

DOD's Energy Challenge as Strategic Opportunity

By AMORY B. LOVINS

Energy is the lifeblood of modern societies and a pillar of America's prowess and prosperity. Yet energy is also a major source of global instability, conflict, pollution, and risk. Many of the gravest threats to national security are intimately intertwined with energy, including oil supply interruptions, oil-funded terrorism, oil-fed conflict and instability, nuclear proliferation, domestic critical infrastructure vulnerabilities, and climate change (which changes everything).¹

Every combatant command has significant and increasing energy-related missions. Energy has become such a "master key"—it is so pervasive in its tangled linkages to nearly every other security issue—that no national security strategy or doctrine can succeed without a broad and sharp focus on how the United States and the world get and use energy. For the first time, 37 years after

the 1973 oil embargo, the 2010 Quadrennial Defense Review is expected to recognize energy's centrality to the mission of the Department of Defense (DOD), and to suggest how DOD can turn energy from a major risk into a source of breakthrough advantage.

DOD faces its own internal energy challenges. The heavy steel forces that defeated the Axis "floated to victory on a sea of oil," six-sevenths of which came from Texas. Today, Texas is a net importer of oil, and warfighting is about 16 times more energy-intensive: its oil intensity per warfighter rose 2.6 percent annually for the past 40 years and is projected to rise another 1.5 percent annually through 2017 due to greater mechanization, remote expeditionary conflict, rugged terrain, and irregular operations.² Fuel price volatility also buffets defense budgets: each \$10 per barrel (bbl) rise in oil price costs DOD over \$1.3 billion per year. But of immediate concern, DOD's mission is

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Oil field burns as Marines advance on Baghdad, Operation Iraqi Freedom, 2003

U.S. Marine Corps (Andrew P. Roufs)

at risk (as recent wargaming confirms), and the Department is paying a huge cost in lives, dollars, and compromised warfighting capability for two reasons:

- pervasively inefficient use of energy in the battlespace
- ~99 percent dependence of fixed-facility critical missions on the vulnerable electricity grid.

This discussion of both issues draws heavily on the Defense Science Board's (DSB's) 2008 report *More Fight—Less Fuel*.³ That analysis, building on and reinforcing its largely overlooked 2001 predecessor, found that solutions are available to turn these handicaps into revolutionary gains in warfighting capability, at comparable or lower

lately led some to question the Department's long-term access to mobility fuel. Echoing the International Energy Agency's chief economist, Fatih Birol—"We must leave oil before it leaves us"—some analysts assert world oil output capability has peaked or soon will. They overlook recent evidence that "peak oil" is more clearly imminent in demand than in supply. U.S. gasoline use—an eighth of world oil—is probably in permanent decline.⁵ So may be Organisation for Economic Co-operation and Development countries' oil use, which has been falling since early 2005.⁶ Deutsche Bank projects world oil use to peak in 2016, then be cut by electric cars to ~40 percent below the consensus forecast or ~8 percent below current levels by 2030.⁷ This assumes China's new cars will be 26 percent electrified by 2020 (China's target is 80 percent), and omits lightweight and

are proposals to create a defense synthetic fuel industry. Indeed, DOD is probably the world's largest institutional oil buyer, consuming in fiscal year (FY) 2008 120 million barrels costing \$16 billion—93 percent of all U.S. Government oil use (see figure). But oil is a largely fungible commodity in a global market; the Department uses only 0.4 percent of the world's oil output (about what two good-sized Gulf of Mexico platforms produce); and in a crisis, DOD has oil-buying priority. Rather, the issue is that DOD's unnecessarily inefficient use of oil makes it move huge quantities of fuel from purchase to use, imposing high costs in blood, treasure, and combat effectiveness.

Logistics uses roughly half the Department's personnel and a third of its budget. One-fifth of DOD's oil—at least 90 million



Airman monitors level of JP-8 fuel

nobody knows how much oil is in the ground: governments, which often do not know or will not transparently reveal what they have, hold about 94 percent of reserves

gallons each month—supports Iraq and Afghanistan operations that have increased forward bases' oil use tenfold.⁸ Of the tonnage moved when the Army deploys, roughly half is fuel.⁹ A typical Marine combat brigade needs more than a half-million gallons per day. *Desert Storm's* flanking maneuver burned 70,000 tons of fuel in 5 days.¹⁰ Delivering that quantity is a huge job for brigades of logistics personnel and for the personnel and assets needed to maintain and protect the logistics chain.

Despite extensive land and air forces trying to guard them—a "huge burden on the combat forces"¹¹—fuel convoys are attractive and vulnerable targets, making them one of the Marine Corps Commandant's most pressing casualty risks in Afghanistan.¹² In FY07, attacks on fuel convoys cost the U.S. Army 132 casualties in Iraq (.026/convoy) and 38 in Afghanistan (.034/convoy).¹³ About 12 percent of total FY07 U.S. casualties in Iraq and 35 percent in Afghanistan were Army losses—including contractors but not other Services or coalition partners—associated with convoys.¹⁴ Their constrained routes expose them to improvised explosive devices (IEDs), which probably caused the majority of U.S.

capital cost and at far lower operating cost, without tradeoff or compromise. The prize is great. As the Logistics Management Institute stated, "Aggressively developing and applying energy-saving technologies to military applications would potentially do more to solve the most pressing long-term challenges facing DOD and our national security than any other single investment area."¹⁴

Fuel Logistics: DOD's Soft Underbelly

Fuel has long been peripheral to DOD's focus ("We don't *do* fuel—we *buy* fuel"), but turbulent oil markets and geopolitics have

low-drag cars, superefficient trucks and planes, and other important oil savings well under way. Oil, as predicted for two decades, is becoming uncompetitive even at low prices before it becomes unavailable even at high prices.

Nobody knows how much oil is in the ground: governments, which often do not know or will not transparently reveal what they have, hold about 94 percent of reserves. But DOD, like the United States, has three compelling reasons to get off oil regardless: security, climate, and cost. Long-term oil availability concerns for DOD are misdirected; even more so, as we will see,

U.S. Air Force (Clara Wymbus)

fatalities in Afghanistan in 2009. Should that conflict follow an Iraq-like profile, its casualty rates could rise 17.5 percent annually.¹⁵ Just the dollar cost of protecting fuel convoys can be “upward of 15 times the actual purchase cost of fuel, . . . [increasing] exponentially as the delivery cost increases or when force protection is provided from air.”¹⁶

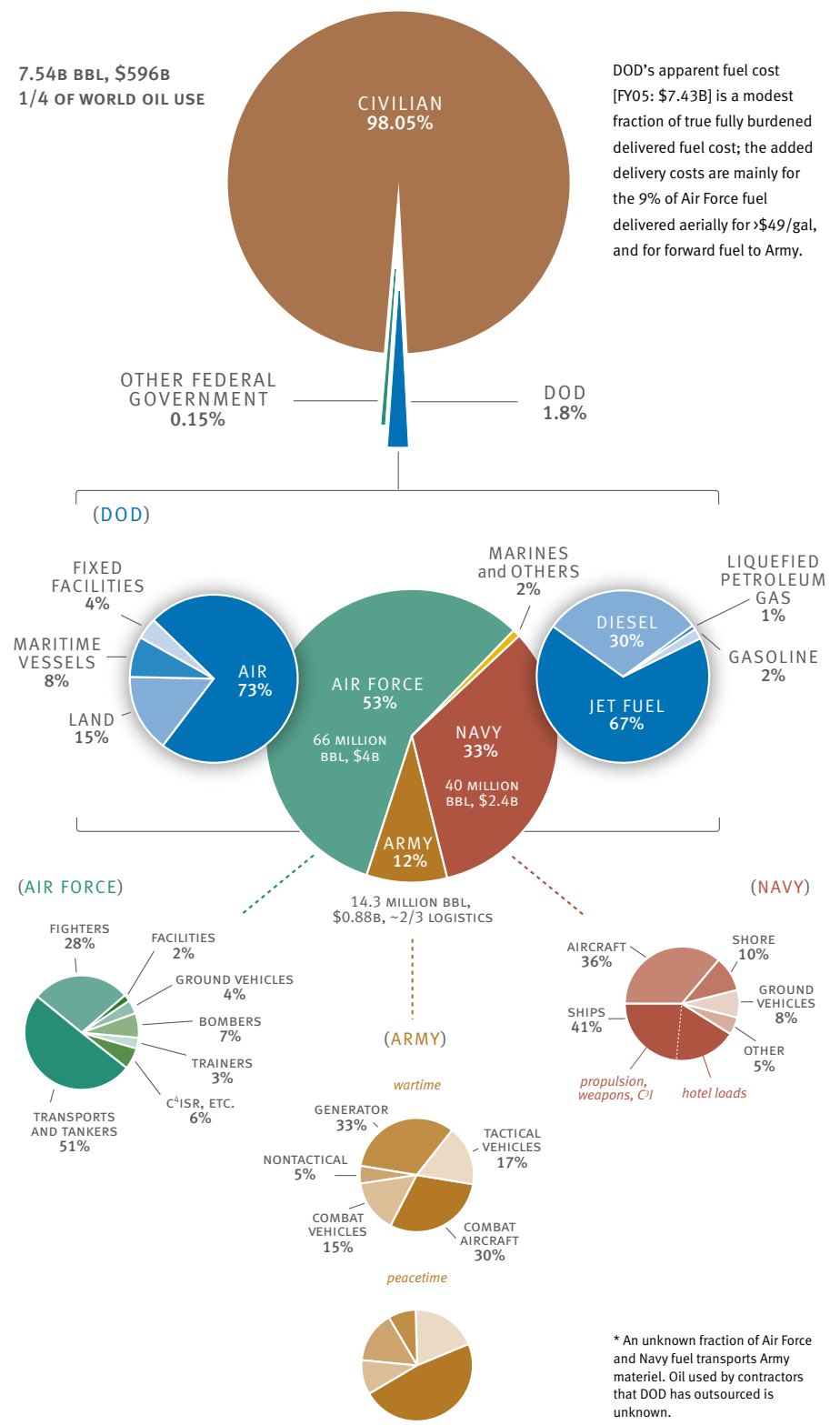
Thus, attacks on fuel assets and other serious hazards to fuel convoys increase mission risk, while fuel logistics and protection divert combat effort and hammer oil-strained budgets. Yet the need for most of the fuel delivered at such high cost could have been avoided by far more efficient use. Efficiency lags because when requiring, designing, and acquiring the fuel-using devices, DOD has systematically assumed that fuel logistics is free and invulnerable—so much so that wargames did not and often could not model it. Instead of analyzing fuel logistics’ burden on effectiveness and signaling it by price, DOD valued fuel at its wholesale price delivered in bulk to a secure major base (around \$1–\$3 per gallon), rather than at its fully burdened cost delivered to the platform in theater in wartime (usually tens and sometimes hundreds of dollars per gallon). Lacking requirements, instructions, shadow prices, rationales, or rewards for saving fuel, hardly anyone considered the military value of achieving, nor strove to achieve, high fuel efficiency.

As consequences became obvious in theater and began to emerge in wargames, the Department in 2007 started changing its policy to value energy savings at the “Fully Burdened Cost of Fuel” (FBCF, in dollars per gallon), including force protection, *delivered* to its end-user in theater. The 2009 National Defense Authorization Act (NDAA) codified both FBCF and new energy Key Performance Parameters (KPPs, in gallons per day or mission). Those are to receive similar weight to traditional KPPs like lethality, protection, and reliability that encapsulate the Department’s pursuit of capability. In principle, both FBCF and energy KPPs will guide requirements writing, analyses of alternatives, choices in the acquisition tradespace, and the focus of DOD’s science and technology (S&T) investments. In practice, energy KPPs have not yet been applied (their “selective use” is allowed but not yet launched), and much work must be organized and resourced to get the FBCF numbers right and apply them systematically.¹⁷

The FBCFs initially in use are incomplete. Current guidance still appears to omit support pyramids, multipliers to rotational force strength, actual (not book) depreciation lives, full headcounts including borrowed

and perhaps contractor personnel, theft and attrition adjustments,¹⁸ and uncounted Air Force and Navy lift costs to and from theater. All should be included: FBCF should count all assets and activities—at their end-to-end,

Approximate Liquid Petroleum Fuel Use by DOD in FY05



lifecycle, fully burdened total cost of ownership—that will no longer be needed, or can be realigned, if a given gallon need no longer be delivered. Thus, if fielded fuel supply needs shrink, so do its garrison costs for related training and maintenance. Conversely, garrison costs should be additive to FBCF, not dilutive: some analysts average peacetime with wartime costs to water down FBCF, or even assume a peacetime operating tempo, but as the 2008 task force stated, “FBCF is a wartime capability planning factor, not a peacetime cost estimate.”¹⁹

Even before these conservatisms are made realistic, initial FBCF estimates value saved fuel often *one to two orders of magnitude* higher than previously. If these new metrics gain momentum and top-level focus, they could drive strategic shifts and innovations that could revolutionize military capability and effectiveness.

More Fight—Less Fuel mapped a detailed military energy reform agenda, broadly backed by DOD's 2008 Energy Security Task Force. DSB offered specific solutions for its key findings: that DOD lacks the strategy, policies, metrics, information, and governance structure to properly manage its energy risks; that technologies are available to make DOD systems more energy-efficient, but they are undervalued, slowing implementation and resulting in inadequate S&T investments; and that there are many opportunities to reduce energy demand by changing wasteful operational practices and procedures.

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The 2009 NDAA codified reforms on the lines recommended by DSB, to be led by a new DOD Director of Operational Energy. As of December 1, 2009, that critical post remained vacant, but some encouraging Service adoption initiatives had begun, such as the *Army Energy Security Implementation Strategy* and Navy Secretary Ray Mabus's invigorating energy goals. But the DSB task force, not stopping with bureaucratic fixes, had added the even more incisive finding that “DOD's energy problems [are] sufficiently critical to add two new strategic vectors”—an older term for “succinct descriptions of capabilities that would make a big difference in military operations”²⁰—to complement the four historic ones: “speed, stealth, precision, and networking.”

In today's more familiar language, Endurance and Resilience are new capabilities that drive *and* apply new operational requirements. An Endurance capability will create transformational strategies and tactics that both tell the requirements writer to make a new platform fuel-efficient *and* inspire the force planner to exploit its increased range and agility. Today's DOD habits would instead tend to make it heavier with the same range—much as Detroit's engine improvements since the 1970s, rather than saving one-third of civilian cars' fuel, only made them more muscular. The need to change entrenched habits in force planning and operational requirements makes big new capabilities both vital and hard. Driving them deeply into doctrine, strategy, organizational structures, cultures, training, reward systems, and behaviors requires strong, consistent, persistent senior leadership. But once so embedded, new capabilities disruptively and profoundly improve military effectiveness and cost-effectiveness.

The Endurance Capability

Endurance traditionally means “ability to sustain operations for an extended time without support or replenishment.”²¹ The DSB task force elaborated: “Endurance exploits improved energy efficiency and autonomous energy supply to extend range and dwell—recognizing the need for affordable dominance, requiring little or no fuel logistics, in persistent, dispersed, and remote operations, while enhancing overmatch in more traditional operations.”²²

A lean or zero fuel logistics tail also increases mobility, maneuver, tactical and operational flexibility, versatility, and reli-

Marine uses metal detector to search for improvised explosive devices in Helmand Province, Afghanistan



U.S. Marine Corps (Artur Shvartsberg)

ability—all required to combat asymmetrical, adaptive, demassed, elusive, faraway adversaries. Endurance is needed in every “platform” using energy in the battlespace, from mobility platforms to expeditionary base power to battery-powered land-warrior electronics. Endurance is even more valuable in stability operations, which often need even more persistence, dispersion, and affordability than the combat operations with which they now enjoy comparable priority.²³

The DSB report found “enormous technical potential to cost effectively become more fuel efficient and by so doing to significantly enhance operational effectiveness.”²⁴ Current, near-term, and emerging efficiency technologies offer major fuel savings in land, sea, and air platforms,²⁵ with better warfighting capability (not one of 143 briefs disclosed a trade-off), and with generally excellent economics and operational characteristics.

Early adoption has begun at a modest scale. For example, field commanders in Iraq noticed that:

*Fuel that is transported at great risk, great cost in lives and money, and substantial diversion of combat assets for convoy protection, is burned in generator sets to produce electricity that is, in turn, used to air condition un-insulated and even unoccupied tents. . . . One recently analyzed FOB [forward operating base] used about 95% of its genset [engine-generator set] electricity for this purpose, and about one-third of the Army's total wartime fuel use is for running gensets.*²⁶

A single typical 60-kilowatt genset burns 4 to 5 gallons per hour, or \$0.7 million per year at a typical Afghanistan FBCF of \$17.44/gal. Fueling one FOB's gensets might cost \$34 million per year—plus, at the FY07 casualty rate, nearly one casualty.²⁷

In response, DOD is spraying over 17 million square feet of insulating foam onto temporary structures in theater, saving over half their air-conditioning energy. This \$146 million investment should repay its cost in 67 to 74 days at the estimated Iraq \$13.80 per gallon FBCF—10 times faster than under the old assumption of undelivered and unprotected fuel. The first \$22 million worth should save more than \$65 million each year—and more than one convoy casualty.²⁸ Next steps include far more efficient gensets and air conditioners, encompassing emerging concepts for cooling without electricity.

Lieutenant General James Mattis's 2003 challenge to “unleash us from the tether of fuel” and Major General Richard Zilmer's 2006 operational request from Anbar Province for a “self-sustainable energy solution”

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stimulated the Army's Rapid Equipping Force to develop a portable renewable/hybrid energy supply system, demonstrated at the National Training Center but not yet fielded. In theater, at the fully burdened cost of fuel, it would probably have been paid back in months²⁹—faster if credited for avoided casualties and enhanced combat capability. The Marines have pledged resources for such work.

Over several decades, concerted adoption of identified energy efficiency technologies holds the estimated potential to cut total DOD mobility-fuel requirements by about two-thirds, perhaps even three-fourths. The fattest targets vary according to intent:

- The most gallons can be saved in aircraft, which use 73 percent of DOD fuel. Saving 35 percent of aircraft fuel would free up as much fuel as all DOD land and maritime vehicles plus facilities use. New heavy fixed-wing platforms can save at least 50 percent and new rotary-wing platforms 80 percent, since those fleets use designs that are, respectively, 50 to 60 and 30 to 50 years old.

- The biggest gains in combat effectiveness will come from fuel-efficient ground forces (land and vertical-lift platforms, land warriors, FOBs). For example, Soldiers carry an average of 2 kilograms of batteries per mission-day.

- Savings downstream in a long logistics chain save more fuel: delivering 1 gallon to the Army spearhead consumes about 1.4 extra gallons in logistics.

- Savings in aeri ally refueled aircraft and forward-deployed ground forces save the most delivery cost and thus realignable support assets.

Reset, such as the tens of billions of dollars slated for Humvee replacement, offers a ripe opportunity for leap-ahead

performance if, for example, a breakthrough light tactical vehicle already substantially developed can get the “intensive development, design and competitive prototyping” recommended by the 2008 DSB task force. A vehicle as protective and lethal as a 23- to 29-ton mine resistant ambush protected (MRAP) vehicle, but with acceleration, agility, and stability similar to a top-of-the-line pickup truck—and fuel economy, weight, and cost better than a 5- to 6-ton up-armored Humvee—sounds more promising than a Humvee or MRAP. Yet the innovative competitor's prototyping remains stalled, and Office of the Secretary of Defense policy bars using reset funds for innovative platforms.

Both DSB task forces recommended changes in DOD doctrine, structure, business processes, and other activities—emphasizing design and acquisition—to capture these opportunities aggressively and exploit five major military energy efficiency benefits:

- *Force protector*, with far fewer vulnerable fuel convoys.

- *Force multiplier*, freeing up convoys for combat tasks—turning fuel-guarders into trigger-pullers.

- *Force enabler*, equipping warfighters with the greatly enhanced dwell, reach, agility, and flexibility that can affordably dominate in both dispersed and focused combat.

- *Key to transformational realignment* from tail to tooth—shifts totaling multi-divisional size, worth many tens of billions of dollars per year.

- *Catalyst for leap-ahead fuel savings in the civilian sector*, which uses more than 50 times as much fuel as DOD. Valuing saved military fuel at FBCF will drive astonishing innovations that accelerate civilian vehicle efficiency, much as past military S&T investment yielded the Internet, Global Positioning System, and jet engine and microchip industries.

DSB's 2008 report summarized: “Unnecessarily high and growing battlespace fuel demand compromises operational capability and mission success; requires an excessive support force structure at the expense of operational forces; creates more risk for support operations than necessary; and increases life-cycle operations and support costs.”³⁰ Yet radically boosting platforms' energy efficiency and combat effectiveness at reasonable or reduced up-front cost can

turn each of these energy risks into major warfighting gains. Requiring and exploiting Endurance can give DOD more effective forces *and* a more stable world, at reduced cost and risk. This better-than-free opportunity must become a cornerstone of military doctrine.

This shift will not be easy. It requires fundamentally redesigning military energy flows to support fast-changing strategic, operational, and tactical requirements. It demands new DOD planning processes that recognize Endurance's operational value so it

becomes a requirement in platforms now in development, and appreciate that delivering an operational effect within a fixed energy budget is itself an important capability. A new system's energy budget is an important requirement—as important as any other—and should be analytically based on the size of the logistics tail the system demands and the burden that assuring successful delivery of that logistics tail imposes on the force. Several-fold greater platform fuel efficiency comes from rapidly adopting and fielding advances in ultra-light and ultra-strong mate-

rials, fluid dynamics, actuators, and propulsion, all synergistic with alternative fuel and power supplies. It also depends on transformational approaches, incentivized by FBCF and potentially required by energy KPPs but unfamiliar to most DOD contractors, that use integrative design to achieve expanding, not diminishing, returns to investments in energy efficiency—yielding major energy savings at *lower* capital cost without trading off nonenergy KPPs. Basic innovation in design and acquisition requires taking intelligent risks and rewarding those who do so. All this will require senior leadership to tackle head-on the issue that a previous DSB report described thus: “Often the very technology that can provide the United States with a disruptive advantage is itself disruptive to DOD's culture . . . and antibodies rapidly and reflexively form to reject it.”³¹ Yet such disruptive concepts can be so clearly beneficial that masterful and resolute leadership breaks through hesitancy and resistance. This is the Department's imperative today.

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Fuel and Power Autonomy. Very efficient energy use stretches fuel and power made in theater from wastes, opportunistically acquired feedstocks, or renewable energy flows. FedEx and Virgin Airways plan to fuel 30 percent and 100 percent of their respective fleets with biofuels by 2020. Domestically produced biofuels from centralized, specialized plants do little for DOD's expeditionary needs, but much cutting-edge research emphasizes portable biofuel converters akin to an “opportunistic foraging herbivore.”³² The 2008 DSB task force favored promising expeditionary biofuel and synfuel technologies, and the Services are examining some.

In contrast, the DSB task force expressed “strong concerns” about the coal-to-liquids synfuels favored by the Air Force and Navy (but illegally carbon-intensive under a 2007 law), finding they “do not contribute to [solving] DOD's most critical fuel problem—delivering fuel to deployed forces,” “do not appear to have a viable



Airman fuels F-15E for sortie

U.S. Air Force (Rae Perry)

market future or contribute to reducing battlespace fuel demand,” and do not appear to address a real problem. Fuel interdiction risk in theater is best countered by efficient use, diversified fuels and supply chains, and greater or more secure local stockpiling. If the concern is long-term fuel availability, military and civilian end-use efficiency is by far the cheapest choice. In 2005, Wal-Mart’s giant Class 8 truck fleet launched gallon per ton-mile savings that reached 38 percent in 2008 and are targeted to reach 50 percent in 2015. General U.S. adoption of those doubled-efficiency civilian trucks will save 6 percent of U.S. oil—triple DOD’s total use. The Secretary of Defense’s JASON science advisors, whose energy report also pointedly failed to endorse coal-to-liquids, suggested saving oil by redesigning the Postal Service’s delivery fleet.³³

Nuclear power is sometimes suggested for land installations or even expeditionary forces,³⁴ typically without discussing cost (grossly uncompetitive), modern renewables (typically much cheaper), operational reliability (usually needing 100 percent backup), or security. For these and other reasons, the 2008 DSB and JASON task forces did not

endorse this option. After vast investment in hardware and a unique technical culture, nuclear propulsion has proven its merit in submarines and aircraft carriers. In 2006–2009, congressional enthusiasts announced supposed Naval Sea Systems Command (NAVSEA) findings that nuclear propulsion in new medium surface combatants could beat \$70/bbl oil. However, the 2008 DSB task force discovered that NAVSEA’s actual

studies are redirecting military energy conversation from exotic, speculative, and often inappropriate supplies to efficient use

finding (\$75–\$225/bbl) had improperly assumed a zero real discount rate. A 3 percent annual real discount rate yielded a \$132–\$345/bbl breakeven oil price; NAVSEA did not respond to requests to test the 7 percent annual real discount rate that the Office of Management and Budget probably mandates. Presumably, the Secretary of Defense will

reject this option and focus resources on making ships optimally efficient.

The 2008 DSB and JASON studies are redirecting military energy conversation from exotic, speculative, and often inappropriate supplies to efficient use, which makes autonomous in-theater supply important and often cost-effective. But all such choices depend on a further fundamental reform in DOD’s metrics and procedures.

Gross versus Net Capability. A change that would boost operational capability by greatly increasing tooth-to-tail ratios was identified in a little-noticed but “important observation of the [2008 DSB] Task Force”:

[W]hat [the Joint Capabilities Integration Development System]³⁵ currently calls “capability” is actually the theoretical performance of a platform or system unconstrained by the logistics tail required for its operation. But tail takes money, people, and materiel that detract from tooth. True net capability, constrained by sustainment, is thus the gross capability (performance) of a platform or system times its “effectiveness factor”—its ratio of effect to effort:



Combat Tactical Vehicle under development is tested at Nevada Automotive Test Center

U.S. Navy (John F. Williams)

$Effectiveness\ Factor = Tooth / (Tooth + Tail)$

Also, in an actual budget, $Tooth = (Resources - Tail), so$

$Effectiveness\ Factor = (Resources - Tail) / Resources.$

Effectiveness factor ranges from zero (with infinite tail) to one (with zero tail). If tail > 0, true net capability is always less than theoretical (tail-less) performance, but DOD consistently confuses these two metrics, and so misallocates resources. Buying more tooth that comes with more (but invisible) tail may achieve little, no, or negative net gain in true capability. While the Department recognizes the need to reduce tail, the analytical tools needed to inform decisions on how to do so are not in place. Focusing on reducing tail can create revolutionary capability gains and free up support personnel, equipment, and budget for realignment. The task force recommendations are intended to build the analytical and policy foundation to begin introducing this way of thinking into the requirements, acquisition and budget forecasting processes.³⁶

To summarize, current force planning does not and cannot predict or compare competing options' needed tail size or their net capability, so after decades, the "tail is eating the tooth." Reversing this impairment needs five missing steps: (1) an Endurance capability to drive and exploit operational requirements for radical efficiency, (2) enforced by energy KPPs, (3) valued at FBCF, (4) competed on net capability, and (5) tested with wargaming and campaign-modeling tools revised so they "play fuel" and reveal the full operational value of lean fuel logistics. All five together will help drive DOD toward ultimately breeding, where possible, a Manx force—one with no tail. Efficient and passively or renewably cooled tents in the desert can mean no gensets, no fuel convoys, no problem. Such a thrust toward efficiency in every use of fuel and electricity also strongly supports the second proposed new key capability—Resilience.

The Resilience Capability

Resilience "combines efficient energy use with more diverse, dispersed, renewable supply—turning the loss of critical missions from energy supply failures (by accident or malice) from inevitable to near-impossible."³⁷ This capability is vital because the:

[a]most complete dependence of military installations on a fragile and vulnerable commercial power grid and other critical national infrastructure places critical military and Homeland defense missions at an unacceptably high risk of extended disruption. . . . [Backup generators and their fuel supplies at military installations are generally sized] for only short-term commercial outages and seldom properly prioritized to critical loads because those are often not wired separately from non-essential loads. DOD's approach to providing power to installations is based on assumptions that commercial power is highly reliable, subject to infrequent and short term outages, and backups can meet demands. [These assumptions are] . . . no longer valid and DOD must take a more rigorous risk-based approach to assuring adequate power to its critical missions.³⁸

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The 2008 DSB Task Force found that the confluence of many risks to electric supply—grid overloads, natural disasters, sabotage or terrorism via physical or cyberattacks on the electric grid, and many kinds of interruptions to generating plants—hazards electricity-dependent hydrocarbon delivery, the national economy, social stability, and DOD's mission continuity.

The U.S. electric grid was named by the National Academy of Engineering as the top engineering achievement of the 20th century. It is very capital-intensive, complex, technologically unforgiving, usually reliable, but inherently brittle. It is responsible for ~98–99 percent of U.S. power failures, and occasionally blacking out large areas within seconds—because the grid requires exact synchrony across subcontinental areas and relies on components taking years to build in just a few factories or one (often abroad), and can be interrupted by a lightning bolt, rifle bullet, malicious computer program, untrimmed branch, or errant squirrel. Grid vulnerabilities are serious, inherent, and not amenable to quick fixes; current Federal investments in the "smart grid" do not even require simple mitigations. Indeed, the policy reflex to add

more and bigger power plants and power lines after each regional blackout may make the next blackout more likely and severe, much as suppressing forest fires can accumulate fuel loadings that turn the next unsuppressed fire into an uncontrollable conflagration.

Power-system vulnerabilities are even worse in-theater, where infrastructure and the capacity to repair it are often marginal: "attacks on the grid are one of the most common and effective tactics of insurgents in Iraq, and are increasingly seen in Afghanistan."³⁹ Thus electric, not oil, vulnerabilities now hazard national and theater energy security. Simple exploitation of domestic electric vulnerabilities could take down DOD's basic operating ability and the whole economy, while oil supply is only a gathering storm.

The DSB Task Force took electrical threats so seriously that it advised DOD—following prior but unimplemented DOD policy⁴⁰—to replace grid reliance, for critical missions at U.S. bases, with onsite (preferably renewable) power supplies in netted, islandable⁴¹ microgrids. The Department of Energy's Pacific Northwest National Laboratory found ~90 percent of those bases could actually meet those critical power needs from onsite or nearby and mainly renewable sources, and often more cheaply. This could achieve zero daily net energy need for facilities, operations, and ground vehicles; full independence in hunker-down mode (no grid); and increased ability to help serve surrounding communities and nucleate blackstart of the failed commercial grid.

Implementing these sensible policies merits high priority: probably only DOD can move as decisively as the threat to national security warrants. And as with the Endurance capability, exploiting Resilience—building on DOD's position as the world's leading direct-or-indirect buyer of renewable energy—would provide leadership, market expansion, delivery refinement, and training that would accelerate civilian adoption. Already, the 2008 NDAA requires DOD to establish a goal to make or buy at least 25 percent of its electricity from renewables by 2020, and study solar and windpower feasibility for expeditionary forces. Under 2007 Executive Order 13423's Government-wide mandate, DOD must also reduce energy intensity by FY15 to 30 percent below FY03. The Resilience capability would focus all these efforts on robust architectures and implementation paths, ensuring that bases' onsite renewables deliver reliable power to

critical loads whether or not the commercial grid is working—a goal not achieved by today’s focus on compliance with renewables quotas.

Resilience is even more vital and valuable abroad, in fixed installations and especially in FOBs (whose expeditionary character emphasizes the Endurance logic of Fully Burdened Cost of Electricity). Foreign grids are often less reliable and secure than U.S. grids; protection and social stability may be worse; logistics are riskier and costlier in more remote and austere sites; and civilian populations may be more helped and influenced. Field commanders strongly correlate reliable electricity supplies with political stability. In Sadr City, Army Reserve Major General Jeffrey Talley’s Task Force Gold proved in 2008–2009 that *making* electricity reliable, and thus underpinning systematic infrastructure-building, is an effective cornerstone of counterinsurgency.

Reconstruction in Iraq and Afghanistan is starting to define and capture this opportunity to build civic cohesion and dampen insurgency, while reducing attacks’ disruption and attractiveness. A resilient, distributed electrical architecture can bring

important economic and social side-benefits, as with Afghan microhydropower programs for rural development. Cuba lately showed, too, that aggressively integrating end-use efficiency with micropower can cut national blackouts—caused by decrepit infrastructure, not attacks—by one to two orders of magnitude in a year.

At home, DOD efficiency and micropower echo new domestic energy policy and startling developments in the marketplace. In 2006, micropower⁴² delivered one-sixth of the world’s electricity, one-third of its new electricity, and 16 to 52 percent of all electricity in a dozen industrialized countries (the United States lagged with 7 percent). In 2008, for the first time in about a century, the world invested more in renewable than in fossil-fueled power supplies; renewables (excluding big hydroelectric dams) added 40 billion watts of global capacity and got \$100 billion

of private investment. Their competitive and falling costs, short lead times, and low financial risks attract private capital. Shifting to these more resilient energy solutions goes with the market’s flow.

Expanding DOD’s Energy Voice

Endurance and Resilience offer synergistic national security benefits far beyond those internal to the Department’s mission effectiveness. As a dozen retired flag officers concluded, “We can say, with certainty, that we need not exchange benefits in one dimension for harm in another; in fact, we have found that the best approaches to energy, climate change, and national security may be one and the same.”⁴³ Moreover, whether we care most about national security, climate change, or jobs and competitiveness, we should do exactly the same things about energy. Thus, focusing on our energy actions’

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Soldier guards newly constructed electrical facility in Baghdad

U.S. Army (James Selesnick)

attributes and outcomes, not motives, could build broad consensus.

The resulting benefits could be enlarged by bringing DOD's perspective and expertise more vigorously into national energy policy-making. A common critique holds that past Federal energy policy has constituted the most comprehensive threat to national energy security by:

- perpetuating America's expanding oil dependence
- strongly favoring overcentralized energy system architectures inherently vulnerable to disruption
- creating attractive new terrorist targets
- aiming to increase and prolong reliance on the most vulnerable domestic infrastructure
- promoting technologies that encourage proliferation.

Now that national energy policy is shifting—often for additional reasons such as economic recovery, competitive advantage, and climate protection—DOD's knowledge of energy-related security risks needs to inform the councils of government more systematically. If past national security outcomes are not what DOD wants, it is the duty of military professionals to say so. Their guidance, and increasingly their achievements, can help the Department of Defense build a stronger America and a richer, fairer, cooler, and safer world.

The United States can and must make oil obsolete as a strategic commodity—just as refrigeration did to salt (once so vital a preservative that countries fought over salt mines)⁴⁴—and electric power a boon unshadowed by threat. DOD's leadership in adopting and exploiting the two new capabilities proposed here would dramatically speed that journey toward a world beyond oil—with “negamissions” in the Persian Gulf, Mission Unnecessary—and indeed beyond all energy vulnerabilities. Fighting for Endurance and Resilience in Pentagon decisions today can eliminate the need to fight for oil on the battlefield tomorrow. **JFQ**

NOTES

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¹¹ Ashton Carter, 2009 congressional testimony, quoted in Deloitte, 15.

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¹³ Army Environmental Policy Institute, “Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys,” September 2009.

¹⁴ Deloitte; total U.S. casualty data available at <<http://icasualties.org>>.

¹⁵ *Ibid.*, 18.

¹⁶ *Ibid.*, 19.

¹⁷ Andrew Bochman, “Measure, Manage, Win: The Case for Operational Energy Metrics,” *Joint Force Quarterly* 55 (4th Quarter 2009), 113–119.

¹⁸ Deloitte also notes that attacks are far from the only hazard: bad weather, traffic accidents, and pilferage lost DOD some 44 trucks and 220,000 gallons of fuel in June 2008 alone (15).

¹⁹ DSB, 31.

²⁰ DSB, *Defense Science Board 2006 Summer Study Report on 21st Century Strategic Technology Vectors*, vol. 1, Main Report (February 2007), x–xi, available at <www.acq.osd.mil/dsb/reports/ADA463361.pdf>.

²¹ DSB, “*More Fight—Less Fuel*,” 25.

²² *Ibid.*, 35.

²³ DOD Instruction 3000.05, “Stability Operations,” September 16, 2009, §4.1, available at <www.dtic.mil/whs/directives/corres/pdf/300005p.pdf>.

²⁴ *Ibid.*, 37.

²⁵ DSB, “*More Fight—Less Fuel*.” Innovation was encouraging on the supply side in the recent Wearable Power Prize Competition but seems to lag in efficient use.

²⁶ *Ibid.*, 29–30.

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³⁵ *Manual for the Operation of the Joint Capabilities Integration and Development System*, July 31, 2009, available at <<https://acc.dau.mil/Community-Browser.aspx?id=267116&lang=en-US>>.

³⁶ DSB, “*More Fight—Less Fuel*,” 28–29.

³⁷ As of FY97, Defense Science Board Summer 1998 Study Task Force, *DOD Logistics Transformation*, Annotated Briefing Slides, slide 7, which also shows that “Active duty combat forces [were then] half [the] size of active logistics forces.” One estimate of DOD's FY09 logistics and sustainment cost is \$270 billion—over half the base budget (35).

³⁸ *Ibid.*, 3 and 53.

³⁹ DSB, “*More Fight—Less Fuel*,” 55.

⁴⁰ *Ibid.*, 59–60; DOD Instruction 1470.11 §5.2.3.

⁴¹ *Islandable* describes onsite supplies that can continuously serve the base and neighboring communities whether or not the commercial grid is operating.

⁴² Defined here as cogeneration plus renewables minus big (>10 megawatt electrical) hydro. RMI maintains a global database.

⁴³ Center for Naval Analyses Military Advisory Board, *Powering America's Defense: Energy and the Risks to National Security*, May 2009.

⁴⁴ R. James Woolsey and Anne Korin, “Turning Oil into Salt,” *National Review*, September 25, 2007.