

Battling Fuel Waste

in the Military



By Amory Lovins

Most Americans are only too aware that their tax dollars support a massive military machine. The Department of Defense's annual budget is over \$291 billion and rising. DOD has three million people, 36 million acres, over 250 major installations, 40,000 additional properties, 550 public utility systems, over 150,000 land vehicles, 22,000 aircraft, and over 300 ocean-going vessels.

But most of us don't realize that despite a 36 percent drop in total DOD energy use during 1990–99, chiefly due to force reduction, around \$5+ billion of the military budget buys energy. Most of DOD's five billion gallons of annual petroleum use fuels weapons platforms—land, sea, and air—that are manifestly inefficient. To add a little irony, much of the fuel used by the military is exhausted moving fuel around. Of the gross tonnage moved when the Army deploys, 70 percent is fuel.

Since it was founded, RMI has welcomed opportunities to work with and learn from military professionals who pursue security goals by different means. RMI's pioneering

work in the 1980s on nuclear nonproliferation, domestic energy vulnerability, and “least-cost security,” attracted much attention in military circles.

In recent years, RMI's involvement with the military has expanded. In 1995, my brief to Naval leadership launched a series of collaborations, which between 1995 and 1998 saw RMI's Green Development Services helping the Naval Facilities Engineering Command (NAVFAC) overhaul how the Navy designs buildings. Nowadays, all bidders for NAVFAC contracts must be good at integrative design. RMI has also supported similar efforts for the Army in Texas and Illinois, the Marine Corps in North Carolina, and the Air Force in Colorado.

All of the Armed Services are variously adopting green design—not just to save money, but also to improve the quality of service life, which is critical to recruitment, retention, and operational effectiveness. And efficient buildings slow the conversion of tax dollars into climate change—perhaps the gravest threat to global security.

In 1999, our technical work with the mili-

Aerial refueling of a B-52 bomber by a KC-10A.
Photo: U.S. Air Force

tary moved beyond buildings when I was invited to serve on an unclassified Defense Science Board Task Force. It sought to ascertain why the Defense Department is the nation's largest energy user (using one percent of all energy in the United States) and probably the world's largest oil buyer. Clearly, the Task Force would like to change that ranking.

Most of the things we looked at were not, as the saying goes, rocket science. It wasn't hard to decide that 0.56-mpg tanks and 17-foot-per-gallon aircraft carriers are just as unnecessarily wasteful as civilian gas-guzzlers. Through a hundred-odd briefings in a year and a half, the Task Force found more than a hundred effective fuel-saving technologies. None would impair and most would improve what the Defense Department is there for—warfighting capability. Much, perhaps most, of DOD's fuel could be cost-effectively saved. That tech-

nology assessment was the easy part. The harder question was why a capable meritocracy with more wants than funds hadn't achieved all the savings already.

The institutional reasons that trapped good people inside a dysfunctional system were complex, but they were rooted in false price signals due to a lack of activity-based costing. When weapons platforms are designed and bought, their fuel is assumed to cost what the DOD-wide supplier, the Defense Energy Supply Center, charges as its average wholesale price, fluctuating around a dollar per gallon (currently \$1.34).

Further Reading:

- Lovins, Amory B. and L. Hunter. *Brittle Power: Energy Strategy for National Security*. Includes a foreword by President Reagan's Chairman of the Joint Chiefs of Staff and President Carter's Undersecretary of the Navy. Andover, Mass.: Brick House, 1982. Out of print; to be reposted at www.rmi.org. Summarized in "The Fragility of Domestic Energy," *Atlantic*, November 1983.
- "Nuclear Power and Nuclear Bombs," *Foreign Affairs*, **58**:1136 (summer 1980), **59**:172 (Fall 1980).
- Shuman, Mike, and Hal Harvey. *Security Without War*. Boulder, Colo.: Westview, 1993. A book credited with contributing to Gorbachev's revolution in Soviet policy.
- *The Defense Science Board's report More Capable Warfighting Through Reduced Fuel Burden* was released in May 2001 by the Office of the Undersecretary of Defense for Acquisition and Technology, Washington, D.C. 20301-3140. It was summarized in *Business Week*, 3 September 2001.

However, the cost of delivering that fuel to the platform is assumed to be zero. Logistics—moving stuff around—takes roughly a third of DOD's budget and half its personnel. But when designing and buying platforms, logistics is considered free to the platform that consumes the fuel. This practice understates delivered fuel cost by a factor that I estimate to average at least three for DOD as a whole, and tens or hundreds in some particular cases.

The venerable B-52 bombers now being flown by the children of their original pilots have inefficient, low-bypass engines from the 1960s. Those could be refitted to modern ones using a third less fuel to achieve up to half again as much range. But they haven't been, because the fuel is thought to be cheap. And so it is, when delivered in peacetime to a U.S. airbase, where delivery to the plane adds only about 20 cents a gallon. But when the plane is on the long-distance mission for which it was built, it typically needs midair refueling. That adds \$17.50 a gallon, not counting the \$9-billion cost of at least 55 tankers the Air Force would need to replace. Thus the Air Force in FY1999 paid \$1.8 billion for two billion gallons of fuel, but delivering that fuel into the aircraft added another \$2.6 billion, so the actual delivered fuel bill was \$4.4 billion: the Air Force spent 84 percent of its fuel-delivery cost on the 6 percent of its gallons that were delivered in midair. If you count that delivery cost, re-engining the B-52s has a quick payback—all the more so because it typically makes midair refueling unnecessary!

The Army's formidable half-mile-a-gallon M1A2 tanks are powered by inefficient 1960s-design gas turbines that yield 1500 horsepower to make 68 tons dash around a battlefield at 30 mph (42 on the road). They do that pretty well. But 60- to 80-odd percent of the time, that huge turbine is idling at one percent efficiency to run a 5-kilowatt "hotel load," mostly air conditioning and electronics. Most civilian vehicles would use a small auxiliary power unit to serve such tiny, steady loads efficiently. Tanks don't,

because their fuel was assumed to cost about a buck a gallon. But to keep up with a rapidly advancing armored unit on the battlefield, cargo helicopters may have to leapfrog big bladders of fuel hundreds of kilometers into theater, using much of the fuel to do so. The delivery cost can then rise to \$400–600 a gallon—yet it was assumed to be zero. If the designers had known the real delivery cost, they'd have designed the tanks very differently.

Fuel-wasting design doesn't just cost money; it inhibits warfighting. Each tank is trailed by lumbering fuel tankers. An armored division may use as much as 20, perhaps even 40, times as many daily tons of fuel as it does of munitions—around 600,000 gallons a day. Of the unit's top ten battlefield fuel guzzlers, only Abrams tanks (#5) and Apache helicopters (#10) are combat vehicles. Several of the rest carry fuel. This takes a lot of equipment and people. The Army directly uses about \$0.2 billion dollars' worth of fuel a year, but pays about 16 times as much, \$3.2 billion a year, just to maintain 20,000 active and 40,000 reserve personnel to move that fuel. And unarmored fuel carriers are vulnerable. Attacks on rear logistics assets can make a fuel-hungry combat system grind to a halt. Yet the warfighting benefits of fuel economy—in deployability, agility, range, speed, reliability, and maneuverability—are as invisible as the fuel delivery cost.

Today's armored forces were designed to face Russian T-72s across the North German plain. Nowadays, however, their missions demand mobility. Only one 68-ton tank fits into the heaviest U.S. lift aircraft, so deployment is painfully slow, and when the tank arrives in, say, the Balkans, it breaks bridges and gets stuck in the mud. Army Research has a better idea—an innovative 7–10-ton version that uses about 87 percent less fuel, yet is said to be as lethal as current models and no more vulnerable. (The Army figures such redesign could save about 20,000 personnel—plus their equipment and their own

CONTINUED ON NEXT PAGE

All Energy Experts on Deck!

BY AMORY B. LOVINS



USS Princeton

Wandering around some Navy ships, I noticed that many design details were as inefficient as those in civilian buildings and equipment. Inefficient pumps fought against throttling valves; oversized motors and chillers ran suboptimally; operators lacked proper readouts and controls. How much energy, I wondered, is

thereby wasted? Might the Navy unknowingly have energy-saving opportunities at least as big in its ships as RMI was finding in Navy buildings?

Calculations in the Defense Science Board Task Force confirmed that nearly a third of the Navy's nonaviation fuel goes to "hotel loads"—not to propulsion, radars, weapons systems, or aircraft-launching catapults, but to mundane pumps, fans, chillers, and lights. And based on some casual observations, much, perhaps most, of their energy seemed to be wasted.

To be sure, the Navy has different design imperatives than civilian architects: ships must go far and fast through all the world's climates, project power, protect crews, and fight through gales and missile strikes. Being shot at demands serious redundancy and special operational methods. Cramped space often makes pipes and ducts small and twisting, especially when whichever get installed second must snake around whichever got installed first. Nonetheless, there seemed much room for improvement, even though the Navy had already led all the Services in energy savings—partly by letting skippers keep for their own ships' needs half the fuel dollars they saved.

I discussed this hypothesis with Vice Admiral Denny McGinn, the dynamic Commander of Third Fleet (now Deputy Chief of Naval Operations) whom I had met a decade earlier while lecturing at the Naval War College. We liked the idea of an experiment: let's just go measure how a ship works and see how much energy we can save. The Admiral nominated as a testbed his own command ship, *USS Coronado*, but that converted amphibious support vessel was too atypical. A typical surface combatant was soon chosen instead—*USS Princeton*, a 9,600-ton, 567-foot, billion-dollar Aegis cruiser homeported in San Diego. With support from Navy Secretary Richard Danzig, the Office of Naval Research gave RMI a \$50,000 grant to go see what energy-saving potential we could find. The Naval Sea Systems Command's able engineers had estimated that 19 percent could be saved on ships of this class, of which *Princeton* was in the top one fourth for efficiency.

CONTINUED ON NEXT PAGE

MILITARY ENERGY ▼

FROM PREVIOUS PAGE

in sum, billions of dollars a year.)

A little-known 1982 Army experiment suggests the potential value of even more radical lightweighting, possibly to a 0.7-ton version. When 30 tanks were set against 30 Baja dunebuggies armed with precision-guided munitions, the prompt result was 27 dead tanks (21 completely immobilized) and three dead dunebuggies. That exercise was done in desert, not forest or city, and not under chemical warfare conditions, but it's still enlightening. With different tactics, light and even ultralight forces may be more militarily effective than familiar heavy ones.

Recent tactical experience, from Iraq to Somalia, suggests that the Joint Chiefs' new doctrine emphasizing light, mobile, agile, flexible, and easily-sustained forces is vital to modern warfighting. Yet it's very far from most of the forces now fielded. Heavy-metal tradition dies hard, and porkbarrel politics impedes fundamental military reform.

Other policies inhibit capability as well. When I visited the Navy's newest nuclear aircraft carrier, I was startled to find that its design had been frozen 23 years earlier due to the cumbersome procurement process. That's a disadvantage of over 40,000-fold against electronic equipment that's subject to Moore's Law and bought at Radio Shack. Wargames suggest that an adversary with a few billion dollars' worth of up-to-date over-the-counter hardware could even beat the United States, which has excellent warriors but often outmoded equipment.

A sweeping revolution in military affairs is underway. The Defense Department is trying to jettison or bypass its antiquated procurement methods and buy commercial off-the-shelf equipment wherever possible—it's usually far more modern and capable, but much cheaper and often durable enough. Similarly, DOD is asking why it takes six months to plan a divisional deployment

CONTINUED ON PAGE 28

All Energy Experts on Deck!

FROM PREVIOUS PAGE

RMI's Chris Lotspeich and three of RMI's consulting engineers—Ron Perkins and Ned Orrett (both ex-Navy men) and Jim Rogers—did two “floats” aboard *Princeton* to observe, study, measure, and learn about hotel loads from the officers and crew. Our preliminary survey found gratifyingly large potential savings: perhaps, if found feasible, as much as several times NAVSEA's expectations.

Princeton uses nearly \$6 million worth of diesel-like turbine fuel each year. Her gas turbines, akin to those on an older passenger jet aircraft, use about \$2–3 million worth of oil to make up to 2.5 megawatts of electricity, the rest for 80,000 horsepower of propulsion. The RMI team found that retrofitting motors, pumps, fans, chillers, lights, and potable water systems could save an estimated 20–50 percent of the ship's electricity. That could cut total fuel use by an estimated 10–25 percent—perhaps even 50–75 percent if combined with other potential improvements we sketched for propulsion and electric generation. (However, if the electricity-generating gas turbines weren't run differently, even heroic electricity savings would save little fuel, because they'd be offset by even less efficient operation of the underloaded turbines.)

Just as in civilian facilities ashore, the RMI team started by calculating what it's worth to save a kilowatt-hour. Since the electricity is being made inefficiently from fuel that's mainly delivered by “oiler” ships, the answer is an eye-popping 27 cents, six times a typical industrial tariff ashore. This high cost makes “negawatts” really juicy. For example, each percentage point of improved efficiency in a single 100-horsepower always-on motor is worth \$1,000 a year. Each chiller could be improved to save its own capital cost's worth of electricity (about \$120,000) every eight months. About \$400,000 a year could be saved if—under noncritical, low-threat conditions—certain backup systems were set to come on automatically when needed rather than running all the time. Half that saving could come just from two 125-horsepower firepumps that currently pump seawater continuously aboard, around the ship, and back overboard. In a critical civilian facility like a refinery, where one wanted to be equally certain the firefighting water was always ready, one would instead pressurize the pipes (usually with freshwater) with a 2-hp pump, and rig the main pumps to spring into action the instant the pressure dropped.

Princeton's total electricity-saving potential could probably cut her energy costs by nearly \$1 million a year, or about \$10 million in present value, while improving her warfighting capability. (A ship that burns less fuel can go farther and faster between refuelings, and emits less conspicuous signatures to announce her presence.) The Navy has 27 ships of this class, 317 in total (surface and submarines, fossil- and nuclear-fueled), most with analogous designs and operations. RMI has invited the Navy to tear our conclusions apart, and, if they find them useful, consider implementing them just as aggressively as, in the second half of the '90s, they adopted RMI's recommendations for green building design.

Maybe those who seek offshore oil resources beneath fragile seabeds are drilling in the wrong place—under the ocean rather than atop it. Aboard the U.S. Navy's ships, it seems, are rich reserves of “negabarrels.” Exploiting them will save hard-earned tax dollars, reduce pollution, and improve our nation's security and prosperity. You might call this approach applied patriotism. ☉



Above: The view from *USS Princeton* as she pulls over a fuel line to take on hundreds of thousands of dollars' worth of fuel from an oiler. On the far side of the oiler, another cruiser is fueled simultaneously. Photo: Chris Lotspeich.

CONTINUED FROM PAGE 8

when global companies can deliver a spare part pretty much anywhere on earth in 24 hours. The result: a commendable effort to redesign a creaky old logistics system from scratch.

These innovations will all save prodigious amounts of energy, pollution, and money. From data in the DSB report, I estimate that comprehensive military fuel efficiency could probably save upwards of ten billion dollars a year, because the few billion dollars of direct annual fuel savings can trigger far larger avoided fuel delivery costs. Fuel efficiency could displace—or redeploy from tail to tooth—at least a division's worth of fuel-delivery personnel and their equipment and support pyramids.

As for whether such innovations also make the world more secure, that depends on how well citizens exercise their responsibility to use military power wisely—and to create the sort of world in which its use or threatened use becomes less necessary.

If we get that right, we can all be safe and feel safe in ways that work better and cost less than present arrangements, and fewer of the men and women in the Armed Forces need go in harm's way. 

