Powering America's Defense:

Energy and the Risks to National Security

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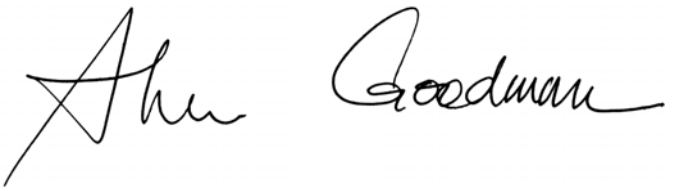

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This document represents the best opinion of CNA at the time of issue.

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To the Reader

During our decades of service in the U.S. military, we witnessed some of the impacts of America's energy choices.

Many of our overseas deployments were defined, in part, by the strategic decision to ensure the free flow of oil, to the U.S. and to our allies. Many of the troops we commanded were aided by air cover from high thrust delivery systems that only an energy-intense society can provide. Many of these same troops were often burdened and imperiled by battlefield systems that were energy inefficient. Some of the attacks on our troops and on American civilians have been supported by funds from the sale of oil. Our nation's energy choices have saved lives; they have also cost lives.

As we consider America's current energy posture, we do so from a singular perspective: We gauge our energy choices solely by their impact on America's national security. Our dependence on foreign oil reduces our international leverage, places our troops in dangerous global regions, funds nations and individuals who wish us harm, and weakens our economy; our dependency and inefficient use of oil also puts our troops at risk. Our domestic electrical system is also a current and significant risk to our national security: many of our large military installations rely on power from a fragile electrical grid that is vulnerable to malicious attacks or interruptions caused by natural disasters.

In offering our recommendations, we considered a context that will be increasingly shaped by climate change. (We encourage readers to view our earlier report: *"National Security and the Threat of Climate Change."*) The effects of global warming will require adaptive planning by our military. The effects of climate policies will require new fuels and energy systems. Ignoring these trends will make us less secure; leading the way can make us more secure.

The challenges inherent in this suite of issues may be daunting, particularly at a time of economic crisis. Still, our experience informs us there is good reason for viewing this moment in history as an opportunity. 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.

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About This Report

To better inform U.S. policymakers and the public about the impact of America's energy choices on national security policies, CNA, a nonprofit research organization that runs the Center for Naval Analyses and the Institute for Public Research, convened a panel of retired senior military officers and national security experts.

The Military Advisory Board consists of retired generals and admirals from all four services, many of whom served on the Military Advisory Board that produced the 2007 report, *National Security and the Threat of Climate Change* [1]. That report found that "climate change, national security, and energy dependence are a related set of global challenges."

This new volume builds on that finding by considering the security risks inherent in America's current energy posture, energy choices the nation can make to enhance our national security, the impact of climate change on our energy choices and our national security, and the role DoD can play in the nation's approach to energy security. These issues were viewed through the lens of the extensive military experience of the Military Advisory Board. The issues were considered solely for their impact on America's national security.

The Military Advisory Board and the study team received briefings from energy experts, DoD officials, representatives of the U.S. intelligence community, scientists, engineers, policymakers, senior military officers, business leaders, legislators and their staff, regulators, and leaders of public interest non-profit organizations. The Military Advisory Board also visited the Department of Energy's National Renewable Energy Laboratory in Golden, Colorado to meet with senior scientists and engineers, and receive briefings on the latest energy technologies.

The Military Advisory Board views climate change and energy security strategies as complementary and mutually reinforcing. A complementary approach broadens the base of support for necessary adjustments to energy security strategy.

Executive Summary

In 2007, the CNA Military Advisory Board (MAB) released the landmark report "*National Security and the Threat of Climate Change,*" which found that climate change constitutes a "threat multiplier" to existing security risks in some of the most volatile regions in the world. A 2008 National Intelligence Assessment confirmed the report finding that climate change is a serious threat to national security and long-term global stability. The MAB, which is comprised of some of the nation's most respected retired admirals and generals, also found that "Climate change, national security, and energy dependence are a related set of global challenges."

A year later, the CNA MAB reconvened to study America's energy posture and further examine the issue of energy security and how it relates to climate change and national security. Moving beyond recent studies on the dangers of imported oil, this 2009 report finds that fossil fuels, as well as the nation's fragile electricity grid, pose significant security threats to the country as a whole and the military in particular.

This report identifies a series of current risks created by America's energy policies and practices that constitute a serious and urgent threat to national security—militarily, diplomatically, and economically:

- U.S. dependence on oil weakens international leverage, undermines foreign policy objectives, and entangles America with unstable or hostile regimes.
- Inefficient use and overreliance on oil burdens the military, undermines combat effectiveness, and exacts a huge price tag—in dollars and lives.
- U.S. dependence on fossil fuels undermines economic stability, which is critical to national security.
- A fragile domestic electricity grid makes our domestic military installations, and their critical infrastructure, unnecessarily vulnerable to incident, whether deliberate or accidental.

Looking forward, the report warns that continuing business as usual is perilous because of the converging national security risks of energy demand and climate change:

- The market for fossil fuels will be shaped by finite supplies and increasing demand. Continuing our heavy reliance on these fuels is a security risk.
- Regulatory frameworks driven by climate change concerns will increase the costs—both economic and geopolitical—of using carbon-based fuels.
- Destabilization driven by ongoing climate change has the potential to add significantly to the mission burden of the U.S. military in fragile regions of the world.

Confronting these converging risks is critical to ensuring America's secure energy future. Due to the destabilizing nature of increasingly scarce resources, the impacts of energy demand and climate change could increasingly drive military missions in this century. The first priority for the new Administration, the MAB recommends, is to

clearly and fully integrate energy security and climate change goals into national security and military planning processes.

Consistency with emerging climate policies should shape America's energy and national security planning; the U.S. should not pursue energy options inconsistent with the national response to climate change. Diversifying energy sources and moving away from fossil fuels where possible is critical to future energy security.

While the current financial crisis provides enormous pressure to delay addressing these critical energy challenges, the MAB warns against delay. The economic risks of this energy posture are also security risks. The U.S. consumes 25 percent of the world's oil production, yet controls less than 3 percent of an increasingly tight supply. Oil is traded on a world market, and the lack of excess global production makes that market volatile and vulnerable to manipulation by those who control the largest shares. Reliance on fossil fuels, and the impact it has on other economic instruments, affects our national security, largely because nations with strong economies tend to have the upper hand in foreign policy and global leadership. As economic cycles ebb and flow, the volatile cycle of fuel prices will become sharper and shorter, and without immediate action to address our nation's long-term energy profile, the national security risks associated with the nation's and the military's current energy posture will worsen.

The U.S. should not pursue energy options inconsistent with the national response to climate change.

The Military Advisory Board calls on the Department of Defense (DoD) to take a leadership role—for government and the nation—in transforming America's energy posture. The DoD is the nation's single largest consumer of energy, and is seriously compromised by the nation's current energy posture. By addressing its own energy security needs, DoD can stimulate the market for new energy technologies and vehicle efficiencies. In policy and technology areas that would benefit the Department's operational capabilities, the Department's historical role as a technological innovator and incubator should be harnessed to benefit the nation as a whole.

Confronting this challenge is paramount for the military. To achieve the desired endstate, America must have a national approach. Securing the country's energy future will require the active leadership and consistent participation of governments at all levels, as well as that of all Americans.

Recognizing the enormity of this challenge, the MAB submits the following findings and Roadmap for Energy Security to the Administration and Department of Defense.

Findings:

1. The nation's current energy posture is a serious and urgent threat to national security.

    a. Dependence on oil undermines America's national security on multiple fronts.

b. The U.S.'s outdated, fragile, and overtaxed national electrical grid is a dangerously weak link in the national security infrastructure.

2. A business as usual approach to energy security poses an unacceptably high threat level from a series of converging risks.

3. Achieving energy security in a carbon-constrained world is possible, but will require concerted leadership and continuous focus.

4. The national security planning processes have not been sufficiently responsive to the security impacts of America's current energy posture.

5. In the course of addressing its most serious energy challenges, the Department of Defense can contribute to national solutions as a technological innovator, early adopter, and testbed.

A Roadmap for Energy Security:

Priority 1: Energy security and climate change goals should be clearly integrated into national security and military planning processes.

Priority 2: DoD should design and deploy systems to reduce the burden that inefficient energy use places on our troops as they engage overseas.

Priority 3: DoD should understand its use of energy at all levels of operations. DoD should know its *carbon bootprint*.

Priority 4: DoD should transform its use of energy at installations through aggressive pursuit of energy efficiency, smart grid technologies, and electrification of its vehicle fleet.

Priority 5: DoD should expand the adoption of distributed and renewable energy generation at its installations.

Priority 6: DoD should transform its long-term operational energy posture through investments in low-carbon liquid fuels that satisfy military performance requirements.

THE CNA MILITARY ADVISORY BOARD

A Direct Appeal

We began this project by considering the energy choices American military personnel, and their civilian leaders, can make to enhance our national security. The urgency and scale of America's challenges led us to expand the reach of our study.

National security is not solely the responsibility of our military. American civilians know this, and have always shown the capacity and willingness to participate in meaningful efforts to help our country in times of need.

Americans made clear sacrifices during World War II for reasons that are obvious in hindsight: they understood the stakes, and they were asked.

In World War II, a concerted effort helped civilians understand their role. Recycling rubber and metal scraps preserved key materials for an industrial buildup. Growing food locally in Victory Gardens meant industrial food production facilities could focus on food shipments to soldiers overseas; it also saved the fuel used for domestic transport of canned fruits and vegetables. Conserving fuel at home left more of it for our troops. These steps could be described as sacrifices, frugality, lifestyle changes—the wording depends on the era and one's perspective. Whatever the terminology, these actions made the totality of America's war effort more successful. They shortened the war and saved lives.

Today, all Americans can help us meet our emerging security challenges.

Each of us can help make our country more energy efficient. Using less electricity in our homes and offices reduces stress on a fragile electrical grid; it also reduces carbon emissions. Supporting efforts to rebuild our electrical grid can make us less vulnerable to domestic attacks, and can allow us to develop a rich diversity of non-carbon energy sources.

Each of us can help end America's addiction to oil. Using less fuel in our cars and trucks reduces overall demand, and helps us meet the President's goal of eliminating foreign oil imports; it also reduces carbon emissions. We can support efforts to electrify personal transport, with liquid fuels used primarily for aircraft and the military.

These steps, taken individually, may seem small. Collectively, they can make us more secure.

Americans made clear sacrifices during World War II for reasons that are obvious in hindsight: they understood the stakes, and they were asked. With this report, we have tried to make known the current stakes by clearly articulating the need to establish energy security and plan for the effects of climate change. This will require a commitment to conservation and a willingness to reconsider old ways. It will require discipline and the broadest participation possible. All of us have a role to play in making our nation more secure.

There is room for differences and for debate. We know this, because we've had these arguments ourselves. But there are moments in a nation's history when the confluence of events suggests that the time is ripe for action. Even as the debates rage, as important differences in opinion are surfaced, there is a quiet consensus that the time has come. The American people—all of us—through our energy choices, can contribute directly to the security of our nation.

Chapter 1

The National Security Threats of America's Current Energy Posture

The relationship between America's national security and its dependence on foreign oil has been clear ever since President Franklin Roosevelt hosted Saudi King Abdel Aziz ibn Saud aboard the U.S.S. Quincy in the Suez Canal in 1945. While the threat associated with foreign oil remains daunting, we also see a much broader suite of energy related threats. America's approach to energy has placed the nation in a dangerous and untenable position.

America's energy posture constitutes a serious and urgent threat to national security—militarily, diplomatically, and economically.

Energy for America's transport sector depends almost wholly on the refined products of a single material: crude oil. Energy for homes, businesses, and civic institutions relies heavily on an antiquated and fragile transmission grid to deliver electricity. Both systems—transport and electricity—are inefficient. This assessment applies to our military's use of energy as well. Our defense systems, including our domestic military installations, are dangerously oil dependent, wasteful, and weakened by a fragile electrical grid. In fact, the Department of Defense (DoD) is the largest single energy consumer in the nation. In our view, America's energy posture constitutes a serious and urgent threat to national security—militarily, diplomatically, and economically. This vulnerability is exploitable by those who wish to do us harm.

America's current energy posture has resulted in the following national security risks:

- U.S. dependence on oil weakens international leverage, undermines foreign policy objectives, and entangles America with unstable or hostile regimes.
- Inefficient use and overreliance on oil burdens the military, undermines combat effectiveness, and exacts a huge price tag—in dollars and lives.
- U.S. dependence on fossil fuels undermines economic stability, which is critical to national security.
- A fragile domestic electricity grid makes our domestic military installations, and their critical infrastructure, unnecessarily vulnerable to incident, whether deliberate or accidental.

U.S dependence on oil weakens international leverage, undermines foreign policy objectives, and entangles America with unstable or hostile regimes.

Dependence on oil constitutes a threat to U.S. national security. The United States consumes 25 percent of the world's oil production, yet controls less than 3 percent of an increasingly tight supply [2, 3]. Even if America exploited fully all available domestic supplies, the market would remain tight and largely beyond our control: oil is

Voices of Experience

GENERAL CHARLES F. "CHUCK" WALD, USAF (RET.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM); Chairman, CNA MAB

On How Oil Shapes Our Foreign Policy

Retired Air Force General Chuck Wald wants to see major changes in how America produces and uses energy. He wants carbon emissions reduced to help stave off the destabilizing effects of climate change.

"We've always had to deal with unpredictable and diverse threats," Gen. Wald said. "They've always been hard to judge, hard to gauge. Things that may seem innocuous become important. Things that seem small become big. Things that are far away can be felt close to home. Take the pirates off the African coast. To me, it's surprising that pirates, today, would cause so much havoc. It's a threat that comes out of nowhere, and it becomes a dangerous situation.

"I think climate change will give us more of these threats that come out of nowhere. It will be harder to predict them. A stable global climate is what shaped our civilizations. An unstable climate, which is what we're creating now with global warming, will make for unstable civilizations. It will involve more surprises. It will involve more people needing to move or make huge changes in their lives. It pushes us into a period of nonlinear change. That is hugely destabilizing."

"Our hands are tied in many cases because we need something that others have. We need their oil."

He gives another reason for major changes in our energy policy: He wants to reduce the pressure on our military.

"My perception is that the world, in a general sense, has assumed the U.S. would ensure the flow of oil around the world," Gen. Wald said. "It goes back to the Carter Doctrine. I remember seeing the picture of the five presidents in the Oval Office. [He referred to a January photo, taken just before President Obama assumed office.] Most people would not guess it was Jimmy Carter who said the U.S. would protect the flow of Persian Gulf oil by any means necessary. But he did. He recognized it as a vital strategic resource.

"And since that time, as global demand has grown, we see oil used more and more often as a tool by foreign leaders. And that shapes where we send our military. You look at the amount of time we spend engaged, in one way or another, with oil producing countries, and it's staggering. Hugo Chavez in Venezuela gets a lot of our attention because he has a lot of oil. We spend a lot of money and a lot of time focused on him, and on others like him."

Gen. Wald cautions against simplistic responses to the challenge of energy dependency.

"The problem is dependence, and by that I mean our hands are tied in many cases because we need something that others have. We need their oil. But the solution isn't really independence. We're not going to become truly independent of anything. None of this is that simple. Reaching for independence can lead us to unilateralism or isolationism, and neither of those would be good for the U.S. The answer involves a sort of interdependence. We need a diversity of supply, for us and for everybody. We need clean fuels that are affordable and readily available, to us and to everybody. That's not independence. It might even be considered a form of dependency—but we'd be dependant on each other, not on fossil fuels."

traded on a world market, and the lack of excess global production makes that market volatile and vulnerable to manipulation by those who control the largest shares.

The West's dependence on oil has helped a small group of nations emerge as new energy powerhouses. The vast majority of oil reserves (and specific knowledge of those reserves) is controlled not by publicly traded companies, but by national governments, which control 77 percent of the world's estimated 1.15 trillion barrels of proven reserves [4]. In addition, 16 of the top 25 oil-producing companies are either majority or wholly state-controlled [5]. These oil reserves can give extraordinary leverage to countries that may otherwise have little; some are using that power to harm Western governments and their values and policies.

Russia is another nation whose international connections largely depend on its energy exports.

Venezuela, which depends on oil revenues for more than half of its federal budget [6], offers an interesting case study in this regard. Oil forms a strong economic bond between Venezuela and the U.S.: Venezuela provides roughly 11 percent of U.S. oil imports, the U.S. makes up 60 percent of Venezuelan oil exports, and Venezuela has partial or complete ownership of nine U.S.-based refineries [7, 8]. However, Venezuela's democratically elected President, Hugo Chavez, regularly espouses anti-American and anti-Western rhetoric both at home and abroad. Venezuela promotes a destabilizing and anti-U.S. influence in parts of Latin and South America through foreign aid (largely in the form of subsidized oil); its oil wealth has also enabled Venezuela to engage in a large buildup of arms and equipment [7, 9]. Venezuela's oil wealth has not only helped Chavez expand his influence regionally; it has also helped him cling to power at home. Chavez has directed billions of dollars in oil revenues to this end by funding free medical clinics, new schools and adult education programs, and other social initiatives. Oil wealth has also helped Chavez to silence his domestic critics and extinguish freedom of the press [7].

Russia is another nation whose international connections largely depend on its energy exports. Russia is the world's largest exporter of natural gas and the second largest exporter of oil (although its production is in decline due to lack of investment) [10]. Europe is particularly dependent upon Russia for natural gas, receiving 40 percent of its supplies through old Soviet pipelines now owned by Ukraine and Belarus. In turn, Russia is deeply dependent upon gas from Central Asian countries, notably Turkmenistan, to fill those pipelines after meeting its own domestic needs. Not having diversified its economy enough, the Russian government is dependent upon its revenues from energy sales to fund its domestic programs and stimulate its economy. Such dependence, combined with volatile prices, has caused Russia to take harsh actions over price disputes and unpaid natural gas bills: Russia has halted gas supplies to Ukraine and Belarus (and thus to much of Europe) in the middle of winter on three occasions in recent years [11, 12, 13]. Some international observers have suggested that Russia has been using its energy supplies as a bargaining chip in negotiations over issues such as the European-

based U.S. missile shield and NATO's discussions with Ukraine [14].

Another troubling aspect of our oil addiction is the resulting transfer of wealth. American and overall world demand for oil puts large sums in the hands of a small group of nations; those sums, in the hands of certain governments or individuals, can be used to great harm. Iran's oil exports, which reached an estimated $77 billion in 2008, provide 40 percent of the funding for a government that the U.S. State Department says is the world's "most active state sponsor of terrorism" [15]. Iran provides materiel to Hezbollah, supports insurgents in Iraq, and is pursuing a nuclear weapons program [16]. While the U.S. does not trade directly with Iran, many of our allies do (including Japan, South Korea, Italy, and France) [17]. Saudi Arabian private individuals and organizations, enriched by the country's $301 billion in estimated 2008 oil, reportedly fund organizations that promote violent extremism revenues [18]. The sad irony is that this indirectly funds our adversaries. As former CIA Director James Woolsey said, "This is the first time since the Civil War that we've financed both sides of a conflict" [19].

America's strategic leadership, and the actions of our allies, can be greatly compromised by a need (or perceived need) to avoid antagonizing some critical oil suppliers. This has become increasingly obvious since the early 1970s, when the first OPEC embargo quadrupled oil prices, contributed to an inflationary spiral, and generated tensions across the Atlantic as European nations sought to distance themselves from U.S. policies not favored by oil-exporting nations [20]. Today, while the U.S. has been openly critical of the political environments in some of the world's major oil producers (such as Venezuela and Iran), oil has been the central factor in the mutually supportive relationship between the U.S. and Saudi Arabia. While the Saudis have been key allies in the region since World War II and serve as one of the nation's most critical oil suppliers [21], Saudi Arabia is also one of the most repressive governments in the world.

The sad irony is that this indirectly funds our adversaries.

Even in countries that are not major suppliers for the U.S., the presence of oil deposits has complicated the ability of the U.S. and the international community to promote Western values and stability [22]. The presence of the world's third largest oil reserves—and a line of willing customers—have contributed to the Iranian government's ability to pursue its nuclear weapons program in the face of international sanctions [17, 23]. Sudan provides another example: in an effort to pressure the Sudanese government to stop the genocide occurring in Darfur, the U.S. and most of Europe have limited or halted investment in Sudan. However, China and Malaysia have continued to make investments worth billions of dollars (mainly in the oil industry) while actively campaigning against international sanctions against the country. Sudan, which depends upon oil for 96 percent of its export revenues, exports the vast majority of its oil to China and provides China with nearly 8 percent of its oil imports [24]. When layered on top of China's other motivating interests (such as expanding its regional influence) and the nature of U.S. and Chinese relations, the presence of

these deep economic ties between China and Sudan increases the complexity of the international diplomatic efforts regarding Darfur.

For many countries, however, the presence of oil can be as much a curse as a gift. While oil can enable some nations to flex their muscles, it can also have a destabilizing effect on their economic, social, and political infrastructure. In many cases, the discovery of oil deposits can bring about "Dutch disease," an economic condition that can occur when a nation's large endowment of a natural resource attracts all capital away from other sectors while simultaneously increasing the currency valuation to the point where trade in other economic sectors collapses. When the natural resource that caused the Dutch disease goes from boom to bust (as has been the case with oil), the economy and social fabric of the afflicted nation can be left in tatters [25].

Venezuela, which has taken great advantage of its oil wealth, is often cited as being afflicted with Dutch disease [25]. The volatility of the oil market and the lack of transparency from its government managers have left the operational and financial health of Petroleos de Venezuela, S.A. (PDVSA), the state-owned petroleum company, under considerable question. Under Chavez, Venezuela's gross domestic product and public spending have grown increasingly dependent upon oil revenues; a sustained decrease in global prices threatens to plunge its economy, and perhaps the political system, into crisis [7, 26].

Russia has also been afflicted with Dutch disease due to its heavy dependence on the exportation of oil, natural gas, and other raw materials. The Russians have attempted to use the accumulated reserves from the high oil and gas prices to insulate their exchange rate and budget from the volatile swings in energy prices, but have still shown economic vulnerability. In 2008, a confluence factors—including capital flight, a 70-percent drop in oil prices in the second half of the year, and a 70-percent decrease in their stock market fueled by the international financial—have wreaked havoc on the Russian economy [27]. Rampant corruption in the Russian energy sector and loss of revenues resulting from the Ukrainian gas disputes have also had detrimental impacts on Gazprom's receipts and investment programs.

While oil can enable some nations to flex their muscles, it can also have a destabilizing effect on their economic, social, and political infrastructure.

Nigeria, which accounts for nearly 9 percent of U.S. oil imports, has experienced a particularly high level of economic and civil unrest related to its oil [8]. Already engulfed by violence and civil war, Nigeria was severely afflicted by Dutch disease in the 1980s and is in danger of being so again [28].

In addition to Dutch disease, Nigeria also shows another corrosive impact of oil. The large oil trade (and unequal distribution of its profits) has fueled the Movement for the Emancipation of the Niger Delta (MEND), an armed group that stages attacks against the foreign multinational oil

companies and the Nigerian government[1]. In one of its most serious actions, in September 2008, the MEND retaliated against a strike by the Nigerian military by attacking pipelines, flow stations, and oil facilities; they also claimed 27 oil workers as hostages and killed 29 Nigerian soldiers. The result was a decrease in oil production of 115,000 barrels per day over the week of attacks [29]. In the years preceding this attack, instability caused by the MEND decreased oil production in the Niger Delta by 20 percent [30].

Dependence on foreign oil has had a marked impact on national security policies.

The MEND is but one example of a group operating in an unstable region that targets oil and its infrastructure for its strategic, political, military, and economic consequences. By 2007 in Iraq, in comparison to pre-2003 levels, effects from the war and constant harassment of the oil infrastructure by insurgent groups and criminal smuggling elements reduced oil production capacity in the northern fields by an estimated 700,000 barrels per day [31]. In 2006, al Qaeda in the Arab Peninsula carried out a suicide bombing against the Abqaiq oil production facility in Saudi Arabia, which handles about two-thirds of the country's oil production [32]. Fortunately, due largely to the intense focus of the Saudis on hardening their processing facilities (to which they devote billions of dollars each year), the attack was suppressed before the bombers could penetrate the second level of security gates. However, both the Saudi level of protection and al Qaeda's selection of the oil infrastructure as a target signify the strategic and economic value of such facilities.

The effects of these attacks have been regional, and none resulted in a catastrophic disruption in the flow of oil. However, these attacks have demonstrated the vulnerability of oil infrastructure to attack; a series of well-coordinated attacks on oil production and distribution facilities could have serious negative consequences on the global economy. Even these small-scale and mostly unsuccessful attacks have sent price surges through the world oil market.

In the U.S., dependence on foreign oil has had a marked impact on national security policies. Much of America's foreign and defense policies have been defined, for nearly three decades, by what came to be known as the Carter Doctrine. In his State of the Union address in January 1980, not long after the Soviet Union invaded Afghanistan, President Jimmy Carter made it clear that the Soviets had strayed into a region that held "great strategic importance" [33]. He said the Soviet Union's attempt to consolidate a position so close to the Straits of Hormuz posed "a grave threat to the free movement of Middle East oil." He then made a declaration that went beyond a condemnation of the Soviet invasion by proclaiming the following:

[1] The MEND claims it operates to fight environmental and human rights abuses by multinational oil companies and the Nigerian government; critics describe the group as criminal gangs extorting money from oil companies operating in the region [30]. Our aim is not to argue for or against the cause of the MEND, but instead to characterize the impacts these types of groups can have on oil production in unstable regions.

> *An attempt by any outside force to gain control of the Persian Gulf region will be regarded as an assault on the vital interests of the United States of America, and such an assault will be repelled by any means necessary, including military force.*

When President Carter made his declaration, the U.S. imported roughly 40 percent of its oil. While the U.S.'s dependence on imported oil dipped below 30 percent in the early 1980s, that percentage has since doubled. In fact, due to the increase in U.S. demand, the total annual volume of oil imported into the U.S. has tripled since the early 1980s [34]. As a result, the stakes are higher, and the U.S. has accordingly dedicated an enormous military presence to ensure the unimpeded flow of oil—in the Persian Gulf and all across the globe. Our Commanders-in-Chief chose this mission not because they want America to be the world's oil police; they did so because America's thirst for oil leaves little choice.

Inefficient use and overreliance on oil burdens the military, undermines combat effectiveness, and exacts a huge price tag—in dollars and lives.

Supply lines delivering fuel and other supplies to forward operating bases can stretch over great distances, often requiring permission for overland transport through one or more neighboring countries. As these lines grow longer, and as convoys traverse hotly contested territory, they become attractive targets to enemy forces. A Defense Science Board (DSB) task force identified this movement of fuel from the point of commercial procurement to the point of use by operational systems and forces as a grave energy risk for DoD [35]. Ensuring convoy safety and fuel delivery requires a tremendous show of force. Today, armored vehicles, helicopters, and fixed-wing fighter aircraft protect the movement of fuel and other supplies. This is an extraordinary commitment of combat resources, and it offers an instructive glimpse of the true costs of energy inefficiency and reliance on oil.

More combat troops and assets must divert to protect fuel convoys rather than directly engage enemy combatants.

Let us be clear here: logistics operations and their associated vulnerabilities are nothing new to militaries; they have always been a military challenge. Even if the military did not need fuel for its operations, some amount of logistics supply lines would still be required to ensure our forces have the supplies they need to complete their missions. However, the fuel intensity of today's combat missions adds to the costs and risks. As in-theater demand increases, more combat troops and assets must divert to protect fuel convoys rather than directly engage enemy combatants. This reduces our combat effectiveness, but there is no viable alternative: our troops need fuel to fight.

The role of energy in impeding military effectiveness has been demonstrated clearly in recent U.S. engagements. When American troops advanced on Baghdad in 2003, highly mobile American forces crossed Iraq with great speed of maneu-

Voices of Experience

VICE ADMIRAL RICHARD H. TRULY, USN (RET.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

On DoD's Efficiency Needs

Having served as commander of the space shuttle, retired Vice Admiral Richard Truly has traveled great distances on a single tank of fuel. His views on energy, however, are shaped by his time as Director of the National Renewable Energy Laboratory, and by a clear sense of how America's energy choices affect troops on the ground. He believes the fastest gains for the U.S. military will come from a focus on energy efficiency.

This issue "is well recognized by a lot of the troops. They've seen friends getting hurt because of poor energy choices we've made in the past."

"Efficiency is the cheapest way to make traction," Adm. Truly said. "There's a thousand different ways for the military to take positive action. And these are things that can help them from a war-fighter's point of view and also make things cheaper in the long run.

"You can see the need by what we've done in Iraq and Afghanistan on logistics," he said. "We've put inefficient systems very deep into these regions. And as a result, we end up with long lines of fuel trucks driving in. And we have to protect those fuel trucks with soldiers and with other vehicles."

Truly says this issue "is well recognized by a lot of the troops. They've seen friends getting hurt because of poor energy choices we've made in the past." But he sees key obstacles in the way of change.

"The Defense Department is the single largest fuel user in the country, but if you compare it to the fuel used by the American public, it's a piker," Adm. Truly said. "When you think of the companies that make heavy vehicles, DoD is an interesting customer to them, but it's not how they make their money. These companies are in the business of selling large numbers of commercial vehicles. So even if our military wants a new semi with a heavy-duty fuel-efficient diesel engine, it's not likely to happen unless there is enough interest from other sectors to justify mass production. The real demand, if it exists, comes from the other 99 percent of users. That's the rest of us. The real big market is the American people, and it's their attitude that needs to change."

Adm. Truly said a series of studies on energy use by the U.S. military hit their mark substantively, but may not have reached a broad enough audience.

"We're pressing DoD to do something that's very hard, and it's not something the Department can actually do totally on its own," he said. "If you go back to the first Defense Science Board report, we were targeting DoD, and describing changes they could make. But the problem goes well beyond DoD, and we didn't tell that story well enough. We didn't explain these issues to the trucking industry or the auto industry. We may need to do more of that."

He highlighted a reason for optimism, suggesting that the awareness of energy impacts will be reinforced by new members of the officer corps being commissioned from America's universities.

"On this subject, there have been huge changes that haven't caught up to the culture that I think eventually will," he said. "I spend my time looking at a lot of engineering schools around the country and dealing with them in different ways. 15 years ago, if you wanted to have a discussion on sustainability, you would have a hard time filling up a room with people who are knowledgeable about the concept or able to talk about the concept in sophisticated ways.

"If you go to any good engineering schools today, it's ingrained. Energy efficiency is second nature to them. If you go to the Naval Academy or M.I.T. or Georgia Tech today, you will find real interest in sustainability, environmental issues and energy-efficient design. They teach it, they talk about it, they understand it. Those who graduate and are commissioned into the officer corps are going to bring this knowledge with them."

ver. The broad battlespace in their wake required heavy security—the supply convoys bringing new supplies of fuel were constantly under threat of attack. The security measures necessary to defend this vast space slowed American movements and reduced the options available to Army and Marine field commanders. It prompted a clear challenge from Marine Lieutenant General James Mattis: "Unleash us from the tether of fuel" [36]. This situation plays out still in Afghanistan, where 3-mile fuel convoys are exposed as they crawl along dangerous mountainous routes.

Energy use in the battlespace is a complex matter and often runs counter to conventional wisdom. A study of the 2003 I Marine Expeditionary Force (I MEF) in Iraq found that only 10 percent of its ground fuel use was for the heavy vehicles that deliver lethal force, including M1A1 tanks, armored vehicles, and assault amphibious vehicles; the other 90 percent was consumed by vehicles—including Humvees, 7-ton trucks, and logistics vehicles—that deliver and protect the fuel and forces [37, 38]. It is the antithesis of efficiency: only a fraction of the fuel is used to deliver lethal force. A different study showed that, of the U.S. Army's top ten battlefield fuel users, only two (numbers five and ten on the list) are combat platforms; four out of the top ten are trucks, many of them used to transport liquid fuel and electric generating equipment [39].

The military uses fuel for more than mobility. In fact, one of the most significant consumers of fuel at forward operating bases in operations in Afghanistan and Iraq is not trucks or combat systems; it is electric generators [35, 117]. This demand is a function of what could be called the *electrification of combat*. Forward operating bases—staging grounds for direct military engagement—contain communications infrastructure, living quarters, administrative areas, eating facilities and industrial activities necessary to maintain combat systems. All of these require electricity. The electricity used to power these facilities is provided by towed-in generators fueled by JP-8, the same fuel used by combat systems. The fuel used by these generators comes from the same vulnerable supply chain that provides liquid fuel or motorized vehicles.

The use of electric power extends beyond the battlefield bases: an infantry soldier on a 72-hour mission in Afghanistan today carries more than 26 pounds of batteries, charged by these generators [40]. The weight of the packs carried by these troops (of which 20 to 25 percent can be batteries) hinders their operational capability by limiting their maneuverability and causing muscular-skeletal injuries [41]. Soldiers and marines may not be tethered directly to fuel lines, but they are weighed down by electrical and battery systems that are dangerously inefficient.

This demand is a function of what could be called the electrification of combat.

In 2006, while commanding troops in Iraq's Al Anbar province, Marine Corps Major General Richard Zilmer submitted an urgent request because American supply lines were vulnerable to insurgent attack by ambush or roadside bombs. "Reducing the military's dependence on fuel for

GENERAL RONALD E. KEYS, USAF (RET.)

Former Commander, Air Combat Command

On Energy Efficiency and Mission Effectiveness

For retired Air Force General Ron Keys, former Commander of the Air Combat Command, energy conversations tend to have a very specific focus.

"My biggest concern is that it's got to be attached to the mission," said Gen. Keys. "That's what gives it legs. That's what we buy the military for—to go and fight and win America's wars when we call upon them to do so. So this has got to be about accomplishing the mission faster, better, cheaper—but accomplishing the mission."

"The basic question is: do I have enough fuel to get where I need to go, do my mission, and come back home?"

He says fuel efficiency is central to the mission of the United States Air Force.

"It's a numbers game for the Air Force," said Gen. Keys. "You balance things like speed, range, payload and persistence. These are survivability and lethality issues. The basic question is: do I have enough fuel to get where I need to go, do my mission, and come back home?

"Let's say you have a combat air patrol (CAP) of six planes flying with tanker support. You might have two planes at the tanker, two flying to or from the tanker, and two in the CAP. If you get more efficient and the planes can stay out longer, you might be able to man it with four planes. You might fly it without a tanker. You benefit because you want to make that operation less complicated, you want to deploy quicker and lighter. You want to be less susceptible to something the enemy or the weather might do to disrupt your plan – but in the end, you are going to put on station the jets you need to accomplish the mission."

Gen. Keys says the military can push for efficiency on a wide range of fronts.

"At peacetime military installations, it seems to me right now we can use off-the-shelf products," Gen. Keys said. "Better lighting, slow speed and hybrid vehicles, metering for buildings, insulation, better peak use tools, better partnering with companies and communities—we can do these things now, across the board. Some of these can be adapted for expeditionary use. Every drop of fuel you don't use due to more efficient deployed grids, more efficient insulation or more efficient lighting translates into fuel you don't have to buy, store, convoy, and protect.

"The imperative is to properly fund (not just mandate), scale fast across the force, and plow the savings back into completing the change-over. It's important that the people making the hard choices and working the shortages see some benefit from their work to save costs.. and that benefit has to be efficient mission effectiveness. There is a lot of talk about changing the culture, but the culture is not just people. It is just as much about the budget process itself, how we calculate investment payback, what rules impede innovation, and how we set priorities. That often gets overlooked in the hoopla of the moment and ends up on the backs of our people at the operating level.

"It's a lot tougher with tactical systems. They are expensive, are with the force for 30 or more years, and you can only do so much with the turbines and diesels you have. Even if you had the technology in hand today, it will take decades to replace the legacy force. The key is that you have to plan for it and pay for it upfront."

power generation could reduce the number of road-bound convoys," he said, adding that the absence of alternative energy systems means "personnel loss rates are likely to continue at their current rate. Continued casualty accumulation exhibits potential to jeopardize mission success" [42]. In response, the Army dispatched its Rapid Equipping Force, which concluded that energy efficiency measures would produce the deepest, fastest and most cost-effective reductions in electricity, and hence fuel, demand [43]. It would reduce risks and save lives. The DSB came to the same conclusion, issuing stark warnings about the burden of fuel in two reports in 2001 and 2008 [35, 44].

In addition to burdening our military forces, over-reliance on oil exacts a huge monetary cost, both for our economy and our military. The fluctuating and volatile cost of oil greatly complicates the budgeting process within the Department: just a $10 change in the per-barrel cost of oil translates to a $1.3 billion change to the Pentagon's energy costs [45]. Over-allocating funds to cover energy costs comes with a high opportunity cost as other important functions are under-funded; an unexpected increase results in funds being transferred from other areas within the Department, causing significant disruptions to training, procurement and other essential functions[2].

In addition to buying the fuel, the U.S devotes enormous resources to ensure the military receives the fuel it needs to operate. A large component of the logistics planning and resources are devoted to buying, operating, training, and maintaining logistics assets for delivering fuel to the battlefield—and these delivery costs exceed the cost of buying the commodity. For example, each gallon of fuel delivered to an aircraft in-flight costs the Air Force roughly $42 [35]; for ground forces, the true cost of delivering fuel to the battlefield, while very scenario dependent, ranges from $15 per gallon to hundreds of dollars per gallon [35]. A more realistic assessment of what is called the "fully burdened price of fuel" would consider the costs attributable to oil in protecting sea lanes, operating certain military bases and maintaining high levels of forward presence. Buying oil is expensive, but the cost of using it in the battlespace is far higher.

Buying oil is expensive, but the cost of using it in the battlespace is far higher.

U.S. dependence on fossil fuels undermines economic stability, which is critical to national security

The volatile fossil fuel markets have a major impact on our national economy, which in turn affects national security. Upward spikes in energy prices—tied to the wild swings now common in the world's fossil fuel markets—constrict the economy in the short-term, and undermine strategic planning in the long-term. Volatility is not limited to the oil market: the nation's economy is

[2] This is a problem that is not unique to the Department of Defense: for American Airlines, every $10 increase in the per-barrel cost of oil adds an additional $800 million to its annual fuel costs; for the aviation industry as a whole, the increase amounts to $16 billion [46].

also wrenched by the increasingly sharp swings in price of natural gas and coal. This volatility wreaks havoc with government revenue projections, making the task of addressing strategic and systemic national security problems much more challenging. It also makes it more difficult for companies to commit to the long-term investments needed to develop and deploy new energy technologies and upgrade major infrastructure.

A significant and long-lasting trade deficit can put us at a disadvantage in global economic competitions. In 2008, our economy paid an average of $28.5 billion each month to buy foreign oil [47]. This amount is expected to grow: while oil prices wax and wane periodically, in the long term, oil prices are trending upward [48]. This transfer of wealth means America borrows heavily from the rest of the world, making the U.S. dependent economically.

We are also dependent economically on a global energy supply market increasingly susceptible to manipulation. In recent years, even the smallest incident overseas, such as just a warning of pipeline attack from the MEND in Nigeria, has caused stock markets to roil and oil prices to jump. Perhaps most worrisome in regard to the manipulation of the global oil trade are the critical chokepoints in the delivery system: 40 percent of the global seaborne oil trade moves through the Strait of Hormuz; 36 percent through the Strait of Malacca, and 10 percent through the Suez Canal [49]. The economic leverage provided by the Strait of Hormuz has not been lost on Iran, which has employed the threat of closing down the shipping lane to prevent an attack on its nuclear program [50]. The probability of Iran performing such an action is far from certain: the U.S. national security establishment would work to ensure that the Strait would not be closed for a significant period of time; additionally, such an action would have severe consequences for Iran (including the crippling of its military forces and the loss of oil export revenues and key coastal facilities) [51]. However, security experts believe that if Iran were to choose an irrational path by taking action against the open flow of trade through the Strait, even a temporary disruption would have serious consequences for the global economy [52, 53, 54].

When economies are troubled, domestic strife increases, prospects of instability increase, and international leverage diminishes.

There is a more general economic point to consider as well. Nations with strong economies have the advantage in foreign policy and global leadership. China and India offer a clear example: their rise in global influence in recent years has been concurrent with their growing economies. For the U.S., our economic might and easy access to natural resources have been important components of national strength, particularly over the last century. They have also allowed us to use economic aid and soft power mechanisms to retain order in fragile regions—thereby avoiding the need to use military power. When economies are troubled, domestic strife increases, prospects of instability increase, and international leverage diminishes. This is why the discussions of energy and economy have been joined,

and is why both are matters of national security. Choices made to support our economy will affect our national security; these decisions should be made deliberately.

A fragile domestic electrical grid threatens our security

Our vulnerabilities from energy use are not limited to battlefields and forward operating bases; they also exist at home. The biggest impacts may be local, but can extend to locations and operations around the world.

In August 2003, 50 million people living in the Northeast, Midwest, and Ontario were suddenly left in the dark when their electric power failed. More than 500 generating units at 265 power plants shut down—a quiet collapse cascading across the landscape. Most homes and businesses regained power within a day (though some plants took two weeks to regain full capacity), a quick restoration that was possible primarily because no significant equipment was damaged. Still, critical national security systems failed. U.S. border check systems were not fully operational, causing a severe backup of truck traffic on our northern boundary. There were related effects from the outage as well. Water and sewage plants shut down. Gas stations stopped working, and rail service was curtailed. Many cellular phone providers, radio stations, and television stations lost service—their backup power systems were insufficient. The blackout is estimated to have caused economic losses of $7 to $10 billion [55]. The trigger for this massive blackout was tragically simple: An Ohio utility had failed to properly trim trees near a power line [56].

These installations are almost completely dependent on commercial electrical power delivered through the national electrical grid.

American utilities have experience responding to interruptions caused by extreme weather. Even after severe ice storms and hurricanes, power is most often restored within a few days. But the effects of a long-term power outage are unknown. Our ability to recover from a dedicated attack is also not known—except to say that a deliberate attack would require a different response.

There have been numerous attacks on the operating systems of major critical infrastructure facilities, including power grids, around the world in recent years:

- In one instance outside the U.S., a power outage was triggered that affected multiple cities; in other instances, hackers have extorted hundreds of millions of dollars out of their victims [57, 58].
- Foreign cyber spies are also a serious concern: U.S. Homeland Security and Intelligence officials revealed that Chinese and Russian spies have "penetrated the U.S. electrical grid" and left behind dormant but malicious software [59].
- In 2007, the discovery of what is now known as the "Aurora threat" revealed the possibility that sophisticated hackers could seriously dam-

GENERAL PAUL J. KERN, USA (RET.)

Former Commanding General, U.S. Army Materiel Command

On the Vulnerability of Energy Inefficiency

In 1991, General Paul Kern commanded the Second Brigade of the 24th Infantry Division in its advance toward Baghdad—a sweeping left hook around Kuwait and up the Euphrates River Valley. It involved moving 5,000 people, plus materiel support, across 150 kilometers of desert. The route covered more ground than the Red Ball Express, which moved materiel across the Western European front in World War II.

"As we considered the route and began planning, our biggest concern was not our ability to fight the Iraqis; it was keeping ourselves from running out of fuel," Gen. Kern said. "We also made a decision to never let our tanks get below half full, because we didn't want to refuel in the middle of a fight."

"When the power goes out here, or if we have a lengthy collapse of the grid, that flow of materiel affects our troops in important ways."

Meeting this commitment, given the fuel inefficiency of the Abrams tank, required stopping every two and a half hours. Fueling was done with 2,250-gallon HEMMT fuel tankers, which in turn were refueled by 5,000-gallon line-haul tankers (similar to those seen on U.S. highways).

"We set up and moved out in a tactical configuration, and were ready to fight whenever necessary," Gen. Kern said. "To refuel, we would stop by battalions and companies. As we advanced, we laid out a system with roughly 15 stations for refueling. This was occurring almost continuously. We did it at night in a blinding sandstorm—having rehearsed it was key."

The vulnerability of these slow-moving, fuel-intense supply lines has made Gen. Kern a strong advocate for increasing fuel efficiency in military operations. "The point of all this is that the logistics demands for fuel are so significant. They drive tactical planning. They determine how you fight. More efficiency can give you more options. That's what you want as a commander."

Gen. Kern used a different example—the 2003 northeast power outage, when 50 million people lost electric power—to highlight another energy impact on military operations.

"I was running the Army Materiel Command," Gen. Kern said. "We had a forward operation in Afghanistan, which would forward all the requisitions back here. They had a generator and a satellite radio to talk, but when the outage hit here in the U.S., they had no one to talk to. We quickly came up with back-up plans, but it showed me the vulnerability of the infrastructure here to support a deployments.

"In some cases, the need to communicate with supply depots is day-to-day. The Afghan operation then was very fragile. Access was very important. Everything was getting flown in, and because you couldn't get a lot in with each trip, we wanted a continuous flow. That's a factor in agility—if you have less materiel on the ground, you can be more agile. But with the limited supplies, you do want to be in constant contact. You want that continuous flow. When the power goes out here, or if we have a lengthy collapse of the grid, that flow of materiel affects our troops in important ways."

Gen. Kern said agility (and continuous communications) will be increasingly important.

"If you think of humanitarian relief, you don't know what the community needs. You can't know that in advance, so you have to be agile. The same is true with asymmetrical threats—you don't know what you'll face. You build strong communications networks to help you respond quickly—that's the planning you can do in advance. But these networks depend, for the most part, on our power grids. That's a vulnerability we need to address."

age the grid by destroying mechanisms downstream from the initial point of attack. Aurora involves opening and quickly closing a high voltage circuit breaker, which can result in an out-of-synchronism condition that can physically damage rotating equipment connected to the power grid [60-63].

At military installations across the country, a myriad of critical systems must be operational 24 hours a day, 365 days a year. They receive and analyze data to keep us safe from threats, they provide direction and support to combat troops, and stay ready to provide relief and recovery services when natural disasters strike or when someone attempts to attack our homeland. These installations are almost completely dependent on commercial electrical power delivered through the national electrical grid. When the DSB studied the 2003 blackout and the condition of the grid, they concluded it is "fragile and vulnerable... placing critical military and homeland defense missions at unacceptable risk of extended outage" [35].

As the resiliency of the grid continues to decline, it increases the potential for an expanded and/or longer duration outage from natural events as well as deliberate attack.

As the resiliency of the grid continues to decline, it increases the potential for an expanded and/or longer duration outage from natural events as well as deliberate attack. The DSB noted that the military's backup power is inadequately sized for its missions and military bases cannot easily store sufficient fuel supplies to cope with a lengthy or widespread outage. An extended outage could jeopardize ongoing missions in far-flung battle spaces for a variety of reasons:

- The American military's logistics chains operate a just-in-time delivery system familiar to many global businesses. If an aircraft breaks down in Iraq, parts may be immediately shipped from a supply depot in the U.S. If the depot loses power, personnel there may not fill the order for days, increasing the risk to the troops in harm's way.

- Data collected in combat zones are often analyzed at data centers in the U.S. In many cases, the information helps battlefield commanders plan their next moves. If the data centers lose power, the next military move can be delayed, or taken without essential information.

- The loss of electrical power affects refineries, ports, repair depots, and other commercial or military centers that help assure the readiness of American armed forces. When power is lost for lengthy periods, vulnerability to attack increases.

President Obama, Congress, and major utilities, among others, are discussing an upgrade of the national electrical grid for a variety of reasons. We add our voice to this discussion with a singular perspective: we see that our national security is directly linked to the security and reliability of our system of energy production and delivery.

GENERAL GORDON R. SULLIVAN, USA (RET.)

Former Chief of Staff, U.S. Army; Former Chairman of the CNA MAB

On the Connections Between Energy, Climate, and Security

Former U.S. Army Chief of Staff General Gordon R. Sullivan served as chairman of the Military Advisory Board that released *National Security and the Threat of Climate Change*. He started that process with little connection to the issue of climate change, but the briefings have stayed with him. He keeps reaching out for new information on the topic.

> *"There is a relationship between the major challenges we're facing. Energy, security, economics, climate change—these things are connected."*

"What we have learned from the most recent reports is that climate change is occurring at a much faster pace than the scientists previously thought it could," Gen. Sullivan said. "The Arctic is a case-in-point. Two years ago, scientists were reporting that the Arctic could be ice-free by 2040. Now, the scientists are telling us that it could happen within just a few years. The acceleration of the changes in the Arctic is stunning.

"The climate trends continue to suggest the globe is changing in profound ways," Gen. Sullivan said. He noted that these lead indicators should be enough to prompt national and global responses to climate change, and referenced military training to explain why. "Military professionals are accustomed to making decisions during times of uncertainty. We were trained to make decisions in situations defined by ambiguous information and little concrete knowledge of the enemy intent. We based our decisions on trends, experience, and judgment. Even if you don't have complete information, you still need to take action. Waiting for 100 percent certainty during a crisis can be disastrous."

Gen. Sullivan said the current economic crisis is not a reason to postpone climate solutions.

"There is a relationship between the major challenges we're facing," Gen. Sullivan said. "Energy, security, economics, climate change—these things are connected. And the extent to which these things really do affect one another is becoming more apparent. It's a system of systems. It's very complex, and we need to think of it that way.

"And the solutions will need to be connected. It will take the industrialized nations of the world to band together to demonstrate leadership and a willingness to change—not only to solve the economic problems we're having, but to address the issues related to global climate change. We need to look for solutions to one problem that can be helpful in solving other problems. And here, I'd say the U.S. has a responsibility to lead. If we don't make changes, then others won't."

Gen. Sullivan tends to keep his discussions of climate change focused on the national security aspects. But he occasionally talks about it from a different perspective, and describes some of the projected changes expected to hit his native New England if aggressive measures are not embraced.

"I have images of New England that stick with me," Gen. Sullivan said. "Tapping sugar maples in winter. Fishing off the Cape. These were images I held close when I was stationed overseas. They were important to me then. And they are important to me now when I think of how we'll respond to climate change. Those treasures are at risk. There's a lot at stake."

Chapter 2

America's Energy Future: The National Security Risks of Business as Usual

The national security risks of our current energy posture provide clear and compelling reasons to change our national and military approach to energy. Economic crises will come and go, U.S. energy demands will increase, the volatile cycle of fuel prices will become sharper and shorter, and without immediate action to address our nation's long-term energy profile, the national security risks associated with the nation's and the military's current energy posture will worsen.

Continuing our heavy reliance on these fuels is a security risk.

Confronting this challenge is paramount for the military; achieving the endstate will require a national approach. Replacing one limited fuel source with another will not give Americans the lasting security they expect and deserve. This is true because many of the alternatives that currently appear within reach may pose a new set of problems—and could come with their own set of security risks

This new approach must be based on a realistic assessment of our energy options and on the realities of a changing climate. The converging risks associated with future energy choices include:

- The market for fossil fuels will be shaped by finite supplies and increasing demand. Continuing our heavy reliance on these fuels is a security risk.
- Regulatory frameworks driven by climate change concerns will increase the costs—both economic and geopolitical—of using carbon-based fuels.
- Destabilization driven by ongoing climate change has the potential to add significantly to the mission burden of the U.S. military in fragile regions of the world.

In our view, confronting these converging risks is critical to ensuring America's energy-secure future.

The market for fossil fuels will be shaped by finite supplies and increasing demand. Continuing our heavy reliance on these fuels is a security risk.

Despite the global economic downturn that began in the fall of 2008, U.S. and worldwide energy demand is expected to increase dramatically in the coming decade. If the U.S. continues on a business as usual trajectory, meeting future U.S. energy demands will require much more power capacity. The Pacific Northwest National Laboratory (PNNL), a research arm of the Department of Energy (DOE), analyzed future energy scenarios, including a business as usual projection that assumed the U.S. and other industrial nations did not adopt mandatory caps on carbon or institute meaningful carbon pricing mechanisms. This scenario projects greater reliance on the same composition of fuels currently used today, but on a

much broader scale. Even allowing for additional generation capacity, the PNNL analysis confirms that the energy security concerns of our current energy posture worsen significantly, due to a long-term upward trend in prices, short-term fluctuations in price, and uncertain availability.

The demand for oil is expected to increase even as the supply becomes constrained. A 2007 Government Accountability Office (GAO) report on peak oil, which considered a wide range of studies on the topic, concluded that the peak in production is likely to occur some time before 2040 [64]. While that 30-year timeframe may seem long to some, it is familiar to military planners, who routinely consider the 30- to 40-year life span of major weapon systems. According to the International Energy Agency (IEA), most countries outside of the Middle East have already reached, or will soon reach, the peak of their oil production [65]. This includes the U.S., where oil production peaked in 1970.

The wild fluctuations in oil prices during 2008 have been noted previously, but the fluctuations in other fossil fuel prices are also troubling.

Just how constrained will oil supplies be? A November 2008 article by Fatih Birol, the IEA's chief economist, outlined what it will take just to make up for the declining production in today's oil fields, which Birol describes as "just standing still" [66]. Continuing to produce 85 million barrels of oil for the next 22 years will require 45 million barrels per day of new production. "That means four Saudi Arabias," according to Birol. When an increase in demand is factored in, he says meeting demand will require finding the equivalent of an additional two more Saudi Arabias. This strain on production capacity suggests intense competition.

Other fossil fuels will face similar pressures. The wild fluctuations in oil prices during 2008 have been noted previously, but the fluctuations in other fossil fuel prices are also troubling. The average domestic natural gas wellhead price doubled in the nine months before July 2008 [67]. Coal saw even bigger spikes. The average spot price for Central Appalachia (CAP) coal in November 2007 was less than $50 per short ton. The spot price for CAP in August 2008 hit $140 per short ton, nearly tripling in only 9 months [68]. The global recession has driven oil, coal, and gas prices back down, but the growing demand means the long-term pricing trend is an upward one. In the absence of policies or legislation that would limit the growth of coal use, the U.S., China, and India are expected to rely more heavily on coal. In fact, China has already doubled its coal use in this current decade [69].

The increased prices, volatile markets, and uncertain access to these fuels make them an unsafe bet as the primary fuels to drive our economy and our defense efforts. There are also additional costs associated with fossil fuel impacts that cannot be ignored: The coal fly ash slurry spill that occurred in December 2008 in Tennessee, which covered 300 acres with sludge that in some areas is 9 feet thick, may cost up to $825 million to clean up [70].

Regulatory frameworks driven by climate change concerns will increase the costs—both economic and geopoliticalof using carbon-based fuels.

A global consensus on the need for responses to climate change is leading governments to embrace policies designed to discourage the use of fossil fuels, increase efficiency, and advance the development of alternatives. This trend, already underway, will continue. Even with the current recession, the pace of this trend is likely to quicken.

Regardless of whether or not America leads such a trend, it appears inevitable that regulatory constraints on the use of carbon-based fuels will expand significantly.

In February 2009 testimony before Congress, Admiral Dennis Blair, the Director of National Intelligence, suggested that the U.S. will be expected to play a leading role in this regulatory advance [71].

> "Multilateral policymaking on climate change is likely to be highly visible and a growing priority among traditional security affairs in the coming decades. We observe the United States is seen by the world as occupying a potentially pivotal leadership role between Europe, which is committed to long-term and dramatic reduction in carbon emissions, and a heterogeneous group of developing states wary of committing to greenhouse gas emissions reductions, which they believe would slow their economic growth. As effects of climate change begin to mount, the United States will come under increasing pressure to join the international community in setting meaningful long-term goals for emissions reductions, to reduce its own emissions, and to help others mitigate and adapt to climate change through technological progress and financial assistance."

His testimony highlighted the risks to the U.S. of being a policy outlier in the global climate change discussions. These risks are significant, but we note an even simpler calculation: regardless of whether or not America leads such a trend, it appears inevitable that regulatory constraints on the use of carbon-based fuels will expand significantly. When this comes to pass, there will be additional financial costs associated with carbon emissions at some point in the foreseeable future. The timing and the details of this change are uncertain, but regulatory changes will happen. This regulatory cost will make use of carbon-based fuels less economically competitive compared to alternatives. If our defense agencies continue their reliance on carbon-based fuels, their costs will be driven higher.

These factors—the finite supply of fossil fuels, the increasing demand for fossil fuels, expected regulatory costs associated with carbon emissions—suggest the onset of a carbon-constrained global economy. This is the context in which America must consider a new approach to energy.

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (RET.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

On Finding the Points of Agreement

When retired Air Force Lieutenant General Larry Farrell is involved in a discussion of climate change, chances are good that he'll turn it into a discussion of energy efficiency. He does this deliberately. Rather than focus on a topic that might get stuck on differences of opinion, Gen. Farrell would rather talk about solutions.

"Military guys tend to be experts in fairly narrow topics," Gen. Farrell said. "I was a fighter pilot, and if somebody asked me about fighter operations, we could have a good conversation. But even at that, I was careful not to get into topics I didn't know. And that's what a lot of military guys do. They stay within the bounds, they're professional, and they don't say things they can't back up. You're not going to reach them or get them really engaged if you stay on topics that are pretty far removed from what they know and what the American people expect them from us.

"But we all understand the energy equation. Military guys are conversant with it, so why not focus on the points of agreement?"

Farrell pushes hard for energy efficiency, with a long list of reasons that have nothing to do with climate change. He says fuel efficiency would increase the ratio of shooters to support personnel on the battlefield, allow us to import less oil from nations that don't like us, and reduce pressure on the military to remain involved in oil-developing regions.

"And these commanders have a budget for energy use for their installations and vehicles," Gen. Farrell adds. "They have to pay for everything, so they can see the financial incentive for being more efficient in electricity, heating, lighting and use of petroleum in vehicles."

Farrell says the military can be an excellent proving ground for new energy technologies, including smart grids, plug-in hybrid installations, distributed power generation and large-scale energy production. Picking individual bases to serve as prototypes for different projects quickens the learning.

"I like prototypes that you can clearly define, and you're pretty sure you can get some benefit out of it. You don't need to spend a lot of money on it, but you can gel a lot our of it. We learn a lot about an airplane when operators start using it. They use it in ways the designers didn't consider, and get it outside its envelope. We can get that same kind of learning from operators on bases."

Farrell pushes hard for energy efficiency, with a long list of reasons that have nothing to do with climate change.

He suggested another way to enhance learning at bases.

"I think you can make this competitive. If we set aside a pot of money for building rehab, you can let the installations compete for it on the basis of improved energy efficiency. You can set a minimum percentage savings, but will likely get something higher, because the best proposals get the money." He says that if base commanders can retain the savings on their base, they'll find ways to innovate. And those innovations can be replicated at other bases.

"These guys are competitive anyway. They hate to lose. Why not use that to our advantage?"

Destabilization driven by ongoing climate change has the potential to add significantly to the mission burden of the U.S. military in fragile regions of the world.

Our 2007 report identified the national security risks associated with climate change [1]. Chief among the report's findings:

- Projected impacts of climate change pose a serious threat to America's national security.
- Climate change acts as a ***threat multiplier*** for instability in some of the most volatile regions of the world.
- Projected impacts of climate change will add to tensions even in stable regions of the world.
- Climate change, national security, and energy dependence are a related set of global challenges.

After this report, the National Intelligence Council produced its first National Intelligence Assessment (NIA) of the security threats associated with climate change. The NIA, finalized by the Bush Administration in June 2008, reinforced our finding that climate change is a serious threat to national security and long-term global stability.

The NIA draws many of the same conclusions we drew in our first report. According to Dr. Thomas Fingar, the former Chairman of the National Intelligence Council, the NIA stated that "global climate change will have wide-ranging implications for US national security interests over the next 20 years" [72]. The NIA finds that climate change impacts—including food and water shortages, the spread of infectious disease, mass migrations, property damage and loss, and an increase in the intensity of extreme weather events—will increase the potential for conflict. The impacts may threaten the domestic stability of nations in multiple regions, particularly as factions seek access to increasingly scarce water resources.

The impacts may threaten the domestic stability of nations in multiple regions, particularly as factions seek access to increasingly scarce water resources.

The NIA describes potential impacts on global regions. In describing the projected impacts in Africa, for example, it suggests that some rainfall-dependent crops may see yields reduced by up to 50 percent by 2020. In testimony before the U.S. Congress, Dr. Fingar said the newly established Africa Command "is likely to face extensive and novel operational requirements. Sub-Saharan African countries, if they are hard hit by climate impacts, will be more susceptible to worsening disease exposure. Food insecurity, for reasons both of shortages and affordability, will be a growing concern in Africa as well as other parts of the world. Without food aid, the region will likely face higher levels of instability, particularly violent ethnic clashes over land ownership."

This proliferation of conflicts could affect what Dr. Fingar described as the "smooth-functioning international system ensuring the flow of trade and market access to critical raw materials" that

Voices of Experience

GENERAL CHARLES G. BOYD, USAF (RET.)

Former Deputy Commander-in-Chief, Headquarters U.S. European Command (USEUCOM)

On Climate Change and Human Migrations

Retired Air Force General Chuck Boyd, former Deputy Commander-in-Chief of U.S. Forces in Europe, sees the effects of climate change in a particular context, one he came to understand while serving as executive director of the U.S. Commission on National Security/ 21st Century (commonly known as the Hart-Rudman Commission). The Commission's reports, issued in advance of the 9/11 terrorist attacks, predicted a direct attack on the homeland, noted that the risks of such an attack included responses that could undermine U.S. global leadership, and outlined preventative and responsive measures.

He explains this context by telling the story of a dinner at the home of the Japanese ambassador to the United Nations.

Climate change "is about instability. It is a destabilizing activity, with murderous consequences."

"When I was at EUCOM, I formed a friendship with the UN High Commissioner for Refugees, Madame Sadako Ogata," Gen. Boyd said. "I was seated next to her at this dinner. When I told her about the project, she said you cannot talk about security without talking about the movement of people. She said we had to come to Geneva to talk with her about it.

"She's this little bitty person with a moral presence that's overwhelming," said Gen. Boyd, after a pause. "She's a bit like Mother Teresa in that way. So we went—we went to Geneva.

"We spent the day with her and a few members of her staff pouring over a map of the world," he said. "We looked at the causes of dislocations—ethnic, national and religious fragmentation mostly. And we looked at the consequences. It was very clear that vast numbers of conflicts were being caused by these dislocations. She was very strategic in her thinking. And she made the point that this phenomenon—the movements of people—would be the single biggest cause of conflicts in the 21st century."

For Gen. Boyd, climate change is an overlay to the map of dislocations and conflicts provided by Madame Ogata.

"When you add in some of the effects of climate change —the disruption of agricultural production patterns, the disruption of water availability—it's a formula for aggravating, in a dramatic way, the problem and consequences of large scale dislocation. The more I think about it, the more I believe it's one of the major threats of climate change. And it's not well understood.

"As water availability changes, people who need water will fight with people who have water and don't want to share it. It's the same with agriculture. When people move away from areas that can't sustain life anymore, or that can't sustain their standard of living, they move to areas where they are not welcome. People will fight these incursions.

"Their interaction with different cultures causes tension. It's very much like the tension we see with religious fragmentation. It's the same pattern of consequences Madame Ogata was describing, only on a larger scale. This is about instability. It is a destabilizing activity, with murderous consequences."

is a key component of security strategies for the U.S. and our allies. A growing number of humanitarian emergencies will strain the international community's response capacity, and increase the pressure for greater involvement by the U.S. Dr. Fingar stated that "the demands of these potential humanitarian responses may significantly tax U.S. military transportation and support force structures, resulting in a strained readiness posture and decreased strategic depth for combat operations." In addition, the NIA cites threats to homeland security, including severe storms originating in the Gulf of Mexico and disruptions to domestic infrastructure.

The Intelligence Assessment underscores the importance to national security of U.S. leadership on both climate mitigation and adaptation issues.

The Intelligence Assessment underscores the importance to national security of U.S. leadership on both climate mitigation and adaptation issues. Dr. Fingar testified that "government, business and public efforts to develop mitigation and adaptation strategies to deal with climate change… may affect U.S. national security interests even more than the physical impacts of climate change itself." He said the issue of climate change will become a more prominent international issue, and the "U.S.'s leadership overall in the global arena will be judged by the extent to which it is perceived as forging a viable and effective global consensus for tackling climate change." America's role in this process moving forward will be scrutinized closely by friend and foe, with significant impact on our ability to negotiate and act in other international arenas.

Admiral Blair, in his February 2009 testimony, referenced the NIA and described some of the potential impacts of energy dependency and climate change:

> "Rising energy prices increase the cost for consumers and the environment of industrial-scale agriculture and application of petrochemical fertilizers. A switch from use of arable land for food to fuel crops provides a limited solution and could exacerbate both the energy and food situations. Climatically, rainfall anomalies and constricted seasonal flows of snow and glacial melts are aggravating water scarcities, harming agriculture in many parts of the globe. Energy and climate dynamics also combine to amplify a number of other ills such as health problems, agricultural losses to pests, and storm damage. The greatest danger may arise from the convergence and interaction of many stresses simultaneously. Such a complex and unprecedented syndrome of problems could cause outright state failure, or weaken important pivotal states counted on to act as anchors of regional stability."

Here, we reference some of the many ways climate change will adversely affect our military's ability to carry out its already challenging missions:

A changing Arctic forces a change in strategy. As the Arctic Ocean has become progressively more accessible, several nations are responding by posturing for resource claims, increasing military ac-

tivity, expanding commercial ventures, and elevating the volume of international dialogue. Due to the melting ice, the U.S. is already reconsidering its Arctic strategy [73]. The change in strategy will lead to a change in military intelligence, planning, and operations. The Arctic stakes are high: 22 percent of the world's undiscovered energy reserves are projected to be in the region (including 13 percent of the world's petroleum and 30 percent of natural gas [74]). There are also valuable fish stocks and mineral resources. The relatively small number of heavy ice breakers in operation by Arctic nations suggests that no country currently has the ability to easily operate in the region for purposes of maritime security, humanitarian assistance, disaster response or forward presence.

Damage to and loss of strategic bases and critical infrastructure. As sea level rises, storm waves and storm surges become much more problematic. Riding in at a higher base level, they are much more likely to overflow coastal barriers and cause severe damage. Recent studies project that, by the end of the century, sea levels could rise by nearly 1 meter [75, 76]. A 1-meter rise in sea level would have dramatic consequences for U.S. installations across the globe, including the loss of one of our most important forward operating bases: Diego Garcia in the Indian Ocean. At minimum, this amount of sea level rise would render it fully useless, without a single shot fired. Other significant military installations, such as Naval Station Norfolk, are at serious risk from rising seas. A 1-meter rise in sea level would also render useless numerous commercial and industrial installations that are important to ongoing military operations. If operations continue to be fuel-intensive, supply interruptions caused by loss of infrastructure could pose a serious threat to our troops.

Storm intensity affects readiness and capabilities. The projected increase in storm intensity can affect our ability to quickly deploy troops and materiel to distant theaters.

A 1-meter rise in sea level would also render useless numerous commercial and industrial installations that are important to ongoing military operations.

Increased conflict stretches American military. In other sections, we have noted the likelihood of increased global conflicts, which in turn increases the likelihood that American military forces will be engaging in multiple theaters simultaneously. In addition, at the very same time, there may be increased demands for American-led humanitarian engagements in response to natural disasters exacerbated or caused by climate change.

These factors will require substantial changes in military strategies and operations; these factors will add to the already significant challenges facing current and future military leaders. They are part of a confluence of circumstances that will reshape the context for action. The destabilizing nature of increasingly scarce energy resources, the impacts of rising energy demand, and the impacts of climate change all are likely to increasingly drive military missions in this century.

Chapter 3

Achieving Energy Security in a Carbon-Constrained World

Given the national security threats of America's current energy posture, a major shift in energy policy and practice is required. Given the interrelationship between energy and climate, it is critical that this shift be in the right direction.

Our nation's approach to energy and its approach to climate change have profound impacts on each other—and both have profound impacts on national security. There have always been linkages between energy and security, but these links are fundamentally different today than they were only decades ago. The energy intensity of contemporary society has reshaped them strategically; the energy intensity of contemporary warfare has reshaped them tactically. The climate crisis brings another layer of fundamental change. It will shape the security context for the remainder of this century and beyond. As military planners, we often focused on specific theaters—geographic areas where conflict is contained in ways that allow it, or require it, to be managed separately. Many Americans recall World War II references to the Pacific Theater and European Theater. Climate change introduces the notion of a global theater; its impacts cannot be contained or managed regionally. It changes planning in fundamental ways. It forces us to make changes in this new, broader context.

Planning for a new energy future

To achieve energy security in a carbon-constrained world, the U.S. must pursue energy choices that protect the immediate needs of American forces and the interests of America and her allies. This should be done in a context shaped by the long-term regulatory adjustments accompanying climate change and the long-term trend toward climate policies. Any changes in our approach should be judged by the extent to which they support or interfere with adaptation efforts. Changes should also be judged by the extent to which they support or contradict domestic and international climate policies.

There have always been linkages between energy and security, but these links are fundamentally different today than they were only decades ago.

Given the risks outlined earlier, diversifying our energy sources and moving away from fossil fuels where possible is critical to our future energy security. So too, any major shift in energy policy must consider the impact on our national approach to climate change. Some energy choices could contradict future national climate goals and policies, which should lead us to avoid such energy options. Developing coal-to-liquid (CTL) fuels for the U.S. Air Force is a useful example. Because of America's extensive coal resources, turning coal into liquid aviation fuel is, on the surface, an attractive option to make the nation more energy independent. However, unless cost-effective and technologically sound means of sequestering the resulting carbon emissions are developed, producing liquid fuel from coal would emit nearly

twice as much carbon as the equivalent amount of conventional liquid fuel[3]. As regulatory frameworks are shaped to increase the costs of carbon-intensive energy, a strategy of investing heavily in CTL would burden the military with uncertain future economic penalties and drive their long-term energy posture away from that of the rest of the nation. By focusing on energy security and the direction of climate change regulations, U.S. leaders can ensure that policies not only avoid contradiction, but are mutually supportive.

By focusing on energy security and the direction of climate change regulations, U.S. leaders can ensure that policies not only avoid contradiction, but are mutually supportive.

What does that new energy future look like? It will have a number of features, including:

- *Diversity.* Electricity produced with sources like wind, solar, and geothermal power would produce substantially more of our nation's electricity than today. Solar thermal facilities (these not only generate electricity during sunlight hours, they heat liquids that can be used to power steam generators at night) offer a current example of how the intermittency of some renewable sources can be overcome. Additional low carbon solutions, such as nuclear energy, will also be part of a diversified energy portfolio.

- *Stability.* Because the sources of these renewable energy technologies are free and abundant—in the U.S. and in many regions around the world—they would bring stability to our economy. This is quite the opposite of the current crude oil, coal, and natural gas markets, which are highly unstable.

- *Smarter use of energy resources.* The wide-scale adoption of "smart grid" technologies (such as advanced electricity meters that can indicate which household appliances are on and communicate that information back to the grid) would allow power to be used with maximum efficiency, be able to heal the grid in the event of natural disasters and cyber attacks, and allow for all sources of electricity to provide power to the grid [78].

- *Reliability.* A unified electrical grid designed around distributed generation nodes and outfitted with the proper technology would provide greater consistency of electrical power. It would assure sources of power necessary to protect our homeland and support deployments.

- *Electrification of ground transport.* Relying on transport vehicles powered largely with electricity derived from this low carbon sector, such as plug-in hybrids, would reduce America's need for imported oil for use in transportation. Some studies show that plug-in hybrids and a renewable energy sector could give consumers (which could include DoD) the equivalent of $1 per gallon gasoline [79].

[3] In converting coal to liquid fuel, carbon is emitted at two stages: first, during the conversion process, and second, when the liquid fuel is combusted. The total carbon emitted during the processing and combustion is approximately 1.8 times the amount emitted when converting and combusting gasoline or diesel made from conventional crude oil [77].

- *Bio-based mobility fuels*. For mobility applications that are likely to require liquid fuels into the foreseeable future—including aviation and military operations—non-food-based biofuels would be employed that are made with materials and processes that do not tax productive farmlands. To ensure that domestically produced fuel does not need to be transported to theaters of military operations, these bio-based fuels would be designed to match the specifications of military fuels (such as JP-8). In the interim, significant gains in mobility efficiency could make liquid petroleum fuels more available and affordable to the military when or if it is needed.

Such an energy future would enhance our national security. If Americans lead the way in building such a future, this energy future would also enhance America's economic security.

Achieving this energy future would not require unlikely or impossible technological leaps, and need not take many decades. (In the above description, only the bio-based fuels for military application have a long-term development horizon.) A U.S. Department of Energy study indicated that 20 percent of America's electrical supplies could come from wind power by 2030 [80]. Similar, but less aggressive, growth curves can be projected for utility-scale solar power generation. Google, which has experience in scaling new technologies, reports that the U.S. can generate nearly all of its electrical power from non-carbon sources by 2030 [81]. While renewable energy generating plants currently cost more than their fossil counterparts, renewable energy production is expected to become competitive with traditional electricity sources as the manufacturing industry matures, markets expand, and the regulatory framework to govern carbon emissions is implemented [80, 82].

Achieving this energy future would not require unlikely or impossible technological leaps, and need not take many decades.

No matter what strategy is adopted to upgrade the national electrical grid, it is clear that a certain amount of investment will be required: in 2030, the U.S. Department of Energy projects that domestic electricity demand will be 29-percent higher than today's levels [65]. To meet this increased demand, new power plants will have to be built and additional transmission and distribution stations will be necessary.

So how much will the grid upgrade cost? Studies have indicated that a business as usual approach to maintaining America's electrical infrastructure (that is, no smart grid upgrades and limited investment in new technologies) would require a total investment in the range of $1.5 to $1.7 trillion by 2030 [65, 83]. Adding efficiency improvements and smart-grid technologies (such as advanced meters) do not cause the price to vary greatly from these estimates as the addition of efficiency improvements negates the need to build new generating capacity. A heavy focus on renewables, however, could increase the total investment to $2.0 to $2.5 trillion [81, 83].

These investments, however, will generate economic returns. According to Google, 75 per-

GENERAL ROBERT MAGNUS, USMC (RET.)

Former Assistant Commandant of the U.S. Marine Corps

On Moving Away From Fossil Fuels

Retired General Robert Magnus, former Assistant Commandant of the Marine Corps, says there are many opportunities for our military to lead the way on energy innovations, but he makes it very clear that there are limits to that role.

"This discussion has to be about having the smartest and most efficient use of energy to do the military missions," Gen. Magnus said. "Sound business decisions regarding energy—particularly using positive incentives for the up-front investments—cannot detract from unit and equipment readiness, installations, or the well being of our troops and families. That's the starting point. But we quickly see we can do more. We can improve our long-term effectiveness by relying less on fossil fuels or by improving incentives for commanders to adopt new technologies and practices. The military can break new ground on energy and efficiency, but it needs to do so as a contribution to current and future readiness and capabilities. This is what matters."

He says the basis for military planning in this area should be a clearly formulated strategic vision—the kind that can only come from the Commander-in-Chief.

"We can improve our long-term effectiveness by relying less on fossil fuels or by improving incentives for commanders to adopt new technologies and practices."

"Where does he want us to be in ten, fifteen or twenty years? That kind of vision looks beyond a presidency, but is not so many years out that no one pays attention to it. It can evoke grand plans. It can be a real stretch, the kind that forces innovation and forces risk. I'd like to see an uplifting challenge for us, and that's something this President obviously understands. It would be a lot of hard work for the military, but it doesn't have to be a slog—just a lot of good, hard work.

"I think we could use some very specific goals for a ten-year time frame," Gen. Magnus added, launching into a discussion of potential goals.

"Islanding some major bases is a great idea," Magnus said. "You want to make sure that, in a natural or man-made disaster, the basic functions of an electrical grid can be conducted from a military installation. That's a great idea. And a great challenge. And you can not only island, but be in a position where you can take energy from the grid when needed, and deliver energy back to the grid when you have a surplus. There will be tremendous resistance from the public utilities, so we need to find a way for everyone to benefit.

"Working with fuel cells is another great idea for the military. If there is an earthquake in Pakistan, and you deploy 400 troops, you need electricity to support the mission. You need electricity to support the community. If we start using fuel cell technologies, they can help in places like this."

Gen. Magnus also says climate change—preparing for it or trying to stave off the worst effects—presents major challenges for the American military.

"We can debate when the impacts will occur and how big they will be, but there will be impacts," Gen. Magnus said. "It's going to change the shorelines. It's going to change the amount of snowmelt from mountains and glaciers. Some areas will experience increased rainfall, and some will experience increased drought. These are destabilizing events, even if they happen slowly. People in marginal economic areas will be hardest hit—and guess where we send our military?

"The more instability increases, the more pressure there will be to use our military," he said. "That's the issue with climate change. The U.S. is all about preventing big wars by managing instability. But as populations get more desperate, the likelihood of military conflicts will go up. We'll have to cope with the ill effects of climate change."

cent of the investment cost would be made up through: increased efficiency, avoided cost of building fossil-generating plants, and avoided cost of fossil fuels; in fact, the savings from energy efficiency improvements nearly offset the entire cost of building the new renewable energy power plants [81].

It will require the active and consistent participation of all Americans.

The transition to a vehicle fleet that depends heavily upon electricity will take some time. At present turnover rates, replacing the vehicle fleet would take approximately 15 years [84]. However, the gains from electrified vehicles could be substantial. Google's plan calls for the U.S. to accelerate the adoption of plug-in hybrid and electric vehicles. Through a combination of policies such as incentives for consumers and increasing standards of fuel efficiency, they estimate that the nation could save more than $1 trillion over and above the cost of implementing the policy structure [81].

Our point in citing these studies and campaigns is not to necessarily endorse them, but instead to note the growth potential for these industries, and the compelling power of a clearly identified target.

Broad Participation is Necessary

This new energy future is within our reach, but will require the active and consistent participation of governments at all levels. Municipalities and states have already led the way with government directives that guide investments to the new energy infrastructure. Regional climate registries are showing that states (and, in some cases, U.S. states and Canadian provinces) can find new methods of cooperation.

It will also require the active and consistent participation of all Americans. It is, in many ways, the next long war facing our country. A long war takes many years of work, and a great deal of unity. It takes the level of focus most often exhibited in battle—a focus that is hard to maintain over a period of years.

The participation of millions of Americans in this struggle can make a material difference.

The participation of millions of Americans in this struggle can make a material difference. Energy efficiency efforts decrease the load on the electrical grid and reduce the need for fossil fuels even before alternatives are developed. A McKinsey Global Institute report calculated the impact of a suite of efficiency steps, finding that annual investments in energy productivity of $170 billion from now through 2020 would not only generate energy savings of $900 billion annually, but could cut global energy demand growth by at least half [85]. The efficiency solutions suggested by the report included investments that could be made by individuals (such as new light bulbs and insulation) and governments (upgrade of the national

Voices of Experience

VICE ADMIRAL DENNIS V. MCGINN, USN (RET.)

Former Deputy Chief of Naval Operations for Warfare Requirements and Programs

On Supporting Our Troops

Resource scarcity is a key source of conflict, especially in developing regions of the world. Without substantial change in global energy choices, Vice Admiral Dennis McGinn sees a future of potential widespread conflict.

"A yellow ribbon on a car or truck is a wonderful message of symbolic support for our troops. I'd like to see people take it several steps further."

"Increasing demand for, and dwindling supplies of, fossil fuels will lead to conflict. In addition, the effects of global climate change will pose serious threats to water supplies and agricultural production, leading to intense competition for essentials," said the former commander of the U.S. Third Fleet, and deputy chief of naval operations, warfare requirements and programs. "The U.S. cannot assume that we will be untouched by these conflicts. We have to understand how these conflicts could play out, and prepare for them."

With an issue as big as climate change, Adm. McGinn said, "You're either part of the solution or part of the problem. And in this case, the U.S. has to be more than just part of the solution; we need to be a big part of it. We need to be a leader. If we are not, our credibility and our moral authority are diminished. Our political and military relationships are undermined by not walking the walk."

He believes these issues of credibility have a direct impact on our military. It's one of many reasons why he sees climate change and energy security as inextricably linked national security threats.

"We have less than ten years to change our fossil fuel dependency course in significant ways. Our nation's security depends on the swift, serious and thoughtful response to the inter-linked challenges of energy security and climate change. Our elected leaders and, most importantly, the American people should realize this set of challenges isn't going away. We cannot continue business as usual. Embedded in these challenges are great opportunities to change the way we use energy and the places from which we get our energy. And the good news is that we can meet these challenges in ways that grow our economy and increases our quality of life."

Adm. McGinn is clear about the important role to be played by the American public.

"Our national security as a democracy is directly affected by our energy choices as individual citizens," Adm. McGinn said. "The choices we make, however small they seem, can help reduce our dependence on oil and have a beneficial effect on our global climate." Individually, it may be hard to see, but collectively we can all make a tangible contribution to our national security. One way of thinking about this is that our wise energy choices can provide genuine support for our troops.

"A yellow ribbon on a car or truck is a wonderful message of symbolic support for our troops," said Adm. McGinn. "I'd like to see the American people take it several steps further. If you say a yellow ribbon is the 'talk,' then being energy efficient is the 'walk'. A yellow ribbon on a big, gas-guzzling SUV is a mixed message. We need to make better energy choices in our homes, businesses and transportation, as well as to support our leaders in making policies that change the way we develop and use energy. If we Americans truly embrace this idea, it is a triple win: it reduces our dependence on foreign oil, it reduces our impact on the climate and it makes our nation much more secure."

level of electrical grid and elimination of policy barriers to renewable energy development).

As oil provides 96 percent of the energy to power the U.S.'s transportation sector, how one chooses to use and power vehicles is a clear national security choice [84, 86]. The choice to continue on a business as usual course is perilous: it maintains our dependency on foreign oil and contradicts our emerging response to climate change. This choice will be made by policy makers at all levels of government; it will also be made, cumulatively, by all Americans.

A Key Role for DoD

Historically, the Department of Defense has been a leader in many advances—both technological and cultural—that have proven immensely valuable to the nation at-large. One of the most widely cited examples is the internet, which was formed in the research labs of the Defense Advanced Research Projects Agency (DARPA). The military also served as an example for the nation during the civil rights movement of the mid-20th century: President Truman ordered the military to be integrated in 1948 via Executive Order; by 1953, 95 percent of African-American troops served in integrated units [87]. In this instance, the military benefit of integrating the armed forces provided the push needed to break through the cultural barriers that existed in the nation at that time.

DoD is also not a new player in developing disruptive energy technologies. It was the Army Corps of Engineers, working with civilian scientists like J. Robert Oppenheimer, that transformed decades of theoretical research into the successful harnessing of nuclear power [88]. The knowledge and technology they produced formed the foundation of the nation's (and world's) civilian nuclear power industry. While the military handed control of nuclear research into civilian hands shortly after World War II, it has played an important role in its development since: the U.S. Navy is recognized around the world for its record of maintaining and operating a safe nuclear-powered fleet of submarines and aircraft carriers.

The historical records show that it is clear that the Department of Defense can serve as a national leader in cultural change or technological innovation when such advances increase the ability of the military to perform its mission.

The Department of Defense can serve as a national leader in cultural change or technological innovation when such advances increase the ability of the military to perform its mission.

In achieving this new energy future, DoD should once again play an important role. DoD can cut its own fossil fuel use and find ways to decrease its own energy use to improve its operational effectiveness, protect American troops, and save money. DoD's primary role in the development of this new energy approach may be as product incubator. While the private sector buys, funds, and develops technologies to generate a profit, DoD does so in order to help secure the nation;

Voices of Experience

REAR ADMIRAL DAVID R. OLIVER, JR., USN (RET.)

Former Principal Deputy to the Navy Acquisition Executive

On Culture Change Within the Military

Having commanded both diesel and nuclear power submarines, retired Rear Admiral David Oliver understands the challenge of shifting reliance from one fuel to another. He used a series of stories to describe the expected resistance to new energy approaches in the Defense Department, and said the best path forward will focus on organizational culture.

> *"Any major change at the Defense Department has to be managed as a culture change."*

"Nuclear and diesel powered subs are very different," Adm. Oliver said, describing the era when the Navy's committed to nuclear subs. "The requirements for officers on these boats were very different. The cultures were completely different. We found it was very difficult for the same people to adapt. And these officers—the diesel guys—were exceptional people who helped win World War II. However change is always a cultural disruption which involves trauma and few can adapt. These things can get very emotional. People get attached to what they think they know. And in the case of submarines, you had to essentially destroy the diesel boat community in order to ensure that the nuclear boats could emerge.

"I saw it in another case," Adm. Oliver said, this time with a lighter tone. "Secretary Lehman wanted to bring blimps back, in order to provide an inexpensive platform on which to mount persistent airborne radar. But the fixed-wing aviators who had overcome the blimp pilots in the twenties, who again felt threatened, insisted that the valves on the new blimps be made of cast iron. They also insisted on a weight room on board so the pilots could work out when whey weren't at the controls. Think about that: cast iron and weights, on a blimp! The extra weight detracted directly from the warfighting payload, and I was convinced the extra weights were deliberate additions. So these are not inadvertent or thoughtless errors. People get wedded to their systems.

"My experience is that any major change at the Defense Department has to be managed as a culture change. You need to think about what you are changing and what changes you want to make tin the existing culture. Therefore, you need to think about articulation. You have to search for the right message—you have to identify and articulate carefully to get where you want to go. You have to know and accept that change is going to require ten years. You have to have your message down pat. You have to have people ready to carry that message. You have to make a market plan in advance."

Adm. Oliver talked about a different transition in the Navy, starting with a story that revealed how personal motivations can drive change and how strong leadership can transform a culture.

"As a young officer, I was very lucky to work for [Admiral Elmo] Zumwalt," he said. "Our wives were good friends. At the time, northern Virginia was still segregated. On Wednesdays our spouses would attend a service at church and sit in the balcony, where blacks were required to sit. My wife would come home crying about the segregation, and I knew right then that the next day would be a tough one at work. I knew Zumwalt (whose wife would have also come home upset about segregation) would come into the office and start pushing us. He really wanted to push racism out of the Navy."

Admiral Zumwalt, the Navy CNO, already had his hands full, with the Vietnam War and a series of race riots on ships stationed in the Pacific.

"He focused on building the Navy of the future. He knew he would not have sufficient sailors in 30 years if he could not recruit blacks, Hispanics and women and that the Navy could not recruit any of these unless we changed our image (and our racist and sexist policies)," Adm. Oliver said. "Zumwalt knew change was a ten-year process. He knew he only had a few years to get it started. He therefore gathered sufficient people who understood what he planned to do and the importance and value of the change. Then, as he was retiring, he seeded us all throughout different parts of the Navy. It was a deliberate policy to change the culture. You will need to do something similar with respect to energy."

as such, it can invest more heavily in technologies that may require more patience and risk than most traditional investors can tolerate. The Department can provide essential aid in moving important new energy systems through what venture capitalists call "the valley of death"—the period after prototyping and before fully developing the product to scale. DoD also excels at the combination of speed and scale—building a huge or complex system in a short period of time. This challenge to hit speed and scale is the same challenge facing developers of new energy technologies. The focus of DoD is rightfully "mission effectiveness." DoD's focus, when shaped by the converging risks of energy security and climate change, must be "efficient mission effectiveness."

Initial Steps Within DoD Highlight the Possibilities, and Show the Need for Strategic Direction

DoD is now beginning to take initial steps in exploring the value of advances in efficiency and renewable and alternative energy to performing its mission. In response to legislation and Executive Orders, the agencies of the Federal government, and particularly DoD, have taken some initial actions in reducing their energy consumption and increasing the use of renewable energy technologies [89-91]. In 2006, the Department began work on an Energy Security Strategic Plan that aims to reduce total force energy demands, assure access to alternative energy sources, consider energy fully in its business operations, and track Department-wide energy usage [92]. DoD is developing this plan under the auspices of the Energy Security Task Force [93]. The Army, Navy, and Air Force are all developing separate strategic energy plans. Through this process, the Department and the Services are beginning to show DoD can institutionalize the way it considers energy in its operations [94].

Leaders within the DoD and the Services have made important gains in regard to energy in ongoing theater operations, at domestic installations, and in long-term investments in energy technologies.

In advance of the congressional mandate to do so, DoD committed to using the "fully burdened cost of fuel" as a meaningful factor in all capability and acquisition trade analyses. To begin this process, it identified three pilot programs: the Joint Light Tactical Vehicle, alternative ship propulsion for the next generation cruiser, and the Next Generation Long-Range Strike bomber [93, 95]. With each of these new delivery systems, the benefits of energy efficiency would be obvious to field-level commanding officers: a tactical vehicle with 50-percent greater fuel efficiency could operate with less dependence on vulnerable fuel convoys; cruisers and bombers with 50-percent greater fuel efficiency could have much greater range.

In addition to the formation of the Energy Security Task Force and the development of the Department's Energy Security Strategic Plan, leaders within the DoD and the Services have made important gains in regard to energy in ongoing

theater operations, at domestic installations, and in long-term investments in energy technologies.

Energy improvements to ongoing theater operations

The Energy Security Task Force noted what many military personnel have seen for an extended period: "Field commanders are looking to the Department and Services to provide battlefield solutions that reduce vulnerability but also increase capability" [93]. Based on some initial investments, the Department and Services are beginning to grasp how energy improvements can improve their battlespace operations.

For example, in response to Marine Lieutenant General Mattis' call to reduce dependence on fuel convoys, the DoD stood up the Power Surety Task Force under the auspices of the Army's Rapid Equipping Force [96]. The Task Force has been pursuing a number of projects, including testing exterior spray foam to insulate temporary structures such as tents and containerized living units. Based on an estimated energy savings of 40 to 75 percent, Multi-National Force Iraq awarded a $95 million contract to insulate nine million square feet of temporary structures. The use of spray foam is estimated to have taken about 12 fuel transport trucks off the road every day in Iraq [93, 97].

The Services are not just focusing on transport fuel in theater—they are finding ways to reduce the fuel use in heating, cooling and electricity generation. The Army is testing Tactical Garbage to Energy Refineries in Iraq, which convert the waste of everyday operations into biofuel to power a 60 kW generator. While further development of these units is required, they have the ability to convert one ton of garbage (the amount generated by a battalion-sized forward operating base of 600 to 800 soldiers) into the energy equivalent of 115 gallons of JP-8 fuel. While this amount of fuel will only provide a small fraction of the fuel necessary for operations, these generators also serve to minimize the footprint of the base.

In addition to deploying current technologies to the battlefield, DoD has a number of efforts underway to minimize energy impediments for future operations. The Army, as part of its modernization program, is exploring the development of eight new hybrid-electric powered Manned Ground Vehicles for its armored forces. The Power Surety Task Force and the National Training Center at Fort Irwin installed a range of energy efficient structures (including efficient dome structures and renewable power generators) to show how these might be implemented at forward operating bases. In October 2008, DoD held a competition for wearable power systems that was dominated by fuel cell devices [98].

The Services are finding ways to reduce the fuel use in heating, cooling and electricity generation.

These recent advances in reducing energy consumption and providing renewable energy at forward locations are just the beginning stages in what should be a transformation in the way energy is used in theater. In fact, the GAO reported that DoD does not have "an effective

approach for implementing fuel reduction initiatives and maintaining sustained attention to fuel demand management at its forward deployed locations." GAO stated that with coordination by Department leadership and establishing energy as a clear priority, these deficiencies could be overcome [99].

One issue that needs attention by the Department is to make sure incentives are aligned correctly to reinforce a sustained decrease in demand for energy. The GAO cited an example at the Navy's Camp Lemonier (in the Horn of Africa) where base commanders were discouraged in pursuing multiple avenues to save energy because savings would not be applied to the camp's operations [99].

Energy improvements at U.S.-based installations

The Services are also beginning to take the steps necessary to improve their energy posture at bases within the U.S. Driven by mandates contained in recent legislation and Executive Orders, energy use at domestic military installations is down more than 10 percent since 2003—more evidence that DoD can make quick improvements [100]. DoD goals focus on achieving a 30-percent reduction in energy use at permanent installations by 2015 [92]. Currently, just less than 3 percent of the electricity used at military installations in the continental U.S. is being generated by renewable sources [100].

The U.S. Air Force has demonstrated national leadership in adopting renewable energy at their installations. Through purchasing 5 percent of its electricity from green power[4] sources, the Air Force is the Federal government's leading purchaser of green power electricity and ranks 7th overall in the nation [101]. One of the Air Force's most significant sources of renewable electricity is at Nellis Air Force Base, where a 14.2 MW photovoltaic solar array is housed—the largest in the Americas. The solar array provides one-quarter of the base's energy and saves an estimated $1 million per year. Tinker and Robins Air Force Bases have worked with their neighboring utilities to install 50 to 80 MW combustion gas turbines with dual fuel capability that allow the bases to disconnect from grid (that is, "island" from the grid) in the event of an emergency; this arrangement has allowed the bases to exploit unused land resources, improve their energy resilience, and build positive relationships within their communities.

The U.S. Air Force has demonstrated national leadership in adopting renewable energy at their installations.

The Army is playing a role in providing an early market for the nascent electric vehicle market. In January 2009, the Army announced the single largest acquisition of neighborhood electric vehicles (NEV) [102]. By 2011, the Army will have acquired 4,000 NEVs, which cost nearly 60-percent less to operate than the gasoline-powered vehicles they will replace.

[4] As defined by the EPA's Green Power Partnership, "green power" is electricity derived from sources that have a low environmental impact and that emit no greenhouse gases [101]

ADMIRAL JOHN B. NATHMAN, USN (RET.)

Former Vice Chief of Naval Operations and Commander of U.S. Fleet Forces

On DoD's Big Opportunity

Retired Admiral John Nathman says the Department of Defense should be expected to help lead the way in developing new energy solutions.

"I think DoD wants the chance to be innovators," Adm. Nathman said. "There's real evidence of that, because the services are already thoughtfully moving forward on energy issues."

"Norfolk would be a great place to work on developing a smart grid. Give them that challenge. The Navy will get it done."

Adm. Nathman highlighted smart grid pilot programs at a small number of bases, and looks forward to seeing these projects play out at bigger installations. He said the Navy will need to take risks, but will ultimately gain better service and reduce its operating costs.

"Aircraft carriers or nuclear subs at a port like Norfolk are a real challenge to the electrical system," Adm. Nathman said. "When those ships shut down and start pulling from the grid, it's an enormous demand signal. And you can't have interruptions in that power, because that power supports nuclear reactor operations. So the Norfolk bases would represent very real and very tough challenges for a smart grid. Proving that technology, in a controlled environment that the Navy would provide, could streamline applications for larger commercial utilities and their customers. Norfolk would be a great place to work on developing a smart grid. Give them that challenge. The Navy will get it done. They'll prove it.

"You can also do some rapid prototyping for transport. At some of these bases, you have pick-up trucks making an astounding number of 20-mile trips. That's a case where we could use plug-in hybrids. With these types of vehicles, you have to forward-fit the changes. You have enough vehicles to allow some to fail, or to show signs of wear, and then you replace them. That's the process we have to follow, so it will take some time, but that's the good news in my view, because one needs a certain amount of proofing. You want to know you're investing in vehicles that work."

He said the process of innovation is well underway, but the key to sustaining it is to ensure it isn't ad hoc. Structure is essential, according to Adm. Nathman. So are strong relationships.

"The ideas have to be connected," Adm. Nathman said. "DoD's relationship with NREL (the National Renewable Energy Laboratory) is very good. It's a great example of how you can connect the idea people to the doers. That practice needs replication. The relationships between the Department of Defense and the Department of Energy are key. The idea people from both departments need to be connected. Aligning the two to develop strong peer relationships across department boundaries. And you need permanent structures to ensure that those relationships can thrive. The maturation of ideas will occur if the relationships are strong."

He said the Defense Department's Director for Operational Energy Plans and Programs, as well as senior operational energy officials within each service (all new positions), can play a lead role in building the structural relationships to sustain energy efficiency and energy innovation.

"There's an enormous opportunity here, particularly because the DoD is willing to share costs, ideas and risks," Adm. Nathman said. "They can quickly turn the ideas around, get them operational, and thoroughly test them. I think you'll see a relative explosion in this interdependence. I think things have the potential to look very different in a year."

Hawaii, with its remote location and utter dependence on external fuel sources, has served as an interesting test-bed for the Services. The Army is taking a variety of actions to improve its energy posture at the "Pineapple Pentagon"—the name given to the buildings constructed in 1944 on Fort Shafter to serve as the command center for the invasion of Japan [103]. Driven by Army guidance and through innovative partnerships with a local utility and a private developer, the base commander is spearheading efforts to install advanced energy and water meters on all Army buildings (which had none at his arrival in 2004), implement "time of day" energy pricing, install solar water heaters on homes, and install solar films on roofs. Overall in Hawaii, the Army is constructing 5,200 new homes that will be made to high energy and environmental standards; 2,300 existing homes are also being retrofitted. The Navy also partnered with the Department of Energy in studying and installing photovoltaic power systems on Navy family housing in Hawaii through a public-private partnership [104].

Hawaii, with its remote location and utter dependence on external fuel sources, has served as an interesting test-bed for the Services.

The Navy has also played an important role in adopting energy efficient technologies and renewable energy sources. During the 1980s, the Navy helped develop a 270 MW geothermal power facility at China Lake, California, and can sell the power to utilities to provide electricity for more than 180,000 homes. The Navy recently awarded contract for construction of a 30 MW plant at Fallon Naval Air Station in Nevada. The Navy and Marine Corps, in response to federal legislation in 2005, have been leading the way in monitoring their energy use through their Advanced Metering Infrastructure Program, an initiative aimed at installing 12,000 advanced meters at facilities around the world [105-107].

The Services are jointly testing the concept of "net zero" installations at a small number of diverse facilities; that is, bases that produce as much energy on or near the installation as they consume. These installations—McGuire, Barksdale, and Maxwell Air Force Bases; Fort Irwin; Fort Carson; Miramar Naval Air Station; and San Nicholas Island Naval Outlying Field—will be exemplars of building efficiency, energy retrofits, renewable energy generation, and the use of electric vehicles. They may also bring about important advances in the development and use of smart-grids on their bases, ensuring that all energy is used in the most efficient means. By making use of innovative public-private partnerships, private sector sources will fund many of these changes (and will rightfully assume some of the long-term cost savings as their compensation). The intent with these pilot projects is to learn enough, quickly enough, to apply a systems approach Department-wide. It is a stellar example of the military's ability to be a leader in national innovation.

Long-term investments in energy technologies

The U.S. military will be able to procure the petroleum fuels it requires to operate in the near- and mid-term time horizons [108]. However,

as carbon regulations are implemented and the global supplies of fossil fuels begin to plateau and diminish in the long-term, identifying an alternative to liquid fossil fuels is an important strategic choice for the Department.

Identifying an alternative to liquid fossil fuels is an important strategic choice for the Department.

Recognizing this circumstance, DARPA has signaled that it will invest $100 million in research and development funding to derive JP-8 from a source other than petroleum [109]. In early 2009, DARPA awarded more than half of that funding to three firms in an effort to develop price-competitive JP-8 from non-food crops such as algae and other plant-based sources.

The U.S. Air Force has also been active in pursuing alternative fuels to fly its aircraft fleet. While the Air Force cancelled plans in early 2009 to allow a private company to build a CTL plant on land at Malmstrom Air Force Base in Montana [110], it is still planning on achieving the goal of certifying all of its aircraft to fly on synthetic fuel blends by 2011; by 2016, the Air Force would like to obtain more than half of its domestic transportation fuels from U.S.-produced synthetic blends that are more environmentally friendly than conventional petroleum [111]. Through its experiments with CTL fuels over the past several years, the Air Force has gained valuable experience in developing the procedures necessary to certify various aircraft to fly on a mixture of synthetic fuels.

The ongoing research efforts and progress to-date by DoD in finding alternative liquid fuels, however, should not be interpreted to mean that this will be an easy task to accomplish. The equipment and weapons platforms of the Services are complex in both their variety and their operational requirements. For example, when considering the U.S. Navy, the fleet uses 187 types of diesel engines, 30 variations of gas/steam turbine engines, 7,125 different motors (not to mention the various types of nuclear reactors for aircraft carriers and submarines). The Navy also procures liquid fuels for its carrier- and land-based aircraft, which feature a mix of turbojet, turboprop, turboshaft, and turbofan engines [112]. Finding a fuel that contains the appropriate combination of energy content (per unit mass and volume) is a challenging area of research [113].

Progress has been made, but the mission has just begun

From this brief survey of the Department's energy related investments, it is clear that DoD has initiated a variety of activities—at the strategic, operational, and tactical levels—that will help improve their mission effectiveness through pursuing forward leaning energy policies. In fact, from 2006 to 2009, DoD has seen its expenditures in energy related items increase from $400 million to $1.3 billion [92]. Many of these actions have been initiated through mandates dictated by energy related legislation and Executive Orders; others have been driven by operational requirements. The "stimulus bill" that the Congress passed in early 2009 also allowed for some energy related projects to be jump-started [114].

However, there is much work that remains to be done. While the Department is making strides in controlling its installation-based energy usage, DoD's facilities account for only 25 percent of the Department's energy footprint. In the fall of 2009, the U.S. Congress tasked the Department of Defense to better manage the remaining 75 percent of energy use: its operational energy demands [115]. Many of DoD's energy initiatives are in their infancy and will require the appropriation of substantial financial resources for many years to come. In addition, many of these projects are not being undertaken via a strategic decision-making process; rather, they represent the fruition of good ideas pursued by enterprising individuals within the Department [38].

While the Department is making strides in controlling its installation-based energy usage, DoD's facilities account for only 25 percent of the Department's energy footprint.

The Department of Defense clearly has the ability to assume a leadership role in developing and deploying new and innovative energy technologies that could benefit not only themselves, but the nation at-large. Because of their role in ensuring the nation's future security, the Department's leadership must demonstrate the proper focus and attention to ensure that these initiatives, and many others, are realized.

Chapter 4

A Roadmap for Energy Security

The Military Advisory Board offers our findings and recommendations to the Administration as it turns its attention to these intertwined and compounding threats. How America responds to the challenges of energy dependence and climate change will shape the security context for the remainder of this century; it will also shape the context for U.S. diplomatic and military priorities. The Military Advisory Board's objective is to ensure that the capabilities and resources of the Department of Defense are employed in the most effective way towards achieving an energy secure future.

FINDINGS:

Finding 1: The nation's current energy posture is a serious and urgent threat to national security.

The U.S.'s energy choices shape the global balance of power, influence where and how troops are deployed, define many of our alliances, and affect infrastructure critical to national security. Some of these risks are obvious to outside observers; some are not. Because of the breadth of this finding, we spell out two major groupings of risk.

Finding 1A: Dependence on oil undermines America's national security on multiple fronts.

America's heavy dependency on oil—in virtually all sectors of society—stresses the economy, international relationships, and military operations—the most potent instruments of national power. Over dependence on imported oil—by the U.S. and other nations—tethers America to unstable and hostile regimes, subverts foreign policy goals, and requires the U.S. to stretch its military presence across the globe; such force projection comes at great cost and with great risks. Within the military sector, energy inefficient systems burden the nation's troops, tax their support systems, and impair operational effectiveness. The security threats, strategic and tactical, associated with energy use were decades in the making; meeting these challenges will require persistence.

Both the defense and civilian systems have been based on dangerous assumptions about the availability, price, and security of oil and other fossil fuel supplies. It is time to abandon those assumptions.

Finding 1B: The U.S.'s outdated, fragile, and overtaxed national electrical grid is a dangerously weak link in the national security infrastructure.

The risks associated with critical homeland and national defense missions are heightened due to DoD's reliance on an electric grid that is out-dated and vulnerable to intentional or natural disruptions. On the home front, border security, emergency response systems, telecommunications sys-

tems, and energy and water supplies are at risk because of the grid's condition. For military personnel deployed overseas, missions can be impaired when logistics support and data analysis systems are affected by grid interruptions. An upgrade and expansion of the grid and an overhaul of the regulations governing its construction and operations are necessary enablers to growth of renewable energy production—which is also a key element of a sound energy and climate strategy. Others have made compelling arguments for this investment, citing the jobs growth and environmental benefits. We add our voices, but do so from a different perspective: Improving the grid is an investment in national security.

Finding 2: A business as usual approach to energy security poses an unacceptably high threat level from a series of converging risks.

The future market for fossil fuels will be marked by increasing demand, dwindling supplies, volatile prices, and hostility by a number of key exporting nations. Impending regulatory frameworks will penalize carbon-intensive energy sources. Climate change poses severe security threats to the U.S. and will add to the mission burden of the military. If not dealt with through a systems-based approach, these factors will challenge the U.S. economically, diplomatically, and militarily. The convergence of these factors provides a clear and compelling impetus to change the national and military approach to energy.

Finding 3: Achieving energy security in a carbon-constrained world is possible, but will require concerted leadership and continuous focus.

The value of achieving an energy security posture in a future shaped by the risks and regulatory framework of climate change is immense. The security and economic stability of the U.S. could be improved greatly through large-scale adoption of a diverse set of reliable, stable, low-carbon, electric energy sources coupled with the aggressive pursuit of energy efficiency. The electrification of the transportation sector would alleviate the negative foreign policy, economic, and military consequences of the nation's current oil dependency.

While this future is achievable, this transformation process will take decades; it will require patience, stamina, and the kind of vision that bridges generations. Ensuring consistency of the nation's energy security strategy with emerging climate policies can also serve to broaden the base of support for sensible new energy development and help to unify a wide range of domestic policies.

Finding 4: The national security planning processes have not been sufficiently responsive to the security impacts of America's current energy posture.

For much of the post-World War II period, America's foreign and defense policies were aimed at

protecting stability where it existed, and promoting it where it did not. Our national security planning process has continuously evolved to mitigate and adapt to threats as they arose.

From the perspective of energy security, this process has left the nation in a position where our energy needs undermine: our national ideals, our ability to project influence, our security at home, our economic stability, and the effectiveness of our military. America's current energy and climate policies make the goal of stability much more difficult to achieve. While some progress has been made to recognize the risks of our energy posture (including within the U.S. military), the strategic direction of the nation has yet to change course sufficiently to avoid the serious threats that will arise as these risks continue to converge.

Finding 5: In the course of addressing its most serious energy challenges, the Department of Defense can contribute to national solutions as a technological innovator, early adopter, and test-bed.

The scale of the energy security problems of the nation demands the focus of the Defense Department's strong capabilities to research, develop, test, and evaluate new technologies. Historically, DoD has been a driving force behind delivering disruptive technologies that have maintained our military superiority since World War II. Many of these technical breakthroughs have had important applications in the civilian sector that have strengthened the nation economically by making it more competitive in the global marketplace. The same can be true with energy. By pursuing new energy innovations to solve its own energy security challenges, DoD can catalyze some solutions to our national energy challenges as well.

By addressing its own energy security needs, DoD can stimulate the market for new energy technologies and vehicle efficiency tools offered by innovators. As a strategic buyer of nascent technologies, DoD can provide an impetus for small companies to obtain capital for expansion, enable them to forward-price their proven products, and provide evidence that their products enjoy the confidence of a sophisticated buyer with stringent standards. A key need in bringing new energy systems to market is to achieve speed and scale: these are hallmarks of American military performance.

RECOMMENDATIONS:

The Military Advisory Board submits the following Roadmap for Energy Security to help the Department of Defense and the nation as a whole achieve an energy secure future. This roadmap should be used to focus DoD's investments in a strategic manner in order to mitigate its highest energy related risks and make optimal use of its fiscal resources.

While the following priorities are listed in order, we do not mean to suggest that each priority should be accomplished fully before action is taken on subsequent priorities; some actions can be pursued in parallel. However, DoD should work to fully resource the higher priorities before pursuing large-scale efforts regarding lower energy priorities.

Priority 1: Energy security and climate change goals should be clearly integrated into national security and military planning processes.

The nation's approach to energy and climate change will, to a large extent, shape the security context for the remainder of this century. It will shape the context for diplomatic and military engagements, and will affect how others view our diplomatic initiatives—long before the worst effects of climate change are visible to others.

These issues must be viewed together through the lens of national security; the National Security Council of the Obama Administration, led by retired General James Jones, has signaled that it will do exactly that [116]. This holistic view leads us away from simplistic responses. Some energy options would "untether us" from fuel security issues, but would increase greenhouse gas emissions and therefore conflict with national climate policies. If choosing to pursue such energy options, our leaders must be mindful of the consequences. It is important to understand that many short-term, high carbon solutions come with high opportunity costs and are not viable in the long-term context of carbon constraints.

Because of the fundamental importance of recognizing the threats posed by the energy posture of DoD and the nation, the national security apparatus must incorporate energy related risks throughout the national security planning process. The National Security Strategy, National Defense Strategy, National Military Strategy, and Quadrennial Defense Review should more realistically describe the nature and severity of the threat, appropriate roles for the various instruments of national power, including the military, in reducing the nation's dependence on imported energy. They should also highlight the need to adapt to the serious effects of climate change. Recognizing that hard choices must be made, these long-term strategies should seek to promote energy solutions that improve our energy security and reflect climate change realities over those that sacrifice one to improve the other.

Beyond these broad policy documents, Defense Planning Scenarios, wargames and campaign models should realistically incorporate the strategic and tactical risks associated with energy supply disruptions, reduced energy availability in to deployed forces, and climate change effects. The lessons learned must be integrated into the key decisions the Department makes about the kinds of capabilities and force structure it will need for the coming decades. Embedding energy burdens into mission effectiveness metrics will help us design a more efficient military force, be better equipped to prevail against the types of future threats we will face, and operate effectively within the context of future energy risks and climate changes.

Through recognizing the importance of energy security and climate change goals throughout its suite of strategic documents and planning processes, the Department can achieve the culture change necessary to sustain a new direction for its energy posture.

Priority 2: DoD should design and deploy systems to reduce the burden that inefficient energy use places on our troops as they engage overseas.

Because the burdens of energy use at forward operating bases present the most significant energy related vulnerabilities to deployed forces, reducing the energy consumed in these locations should be pursued as the highest level of priority.

In the operational theater, inefficient use of energy can create serious vulnerabilities to our forces at multiple levels. The combat systems, combat support systems, and electrical generators at forward operating bases are energy intensive and require regular deliveries of fuel; the convoys that provide this fuel and other necessary supplies are long and vulnerable, sometimes requiring protection of combat systems such as fixed wing aircraft and attack helicopters. Individual troops operating in remote regions are subject to injury and reduced mobility due to the extreme weight of their equipment (which can include up to 26 pounds of batteries).

The Department of Defense should work to alleviate these serious energy related risks by including energy efficiency as a key factor in: the definition of future requirements, reset and modernization of existing systems, research and development of future technologies, acquisition of future systems, and deployment of our current force.

The suite of equipment carried by troops that operate on foot should be reviewed from a whole-systems perspective, with the goal being to reduce electrical needs of the equipment and weight of batteries. Research and development efforts should be accelerated to find new power solutions, such as the adoption of advanced energy management technologies to reduce demand, higher density and lighter weight energy supplies, and deployable renewable sources.

The DoD should also examine its procedures for ensuring that forward operating bases are as energy efficient as possible. Taking into account the full burdens of delivering the fuel required to sustain its forward locations, the Department should identify the resources necessary to retrofit its existing locations with energy efficiency improvements.

In addition to standard energy efficiency improvements, the Department should field test and, where possible, adopt technologies to implement deployable smart micro-grids. Through better management of energy resources, smart micro-grids offer the possibility of providing more resilient and efficient electrical power.

If these projects cannot be supported through the Department's existing procedures, the Department should define a funding mechanism through which they can be financed.

Only through institutionalizing the importance of energy efficiency in the operating theater will the Department ensure that wasteful and inefficient energy practices at forward locations do not put its personnel and missions at risk. In preparing for future operations, the Department should set stringent efficiency standards for all of its energy

consuming equipment, including generators, facilities, and other materiel used to establish forward operating bases. Because of the high value of energy efficiency, DoD's investments in increasing energy performance should be pursued at a level commensurate with its value on the battlefield—a level much higher than is economically justifiable for commercial users.

Priority 3: DoD should understand its use of energy at all levels of operations. DoD should know its *carbon bootprint*.

To effectively manage its resources, DoD needs to gather the data necessary to understand, with specificity, how it uses energy at its installations and in theater. Such information is necessary to develop meaningful metrics to support an informed decision-process in pursuing new energy advances. Military installations and forward operating bases should establish appropriate procedures and install the equipment necessary to accurately monitor and manage its energy use. Here, we recall the standard business notion: *You can't manage what you don't measure.*

In addition to identifying the most energy inefficient operations of the Department, these data will enable the Department to accurately measure its *carbon bootprint*. Such measurements will help planners understand the potential impacts of carbon pricing as well as identify opportunities to maximize the benefits that can accrue from sound carbon management. The measurements will also help avoid the need to hastily enact a measurement system in response to legislation, allow for more rapid sharing of best practices, and allow DoD to participate fully in a national approach to climate change.

In response to recent legislation and Executive Orders, the Services have begun the process (to varying degrees) of installing the equipment necessary to measure energy use. Because the process of metering is the initial steps towards achieving important energy efficiency improvements, these efforts should be encouraged, standardized across Services, and accelerated.

Priority 4: DoD should transform its use of energy at installations through aggressive pursuit of energy efficiency, smart grid technologies, and electrification of its vehicle fleet.

After evaluating information on which facilities and installations present the largest opportunities for energy improvements, DoD should proceed with all deliberate speed on investments in energy efficiency, smart grid technologies, and electrifying its vehicle fleet.

Energy efficiency improves the operations of the Department's installations and allows them to better sustain operations during electrical disruptions. Energy efficiency also offers the most effective means for reducing energy usage in the near-term at the least cost. For existing structures, the first steps toward increasing its efficiency are theoretically easy to accomplish; however, due to DoD's size and complexity, efficiency gains can be difficult to put into practice in a consistent

manner. The Department should develop a plan and an investment strategy to enable its success. DoD should insist on strict adherence to policies requiring that purchased products meet the highest levels of efficiency in their class, and task its Inspector General to conduct periodic checks to support enforcement. For example, DoD should install only energy efficient lighting, insulation, windows, and heating and air conditioning systems, insisting at a minimum that all purchases adhere to Energy Star and the Department of Energy's Federal Energy Management Program (FEMP) efficiency standards. In addition, the Department must maintain and monitor buildings to ensure their continuing efficient operations.

The initial design of a building can be the most significant factor in its ability to use energy efficiently, and DoD's construction criteria for facilities built using appropriated funds already require good levels of energy efficiency. These high standards should be expanded to include privatized construction as well as facility upgrades and minor construction. More important, these standards cannot remain static: Department policy must continue to evolve to meet increasingly stringent energy efficiency standards as new technologies and products permit. DoD must ensure that buildings are constructed, operated, and maintained to the required standards; properly metering buildings will allow the Department to ensure that high efficiency standards are actually achieved and maintained. DoD should also work to ensure that the relevant policies within the Department and at the Office of Management and Budget allow sufficient funding for the Services to design, construct, and maintain its infrastructure to high energy performance standards. Prevailing attitudes that strive for maximum building size per dollar spent are short-sighted and ultimately cost the Department and the taxpayer more in the long-term.

DoD should pioneer the adoption of smart-grid technologies on its installations. These technologies would help the installations better manage their energy demand, increase efficiency, enable more effective use of renewable sources, and provide resilience against electrical disruptions. In the processing of adopting these technologies, DoD should work with state and local regulatory agencies and the utility sector to examine regulatory and other barriers that prevent these technologies from providing their optimal benefit. DoD is a unique entity in terms of the amount of infrastructure it owns and the geographic variety of its locations; as such, it could become a useful pilot for these technologies, benefit from being an early adopter, and provide a valuable service to the country by sharing its experience with energy companies and communities all across the nation.

In regard to its installation-based transportation, where duty cycle makes them appropriate choices, DoD should transform its non-tactical fleet into electric and hybrid vehicles. Initial investments in this area are underway, but the practice should be implemented DoD-wide and adoption accelerated. The Department should approach this transition strategically, ensuring that vehicle size and power appropriately match each vehicle's true needs, with an eye toward minimizing energy use. Smart grid technologies would allow these vehicles to be charged at periods of low demand as well as provide energy to the installation when required.

The large purchasing power of the DoD for energy efficiency technologies—particularly for new vehicle technologies—could help to provide a sustainable market for these solutions, which would in turn help support these activities in the non-military sector.

To inculcate the kinds of cultural changes needed to produce enduring change at the installation level, an effective incentive structure is crucial. When installation commanders save money through efficiency, those savings (or a portion of them) should be mandated to stay on the installation for a specified period of time. Because military culture is by its very nature competitive, competition among installations and Services could also be an effective means of reducing energy usage.

Priority 5: DoD should expand the adoption of distributed and renewable energy generation at its installations.

Once gains in energy efficiency have been achieved, DoD should assess both the electrical needs and potential availability of renewable sources at its installations. Such an assessment will enable the Department to determine the most appropriate locations for new distributed and renewable energy generation. Distributed and renewable energy generation located on DoD's facilities will help to ensure the Department's critical missions have reliable and resilient electrical energy supplies. Installing smart grid technologies as part of efficiency improvements will have already helped prepare the systems for the integration of this new capacity. The Department should be actively engaged with state and local electrical regulators to implement the policies necessary to allow the installation of new generating capacity. DoD should also work with Congress to achieve legislative reform that would allow the Department to "island" critical portions of installations from the rest of the grid, and use community outreach programs and partnerships to look "outside the fence" and develop opportunities to share any excess generating capacity with surrounding communities. A critical aspect of this process will be to develop partnerships with federal agencies and regulators (including the Department of Energy and the Federal Energy Regulatory Commission); state agencies and regulators; and private sector utilities.

We stress that new generating capacity should be added only after aggressive efficiency measures have been pursued, as efficiency gains decrease the size and cost of the new generating capacity needed.

As part of this effort, DoD should accelerate plans and define the necessary funding to achieve large-scale adoption of Net Zero bases (which produce as much power as they use). Pilot programs in this area are already underway; the Department should both accelerate those programs and ensure that the lessons learned are shared throughout the Department. Working closely with the Department of Energy and private energy companies, the Department should develop an enterprise-wide plan to adopt Net Zero installations.

In pursuing a wide-scale adoption of distributed and renewable energy generation, the De-

partment would be among the nation's earliest adopters of this new energy paradigm. As such, the Department will serve as an invaluable technology test-bed and provide a critical market for new products.

Priority 6: DoD should transform its long-term operational energy posture through investments in low-carbon liquid fuels that satisfy military performance requirements.

In the near-term, the Department of Defense is not faced with a threat to its liquid petroleum fuel supply. As such, DoD should ensure that its resources are properly focused on the energy related problems that present the highest operational risk to its forces.

However, because of the long-term constriction in the world's oil supply and the impending constraints on carbon-based fuels, DoD should be engaged in long-term research and development programs to discover low-carbon alternatives to conventional petroleum for its mobility needs. The development of such fuels would allow DoD to depend on low-carbon fuels when possible (particularly in domestic activities), but still be able to operate on the fuels available in various operational theaters. As such, DoD should be an active partner in the research programs of other federal agencies (such as the Department of Energy) and with private sector and academic partners in the research, testing, and evaluation of low carbon liquid fuels. While there will undoubtedly be new discoveries in this area, research into algae-based fuels have shown particular promise.

Biographies

GENERAL CHARLES F. "CHUCK" WALD, USAF (RET.)

Former Deputy Commander, Headquarters U.S. European Command (USEUCOM); Chairman, CNA MAB

From 2001 to 2002 General Wald was deputy chief of staff for air and space operations at the Pentagon, and from December 2002 until his retirement in 2006 he was deputy commander, Headquarters U.S. European Command, Stuttgart, Germany. USEUCOM is responsible for all U.S. forces operating across 91 countries in Europe, Africa, Russia, parts of Asia and the Middle East, and most of the Atlantic Ocean.

General Wald commanded the 31st Fighter Wing at Aviano Air Base, Italy, where on Aug. 30, 1995, he led one of the wing's initial strike packages against the ammunition depot at Pale, Bosnia-Herzegovina, in one of the first NATO combat operations. General Wald commanded the Ninth Air Force and U.S. Central Command Air Forces, Shaw Air Force Base, South Carolina, where he led the development of the Afghanistan air campaign for Operation Enduring Freedom, including the idea of embedding tactical air control parties in ground special operations forces.

He has combat time as an O-2A forward air controller in Vietnam and as an F-16 pilot flying over Bosnia. The general has served as a T-37 instructor pilot and F-15 flight commander. Other duties include chief of the U.S. Air Force Combat Terrorism Center, support group commander, operations group commander, and special assistant to the chief of staff for National Defense Review. He was also the director of strategic planning and policy at Headquarters U.S. Air Force, and served on the Joint Staff as the vice director for strategic plans and policy.

General Wald is a command pilot with more than 3,600 flying hours, including more than 430 combat hours over Vietnam, Cambodia, Laos, Iraq, and Bosnia. The general earned his commission through the Air Force ROTC program in 1971.

Currently, General Wald serves as president of Wald and Associates, an international management consulting and strategic planning firm, and is an adjunct lecturer at the Atlantic Council. He is also a member of the Bipartisan Policy Center, National Commission on Energy Policy, and the Securing America's Future Energy Commission.

GENERAL CHARLES G. BOYD, USAF (RET.)

Former Deputy Commander-in-Chief, Headquarters U.S. European Command (USEUCOM)

General Charles G. Boyd, U.S. Air Force (Ret.), became president and chief executive officer of Business Executives for National Security (BENS) on May 1, 2002. Before joining BENS, he served as senior vice president and Washington program director of the Council on Foreign Relations.

General Boyd was commissioned through the aviation cadet program in July 1960 and retired in 1995 after 35 years of service. A combat pilot in Vietnam, he was shot down on his 105th mission and survived 2,488 days as a prisoner of war. He is the only POW from that war to achieve the four-star rank.

General Boyd's final military assignment was as deputy commander-in-chief of U.S. forces in Europe. His other assignments as a general officer include vice commander of Strategic Air Command's 8th Air Force, director of plans at Headquarters U.S. Air Force in Washington, D.C., and commander of Air University at Maxwell Air Force Base, Alabama. He is a command pilot with more than 3,000 flight hours.

Following retirement from active duty, he served as Director of the 21st Century International Legislators Project for the Congressional Institute, Inc. and strategy consultant to then Speaker of the House, Newt Gingrich. In July 1998 he became executive director of the Hart-Rudman National Security Commission, which foresaw the growing terrorist threat to the United States well before the September 11, 2001 attacks and advocated priority attention be devoted to homeland security.

His military decorations include the Air Force Cross, Distinguished Service Medal, Silver Star with oak leaf cluster, Bronze Star with combat "V" and two oak leaf clusters, Distinguished Flying Cross, and the Purple Heart with two oak leaf clusters.

General Boyd is a member of the Board of Directors of the Nixon Center, DRS Technologies, Inc., Forterra Sys-

tems, Inc. and In-Q-Tel. He is a member of the USAF Air University Board of Visitors; is Chairman of the Board of Trustees for the Air University Foundation; and serves on the Transformation Advisory Group for U.S. Joint Forces Command as well as the U.S. European Command Senior Advisory Group.

A native of Iowa, he is a graduate of the University of Kansas and the Air War College, and of Harvard's Program for Senior Executives in National and International Security.

LIEUTENANT GENERAL LAWRENCE P. FARRELL JR., USAF (RET.)

Former Deputy Chief of Staff for Plans and Programs, Headquarters U.S. Air Force

Prior to his retirement from the Air Force in 1998, General Farrell served as the deputy chief of staff for plans and programs, Headquarters U.S. Air Force, Washington, D.C. He was responsible for planning, programming and manpower activities within the corporate Air Force and for integrating the Air Force's future plans and requirements to support national security objectives and military strategy.

Previous positions include vice commander, Air Force Materiel Command, Wright-Patterson Air Force Base, Ohio, and deputy director, Defense Logistics Agency, Arlington, Virginia. He also served as deputy chief of staff for plans and programs at Headquarters U.S. Air Force in Europe.

A command pilot with more than 3,000 flying hours, he flew 196 missions in Southeast Asia and commanded the 401st Tactical Fighter Wing at Torrejon Air Base, Spain. He was also the system program manager for the F-4 and F-16 weapons systems with the Air Force Logistics Command at Hill Air Force Base, Utah.

General Farrell is a graduate of the Air Force Academy with a bachelor's degree in engineering and an MBA from Auburn University. Other education includes the National War College and the Harvard Program for Executives in National Security.

General Farrell became the president and CEO of the National Defense Industrial Association in September 2001.

GENERAL PAUL J. KERN, USA (RET.)

Former Commanding General, U.S. Army Materiel Command

General Kern had three combat tours: two in Vietnam as a platoon leader and troop commander, and one as commander of the Second Brigade of the 24th Infantry in Desert Shield/Desert Storm which played a pivotal role in the historic attack on the Jalibah Airfield, allowing the Twenty-Fourth Infantry Division to secure key objectives deep inside of Iraq. He also served as the assistant division commander of the division after its redeployment to Fort Stewart, Georgia.

General Kern's assignments included senior military assistant to Secretary of Defense William Perry, accompanying the Secretary to more than 70 countries, meeting numerous heads of state, foreign ministers, and international defense leaders. He participated in U.S. operations in Haiti, Rwanda, Zaire, and the Balkans, and helped promote military relations in Central and Eastern Europe, South America, China, and the Middle East.

General Kern received the Defense and Army Distinguished Service Medals, Silver Star, Defense Superior Service Medal, Legion of Merit, two Bronze Star Medals for valor, three Bronze Star Medals for service in combat, and three Purple Hearts. He has been awarded the Society of Automotive Engineers Teeter Award, the Alumni Society Medal from the University of Michigan, and the German Cross of Honor of the Federal Armed Forces (Gold).

A native of West Orange, New Jersey, General Kern was commissioned as an armor lieutenant following graduation from West Point in 1967. He holds master's degrees in both civil and mechanical engineering from the University of Michigan, and was a Senior Security Fellow at Harvard's John F. Kennedy School of Government.

He is an adviser to Battelle Memorial Institute and holds the Chair of the Class of 1950 for Advanced Technology at the United States Military Academy. He is also a member of the Cohen Group, which provides strategic advice and guidance to corporate clients.

GENERAL RONALD E. KEYS, USAF (RET.)

Former Commander, Air Combat Command

General Keys' last assignment was as Commander, Air Combat Command, the Air Force's largest major command. He was responsible for organizing, training, equipping, and maintaining combat-ready forces for rapid deployment and employment for more than 1,200 aircraft, 27 wings, 17 bases and 200 operating locations worldwide with 105,000 active-duty and civilian personnel.

General Keys is a distinguished graduate of Kansas State University's ROTC program and was commissioned in 1967. He is also an outstanding graduate of undergraduate pilot training. He is a command pilot with more than 4,000 flying hours in four fighter types, including more than 300 hours of combat time in Southeast Asia.

In his forty-year career, he commanded a fighter squadron, the U.S. Air Force Fighter Weapons School, an F-15 wing, an A-10 and F-16 wing, the Combat Air Forces Operational Test and Evaluation Wing, a numbered air force, and Allied Air Forces Southern Europe. He also was the first commander of the Air Force Doctrine Center, and served as an executive assistant to the Air Force Chief of Staff and to an Assistant Secretary of Defense. Prior to his last assignment, he was Deputy Chief of Staff for Air and Space Operations, Headquarters U.S. Air Force, Washington, D.C.

General Keys holds a bachelor's degree from Kansas State University and a master's degree in business administration from Golden Gate University. He has completed numerous professional military education courses, and participated in the National and International Security Seminar at Harvard's John F. Kennedy School of Government, and in the Center for Creative Leadership's "Leadership at the Peak" in Colorado Springs.

Among his personal decorations are two Defense Distinguished Service Medals, two Distinguished Service Medals, two Legions of Merit, two Distinguished Flying Crosses, and seventeen Air Medals. In September 2007, he received the Air Force Association's most prestigious annual award — the H. H. Arnold Award—as the military member who had made the most significant contribution to national defense.

General Keys is an independent consultant with RK Solution Enterprises, and joined the Bipartisan Policy Center as a senior advisor in February 2008.

ADMIRAL T. JOSEPH LOPEZ, USN (RET.)

Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

Admiral Lopez's naval career included tours as commander-in-chief of U.S. Naval Forces Europe and commander-in-chief, Allied Forces, Southern Europe from 1996 to 1998. He commanded all U.S. and Allied Bosnia Peace Keeping Forces in 1996; he served as deputy chief of naval operations for resources, warfare requirements and assessments in 1994 to 1996; commander of the U.S. Sixth Fleet in 1992 to 1993; and senior military assistant to the secretary of defense in 1990 to 1992.

Admiral Lopez was awarded numerous medals and honors, including two Defense Distinguished Service Medals, two Navy Distinguished Service Medals, three Legion of Merits, the Bronze Star (Combat V), three Navy Commendation Medals (Combat V) and the Combat Action Ribbon. He is one of just two flag officers in the history of the U.S. Navy to achieve four-star rank after direct commission from enlisted service.

He holds a bachelor's degree (cum laude) in international relations and a master's degree in management. He has been awarded an honorary doctorate degree in humanities from West Virginia Institute of Technology and an honorary degree in information technology from Potomac State College of West Virginia University.

Admiral Lopez is president of Information Manufacturing Corporation, an information technology service integrator with offices in Fairfax, Virginia, and Rocket Center, West Virginia.

GENERAL ROBERT MAGNUS, USMC (RET.)

Former Assistant Commandant of the U.S. Marine Corps

General Magnus served as Assistant Commandant of the Marine Corps from September 8, 2005–July 2, 2008.

General Magnus is a graduate of the University of Virginia (1969) and Strayer College (1993). His formal military education includes Naval Aviator Training, U.S. Marine Corps Command and Staff College, and the National War College.

General Magnus' operational assignments include: Intelligence Officer, HMM-264; Operations Officer, H&MS-15 SAR Detachment, Task Force Delta, Nam Phong, Thailand; Training Officer, SOES, MCAS Quantico; Aviation Safety Officer, MAG-26 and HMM-263; Weapons and Tactics Instructor, MAG-26 and HMM-261; Operations Officer, MAG-29; Commanding Officer, HMM-365; Commander, Marine Corps Air Bases Western Area; and Deputy Commander, Marine Forces Pacific.

His staff assignments include: Aviation Assault Medium Lift Requirements Officer; Chief, Logistics Readiness Center, Joint Staff; Executive Assistant to the Director of the Joint Staff; Head, Aviation Plans and Programs Branch; Assistant Deputy Chief of Staff for Aviation; Assistant Deputy Commandant for Plans, Policies, and Operations; and Deputy Commandant for Programs and Resources.

VICE ADMIRAL DENNIS V. MCGINN, USN (RET.)

Former Deputy Chief of Naval Operations for Warfare Requirements and Programs

Vice Admiral McGinn is a Senior Fellow in International Security, at the Rocky Mountain Institute (RMI). He is working with RMI CEO Amory Lovins and other policy experts on national security issues.

He is 1967 graduate of the United States Naval Academy, attended the Naval War College and Harvard's Program for Senior Officials in National Security, andserved as a chief of naval operations fellow on the Strategic Studies Group. He is also a designated naval aviator, test pilot, and national security strategist.

In 1995 Vice Admiral McGinn served as commander, Carrier Group One, responsible for operational training and combat readiness for all Pacific Fleet carrier battle groups. He was assigned as director of the Air Warfare Division in the Office of the Chief of Naval Operations in 1996, and, in 1998, became commander of the U.S. Third Fleet.

In 2000 he assumed duties as the deputy chief of naval operations, warfare requirements and programs.

ADMIRAL JOHN B. NATHMAN, USN (RET.)

Former Vice Chief of Naval Operations and Commander of U.S. Fleet Forces

Admiral Nathman, a native of San Antonio, Texas, graduated with distinction from the United States Naval Academy in 1970. In 1972, he qualified as a carrier aviator, receiving the Naval Training Command's Outstanding Pilot Graduate Award while also completing a Master of Science degree in Aerospace Engineering. He has served in a variety of sea, shore and joint assignments and flown over 40 different types of aircraft during his career.

As a carrier pilot, Admiral Nathman flew the F-4 Phantom with VF-213 and the F-14 Tomcat with VF-51. He commanded VFA-132 flying from the USS Coral Sea, leading his squadron in the first F/A-18 combat sorties against Libya in 1986. He reported to the USS Nimitz (CVN 68) in 1987 as Executive Officer and subsequently assumed command of USS La Salle (AGF 3), the flagship for Commander, Middle East Force, during Operations Desert Shield and Desert Storm. He returned to the carrier Nimitz as her Commanding Officer from 1992-1994.

Ashore, Adm. Nathman graduated with distinction in 1976 from the U.S. Air Force Test Pilot School at Edwards Air Force Base. He then served as an instructor pilot at Topgun and oversaw the advanced tactical training of naval aviators. From 1982-1984 he was the senior naval test pilot flying all MiG aircraft with the 4477 Test and Evaluation Squad-

ron at Nellis Air Force and Tonopah, Nevada. He served briefly in the Pentagon in 1991 as the Director for Navy Fighter requirements.

After his selection to Flag rank in 1994, Admiral Nathman served on the NATO staff of Commander, Allied Forces Southern Europe and as Director of Logistics for Commander, NATO Implementation Force during its deployment to Bosnia. He also commanded Carrier Group 7, Nimitz Carrier Strike Group and Battle Force FIFTY in the Persian Gulf, and subsequently served as Director, Air Warfare on the Chief of Naval Operations staff.

Promoted to Vice Admiral in August 2000, he commanded Naval Air Force, U.S. Pacific Fleet and was later designated the first Commander, Naval Air Forces. Afterward, he returned to the Pentagon as the Deputy Chief of Naval Operations for Warfare Requirements and Programs.

Promoted to Admiral, Nathman served as the 33rd Vice Chief of Naval Operations and most recently commanded all U.S. Fleet Forces from February 2005 until May 2007.

His personal decorations include the Distinguished Service Medal (four awards), Defense Superior Service Medal, Legion of Merit (four awards), Bronze Star with Combat V, Defense Meritorious Service Medal, Meritorious Service Medal (three awards), Navy Commendation Medal with Combat V (two awards) and the Air Force Achievement Medal in addition to numerous campaign and unit awards.

REAR ADMIRAL DAVID R. OLIVER, JR., USN (RET.)

Former Principal Deputy to the Navy Acquisition Executive

Oliver completed a distinguished career in the U.S. Navy in 1995, retiring as a Rear Admiral (Upper Half) in 1995. He served at sea aboard both diesel-electric and nuclear submarines, commanding a nuclear submarine as well as two submarine groups, one in Japan and one in San Diego, and was the Chief of Staff for our Fleet in the Far East. His final military tour was as Principal Deputy to the Navy Acquisition Executive.

His military decorations include the Defense and Navy Distinguished Service Medals as well as six awards of the Legion of Merit. His awards for public service include the Bronze Palm to the Department of Defense Award for Distinguished Public Service as well as the Army and the Navy Public Service Awards.

Oliver served in Iraq as the Director of Management and Budget for the Coalition Forces. Previously, he served the Clinton and Bush Administrations as Principal Deputy Undersecretary of Defense for Acquisition, Technology and Logistics, a position the Senate confirmed him to after his work as an executive at Northrop Grumman Corporation. He currently is Executive Vice President for EADS North America and serves on the Boards of Directors for American Superconductor Corporation and Stratos Global Corporation. He is also the author of an instruction primer for political appointees, Making It in Washington; his wife's biography, Wide Blue Ribbon; and a management book, Lead On.

Mr. Oliver's undergraduate training was from the United States Naval Academy; subsequently he received a Master of Arts in Political Science and International Affairs (specializing in the Middle East) from American University.

GENERAL GORDON R. SULLIVAN, USA (RET.)

Former Chief of Staff, U.S. Army; Former Chairman of the CNA MAB

General Sullivan was the 32nd chief of staff—the senior general officer in the Army and a member of the Joint Chiefs of Staff. As the chief of staff of the Army, he created the vision and led the team that helped transition the Army from its Cold War posture.

His professional military education includes the U.S. Army Armor School Basic and Advanced Courses, the Command and General Staff College, and the Army War College.

During his Army career, General Sullivan also served as vice chief of staff in 1990 to 1991; deputy chief of staff for operations and plans in 1989 to 1990; commanding general, First Infantry Division (Mechanized), Fort Riley, Kansas, in 1988 to 1989; deputy commandant, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas, in 1987 to 1988; and assistant commandant, U.S. Army Armor School, Fort Knox, Kentucky, from 1983 to 1985.

His overseas assignments included four tours in Europe, two in Vietnam and one in Korea. He served as chief of staff to Secretary of Defense Dick Cheney in the administration of President George H.W. Bush.

General Sullivan was commissioned a second lieutenant of armor and awarded a bachelor's degree in history from Norwich University in 1959. He holds a master's degree in political science from the University of New Hampshire.

General Sullivan is the president and chief operating officer of the Association of the United States Army, headquartered in Arlington, Virginia. He assumed his current position in 1998 after serving as president of Coleman Federal in Washington, D.C.

VICE ADMIRAL RICHARD H. TRULY, USN (RET.)

Former NASA Administrator, Shuttle Astronaut and the first Commander of the Naval Space Command

Admiral Truly served as NASA's eighth administrator from 1989 to 1992, and his career in aviation and space programs of the U.S. Navy and NASA spanned 35 years. He retired as a vice admiral after a Navy career of more than thirty years. As a naval aviator, test pilot and astronaut, he logged over 7,500 hours and made over 300 carrier-arrested landings, day and night.

Admiral Truly was the first commander of Naval Space Command from 1983 to 1986 and became the first naval component commander of U.S. Space Command upon its formation in 1984. While still on active duty following the Challenger accident, he was called back to NASA as associate administrator for space flight in 1986 and led the accident investigation. He spearheaded the painstaking rebuilding of the space shuttle, including winning approval from President Reagan and the Congress for building of Endeavor to replace the lost Challenger. In 1989, President Reagan awarded him the Presidential Citizen's Medal.

Truly's astronaut career included work in the Air Force's Manned Orbiting Laboratory program, and NASA's Apollo, Skylab, Apollo-Soyuz and Space Shuttle programs. He piloted the 747/Enterprise approach and landing tests in 1977, and lifted off in November 1981 as pilot of Columbia, the first shuttle to be re-flown into space, establishing a world circular orbit altitude record. He commanded Challenger in August-September 1983, the first night launch/landing mission of the Space Shuttle program.

He served as vice president of the Georgia Institute of Technology and director of the Georgia Tech Research Institute from 1992-1997. Admiral Truly retired in January 2005 as director of the Department of Energy's National Renewable Energy Laboratory.

Truly is a member of the National Academy of Engineering. He has previously served on the board of visitors to the U.S. Naval Academy, the Defense Policy Board, the Army Science Board, and the Naval Studies Board. He is a member of the National Research Council Space Studies Board, a trustee of Regis University and the University Corporation for Atmospheric Research, and a member of the advisory committee to the Colorado School of Mines Board of Trustees.

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