Measure, Manage, Win

Sailor tests samples in fuel analysis laboratory aboard USS *John C. Stennis*

U.S. Navy (Kenneth Abbate)

Air conditioning installed in uninsulated tents is major source of energy waste

U.S. Navy (Wendy Wyman)

THE CASE FOR OPERATIONAL ENERGY METRICS

By ANDREW BOCHMAN

Today, the Department of Defense (DOD) is beset by budgetary problems, hampered by worn-out equipment, faced with skyrocketing personnel costs, and spread thin in short- and long-term obligations that span the globe. One business process change that will improve force effectiveness, reduce mission risk resulting from high fuel and logistics demand, and, by fortunate coincidence, help mend budgets is implementation of energy metrics for operational systems.

Fuel efficiency has not been fully incorporated into the design of DOD warfighting systems. In fact, efficiency is seldom seriously considered because all legacy systems were required, designed, and procured on the assumption that fuel logistics was free and invulnerable, so saved fuel was valued at typically one or two orders of magnitude below its true cost delivered to the platform in theater in wartime. Nor do DOD wargames normally "play fuel"; required fuel is assumed to appear automatically when and where it

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Airman pulls hose to refuel E–3 Sentry in Southwest Asia

U.S. Air Force (Brian J. Ellis)

is needed. Equally apparent, unless change comes quickly, ensuing generations of systems will be fielded with equal or greater energy appetites.

Although DOD naturally focuses on *effectiveness* over efficiency, it is seemingly unaware that the two attributes are not mutually exclusive. For instance, inefficient platforms require fat logistic tails that incur huge costs (in both blood and treasure), tie up whole divisions hauling and guarding fuel, and create attractive targets for our adversaries. Especially now, in the shadow of $150-per-barrel oil and in the middle of a deep fiscal crisis, it is long past time for a change. DOD has shown that it can measure and manage energy requirements on the facilities side; now it is time to do the same with operational systems.

One of the fastest ways to reduce operational fuel demand and gain substantial strategic, operational, and tactical benefits is through the expedited implementation of energy frameworks and metrics mandated in the National Defense Authorization Act (NDAA) of 2009. When fuel efficiency is factored into the design, procurement, and fielding of all DOD systems, the cumulative effects will reduce logistics tails that slow operations, limit maneuver and deployability, tie up force structure in combat support, keep too many Soldiers in force protection mode, and expose Servicemembers to serious and unnecessary risks. In addition, reducing fuel use and fuel logistics will result in smaller DOD budgets that are less vulnerable to fluctuations in the global price of fossil fuels. The primary metrics encompass the inclusion of energy efficiency as a key performance parameter (KPP) in the acquisition process and the use of the fully burdened cost of fuel (FBCF) to determine baseline and continuing costs so that saved fuel is more highly valued in the trade space.

according to OSD, oil price volatility and the sheer amount required to run the modern military are causing big problems

DOD Undervalues Fuel

Out of all the challenges that DOD faces, one condition is chronic and will only get worse if changes are not made fast: the DOD appetite for fuel. In 2006 and 2007, the Department spent $26 billion per year on energy, and in 2008 requested an additional $5 billion on top to offset higher prices. Each $10 per barrel price increase in oil costs DOD over $1.3 billion per year.[1] As cited by the Office of the Secretary of Defense (OSD), those baseline energy expenditures are just the beginning. One presentation says, "Fiscal and operational costs from DOD's fuel demand are orders of magnitude bigger than we appreciate."

The commodity price of oil is comparatively low today, but its recent climb to $150 per barrel put everyone on alert and elevated energy security to the fore of the Presidential campaign. Prices that high were alarming, but from a planning and budgeting perspective, the volatility has been even more problematic. According to OSD, oil price volatility and the sheer amount required to run the modern military are causing big problems:

- 70 percent of the tonnage moved when the Army deploys is fuel and water[2]
- about half of current casualties in theater are associated with convoys[3]
- logistics consumes roughly half of DOD personnel and a third of its budget.[4]

Energy advocates inside and outside the DOD community are well aware of these problems with valuing fuel. Some of the organizations that have contributed recommendations over the last decade include OSD, Center for New American Studies, Center for Strategic and International Studies, Center for Naval Analyses, American Enterprise Institute, Rocky Mountain Institute, two Defense Science Board (DSB) Energy Task Force teams that released encyclopedic reports in 2001 and 2008, and the Government Accountability Office (GAO). In one of its latest reports on this matter, GAO reports that it "found that DOD has made limited progress in incorporating fuel efficiency as a consideration in key business processes—which include developing

the Services have focused on installation power costs, and not on reducing demand in the operational force

requirements for and acquiring new weapons systems."[5] The same report notes the missed opportunities inherent in considering procurement of energy efficiency capabilities in forward operating locations:

Given DOD's high fuel demand for base support activities at its forward-deployed locations, without guidance in place to incorporate energy efficiency considerations into procurement decisions when practical, DOD may be missing opportunities to make significant reductions in demand without affecting operational capabilities.[6]

In short, there seems to be little top-down institutional interest in reducing the billions spent annually on energy and the tens of billions spent to deliver it. But there are a handful of initiatives in the Services that indicate a bottom-up movement toward embracing energy efficiency metrics. Some are moving faster than others, albeit 8 years after initial recommendations were issued by the first DSB task force. Following is a summary of recently announced energy policy from the Service components. The focus remains overwhelmingly on facilities energy; there continues to be a great deal of reluctance to look operational energy challenges square in the eye.

Navy/Marines. It appears that the Navy—unlike OSD, the Air Force, and the Army, all of which have had Senior Executive Service (SES)–level personnel working facilities energy issues for some time—has only recently appointed an SES energy lead who reports to the Secretary of the Navy. The Navy has had success in annually reducing its facilities energy consumption, but its Incentivized Energy Conservation and Fleet Readiness, Research, and Development programs appear to be making fuel reduction headway. A Navy Energy Coordination Office has formed to guide further progress on installations and oversee the operational energy side as well.

Air Force. The *United States Air Force Infrastructure Energy Strategic Plan 2008*, covering buildings, ground vehicle fleets, and renewables, is the most thorough roadmap for military facilities energy managers yet produced. On the operational side, the plan reports that pilots and Airmen now remove every superfluous pound from inside the planes (savings recently identified in four heavy aircraft types have a present value of billions of dollars), and pilots do more simulator work and fly with smaller fuel loads. However, despite claims to the contrary from leadership, it appears that there is little emphasis on calibrating energy-related investments to weigh the risk of mission disruption. The omission is clear when there is almost no mention of the FBCF or a KPP related to energy.

Army. The Army, which is having success with energy demand reduction at its fixed facilities, is also working to reduce demand from weapons systems, tactical vehicles, and power generators. In January 2009, Army Acquisition Executive Dean Popps signed an important new Army energy document, whose distribution list includes every Army senior leader in every significant unit around the globe. And it is not just the reach of the address list that is important; it is what the memo directs: "All new Army acquisition programs, to include new program starts and new increments, with end items that consume energy shall include the fully burdened cost of energy needed to operate the system in their total ownership cost analysis."[7]

Poised for Progress . . . or Simply Stalling?

As indicated above, the Services have focused on installation power costs, and not on reducing demand in the operational force. This first inkling of a change came with a request by General Richard Zilmer, USMC, from the field in 2006 for a less oil-dependent military, but overall DOD is just now getting some appreciation for the military capability angle.

Across DOD, the real potential for embracing energy metrics has little to do with saving money and everything to do with saving lives and maximizing chances for mission success. A handful of commanders in the field, noting fuel convoys' enormous

According to DOD, generators are the single largest battlefield fuel consumer

U.S. Marine Corps (Audrey Graham)

drain on resources, have demanded change from business as usual. The Power Surety Task Force, partially created in response to a request by General James Mattis, USMC, from Iraq to "unleash us from the tether of fuel," is one example of a new understanding of what it takes to manage energy demand to improve chances for tactical success.[8]

Earlier this year, Congress attempted to shine some light on one aspect of operational energy problems facing DOD in a House Armed Services Committee's Readiness Subcommittee hearing on fuel demand management at forward-deployed locations and operational energy initiatives. Indeed, OSD and other DOD energy policy organizations now acknowledge that "DOD planning processes undervalue fuel and its delivery costs,"[9] yet it also appears that few senior DOD leaders are aware of the problem, much less trying to change it.

Apart from demonstrated success with facilities energy reduction, DOD finds itself having made little progress on operational energy strategy or governance structure. The repeated findings of the DSB task force reinforce the impression of inaction. In short, the 2008 report revealed that the most emphatic recommendations of the 2001 report were ignored. There have been several additional indicators of a lack of progress in 2009:

- No central energy security strategy has been articulated.
- Energy risks, and the understanding of vulnerabilities caused by our operational reliance on fuel delivery, have not been mainstreamed.
- Recommended fuel use and energy efficiency metrics have a long way to go before implementation in the Planning, Programming, Budgeting, and Execution System (PPBES).
- The Defense Authorization Act 2009, also known as the Duncan Hunter Act (HR 5658), requires that analyses and force planning processes consider the requirements for, and vulnerability of, fuel logistics. It also created a new Director of Energy Operations Plans and Programs position and directs that fuel use and energy efficiency metrics will be implemented in the PPBES. This position remains unfilled at this writing.

These indicators show that even at this late date, senior DOD leaders are not taking energy measurement and metrics seriously.

Operational Energy Metrics Are Ready

While progress has been made using millions of British thermal units (MBTUs) per square foot to track energy demand reduction and efficiency gains on fixed installations, operational systems have proven resistant to having energy inputs quantified via metrics. For instance, if delivered energy is always assumed, there is no reason to measure it. Iraq and Afghanistan should have taught us that DOD has some bad assumptions. Moreover, operational energy metrics are a tougher nut to crack as the use cases are an order of magnitude more varied than in garrison energy use scenarios.

The two metrics that have yet to play a significant role in DOD thinking are the FBCF and a KPP related to energy efficiency. First proposed in 2001, it took several more years for both to become accepted in DOD guidance, and now in 2009 they are finally being studied for initial use.

The Fully Burdened Cost of Fuel. The FBCF was formally codified last year in NDAA 2009 and DOD Instruction 5000.02. The *fully burdened* cost of energy is defined in the NDAA as "the commodity price for fuel plus the total cost of all personnel and assets required to move and, when necessary, protect the fuel from the point at which the fuel is received from the commercial supplier to the point of use."[10] In theater, this often includes expensive force protection assets and, as has been documented, can drive the delivered cost of a gallon of diesel or J–P8 from a base cost of $2 or $4 to tens or hundreds of dollars. Impossible to measure is the worth of the many Soldiers and Marines and U.S. contractors whose lives are lost while attempting to transport and/or protect fuel resources, and the opportunity cost of their diverted combat capability.

In "The Peculiar Economics of Energy in Defense Operations," Michael Canes cites the 2001 DSB report and suggests the power of the FBCF approach:

The 2001 DSB study made no formal estimates of what it termed the "true cost" of fuel, but stated that Army sources had estimated that it costs $13/gallon merely to deliver fuel to a foreign theater, and much more to deliver it from its landing point to the front lines. In one example, using helicopters to fly bladders filled with fuel to troops several hundred kilometers inland, the fully burdened cost of fuel was estimated to be as much as $400 per gallon.[11]

Almost half of in-theater casualties are associated with convoys, such as this one delivering fuel to airfield in Iraq

U.S. Marine Corps (Kelly R. Chase)

Logistics costs drive up energy costs and are tightly correlated to the type of environment into which fuel is being delivered. Pentagon planners are not paying attention if they think the JP–8 and diesel used in theater cost anything similar to high-grade gasoline at the local Sunoco. But the fuel value assumed when their existing platforms were required and designed is in fact less than that—based simply on the wholesale cost of fuel that is neither delivered nor protected.

Energy Efficiency KPP. According to DOD, a *KPP* is "an attribute or characteristic of a system that is considered critical or essential to the development of an effective military capability."[12] Stated simply, KPPs allow people generating requirements in a systems definition process to quantify their descriptions of the most important characteristics of a given system, based on the scenarios in which it is being designed to operate. KPPs allow series of measured tradeoffs, with some typical KPPs being speed, survivability, stealth, and sustainability. Energy efficiency, or the value of reducing demand for fuel logistics in operations, has never been a consideration. Total cost of ownership can include fuel costs, and for aircraft, range and payload KPPs factor in fuel use, but these estimates currently ignore the support "tail" costs that it takes to make these systems functional. The energy efficiency KPP is called out for "selective implementation" in new procurement guidance from the Chairman of the Joint Chiefs of Staff Instruction 3170.01F.[13] To date, it has not been applied to any program.

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One way of understanding the relationship between these two metrics is that the energy efficiency KPP is monetized via FBCF. Today, the only drivers are schedule, performance, and non-energy costs, and program managers have no tool to measure energy factors. The same holds true for personnel in the field trying to measure (and report on) the effectiveness of all systems creating a fuel demand. A February 2009 GAO report on energy demand management revealed what was a surprise to some: "While weapon platforms require large amounts of fuel, DOD reports that the single largest battlefield fuel consumer is generators, which provide power for base support activities such as cooling, heating, and lighting."[14] Indeed, one-third of the Army's wartime fuel use is for fossil fuel–powered generators to make electricity that is largely wasted: in a typical forward operating base, about 95 percent of the electricity is inefficiently used to cool desert tents that until recently were uninsulated (now about half have been urgently sprayed with insulating foam, with the other half in process).

Marine refuels M1A1 Abrams main battle tank at Twentynine Palms

U.S. Marine Corps (Kelsey J. Green)

At present, it is difficult to set energy efficiency or energy productivity baselines that work across different programs or organizations. Should a new ground vehicle trade armor for acceleration, or should DOD pay more for the lighter but better armor, or reduce both for greater range or resilience, all the while seeking to trim the logistics tail wherever possible? A new unmanned aerial vehicle or manned fighter or bomber can leverage additional fuel efficiency for extended range, heavier payloads, or loiter time, or to reduce logistics costs. The 2008 DSB report even identified a prototype replacement for up-armored Humvees that offers severalfold gains in fuel efficiency, weight, and acceleration with greater lethality and greatly improved stability and protection—yet at comparable cost using integrative design and novel ultralight armor to reverse the normal assumption that efficiency increases costs.[15] Indeed, civilian land, sea, and air platforms have already disproven that assumption, including Boeing's civilian 787 Dreamliner, which saves a fifth of its fuel at no extra cost.

More broadly, when fuel efficiency factors into all of the systems designed, procured, and fielded, the cumulative effects will reveal:

- reduced logistics tails that slow operations, limit maneuver and deployability, tie up force structure in combat support, and keep too many Soldiers in force protection mode when they could be taking the battle to the enemy
- when more energy efficient solutions are sought, entire systems can become better

designed to accomplish the original task (for example, with a more fuel-efficient engine, the space savings from the smaller fuel tank may allow a redesign of other parts of the vehicle and perhaps the entire power train to add even more efficiency traits)

- a smaller and more predictable DOD budget, less reliant on supplemental funding requests to Congress, and much less vulnerable to fluctuations in the global price of fossil fuels.

In sum, the FBCF and energy efficiency KPP would not turn DOD upside down; they are simply a means to give energy a seat at the table in all the discussions that can affect budget, capabilities, force structure, and mission effectiveness.

Reconnaissance, Surveillance, and Targeting Vehicle is joint project to demonstrate potential of hybrid electric drive technology

General Dynamics

Recommendations

The energy efficiency KPP will help program managers and others make better informed decisions. The 2008 GAO report on mobility energy showed the way based on energy lessons learned and gains already achieved at Defense facilities:

DOD has created a management framework to oversee facility energy, which accounts for about 25 percent of the department's energy use. . . . The establishment of such a framework for mobility energy could provide greater assurance that DOD's efforts to reduce its reliance on petroleum-based fuel will succeed without degrading its operational capabilities and that DOD is better positioned to address future mobility energy challenges—both within the department and as a stakeholder in national energy security dialogues.[16]

Factor Energy Efficiency into All New Systems. Depending on the type of system, improvements to energy efficiency will not always be practical or possible. But because procurements, even the most recent ones, have yet to include a KPP for energy efficiency or energy productivity, DOD must ensure that the next wave of systems is scored and selected with input from the energy efficiency KPP. Systems defined today are fielded 10-plus years from now and in some cases remain online 50 years later. The F–22, our current frontline air superiority fighter, was designed 25 years ago.

Give People Needed Tools. At present, program managers, including commanders and managers, have no tools to measure energy efficiency gains and losses, no tools to ensure guidance is provided to help them incorporate energy efficiency targets in their objectives, and no tools to communicate status using terms familiar to all. As noted earlier, facilities campaigns are maturing, with MBTUs per square foot as the common currency used to manage and measure energy progress with buildings.

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Absent the FBCF and energy efficiency KPP and more granular metrics derived from them, leadership trying to manage the energy demands of operational systems simply will not be able to keep up. For example, future system development should consider how systems with varying energy demand requirements drive multiple variables, including force structure and acquisition. For force planning, the benefits immediately accrue when fuel efficiency metrics are employed by:

- building fuel delivery, protection, and vulnerability risks into campaign plans
- setting targets for reducing fuel delivery burden within force plans
- limiting operational fuel demand to improve capability and reduce mission risk and frame the efficiency/effectiveness trades accurately.

Acquisition activities can also benefit from the incorporation of FBCF and energy or energy efficiency KPPs. For example, DOD would be able to base technology investment business cases on the FBCF and operational areas where energy delivery will be contested; incentivize suppliers to offer the most efficient solutions; and award contracts to buy the most efficient solutions, especially in cases where other scores indicate rough parity.

To achieve these benefits, energy metrics–based policy will have to be codified at the acquisition guide book level, and program managers and other acquisition officials will need to be trained in how to work with these new energy metrics and measurement techniques. This will require significant changes. But given the energy security challenges we now face, the changes would be well worth the pain—and there is no time to lose.

Use Energy Metrics to Enable Questions Never Asked Before. A fully implemented DOD energy security strategy with appropriate policy and metrics will allow DOD, for the first time, to answer questions such as these when defining a new system:

- How does this technology specifically influence operational effectiveness and force structure?
- How will it reduce convoy footprints?
- How will it require less logistics mass?
- How will it free up force protection assets so they can be applied to other activities?
- What are the energy impacts of the 2025 force being designed today?

According to OSD and others, fuel savings bring enormous benefits to DOD:

- major warfighting, logistic, and budget benefits

the election of a President with a strong energy security orientation and his creation of an energy-aware National Security Council have laid the groundwork for rapid change

- far fewer convoys at risk of attack
- elimination of the deadly distraction of protecting fuel
- unprecedented persistence (dwell), agility, mobility, maneuver, range, reliability, and autonomy—at low cost, so many small units can cover large areas—needed for asymmetrical, dispersed, elusive, remote, and irregular adversaries
- vast transformational gains.

Crawl, Walk, Run, Win. Once the first steps toward implementing the FBCF and the energy efficiency KPP have been taken, DOD should follow the lead of the true visionary in this field, Amory Lovins, who was an active member of both DSB task forces. Lovins calls for two new "vectors" that subsume and extend energy efficiency not to merely mitigate current energy-reliance weaknesses, but to gain a substantial competitive edge on the battlefield. According to Lovins, two missing strategic vectors could turn energy threats into decisive advantages:

- *Resilience* combines efficient energy use with more diverse, dispersed, renewable supply—turning big energy supply failures (by accident or malice) from inevitable to near-impossible.
- *Endurance* turns radically improved energy efficiency and autonomous supply into many-fold greater range and dwell—hence affordable dominance, requiring little or no fuel logistics, in persistent, dispersed, and remote operations, while enhancing overmatch in more traditional operations.

These two new vectors are as urgent, vital, and fundamental as speed, stealth, precision, and networking. Without them, exploitation of electricity and fuel vulnerability could soon come to the continental United States. But with them, DOD can gain far more effective forces and a safer world—generally at reduced budgetary cost and risk.[17]

The 2008 DSB report endorsed these two new strategic vectors, which would seem ripe for serious development in the 2010 QDR process. This should help to consolidate doctrine and focus DOD senior leadership on the opportunity to build and expand the decisive advantages of the four strategic vectors already driving the revolution in military affairs—speed, stealth, precision, and networking.

The election of a President with a strong energy security orientation and his creation of an energy-aware National Security Council have laid the groundwork for rapid change, should the DOD decide to adapt. Perhaps in a few years, we will catch a glimpse of a slimmer, healthier DOD thoroughly transformed to calibrate its actions with energy security risks and operational benefits in mind. So what would that look like? It is still far too early to tell, but Secretary of Defense Robert Gates' "balanced approach" gives us an idea of where to look for evidence of change:

In the end, the military capabilities needed cannot be separated from the cultural traits and the reward structure of the institutions the United States has: the signals sent by what gets funded, who gets promoted, what is taught in the academies and staff colleges, and how personnel are trained.[18]

We will know that DOD has truly reformed its approach to energy when rewards are given for energy-related improvements to operational systems at every stage in the lifecycle—when robust use of energy metrics is as much a given in system design, force structure planning, and wargaming as is gravity. **JFQ**

NOTES

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