moving in the same direction. To many domestic installations, energy security means reliable sources of power that are not vulnerable to disruption by natural or man-made disruptions affecting the electric grid. To the Army, operational needs and installation energy concerns overlap greatly given that operations abroad center most often on forward operating bases. The Air Force is yet a different case; as aviation fuel

accounts for the majority of its energy demand, liquid fuel supplies are of paramount importance. Thus, for each of the services, the broad requirements of "assured access," "reliable" and "sufficient" supplies could mean any number of energy choices, and will vary depending on whether this definition applies to short-term or long-term needs.

To accommodate all of these needs, yet still provide real guidance, DOD should settle on a single overall goal and ensure that the objectives set by the services align with that goal. It is important that this goal is long-term in nature and general enough to incorporate the work already set by the military services and to allow flexibility, but specific enough to guide real changes in behavior and investment.

A THIRTY-YEAR CHALLENGE

We recommend that DOD establish a goal that by 2040, DOD must be able to operate all of its assets on non-petroleum fuels. The thirty-year timeline is sufficient time for the private sector scaling up adequate supplies, and for DOD aligning its bureaucratic and infrastructure systems to accommodate this change. Knowing that petroleum prices will rise and renewable fuels will become cost-competitive years before the world produces all reserves, it is not prudent to assume that petroleum will remain affordable or that supplies will be reliably available to the United States three decades hence; nor is it wise to perpetuate the geopolitical, operational and environmental costs indefinitely. Ensuring that DOD can operate on non-petroleum fuels 30 years from today is therefore a conservative hedge against the economic, political and environmental conditions and constraints outlined in this report.

Despite the 30-year timeline, DOD does not have several decades to *begin* this transition. The renewable fuel development, testing and evaluation that the services have conducted to date mark the first steps in guaranteeing their long-term ability to meet their energy needs, but even if DOD adopts a hastened timeline, it will take decades to complete this transition. Implementing this strategy must therefore begin immediately.

Though it is important to start the critical process of transitioning to non-petroleum energy sources, mission accomplishment will always remain DOD's top consideration. It is therefore essential that DOD's energy choices do not interrupt or detriment operational capabilities. Rear Admiral Philip Hart Cullom, director of fleet readiness for the Navy staff and head of the Navy's Task Force Energy, calls this creating "off-ramps" from petroleum.[21] In the near term, this indicates the importance of drop-in fuels, or liquid fuels that are chemically equivalent to petroleum-based fuels and can therefore fuel existing platforms. DOD's energy transition should be nearly seamless to the soldiers, sailors, airmen and Marines using these fuels.

Other goals debated in recent years, including a goal of simply increasing the efficiency of petroleum use or a static reduction in overall fuel consumption, will be insufficient. Improving energy efficiency – in other words, getting more power per unit of energy consumed – must be part of a strategy to meet DOD's energy needs without petroleum, but it is important that this not serve as the goal itself. Efficiency is one of the most important short-term operational energy objectives for DOD; for instance, any energy efficiency gains in Iraq and Afghanistan can immediately reduce vulnerable supply lines, save lives and free up manpower for other operations. However, efficiency does not mark a concrete end state over a multi-decade time scale, and therefore cannot serve as an overarching goal. America's energy efficiency has grown since the 1970s, yet its overall petroleum demand and corresponding vulnerabilities have also grown. For DOD, this means that its operational vulnerabilities and costs remain despite its efficiency gains. In other words, gains in efficiency are necessary and important, but there is a danger that too heavy a focus on efficiency over a long-term time scale will mask an increasing reliance on

SERVICE PRIORITIES

The services have set many of the necessary short- and near-term goals and objectives to hit our suggested long-term target for DOD as a whole. The Army, Air Force, Navy and Marine Corps all established energy strategies, and they have since refined them to accommodate new requirements from Congress and executive orders. These include, among others:

AIR FORCE

"By 2016, be prepared to cost competitively acquire 50% of the Air Force's domestic aviation fuel requirements via an alternative fuel blend in which the alternative component is derived from domestic sources produced in a manner that is greener than fuels produced from conventional petroleum."[22]

"Test and certify all aircraft and systems against 50/50 alternative fuel blend by 2011."[23]

"Reduce overall fossil fuel consumption in vehicles by 2 percent annually (2005 baseline) until 2015, and steadily increase the overall fleet average miles per gallon (MPG)."[24]

"Install at least 1 renewable fuel pump at each federal fleet refueling center at each installation that issues more than 100 thousand gallons of ground fuel annually."[25]

ARMY

"Reduce the amounts of power and fuel consumed by the Army at home and in theatre. This goal will assist in minimizing the logistical fuel tail in tactical situations by improving fuel inventory management and focusing installations consumption on critical functions."[26]

"Raise the share of renewable/alternative resources for power and fuel use, which can provide a decreased dependence upon conventional fuel sources."[27]

NAVY

"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."[28]

"The Department of the Navy will by 2015 reduce petroleum use in our 50,000 strong commercial fleet in half."[29]

MARINE CORPS

"Reduce energy intensity 30% by 2015 relative to a 2003 baseline."[30]

"Increase the percentage of renewable electrical energy consumed to 25% by FY 2025."[31]

Once DOD establishes its long-term energy goal, it will need to audit these energy plans to ensure that all service-level energy goals align. Most, if not all, of them will already align with the long-term goal of managing a smooth transition beyond petroleum by 2040. It will be critical to build on these successes by expanding targets past the dates specified above.

fuel that poses further risks to the Department of Defense. Efficiency should therefore be treated as a means and an operational enabler.

It is also important that DOD's energy goal does not amount solely to absolute reductions in energy consumption, devoid of consideration of how DOD uses energy in its efforts to protect and defend U.S. interests. DOD must always retain the flexibility to successfully conduct its missions. Demand reduction can be an important means of reducing vulnerabilities to supply lines abroad and reliance on a fragile grid at home. However, overall energy consumption should remain a function of DOD's activities and global engagements. Total fuel demand must therefore remain flexible and should not serve as a fixed, long-term goal.

2. Establish Clear Energy Guidelines for DOD

DOD should establish, publish and enforce a clear set of overarching rules or guidelines to help the services navigate their energy transitions, and to signal to the private sector what sorts of fuels, infrastructure and efficiency technologies it will need to supply over the long term.

In setting these guidelines, first and foremost, DOD's *energy investments must meet military needs*. Those that cannot be designed or adapted by their producers to meet military needs should not be considered worth DOD's limited energy investment dollars. Otherwise, as the track record to date indicates, new fueling infrastructure, energy production technologies and vehicles will simply not be used. For example, a hydrogen vehicle and fueling station demonstration at Hickam Air Force Base in Hawaii marked a great sign that DOD bases can be used for testing new technologies, but the small scope of the demonstration – a single fueling station and limited range of the vehicles – significantly limited the utility of this investment to the airmen and civilians working at Hickam. DOD's purchases should treat military utility as a mandatory constraint on any energy-related purchases.

Second, the fuels on which DOD relies *must be consistently available long into the future*. This stipulation leads to a preference for renewable fuel technologies versus supplies that will eventually deplete. We do not currently know with much fidelity what energy supplies will be reliably available where and when – even for petroleum beyond the 30-year time frame, with the likelihood of demand spiking, possible recalcitrance on behalf of suppliers, diminishment of easily recoverable supplies and fragile transit routes and delivery infrastructure. DOD requires consistently available supplies and supply systems that will not evaporate for economic or political reasons.

Third, *new fuel sources must hold the potential to be available globally*. DOD relies on international companies and other countries to provide fuel supplies for its use outside of the United States. Reliance on a single fuel that is commonly used in all countries and produced globally (petroleum) benefits DOD logistically, but this system will not survive indefinitely at a bearable cost. Many countries are already producing fuel alternatives to petroleum and increasing their capacity to do so, though there is a lack of information about where these supplies are, whether they can be formulated to fit DOD's technical specifications, and to what scale they are likely to grow in supply availability. DOD must insist that its platforms can operate on fuels that it can procure abroad in order to ensure its ability to operate globally and to take advantage of the benefits that fuel source diversification can offer.

Fourth, *performance is paramount*. DOD cannot waver on its demand for fuels that perform properly. Its assets, particularly aircraft, require chemical consistency in the fuels used. This indicates special concern for reliability in formulating, refining and properly blending drop-in aviation biofuels that are mixed with petroleum.

Fifth, plans to smoothly navigate DOD's long-term energy transition beyond petroleum *must account*

for the changing political and regulatory environment. Congress mandated that federal agencies should not invest in fuel sources that carry lifecycle greenhouse gas emissions higher than their current fuel sources[32] (such as coal-derived fuels, and by some calculations, potentially corn-based ethanol), and private companies are pushing Congress more aggressively than ever to enact legislation to curb emissions. No federal agencies should invest their finite funds in fuel sources with higher lifecycle emissions, or that contribute to extensive damage to food commodity markets or ecosystems. The private sector should not sell DOD fuels that will contribute to extensive rainforest destruction, water supply contamination or climate-changing emissions increases. DOD needs to set and stick to guidelines that clearly indicate to the private sector where it should be investing in order to develop supplies appropriate for DOD needs and national environmental policy standards.

Finally, over the long-term, *DOD should also consider fuel affordability: whether its supply systems will be able to operate for sustained periods of time without crippling negative direct costs and externalities.* In this sense, affordability applies to the actual cost of DOD's energy supplies and the risks that those supplies carry. This standard also indicates a need to consider the effects of potential price spikes on the defense budget – both within DOD if its fuel costs rise, and for the nation as a whole (if high prices negatively affect the economy in ways that lead to a constrained federal budget). Costs associated with the increasing difficulty in tapping the world's oil resources show that dependence on finite, nonrenewable resources is inherently risky. Indeed, the blanket assumption that petroleum would remain affordable indefinitely is what caused the dangerous dependence with which DOD now wrestles. It is critical, however, that affordability be considered with reference to the costs of fuels produced at scale. Any newly developed fuels that are not yet mass produced will cost more in their development stage and less once economies of scale are achieved. It will be incumbent on potential alternative fuel suppliers that their fuels will be affordable over the long term.

3. Plan for an Uncertain Future

DOD should forecast what its fuel vulnerabilities and needs are likely to be decades into the future as a means of guiding energy choices today. The future of DOD aviation and aviation fuel in particular will influence the pace and composition of DOD's energy strategy over the long term, considering that aviation fuel accounted for 56 percent of DOD's energy consumption as of 2008, and about 80 percent of the Air Force's energy needs.[33] The future of manned and unmanned flight will directly impact the balance of DOD's energy investments in jet fuel, energy storage devices and other energy technologies.

DOD should develop a series of planning scenarios to game out fuel needs against different potential future combat concepts. Warfare 20, 30 and 40 years from now will not look like today's wars. Likewise, the way the United States secures its interests will likely not mirror today's efforts. Preparing for this uncertainty requires thinking today about how DOD will operate years down the line – and this by necessity includes envisioning DOD's future energy needs.

The key to successful energy planning will be to ensure diversity within the scenarios: incorporating diverse needs and diverse sources of energy and the supply systems that they will require. Planning scenarios may blend together and overlap, but must involve planning for a very broad range of energy technologies and requirements. This will ensure that DOD is preparing for a wide range of energy contingencies. From these, it can derive estimates of what types of fuels, infrastructure and storage technologies it may need to invest in today.

4. Demand New Fuels for Old Equipment

The majority of the vehicles, aircraft and weapons systems that DOD purchases in the near term will be designed to be fueled by petroleum, as are most of DOD's current assets. Most of these systems will remain in commission for decades before replacements are seriously considered. Notably, the Office of the Secretary of Defense (OSD) is working to fulfill a mandate from Congress that defense suppliers work to increase fuel efficiency as a consistent part of acquisition processes. In the near term, DOD should also sustain its focus on drop-in fuels – that is, liquid fuels designed as chemical equivalents to petroleum-based fuels, and that are therefore ready for immediate use in existing aircraft, vehicles and equipment once they are tested and certified. The Navy and Air Force have already begun moving down this path, and both have now flight-tested drop-in biofuels blended with petroleum-based jet fuel. The key will be to maintain and strengthen the demand signal these tests have begun to create in order to push the private sector to continue producing military-appropriate fuel supplies. It will also be important for DOD to continue to consider the long-term environmental ramifications of these drop-in fuels so as not to violate Congressional requirements that its alternative fuels have lower greenhouse gas emissions than petroleum equivalents.

Diversification of energy supplies stands to be an important benefit to DOD of this focus on drop-in fuels. Even if DOD positions itself to meet all of its energy needs using non-petroleum sources by 2040, there may still be circumstances in which certain fuels are simply not available when and where DOD needs them. If DOD can procure fuels from a portfolio of sources, such as fuels made from locally grown switchgrass, algae, camelina or other crops, that diversity can help to keep prices competitive (especially as a hedge against weather or economic conditions reducing crop output in any given region) and deny suppliers leverage over the United States. Diversification can also ensure that DOD will be able to procure the fuel it needs around the world. Enjoying the full operational and budgetary benefits of fuel diversification will also require DOD to work with foreign governments on international standards for military-grade fuels.

5. Continue to Increase Alternative Fuel Use at Domestic Installations

The best way to begin DOD's energy transition will be to begin with fast-tracked efforts at bases in the continental United States. The services are already increasing renewable power generation at their installations, and leaders at several bases have even set goals of becoming net-zero energy consumers (in other words, producing as much energy as they consume) and developing resilient microgrids. In several conversations with energy managers at U.S. bases during the course of our research, there was a tangible sense that increasing efficiency and use of renewable energy domestically contributed to the broader goal of DOD improving its long-term energy security.

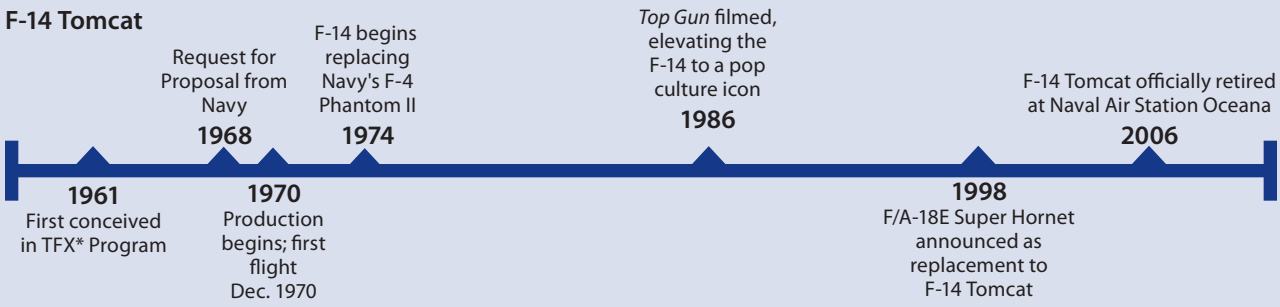
To date, DOD has focused heavily on generating renewable electricity at domestic installations, but it should expand this focus to include reducing petroleum use in vehicle fleets. Moving to alternative fuels in ground vehicles will be easier than displacing aviation fuels, which require an array of additional specifications. At its installations, DOD also has more alternative fueling options that those designed for use in aviation (e.g., DOD cannot fly its aircraft with electricity today, but it can adopt electric ground vehicles if they meet the guiding principles outlined above). This added flexibility allows individual bases to invest in energy sources that make sense given regional renewable energy production capabilities and infrastructure.

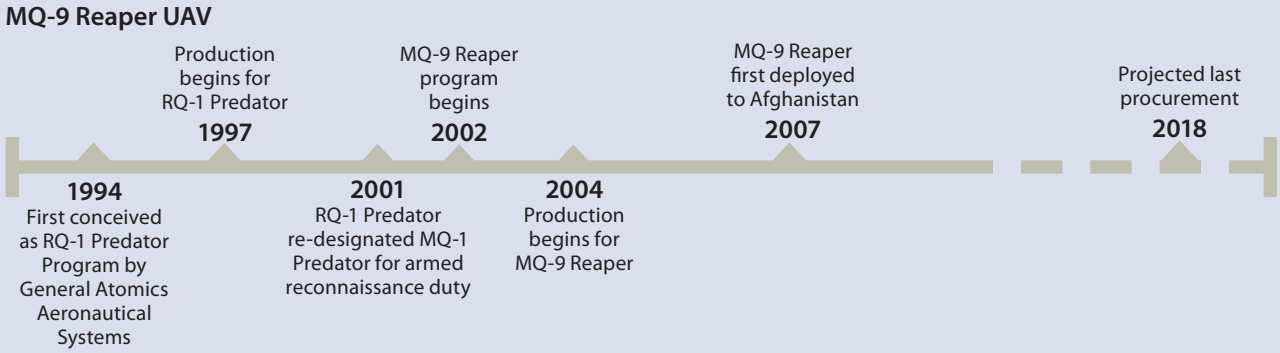
6. Invest for Maximum Impact

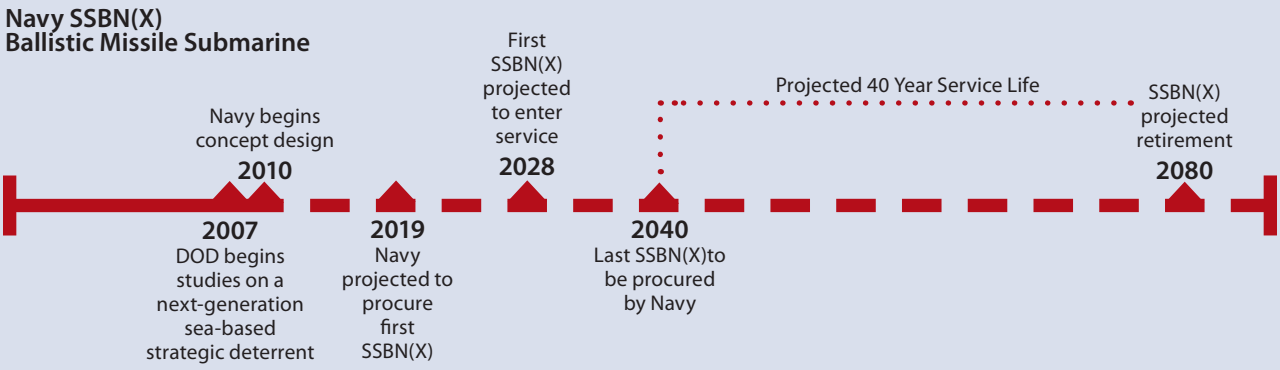
DOD should maximize the impact of its investments by factoring distribution and infrastructure into its decisions on *where* to invest. Because energy

THE LONG LIVES OF DOD ASSETS

Given DOD's long acquisitions process, a majority of the vehicles, aircraft and weapons systems that DOD purchases in the near term will be designed to use petroleum-based fuels, as are most of DOD's current assets. Consider the following: for DOD's 2008 acquisitions programs, 27 of the 80 active programs had been in development for a decade or more. What is more, most of these systems will remain in commission for decades, and any DOD energy strategy will have to account for the fueling needs of these systems. Below are several programs, retired and active, that reflect DOD's long development and deployment timeline.







*Tactical Fighter Experimental program

Source: *Defense Acquisitions: Assessments of Selected Weapon Programs* (Government Accountability Office: Washington, DC, March 2009):10.

production, purchasing, transport and transmission all involve systems of infrastructure and sunk costs, new fuels will not likely displace the old everywhere simultaneously. Prioritizing energy projects is today a bottom-up and organic process: Interested individuals navigate mazes of funding streams, laws, regulations, contract types and public utility relationships in order to gain approval and funding to move forward with renewable energy or efficiency projects. DOD should streamline this process and target it to maximize results.

For DOD to prioritize where to focus its energy transition efforts better, it should identify the locations where transition to non-petroleum fuels would have the greatest, most immediate impact. For example, DOD often uses jet fuel in vehicles and equipment due to the logistical benefits gained in using a single fuel type. Therefore, aviation fuel must be a central focus of this analysis. DOD should identify points at which drop-in biofuel blends or other energy systems will cover the greatest volume of fueling. As it considers this step, it will find the private sector aviation industry, which has considered prioritizing aviation biofuel supplies for the nation's busiest airports, instructive. For example, if biofuels are available at the seven busiest U.S. airports in passenger volume, they could power nearly 28 percent of the country's air traffic.[34] These airports could be used as hubs around which to build energy infrastructure and production capacity in order to hasten the adoption of renewable fuels there. Cities around the United States and institutions such as the U.S. Postal Service have utilized their hub-and-spoke fueling systems to quickly integrate new fuels and vehicles into their fleets – cases which should be studied for best practices and important lessons in adopting new fuels.

Finding the locations with the greatest fuel demand, however, is only the first step since not all locations are currently conducive to the production, transport or use of non-petroleum fuels. DOD should therefore analyze the list of top fuel demand locations against key enablers that could hasten the availability of alternative fuels at a large scale. These enablers should include: permissive state and local laws and incentives; infrastructure to handle transport, storage and fueling; and supply availability (including states or regions with current biofuels development in progress or high production potential).

7. Save Energy, Keep the Change

Several disincentives hinder DOD's transition to more efficient energy use and the use of alternative fuels. The problems here run deep; over the course of research for this report we have heard from energy managers at U.S. military bases, installation policymakers in Washington and officers representing each of the services. Perhaps most importantly, individual bases, the military services and even the DOD writ large cannot always pocket and repurpose the money they save if their energy costs drop. This is a result of the type of funding used for renewable energy or efficiency investments or arrangements with local public utilities for renewable energy installations. Additionally, depending on how DOD pays for renewable energy investments on its bases, it does not always receive the commensurate clean energy credits for the energy generated on its land. These disincentives to save energy also extend to many contractors. Implementing a long-term energy strategy will therefore require DOD to address incentives and disincentives built into budgeting rules and norms, including for contractors. Energy Savings Performance Contracts, which allow contractors to recoup their energy investments in federal projects, are one example of how designing incentives for contractors to reduce energy use can dramatically lower consumption.[35]

Correlated to the current misalignment of incentives, DOD lacks appropriate metrics regarding its energy security activities. This stems in part from the lack of a long-term energy strategy or a specific, unified goal. OSD and the services do have long lists of metrics for meeting objectives that may or may not measure progress toward the endpoint DOD needs to reach. Past metrics have also tended to measure static energy

use and do not account for military activities. New metrics to indicate DOD's success (or lack thereof) in progress toward its long-term energy goals should be both streamlined and meaningful.

8. Understand that Energy is Not Free

Changing how DOD meets its energy needs will involve a shift in its culture. It is important to note that this challenge is not distinct to DOD: Due to relatively (and often artificially) cheap energy and the normalization of consistent and abundant supplies, the country broadly undervalues the true cost of energy and therefore faces few incentives to change its behavior. Change will take time, and it will involve consistent leadership and public education. A culture that recognizes the cost of failing to change the energy status quo will help facilitate DOD's smooth transition to more sustainable long-term energy use. It will also have ripple effects for the country. Whether through disseminating new technologies such as GPS or leading by example to change cultural norms such as with racial integration, changes to DOD's culture often set the stage for significant national change.

Among those who consider DOD's energy challenges on a regular basis, a consensus has formed that cultural change is a necessary component of meeting long-term energy needs. One Marine Corps representative recently described DOD as a victim of its own success in that it manages logistics and engineering so well that energy is taken for granted: it is simply available when and where it is needed.[36] The wars in Iraq and Afghanistan launched the process of reversing this trend, as supply lines have proven extremely vulnerable to attack.

Committed leaders are in place, meeting the first precondition for integrating energy into the normal ways in which DOD does business. Civilian and military leaders of the Navy, Marine Corps, Army and Air Force have all spoken to the importance of improving energy efficiency and assuring long-term fuel availability and created energy offices.

Next steps include raising awareness at every installation, and improving energy education at war colleges and through messaging by higher-ranking officers. The vast majority of representatives we spoke with at all civilian and military ranks during the course of this project understood the operational vulnerabilities involved with the high energy consumption required by the current wars. Subsequent areas of focus must include long-term energy supply and demand trends, the negative economic and environmental effects of fossil fuel dependence and trends in science and innovation.

9. Promote a Shared Vision of DOD's Energy Future

Even with all of DOD's efforts, it cannot meet its long-term energy goals without Congress, the rest of the executive branch and a critical mass of private companies sharing a similar vision. Businesses and academic researchers will have to do the heavy lifting in energy innovation, and DOD relies on Congress and the White House to provide funding. Yet while DOD has worked busily to define and confront its energy challenges over the past few years, its track record in relating its activities to the outside world is mixed at best. Many current successes are driven by individual initiative, making them ad hoc and easily terminated. Some aspects of external relations need major adjustment, while other areas of improvement will require relatively minor refinements.

Most critical is for DOD and Capitol Hill to improve communication on energy issues. Legislators and their staffs often are left to interpret for themselves what energy policies it would be helpful to require for DOD. Many at DOD also express frustration that energy requirements mandated by Congress are not always backed by funding to invest in steps like fuel switching, new infrastructure and efficiency upgrades. DOD should develop a robust plan for Capitol Hill relations and external relations to communicate its long-term energy strategy. It should ensure that its strategic thinking is framed clearly and points toward real policy actions that Congress

(or other government agencies) can adopt. There is also a strong need for Congressional staffers to expand their knowledge on DOD energy issues, and to ensure due diligence in examining how DOD may react to their ideas before they are enacted in law.

A simple way for DOD to improve its relations with other government agencies is to provide an online organization chart of major DOD offices focused on energy and a description of the general roles and responsibilities of those offices. This may seem simplistic, but to those not familiar with the DOD bureaucracy (especially policymakers on the Hill and clean energy entrepreneurs) it can be extremely challenging to find the proper points of contact to discuss energy policies in DOD. There is little hope of improving interagency coordination or Congressional relations if outsiders cannot even figure out whom to engage with questions or ideas.

10. Engage Allies in the Energy Transition

Through foreign military sales, joint exercises and international basing, DOD can promote adoption of shared technical standards and directly influence the energy systems used by its allies. This will improve its own ability to operate by ensuring that the United States has access to needed energy supplies globally and improving interoperability. It will also encourage allies to make compatible choices with respect to energy, instead of working at cross purposes.

DOD's long-term energy strategy must therefore include an international plan of action. At a minimum, this should include information sharing on alternative energy research and development. It should also include cooperation with international partners on fuel testing and evaluation, and setting fuel standards that guarantee interoperability. This should be a familiar concept for DOD, which already sets joint standards with allies by, for example, standardizing the use of 9mm NATO cartridges by all member countries. Where the interests and regulations of both countries permit, such efforts can include working with U.S. allies on energy technology sharing. This will also require better coordination with the State Department, the National Labs and U.S. energy industries. Additionally, it will have the positive effect of signaling to international suppliers (both countries and private companies) that DOD will favor procurement of non-petroleum fuels when possible.

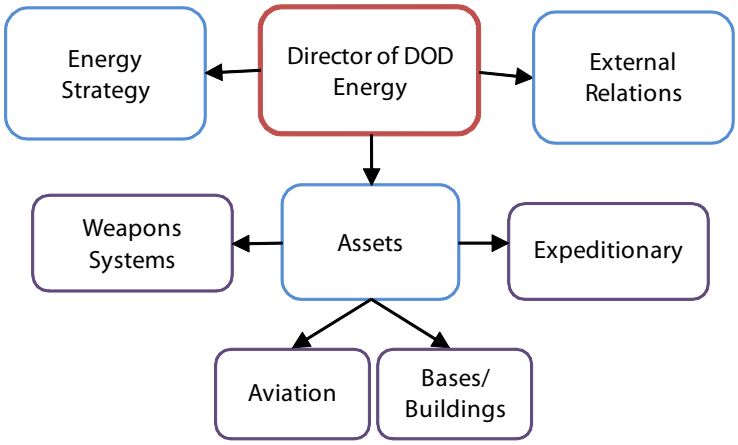
Energy is an increasingly important issue for U.S. diplomacy with traditional allies such as Japan, the Republic of Korea (ROK) and NATO countries. Where these overlap with important military considerations, DOD's active engagement will be critical for ensuring that its needs are considered. But while this step may seem straightforward and relatively easy to implement, in fact each country has its own interests, domestic politics, economic pressures and tradeoffs to consider. Often, logical areas of cooperation on energy are in fact areas of competition. Cooperation regarding installation energy use can be particularly difficult as it is often met with requirements that favor American products.

It is important to remember that DOD already works internationally to secure its energy supplies for the current petroleum-heavy system – and that the process is often neither smooth nor easy. Contracting and using supply systems for petroleum through countries such as Azerbaijan are already costly and require often-difficult relationship management.[37] DOD should actively consider how it can better coordinate with U.S. allies to develop non-petroleum energy systems to meet its requirements for reliable, affordable and sustainable fuels.

11. Streamline Energy Management

Managing a smooth transition from petroleum to meet DOD's long-term energy needs will require bureaucratic and personnel changes. DOD's current structure reflects past thinking about energy rather than current priorities, and the military services and OSD regularly change the structure of their offices and personnel requirements to address questions of energy. Energy planning and policy are also subject

FIGURE 1: RECOMMENDED PERSONNEL STRUCTURE, OFFICE OF THE SECRETARY OF DEFENSE



to changing mandates by Congress and the White House. It is important to underscore that many aspects of DOD's current energy personnel structure mark major improvements and indicate solid leadership on energy. As mentioned earlier, each branch of the armed services and OSD have new offices devoted specifically to energy, including experts on operational fuel use. Nonetheless, incorporating energy better into how DOD does business, as the 2010 QDR mandates, is far from institutionalized.

Within OSD and the services, responsibility is generally split between those managing energy for military installations and those managing operational energy. This is in part a legacy divide: Positions governing operational energy in OSD and the services have only been stood up as dedicated offices over the past few years, while offices governing energy use at military bases have long been part of the DOD organizational structure. However, the separation of energy along these lines is a false distinction; the training and equipping carried out at domestic military installations is geared toward operational utility. The only truly static component of installations is the buildings themselves, whereas the people using energy and how they use it fluctuate regularly and depend on operational requirements. Indeed, the definitions of operational and non-operational energy are not well delineated in related laws or Congressional requirements.

Once a long-term DOD energy strategy is in place, the DOD should assess its related organizational and personnel structures. This assessment should involve an evaluation of personnel needs, and in particular what positions are filled by political appointees versus civil service officers versus contractors, while being cognizant of the work that the military services themselves conduct.

Since the separation of installation and operational energy reflects DOD's energy past more than its energy future, it should seek in the years ahead to merge energy management at the OSD level to a coherent body under the leadership of one individual. The Army, Air Force, Navy and Marine Corps could continue to manage their own unique energy bureaucracies as their leaders deem best. This combined office should include experts focused on the following important areas:

STRATEGY

A major component of DOD's energy strategy will include setting priorities, planning against various scenarios and contingencies, and tracking progress against objectives.

ASSETS

One person should oversee energy issues as related to specific DOD assets, with a team of individuals focused specifically on the very different categories of assets. This component would consider not just the stock of DOD equipment, vehicles, ships and aircraft, but also long-term trends in how DOD employs them.

Aviation: As it comprises more than half of DOD's petroleum use and requires unique technical knowledge, aviation fuel is a category onto itself.

Weapons Systems: Assets such as missile defenses and directed energy weapons also have unique energy signatures and, given their limited numbers and specific uses, are operated differently from other categories of assets. Parsing which weapons systems have unique enough energy requirements to necessitate consideration independent of the expeditionary and aviation categories will be difficult, and they will likely change over time.

Expeditionary Energy: This component would include all mobile assets not represented in the aviation and weapons systems categories. It will be the heart of DOD energy activities during wartime, when fuel to deployed troops represents the most critical energy management.

Buildings/Bases: This component of DOD's energy infrastructure should focus only on installations themselves. It will require coordination with public utility commissions and legal and regulatory bodies, and knowledge of often-complicated state and local dynamics.

EXTERNAL RELATIONS

Many of the conditions that will determine DOD's ability to meet its long-term energy needs will be set by Congress, the private sector and the international community. Meeting DOD's energy needs over the long term requires effective relations with all of these groups. This component will therefore include three important areas of external relations management: private sector partnerships; Congressional relations; and international relations.

Officials focusing on all of these areas will be responsible for interagency coordination and coordination within OSD as it relates to their work. As much of the activity on meeting energy goals does and will continue to reside among the services, coordination among them and by OSD will be imperative. These positions will also represent a straightforward network of points of contact for other government and non-governmental representatives needing to coordinate with DOD on energy issues.

Funding for DOD's investments in reliable long-term energy supplies will come in many forms, and it will be critical for DOD's energy personnel to develop a deep understanding of how to properly resource its energy strategy. New resources should go toward sunk costs – efficiency upgrades, fuel testing and evaluation and energy infrastructure.

However, meeting DOD's goal of making a smooth transition away from petroleum will require the private sector to provide cost-competitive, at-scale renewable fuels that the Defense Logistics Agency can purchase when and where it needs them. This will require DOD to commit to a general direction for its energy future in order to send an effective market signal, and it will require incentives and regulations beyond DOD's control.

Contracting mechanisms and direct funding appropriated by Congress will constitute important means for making the necessary sunk investments for renewable energy adoption. The 2009 American Recovery and Reinvestment Act proved to be a successful and popular stream of funding for several projects at domestic installations, and lessons learned can be collected to indicate where funding may be most effective for future projects. The services also devote significant resources toward meeting this challenge. The Navy and Air Force

have been testing and certifying alternative aviation fuels within their own budgets. They will need to remain consistent in these investments for some time, but the rewards in potential savings to their budgets should over the long-term pay off if DOD can properly align its incentive structures.

Given the urgent need to address operational energy considerations in the current wars, this grand bureaucratic adjustment might best be timed for after significant redeployments from Iraq and Afghanistan are complete. Managing DOD's long-term energy transition may not need a vast personnel structure in its next iteration, though each component of the office can grow or shrink to match the changing nature of DOD's activities. The Army, Navy, Marine Corps and Air Force are also likely to continue to provide personnel who will address energy challenges, and much implementation will be conducted by base managers.

12. Plan for the Worst

DOD should plan for contingencies in which its predictions and plans for moving beyond petroleum turn out to be wrong. In other words, its "off-ramps from petroleum" may turn out to be rough roads, or DOD could make the wrong turns or miss the ramps altogether. For instance, DOD should imagine scenarios involving absolute shortages of energy, major price spikes, alternative fuels that simply cannot scale up fast enough and major technological or environmental game-changers that fundamentally alter how DOD meets its energy needs.

If worst-case scenarios transpire, they could cost DOD its ability to operate effectively. DOD, including the war colleges, combatant commands and OSD, has already conducted war games and scenario exercises that include fuel shortages, extended blackouts and other contingencies. DOD must continue to think through these kinds of scenarios, compile lessons learned from them and apply them to its energy calculations.

IV. CONCLUSION

The steps outlined in this report will help DOD transition to non-petroleum sources of energy, to the benefit of national security and operational effectiveness. Yet DOD's smooth transition to a future energy paradigm that does not rely on petroleum depends heavily on policies that lie beyond its own control. Many relevant policy choices and commitments are up to elected officials, state and local governments, the private sector and the international community (see Appendix II: *How the Rest of the Government Can Contribute to DOD's Energy Strategy*). Congress and the White House will continue to refine energy requirements for all federal agencies, and exert their leadership to improve the American public's understanding that these actions are taken to promote U.S. national security. DOD's long-term energy strategy should include coordination with all these groups, since their decisions will affect DOD's ability to operate.

Meeting DOD's energy demands with new fuel sources in the next 30 years will require patient and persistent leadership by DOD officials. But the benefits will prove to be far-reaching. These changes will help DOD to hedge against unbearable costs, maintain its flexibility and guarantee its ability to protect and defend the United States against all enemies — regardless of the availability of petroleum-based fuels.

Appendices

APPENDIX I: WHY EXAMINE RESERVE-TO-PRODUCTION RATIOS?

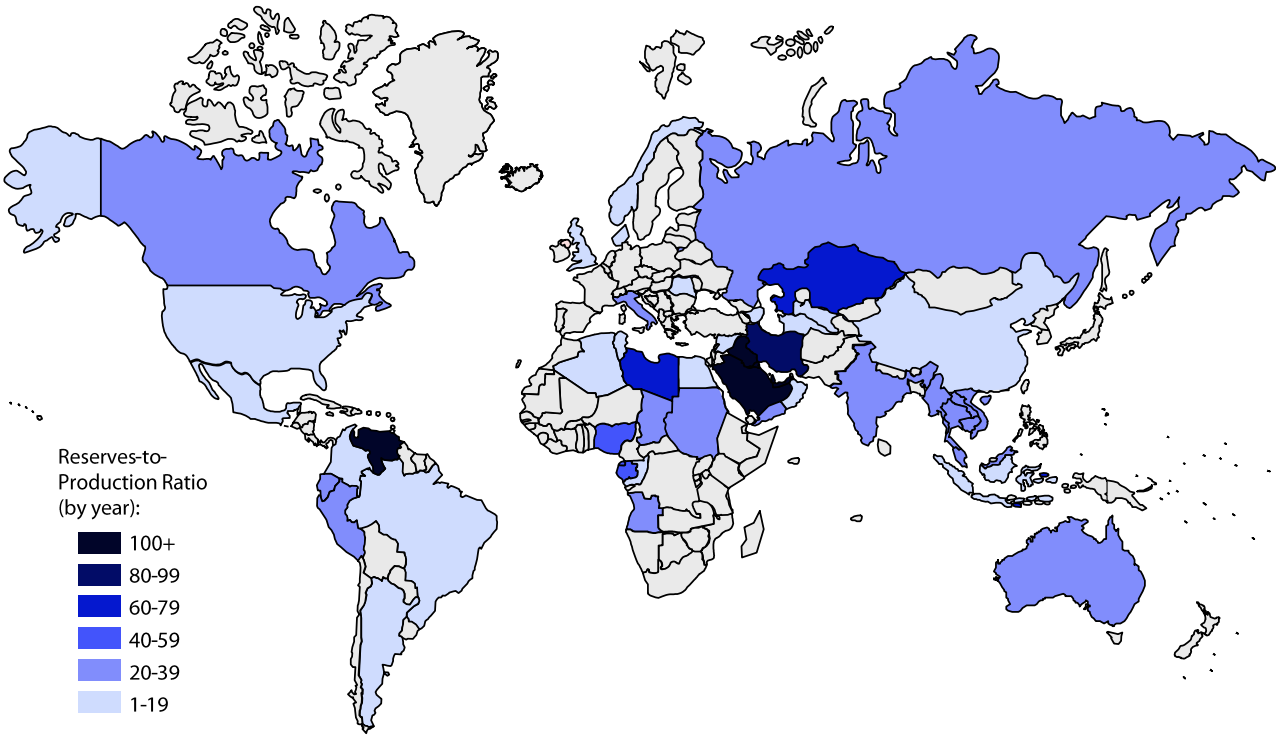
By Alexandra Stark

The U.S. Energy Information Administration defines the R/P ratio as "the number of years that oil and gas reserves would last at the current production rate." The resulting figure indicates the length of time in years that known, recoverable reserves are expected to last if production continues at the same pace. This timeline, while constantly in flux, gives a more useful indicator than just supply, demand or reserve figures for the purpose of long-term policy planning.

As prices change and technology advances, as demand rises and falls, and as new reserves become accessible, R/P ratios are likewise affected.

Global proved reserves (the quantities of oil that exist with reasonable certainty and can be recovered under current geological, economic and technological conditions) are often cited in considering the future of world energy trends. However, this is not always a helpful indicator. For example, Saudi Arabia has almost 20 percent of remaining global proved reserves, but at the current rate would produce its reserves in less time than Venezuela, which has about 13 percent of reserves but produces those reserves much less efficiently. Ominously, many major suppliers to the United States could produce their current proved reserves in fairly short time horizon if they continue at the present rate: For example, the R/P ratio for Canada (the top supplier to the United States in 2009, providing more than 20 percent of total oil imports) stands at about 28 years today. For the

FIGURE 2: WORLD PETROLEUM RESERVE-TO-PRODUCTION RATIOS



Total World Reserve-to-Production Ratio: 45.7 Years

Source: *BP Statistical Review of World Energy 2010*

United States itself, it is 11 years. The only countries with current R/P ratios longer than 75 years are Venezuela, Iran, Iraq, Kuwait and the United Arab Emirates.

It is also important to note that both elements of this ratio change regularly, so even reserve-to-production ratios are not perfect predictions of the future. As prices change and technology advances, as demand rises and falls, and as new reserves become accessible, R/P ratios are likewise affected. However, just as it is possible for countries to have a longer time horizon than projected, it is also possible for countries to exhaust their reserves sooner than expected, and for rising prices to make non-petroleum fuels more cost-competitive than investing in new petroleum production. While no economic and geologic estimates perfectly predict the future, R/P ratios can serve as important indicators for DOD officials and policymakers to plan against.

Sources: *BP Statistical Review of World Energy 2010* and U.S. Energy Administration, "U.S. Imports by Country of Origin." Data are from 2009.

APPENDIX II: HOW THE REST OF THE GOVERNMENT CAN CONTRIBUTE TO DOD'S ENERGY STRATEGY

Many of the policies and measures that will help DOD achieve its long-term energy goal of making a smooth transition away from petroleum by 2040 lie beyond DOD's jurisdiction. The following actions by Congress, the White House and the private sector will contribute to DOD's continued ability to meet its energy demands within the constraints outlined in this report.

Provide a clear long-term legal and regulatory environment. Market-based regulatory adjustments and innovation coming holistically through the private sector will be more helpful than DOD pushing for different systems piece by piece. Unfortunately, today many businesses are biding time and waiting for a more certain business environment rather than producing the fuels they have developed and making the investments they have planned. Hundreds of businesses have encouraged the federal government to pass clean energy and climate change legislation to provide a significant long-term market signal. Doing so should be considered one of the primary ways that the nation's leaders can help ensure that DOD can meet its long-term energy needs.

Mind the grid. DOD's ability to address its electricity reliability concerns is in part beyond its own jurisdiction. Almost all of DOD's domestic installations are connected to the public power grid and must therefore rely on local or regional utilities to grant it permission for renewable energy production and to improve grid reliance. The utilities are working to bolster grid security, but concerns remain sufficient that many at DOD and in Congress are considering plans for "islanding" bases, or detaching them from the public grid system altogether. Public utilities should continue to work closely with nearby installations to ensure that public and defense community needs are taken into account. A consistent legal and regulatory environment would also promote decisions by utilities to make investments in new infrastructure and rules to allow greater renewable energy production.

Extend requirements from Congress. The 2007 Energy Independence and Security Act (EISA) requires federal buildings, including domestic DOD installations, to reduce energy consumption up to 30 percent through 2015. This raised the bar from previous requirements set in 2005. Congress should direct additional requirements for efficiency and use of renewable energy in domestic installations beginning when previous requirements are set to end (often 2015). It should also continue to mandate that the fuels that federal agencies invest in have lower greenhouse gas emissions than the fuels they are meant to displace. However, two changes may be in order. The 2007 legislation requires that DOD reduce energy per square foot, yet this calculation does not account for the dramatic differences in the ways in which DOD uses different facilities. Congress should also be sensitive to the tight budget environment that DOD officials feel, and consider prizes for innovation and other mechanisms to provide funding to meet these requirements. The next round of legislative change to require DOD's continued progress on energy should be designed through extensive discussions and good coordination between DOD and the Hill.

Address information challenges. Credible government estimates are available for fossil fuel resources, including specific estimates of energy reserves, production, consumption and historical prices. These include reserve-to-production projections and future outlooks that are generally reliable, if often conservative. Finding comparable information for non-fossil fuels is difficult to impossible, and often involves wading through dense reports. There is no single-source place where those reports lie, and analysts are left to compare and judge the efficacy of sources on their own. The private sector often provides more accessible information – but not information that can necessarily be relied upon as neutral and accurate. While we do not recommend that the federal government engage in guesswork or estimates that are less than diligent, DOD must recognize this information gap.

Make reliable models available. DOD's incorporating greenhouse gas emissions, economic costs and other lifecycle effects of its energy options presents its own challenges. The computer models used to make these calculations reflect the sum of their parts: the data and mechanisms used by the modelers must be accurate (and reflect honest scientific facts, not political agendas or skewed information) to produce viable calculations. Information on the carbon, water and land use footprints of emerging fuel sources can also be more difficult to calculate than those of long-used sources, as they suffer from relevant information often being proprietary and in the hands of private companies. New fuels may also be adaptable to meet specific environmental footprint requirements once they are developed and produced at scale, which is a positive factor but again difficult to quantify. Meeting environmental constraints can be an inexact science, and calculations can change over time. DOD should therefore rely on energy and related climate models run by or compared to honest brokers, such as academics or the National Labs, in its decision-making.

ENDNOTES

1. U.S. Energy Information Administration, *Annual Energy Review 2009*, "Table 1.13: U.S. Government Energy Consumption by Agency and Source, Fiscal Years 2003, 2008 and 2009." (19 August 2010); and BP, *Statistical Review of World Energy* (2010).

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4. Steve Fainaru and William Booth, "Mexico's Drug Cartels Siphon Liquid Gold: Bold Theft of $1 billion in Oil, Resold in U.S., Has Dealt a Major Blow to the Treasury," *The Washington Post* (13 December 2009).

5. President Jimmy Carter, "State of the Union Address" (23 January 1980).

6. Jan van Tol, "AirSea Battle: A Point-of-Departure Operational Concept" (Washington: Center for Strategic and Budgetary Assessments, 2010): 81-82.

7. U.S. Energy Information Administration, *Annual Energy Review 2008*.

8. U.S. Energy Information Administration, *Annual Energy Outlook 2010*, Table A1: "World total primary energy consumption by region, Reference case, 2005-2035" (11 May 2010).

9. U.S. Energy Information Administration Website, "Petroleum Statistics" (26 January 2010); *Annual Energy Outlook 2010*, Appendix A.

10. The U.S. Department of Energy defines "proved reserves" as follows: "Proved reserves are estimated quantities that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions." U.S. Energy Information Administration, "World Proved Reserves of Oil and Natural Gas, Most Recent Estimates" (March 2009).

11. Energy Information Administration, "Crude Oil and Total Petroleum Imports Top 15 Countries" (May 2010 Import Highlights); BP, *Statistical Review of World Energy* (June 2010).

12. U.S. Energy Information Administration Website, "Biomass" (April 2008).

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14. U.S. Energy Information Administration, *Annual Energy Review 2009*, "Table 1.13: U.S. Government Energy Consumption by Agency and Source, Fiscal Years 2003, 2008 and 2009." (19 August 2010).

15. Donna Miles, "Military Looks to Synthetics, Conservation to Cut Fuel Bills," *American Forces Press Service* (6 June 2008).

16. See, for example, Commander Herbert Carmen, USN, Christine Parthemore and Will Rogers, *Broadening Horizons: Climate Change and the U.S. Armed Forces* (Washington: Center for a New American Security, 2010).

17. Many U.S. policymakers, agencies and documents have recognized the connection between climate change and security: the 2010 QDR says "Climate change and energy will play significant roles in the future security environment": p. xv; the National Intelligence Council has done extensive climate change research including reports on "The Impact of Climate Change to 2030"; President Obama stated in his December 2009 Nobel Peace Prize acceptance speech that "…the world must come together to confront climate change. There is little scientific dispute that if we do nothing, we will face more drought, famine and mass displacement that will fuel more conflict for decades. For this reason, it is not merely scientists and activists who call for swift and forceful action — it is military leaders in my country and others who understand that our common security hangs in the balance"; in remarks in November 2009 Secretary of Defense Robert Gates said that "the melting of the polar ice cap in the Arctic plus the frequency and intensity of weather events in this hemisphere, with the corresponding need for military humanitarian assistance missions, calls for a greater attention to the security implications of climate change."

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28. Secretary of the Navy Ray Mabus, "Remarks at the Naval Energy Forum" (14 October 2009): 8-9.

29. Ibid.

30. United States Marine Corps, "Ten by '10: Top 10 Things To Do by 2010 to Reduce USMC Energy Risks" (2009): 3.

31. Ibid.

32. See GovTrack.us, Text of H.R. 6 [110th]: Energy Independence and Security Act of 2007.

33. U.S. Energy Information Administration, *Annual Energy Review 2009*, "Table 1.13: U.S. Government Energy Consumption by Agency and Source, Fiscal Years 2003, 2008 and 2009." (19 August 2010).

34. According to the FAA, the top seven airports by passenger volume are:

Hartsfield - Jackson Atlanta International: 6.10 percent
Chicago O'Hare International: 4.45 percent
Los Angeles International: 3.94 percent
Dallas/Fort Worth International: 3.83 percent
Denver International: 3.45 percent
John F Kennedy International: 3.26 percent
McCarran International: 2.79 percent
Total: 27.82 percent

35. See Department of Energy, "Energy Savings Performance Contracts," (2010) for further information on ESPCs.

36. Off-the-record CNAS event (July 2010).

37. Craig Whitlock, "Gates brings reassurances to Azerbaijan leader," *The Washington Post* (7 June 2010).

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