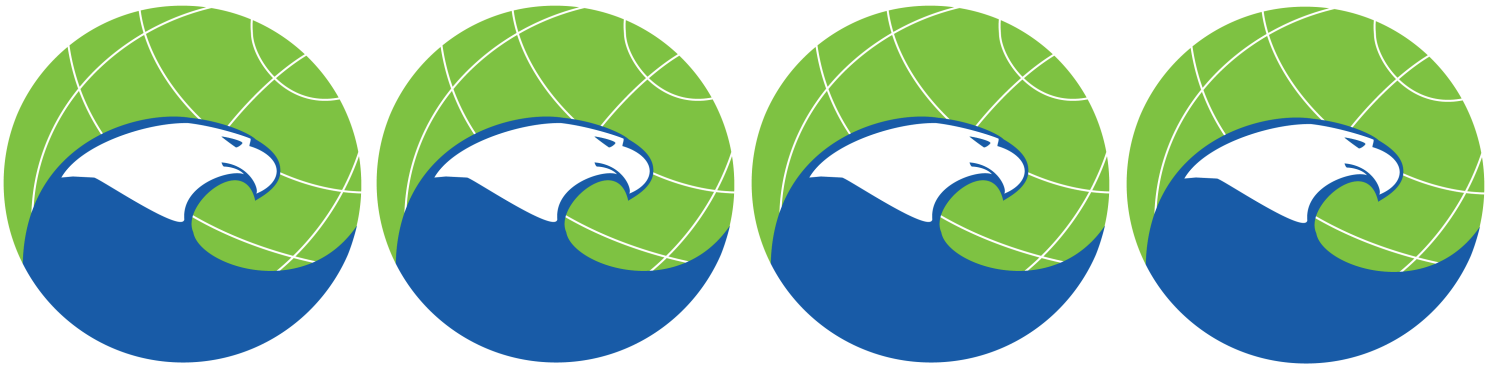
Ensuring America's Freedom of Movement:

A National Security Imperative to Reduce U.S. Oil Dependence



October 2011

CNA
ANALYSIS & SOLUTIONS

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Executive Director, CNA Military Advisory Board
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Letter of Transmittal

Foreword

"Oil is ammunition."

A short, piercing order signaled during World War II by the Chief of Naval Operations, Admiral King, to all "hands," from senior officers to enlisted men, like petty officer 3rd class, USN, John Warner.

Having vivid memories of this period in our nation's history, when gasoline was rationed "on the home front" to 3 gallons per family car, per week, I suggested this poster be included in this report.

Admiral King's incisive knowledge is as true today as it was in W.W. II. General Petraeus, from Afghanistan, issued a similar (but longer) message this past summer to forces under his command.

CNA's Military Advisor Board (MAB), likewise, incorporated the wisdom, the critical reality, of these messages in this report as all America is now facing challenges over our nation's energy policies and impacts from an ever-changing global situation.

As Secretary of the Navy, I worked closely with CNA, which today renders a much broader mission of analyzing and reporting on public issues. The Military Advisory Board was a wise addition. As a member of the U.S. Senate, and on many occasions since my return to the private sector, I have worked with these organizations as they make valued contributions of public service.

This report on Energy, consistent with MAB's previous reports, is well researched, objective, and independent. Parts can even be viewed as provocative!

The MAB clearly articulates the national security threats associated with our nation's overreliance on oil. Moreover, they identify this vulnerability as an urgent threat that requires prompt action by leaders in the Executive and Legislative branches of our Government.

They make the case that our overreliance on oil in the transportation sector impacts every aspect of our national security: our economy; our geopolitical choices and standing; our environment; and our military security. Our government must work in partnership with the private sector.

The MAB is deserving of the public's trust and confidence, for its members have proven records of experience and accomplishment, each having served in uniform more than two decades, in positions of vital responsibility within our nation's national security. They have strongly articulated the linkage between our security and energy; and understandably, have a particular concern for those now in uniform and the risks they face performing missions assuring the military needs for energy.

I am humbled by the opportunity to work with them and submit this foreword as part of their Report.

John W Warner
U.S.S., Ret.

Forwarding letter from former Senator John Warner, U.S. Senate 1979-2009

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To the Reader

All Roads Lead to Rome: On Finding a Common Language

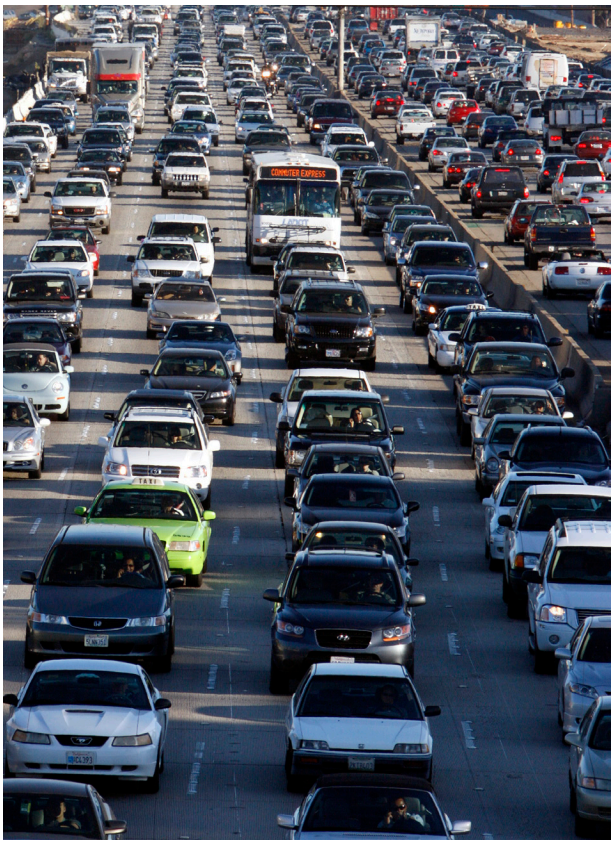
In 2006, CNA brought together 11 recently retired three and four-star generals and admirals to form a Military Advisory Board (MAB), with the goal of examining the national security implications of climate change. Over the last five years, the CNA MAB has published three reports on the nexus of energy, climate, and national security. In this most current report, which is the result of the fourth convening of the MAB, we focused our efforts on the national security implications associated with shifting the U.S. transportation sector to alternative fuels.

Our discussions of transportation fuels and security have ranged widely, partly because national security involves a wide range of factors, and partly because many energy issues are connected to one another. While our conversations roamed and the discussions expanded, periodic course corrections enabled us to refocus on our main topic. Over time, we were struck by a single pattern.

In the age of the Roman Empire, the saying was true: All roads lead to Rome. In the current age, given the scale and nature of our economy, and the extent of global connectivity, one could just as easily coin a similar saying: All roads lead to energy.

As we raised questions about various aspects of America's economy, environment, security and global presence, the answers all sounded familiar. Over and over, we saw the obvious: America must fundamentally reconsider its national approach to energy.

> Those of us expressing concern about America's diplomatic hands being tied, in part by our need to retain access to global oil supplies, ended up seeing that this would stop only when we changed our approach to energy.



Vehicles are seen during rush hour on the 405 freeway in Los Angeles. Lucy Nicholson / Reuters

> Some of us focused on retaining America's long-term economic vitality and restoring a positive balance of trade, and concluded that we can achieve these goals in large part only by changing our approach to energy.

> For those who saw climate change as a significant national security threat multiplier, the answer was the same: We can reduce CO_2 emissions when we change our approach to energy.

> For anyone concerned about the safety of troops on the ground today in Iraq and Afghanistan, you know at least part of the answer: America's military would benefit tactically and strategically if we change our approach to energy.

As a group of thirteen individuals, we bring different experiences and perspectives to these discussions. Our differences have occasionally been substantial and passionate (just as they often were during our time of active duty).

Nevertheless, we found we could always get back on course by focusing on where we agreed. Even if our individual starting points were different, we found we were arriving at the same place. We all saw the value of a fundamental redirection of our approach to energy—including a significant reduction in our use of imported oil. There are plenty of reasons, stemming from many perspectives, for America to reduce its dependence on oil.

It's rarely easy to change one's position on an issue—but that is what many of America's leaders must do. Again, we note that a focus on points of agreement can be the key. Because all of us were unwilling to compromise America's national security, each of us became willing to compromise on our individual positions. This, too, is what America's leaders must do.

Our hope in highlighting the national security value of this course of action is that it will lend a sense of urgency to this issue. And so we reiterate the point: Weaning America from oil in substantive ways will make us safer as a nation. We should not be swayed by the rising or falling prices of gasoline at the pump, which can too easily be manipulated by suppliers trying to deter our path toward energy security. Our resolve must be true, for the pace and consistency of our country's movement along the path to energy security is a vital national security challenge. No matter one's individual perspective—liberal or conservative–we must focus together on concrete steps to reduce our reliance on oil.

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We thank the following individuals for sharing their technical, geopolitical, and policy expertise with the CNA Military Advisory Board:

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Ms. Ruth Cox, Executive Director, U.S. Fuel Cell Council

Mr. Robbie Diamond, President and CEO of Security America's Future Energy (SAFE) and President and CEO of the Electrification Coalition

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Executive Summary

Why Experience Matters

This study examines the national security implications of a transition away from conventional petroleum-based fuels in the U.S. transportation sector.

Our national security focus is based primarily on our experiences as senior military leaders and offers perspectives that differ from traditional energy analysis. We consider geopolitical, economic and environmental aspects of energy as a matter of course, but view the full suite of issues through a security prism honed in military operations.

Collectively, we bring to this work over 400 years of military experience. As a result, the findings, recommendations, and opinions we proffer are grounded in that collective experience. It is what makes this report different from more traditional research reports. However, we have not arrived at our conclusions without substantial analysis, dialogue, and deliberation.

Over the course of our research, we balanced and broadened our perspectives through robust meetings with renowned experts from academia, think tanks, policy makers, senior members of the current and former administrations, and industry. Throughout our research, we have worked closely with the CNA analysts to understand fully the geopolitical implications of oil and alternative fuels, and drew heavily on their synthesis of the existing work on alternative fuels and their futures.

It is through this iterative, vigorous, and participatory process that we reached the consensus of views and collective opinions presented in this report.

The specific questions we address in this report are:

1. How does America's transportation sector dependence on oil affect our geopolitical, economic, environmental, and security landscape?
    a. What are the strategic implications of the United States moving away from oil as a transportation fuel?
2. What are the potential positive and negative impacts that will emerge under large scale adoption of various alternative fuels or combinations of fuels?
3. What policies should the United States consider to ensure that our national transportation fuel transition enhances America's energy, economic, climate and national security?

This work builds upon reports previously issued by the Military Advisory Board and available at www.cna.org:

National Security and the Threat of Climate Change noted that climate change will be a threat multiplier in many global regions. It noted that climate change, national security and energy dependence are a related set of global issues. Based in part on this report, Congress requested a National Intelligence Assessment on climate and security, which ultimately echoed many of the original CNA findings, and directed DOD to include national security implications of energy and climate change in the Quadrennial Defense Review.

Powering America's Defense highlighted the ways in which fuel inefficiencies imperil US troops. It also described how America's fragile electricity grid represents a clear and present danger to U.S. security.

Powering America's Economy explored the connections between the economy, energy, and military strength and outlined steps the DOD could take to help lead a transition to a clean energy economy.

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Findings and Recommendations of this Report

Discussions of energy are discussions of national security. One directly affects the other. Our previous reports have made clear the deep connections between energy, the economy, climate change and security. As we narrow in on one aspect of our energy posture—our heavy reliance on oil, especially imported oil—the connections among these issues are again painfully obvious. Immediate and aggressives action to move our transportation sector away from oil and toward alternative, domestically produced sources of energy are needed to improve our national security posture. The consequences of inaction, or even delayed action, are grave.

The consequences of inaction, or even delayed action, are grave

We view this issue with a sense of genuine urgency and find the time to act is now. We focus the efforts of our study on a ten-year time frame—less time than one might expect, given the scale of energy infrastructure investments the transition demands—because it is a window within which one can reasonably predict the pace of technology changes. We also chose it because we believe that, with respect to our energy posture, America does not have the luxury of time. To the contrary, we find that American leadership is at a perilous point. We note that while many of our allies are looking inward, distracted by their own domestic challenges, the worldwide demand for oil is increasing at an alarming rate. Within ten years, China, India and other developing nations' growing demand for oil will undoubtedly change the oil market. Our military experience tells us that transitional moments such as these are important, and they come and go quickly. When the moment is ripe, nations must act or, all too often, be prepared to fight their way out of the consequences of inaction.

Americans, with good reason, are concerned about the current domestic economic crisis. But that crisis must not divert Americans from moving away from our reliance on oil. In fact, moving away from oil could contribute to restoring our economic strength. The opportunity to show global leadership on energy issues exists now. This is our moment, and we must act.

Findings:

1. America's dependence on oil constitutes a significant national security threat.

Our overreliance on oil is a national vulnerability. If even a small percentage of the daily supply of oil is interrupted, our nation's economic engine, which is heavily reliant on transportation, could be significantly impacted. Despite our strategic oil reserve, the consequences for a sustained oil disruption—oil shock—would impact every aspect of our lives, from food distribution and what (or if) we eat, to manufacturing goods and services and associated jobs, to how we move from place to place in the conduct of our everyday lives. We have seen the consequences of oil shock before. We know the consequences are significant, we know they are immediate, and we know they are far reaching. We have seen how oil can be used as a weapon to attack our national security. We know this; our policy makers know this; our enemies know this.

In the United States, our transportation systems rely almost exclusively on gasoline, diesel, and jet aviation fuel. These three products are refined from a single basic ingredient: oil. How we get to work, how we ship materials, how we farm or produce our food, and how we transport raw products to manufacturers or finished products to or from markets depends, in nearly all cases, on this single source of materials: oil.

Our dependence on oil reduces our foreign policy options—no small concern as Middle East uprisings continue and dangerous regimes work to develop nuclear weapons. It leads us down foreign policy paths that ultimately put our troops in harm's way. Oil dependence drags our economy downward, thwarts investment, and imperils our historic role as technology leaders—potentially depriving our troops of key military advantages. The cost of oil and the volatility of the price of oil hurt our military investments and limit both our military capability and capacity. Finally, our dependence on oil has far-reaching impacts on the environment.

Our overreliance on oil is made worse by our lack of control over global supplies, which is why, in this report, we focus on oil generally and not on foreign oil specifically. Oil is a global commodity, and any amounts of oil produced in North America become part of the global supply. When global prices spike upward, the domestic price also spikes—we don't get "big-box store" discounts just because of our nationality. We too often watch idly how these price swings have been, and continue to be, manipulated by parties beyond U.S. control or influence.

To be clear, we see the value of increased domestic oil production as one of several viable options for reducing our overdependence on foreign oil. A near-term increase in domestic production has the potential to decrease reliance on outside sources, to increase the margin between global demand and global supply, and to increase our diplomatic leverage options. However, we also recognize that domestic oil alone will not satisfy our nation's transportation energy demand. We must have alternatives to oil for our transportation sector. We can increase domestic production, and simultaneously reduce our overall demand for oil. The two need not present a conflict. Together, these steps would significantly strengthen our economic and diplomatic hands.

2. A 30 percent reduction in our use of petroleum would significantly improve our national security.

We chose our reduction target based on a specific military challenge. CNA analysis shows that if America used 30 percent less oil, our economy would have enough resilience to sustain the effects of a complete shutdown of the Strait of Hormuz (the narrow passage for international shipping between the Sultanate of Oman and Iran), or any other major shipping choke point, with little effect. That image is a satisfying one (particularly to those of us who have spent much of our careers focused on Persian Gulf threats), and offers as good a definition as any of oil independence and increased security. If we achieve this 30 percent reduction, any enemy or rogue nation could close a key choke point or otherwise significantly disrupt the global flow of oil, and there would be little, if any, first order economic impact to the United States.

A 30 percent reduction would expand our foreign policy options, because our thirst for oil would no longer tether us as tightly to certain unreliable partners. It would help our military engagements, improve our flexibility, and increase our leverage among our allies.

A 30 percent reduction would also bolster our economy, decrease our trade deficit, and preserve capital for job creation at home. It would enhance our capacity to innovate, in large part because alternative energy investments would no longer be torpedoed by swings in oil prices caused by market forces or deliberately imposed by foreign cartels. Our economy would gain resilience.

The connection is direct: America becomes more secure if Americans use less oil. Economic security is essential to national security.

3. We can achieve a significant portion of a 30 percent reduction through greater efficiency in how we use oil.

The federal government's fuel economy standards have proven to be effective at increasing efficiency and reducing the use of oil. (This is also true of numerous state standards, including California's tailpipe emission standards.) These standards should be supported and strengthened as a means of making our nation more secure. State and federal governments must also explore additional market incentives and research programs to help achieve increased fuel economy, again as a means of reducing oil dependency. Our current approach to energy and transportation, which relies on market forces, is making us less secure.

Some degree of efficiency and fuel savings can be gained without any new technology or government programs. Our collective security can be strengthened by individual actions. We can carpool, combine trips, take public transportation, reconsider whether some trips are necessary, examine how and where we work—each of these steps offers a chance to cut our oil use. These adjustments may seem, to many, like substantial lifestyle changes or difficult economic choices—we see them as steps that make America more secure.

The benefits of efficiency are so obvious and sizeable that it is amazing to consider how or why our country has failed to insist on (or at least incentivize) it up to now. Rather than focus on past failures, however, we see this as a current and crucial opportunity. We can make dramatic reductions in our use of oil—and shame on us if we don't.

While our study focuses on alternative fuels, we repeatedly found the best and most strategically promising alternative to be efficiency.

4. There are many promising alternatives to oil as a transport fuel—some available today, others on the horizon. If managed properly, all of the most promising alternative fuels examined can lower overall national security risks rather than continuing our overreliance on oil as a singular fuel source.

The long list of viable alternatives to oil is good news. We have options. Good ones.

While the options are many, no single option is poised to occupy the singular place that petroleum now holds in American society. This, too, should be viewed with optimism, because it allows us to accept a future characterized by diverse supplies. Our current overreliance on a single fuel is a weakness; relying on diverse fuels and vehicle types can be a strength. Seeking a silver bullet would be a major mistake—we should pursue diversity.

Achieving a diverse, effective, and plentiful supply of energy sources other than oil won't be easy. Americans have optimized oil production and distribution, and have mastered refining techniques to maximize energy density and safety characteristics. Still, it is time to get on with the change. If pursued haphazardly, some of the options for replacing oil could have adverse national security implications. Some of the potential negative impacts that merit attention are: increased reliance on raw materials not produced domestically, excessive water use, altered strategic partnerships, and environmental risks.

National security involves a complex, interrelated range of factors, including economic, geopolitical, military, and environmental factors, and not all alternatives to oil are created equal when it comes to national security impacts. As we move to reduce our dependence on oil, we must assess the costs and benefits of alternatives in relation to these factors. While one fuel may reduce our economic security risks, it

may also result in new geopolitical challenges. While another may have economic consequences, it could significantly reduce environmental effects. Others may have plentiful feedstock, but the process to produce the fuel may have grave, long-term environmental impacts. Short-term gains must be weighed carefully against long-term risks. Simplistic approaches or broad assumptions about the value of a particular fuel will not work. Navigating through the security challenges of alternative fuels will require a combination of market drivers and forward-looking government policy. These issues demand leadership at the national level, foresight, and careful planning to evaluate the competing implications and to mitigate untoward challenges. Obstacles aside, the time for our nation to act is now.

Recommendations:

1. To assure our national security, government must take action to promote the use of a more diverse mix of transportation fuels and to drive wider public acceptance of these alternatives.

Overreliance on oil in the transportation sector is the Achilles heel of our national security. As military professionals, we see this clearly; so do those who would do us harm. Our overreliance on this single commodity makes us vulnerable. We are vulnerable not only to price spikes, which can slow or halt our nation's economic growth and devastate family budgets, but also to price volatility and uncertainty that can negatively affect our investment decisions. We are held hostage to price fixing by a cartel that includes actors who would do our nation harm, and we are too often called upon to risk the lives of our sons and daughters to protect fragile oil supplies from this very cartel.

One of the principal roles of the government is to provide national security. It is in this light that we must push our government to develop a nationwide strategic plan that embraces diverse fuel supplies. With the ability of OPEC to control price, market factors alone will not compel the nation to embrace diverse fuel options at the pace that is needed.

Not only will diversifying transportation fuel supplies enhance our national security, it will help maintain America's technological and industrial edge. Choosing a multi-vectored approach can make our fuel sources—and our economy as a whole—much more flexible, adaptable, and resilient. Most importantly, it will restore choice: choice for the consumer, choice for the businessman, choice for our foreign policy makers, and choice for our nation.

Our various military experiences remind us of the value of diverse approaches. Our troops engage by air, land, and sea. Our nuclear deterrence strategy has long relied on submarines, aircraft, and land-based missiles. Nevertheless, we continue to rely on a single type of fuel that must traverse a single path to a forward operating base—as is often the case with fuel convoys today in Afghanistan—placing our people and operations at great risk.

OPEC can increase production and drive down gas prices, erasing market incentives for developing alternative fuels. Natural price fluctuations, changes in demand, and other market factors can continue to frustrate business planning. This would not be the case if we had a diverse fuel portfolio. This is where clear market signals can play an important role by creating the necessary conditions to incubate a diverse portfolio of transport fuels. Legislation, regulation, and incentives will be required.

To those who oppose such government action, we remind them that our current dependence on oil is a clear and present threat to our national security. We challenge them to use the appropriate powers of government, teamed with the private sector, to make our nation more secure. We believe security should trump ideology.

2. In the immediate future, our nation's leaders must develop a comprehensive energy roadmap or strategic plan to enable consistent and strategic energy policies and investments.

The scale of impact associated with our energy use is massive. The right energy choices can bring down our trade imbalance, lead to new jobs at home, launch new American-made technologies, strengthen our foreign policy hand, and increase our military and foreign policy options. These benefits are time-sensitive—waiting for a convenient time to address this challenge will weaken us while others continue to gain strength. Our security requires a national, cogent, dedicated, and sustained energy roadmap that rises above partisan politics and special interests.

Administration and congressional leaders should require that major energy policy documents address the national security implications of our energy choices. Highlighting the security aspects can help energy issues gain appropriate attention and imbue them with a realistic sense of urgency. Using the security lens, every energy policy discussion would reinforce the multiple values of actions necessary to swiftly reduce our use of oil.

The Department of Defense (DOD) and Department of Energy (DOE) must continue to develop a closer relationship and a better coordinated voice. As the largest governmental consumer of energy, a properly resourced DOD has the capacity to help develop and transition many of the concepts that originate within DOE.

We use the term terms "roadmap" and "strategic plan" instead of "policy", in part because the latter term appears to be politically charged, and in part because policies too often shift with the changing of political leadership. The nation needs a strategic plan that will transcend administrations. Policies will play a role, but only if they can be placed in the context of the larger roadmap. Military operations are built around plans. They are how we define our requirements and make our long term, strategic investments. Military plans include options that allow one to build on successes or work around obstacles. They provide direction, but allow flexibility. The nation needs a strategic energy plan.

3. The U.S. must take swift and aggressive action to reduce our use of oil.

As part of a comprehensive energy roadmap, the Administration and Congressional leaders should work to create clear market signals that unleash America's innovative powers to reduce oil use and increase the use of alternative fuels and vehicles. The free market is vital to innovation and economic strength, but we must take steps to ensure that market incentives favor fuels and vehicles that enhance our national security. If these policies are broad and operate across the American economy, they will not result in government picking winners and losers among fuel types; they will, however, ensure that Americans are winners.

Improving our oil efficiency offers a fast and almost immediately effective means of making great gains toward a 30 percent reduction in oil use. Efficiency can and should involve government direction; it can and should involve voluntary efforts by all Americans, too. We can work together to conserve oil, and doing so will make us safer. We've seen first-hand America's ability and willingness to commit, together, to a mission—the support for our troops engaged in Iraq and Afghanistan has been both inspiring and heartwarming. We need the same level of enthusiastic support for measures—both voluntary and mandatory—that enable Americans to use less oil.

The pace of growing competition for limited supplies of world oil makes the need to reduce Americans' overreliance all the more urgent. Even the most conservative projections of the growth of global com-

petition for this limited resource make clear that we cannot afford to wait a decade to change our behavior. The time for our nation to act is now; this is a call to action.

4. The Department of Defense should continue to be a leader in advancing alternative transportation fuels while balancing mission effectiveness and overall efficiency. DOD must be provided the necessary resources so innovation and experimentation with alternative fuels is not traded for military capability and capacity. DOD should be provided with the necessary authority to establish long-term alternative fuel contracts as a way to assure markets and lower the alternative fuel price.

Our military's first mission is to fight and win America's wars. As members of the Military Advisory Board, we deliberately resist any temptation to add to or complicate this mission; we implore our political leaders to show the same restraint. At the same time, we observe that overreliance on any single commodity such as oil creates vulnerabilities that an enemy can exploit.

We find that while pursuing its war-fighting mission, there is a great deal DOD can do to lower its own overdependence on oil and improve the Department's energy posture. Today's American uniformed military leaders are already implementing important changes in energy use, including efficiency and the use of alternative transportation fuels. Thanks to the concerted efforts from the Office of the Secretary of Defense, and the services, changes are being implemented at a faster pace than envisioned, and to greater effect.

As DOD makes changes to its operational energy posture, the benefits can be counted in lives saved. As noted in our earlier reports, increases in energy efficiency on the battlefield save American lives. (Our earlier reports noted the deaths incurred by fuel convoys in Iraq and Afghanistan. Since the publication of these reports, we have noted that when our forward operating bases found ways to be more energy efficient, the fuel demand was reduced. Fewer convoys left fewer troops vulnerable.) Similarly, we believe that pursuing wider diversity in its energy sources provides a way for DOD to increase overall resilience by assuring multiple supplies of energy for military missions both at home and deployed. Additionally, a more diverse energy portfolio provides insulation from oil price swings and may improve the way we fund and outfit the military.

While we recognize the national and strategic benefits of lowering our dependence on oil, we strongly caution that our military leadership not be overly distracted by alternative fuel innovation and experimentation such that their near-term mission effectiveness becomes hindered. We see this as a balancing challenge for both our uniformed and civilian leadership. Clearly stated, we recognize and applaud DOD's long-term, enduring interest in displacing petroleum, for both strategic and operational reasons. However, alternative fuels that do not benefit military operations in the short term should not compete with investments that do. To that end, DOD should takes steps to promote the development of drop-in alternative fuels for its forward deployed assets while ensuring that in the future, fuel-consuming equipment is capable of using alternative fuels without significant performance penalties. At the same time, we believe that DOD should aggressively move its non-deployed forces to more efficient vehicle systems and alternative fuels.

To make the best use of its forces, DOD needs adequate resources and authority to implement and sustain changes in its transportation energy posture. For example, DOD is currently limited to a maximum of five years for its fuel contracts. This is insufficient to provide industry the necessary assurance to invest in long-term and costly alternative fuel infrastructure. If DOD could instead commit to decade-long purchasing agreements, defense leaders could provide the certainty that companies need to spur investment in new technologies and infrastructure. We are en-

couraged by the language in the proposed Defense Authorization Act that would authorize this type of long-term contracting.

Finally, we reassert our belief that DOD can spur clean energy innovation in a measured and purposeful manner. We have seen DOD at the forefront of our previous shifts from one form of energy to the next. Be it sail to steam, coal to oil, or horse to motor vehicle, the military has led the way. Military culture and organizational disciplines provide the necessary vision, planning and motivation to successfully make these types of revolutionary changes. We are certain that a transition to clean transportation energy will be no different than the past energy transitions. We are confident that our military leadership will recognize that it must be mission first, especially when the lives of our nation's sons and daughters hang in the balance.

GENERAL JAMES T. CONWAY, USMC (RET.)
Former 34th Commandant Of The Marine Corps

Oil dependence as an urgent threat

"We've been at this thing for decades—talking about getting the nation off its vulnerability to foreign oil—but I still don't think people see it as an issue of national security," said retired General James T. Conway. "They're not making that connection."

Conway, former Commandant of the U.S. Marine Corps, says the decades-long conversation may be obscuring the urgency. He says our vulnerability could be exposed very quickly.

"You could wake up tomorrow morning and hear that the Iranians sense an attack on their nuclear power plants," Conway said. "And so they preemptively take steps to shut off the flow of oil in the Gulf," Conway said. "The U.S. would likely view this as a threat to our economy, and we would take action. And there we are, drawn into it."

"When we killed bin Laden, we saw oil tanker designs on his work desk"

Conway described terrorist attempts to attack Saudi refineries, noting that the intent was to cause economic disruption thousands of miles away in the U.S. And he highlighted more recent evidence of a party interested in an attack.

"When we killed bin Laden, we saw oil tanker designs on his work desk," Conway said. He added that such an attack may have been beyond al-Qaeda's means at that point, but stressed that the intent was clear.

Conway expressed concern that political stalemate among political leaders was also delaying a thoughtful national response.

The nation is at risk because of intransigency

"You've got people stuck in their positions on the left and the right," he said. "They look at energy through the prism of ideology, when they could instead look at it through the prism of national security. But right now, we've got people who are entrenched. The nation is at risk because of intransigency. Some of them, or all of them, will have to give up on things they feel strongly about. But compromise is the only way we'll be able to develop a national strategy."

When asked about the political risks of compromise, Conway acknowledged the risks, but offered a challenge.

"We did it all the time," he said, in describing compromise among U.S. military leadership. "We would talk it through, argue about it, and agree on a plan. That process made the plans better. And it helped build buy-in. We had differences, but once we agreed on the plan, we moved together."

Chapter 1

Much to Gain:

The National Security Benefits of Reduced Oil Use

As we consider the national security implications of the alternative fuels and approaches that may be used to reduce our use of oil for transportation, we should first define what we mean by the term national security. As former military commanders, our views have been shaped by our missions and military deployments. For our study, we considered a suite of broad categories often used by defense and foreign policy experts when assessing potential national security threats. These include:

Economic security: A healthy economy suggests the nation is able to provide sustenance for its population, and can provide a level of goods and services that is culturally consistent with what its population has come to expect. In national security discussions, the growth and health of the nation's economy is key.

Military security: A nation's military should be able to protect its borders and citizens (and its interests abroad) from physical threats. A contemporary view of this may also include protection from cyber and other transnational threats.

Political/Geopolitical stability: Political stability involves ensuring internal order and governance, so that major institutions can function continuously and effectively. Geopolitical stability involves healthy relationships with the community of nations, so the nation can thrive in a global economy.

Environmental security: An environmentally secure nation can have confidence that its land, water, air, and natural resources will remain healthy and accessible. When ecological systems are degraded, negatively affecting water supplies, food production, livelihood, and basic shelter requirements—the risks to security climb.

Each of these categories is an important factor in assessing national security. Impacts in one category tend to cause impacts in another. For example, extended drought in Darfur led to economic instability, which in turn, led to political upheaval and civil war. In another case, Singapore's near-total reliance on Malaysia for water after it gained its independence from Britain had economic and political effects that Singapore is only now beginning to overcome completely. The notion that environment and security are linked may seem like a stretch to some, but those of us who have been on the ground in such places have seen the connection: the environment is very clearly a national security issue.

A key term which underscores all of these categories is stability. The U.S. has always pushed for the advance of freedoms, at home and abroad. As we have done so, there is often a tension between this advance and the stability necessary to keep our nation, and other nations, secure. We tend to push for increased global freedoms at a reasonable pace—again because of the value we place on stability. It takes no leap of logic to see how global energy choices have often been destabilizing. (WWII in the Pacific was principally about Imperial Japan's expansion to satisfy their need for raw material and oil in South East Asia.) As demand for energy grows and supply of petroleum shrinks, these effects may be magnified. The global demand for oil has affected military engagements, been associated with economic recession, reshaped geopolitical relationships, caused domestic political upheaval, and led to significant environmental harm. Our own heavy use of oil has allowed or increased some of these destabilizing impacts. Reducing our use of oil can change this balance, increasing the prospects for stability.

It is within this context that we consider the current national security implications of our oil dependence and, specifically, the implications of reduced consumption of imported oil.

Economic Implications: More stability, less interruption

A meaningful reduction in U.S. reliance on imported petroleum over the next decade would provide substantial economic benefits to the United States and U.S. households, ranging from more money for consumers and more investment opportunity for business, to a better macroeconomic posture for the nation.

First, and perhaps most significantly, it would reduce the national trade deficit. In 2010, the cost of petroleum imports accounted for 42 percent of the $645 billion goods trade deficit [1]. These outflows, which increase with rising oil prices, are funds that could otherwise buy domestically produced fuels or other goods, and support jobs and economic development at home [2].

Reducing oil imports would lessen the economic impact of the projected rise of oil prices. Most industry and government experts predict oil prices will continue to rise for decades [3]. They cite growing demand in rapidly developing countries such as China and India; slowed or decreased production in traditional oil-producing regions; and a realization that oil must come increasingly from regions that are politically unstable, environmentally challenging, or technically difficult to access (like ultradeep-sea drilling). These forces will inevitably increase the spending of every American, not only on transportation fuel, but also on food, goods, and services that all rely on oil-fueled transport as well.

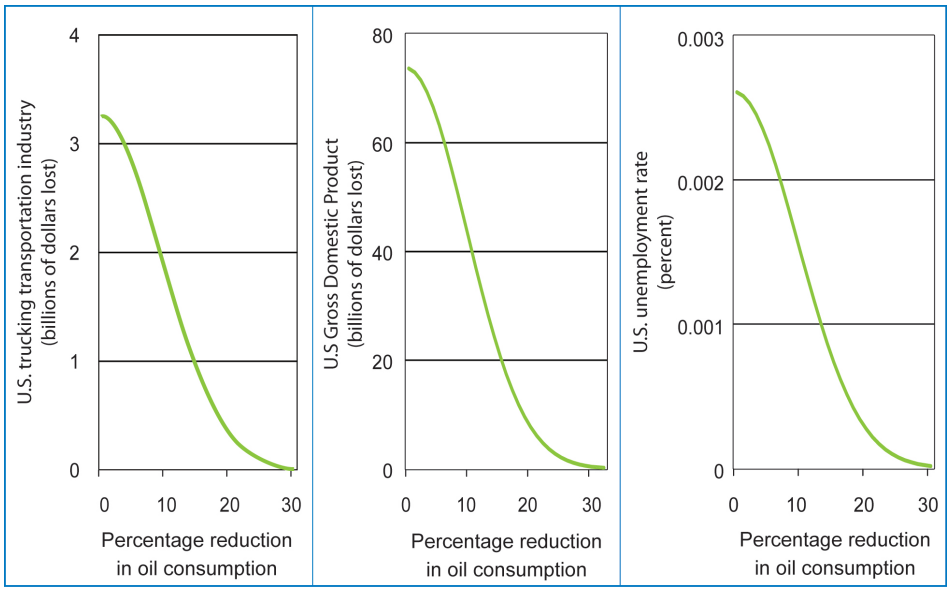
Reducing our use of imported oil would reduce the sizeable risks associated with oil flow interruptions. A recent study by CNA found that some of the world's industrialized countries would suffer severe economic impacts, including reduced GDP, increased unemployment, and sharp recession if a major disruption lasting 90 days occurred in the worldwide flow of oil [4]. Since the Second World War, the price of liquid fuels is associated with recessions [5]. In 1973, the sharp increase in the price of oil involved obvious collusion among oil producing countries in an effort to disrupt Western economies. Their purpose was to create a U.S. recession—and they succeeded [6]. (And, it should be noted, our reliance on foreign supplies for our oil was substantially lower in 1973 than it is now.) The United States will lessen its vulnerability to these shocks by reducing oil imports.

Looking ahead, the leading oil producing countries will likely include Venezuela, Russia, Nigeria, and Kazakhstan, and the volatile, oil-rich Middle East, including Iran, and Iraq. The United States could partially address our vulnerability to the whims of these suppliers by sourcing more of our oil from friendly, stable nations, such as Canada and Mexico, or by increasing domestic production. However, even in these cases, oil shocks—deliberate or otherwise—would still affect U.S. consumers. If global prices rise, the price of oil produced domestically and oil bought from friendly countries will also rise. Oil is sold on a global market; prices here at home are affected by

USS NICHOLAS (FFG-47) escorts the tanker SS CHESAPEAKE CITY through the Persian Gulf—PHCS Mitchell/DefenseImagery

forces we don't control. For example, the Stanford Energy Modeling Forum estimates oil prices would rise by $5. 26 per barrel for each 1 million barrel per day disruption in world supply, regardless of the location of the disruption.

Figure 1: The Impact of reduced oil consumption associated with a 30-day closure of the Strait of Hormuz.



To illustrate the level to which reduced oil dependence makes our economy less sensitive to supply disruptions, we considered the impact of an oil supply shock on just one industrial sector that is heavily dependent on petroleum: the trucking transportation industry. The U.S. Department of Commerce, Bureau of Economic Analysis estimates the inputs for each industry that are required to deliver a dollar of industry output to final users [7]. We used these input-output multipliers to determine the impact of reduced petroleum supplies caused by a temporary closure of a key maritime oil chokepoint. We considered 100 percent disruptions in the flow of oil, lasting 30 days, in the Strait of Hormuz, Suez Canal, Bab el-Mandeb, and Panama Canal.

Results for the closure of the Strait of Hormuz, the most limiting of these analyses, are shown in Figure 1 [8]. We see, in the left column, that a 30-day, complete disruption of the Strait of Hormuz in 2009 would have caused trucking losses of $3. 3 billion, or 2. 9 percent of its output. (If any of the other critical straits were also interrupted, the losses would be additive.) The middle column shows the impact on U.S. GDP, and the right column shows that a closure of the Strait would have caused 37,500 truckers to lose their jobs. These impacts in the trucking sector would be reflective of the rest of the economy.

What is remarkable in these graphs is how strongly these losses drop off in the trucking industry if the U.S. uses less oil. If the U.S.—and this industry in particular—could reduce its use of petroleum by 30 percent, the effect of such supply disruptions would be nearly zero.

Similar results were found in a related study by Oak Ridge National Laboratory. Greene and Leiby found that "oil independence"—defined as the point at which changes in oil supply and price have no significant effect on U.S. economic, military, or foreign policies—would require decreased U.S. oil consumption by a third to a half [9]. This, to us, is remarkable. Persuaded by these results, we chose a 30 percent reduction in oil use as a goal that would represent a significant step toward energy independence and increased national security.

An unemployment line in New York City. Shannon Stapleton/Reuters

These calculations suggest we have a great deal to gain from reduced oil use. But they also indicate that the U.S. does not need to fully wean itself from oil to gain these benefits. A 30 percent reduction of oil use, if achieved, would dramatically improve national security. In fact, even a smaller reduction, of 15-20 percent, would lessen dramatically the impact of an oil supply shock to the U.S. economy and to household incomes. (This does not mean we must reduce domestic production; we can achieve these gains by importing less from adversarial nations.)

Insulating ourselves from the impact of oil price swings and sending less money overseas for fuel are two steps that would help restore the kind of investment climate that has allowed the U.S. to lead the way in technological innovation. That leadership has improved the quality of American lives.

Reducing our trade deficit by producing more transportation fuel in the country would result in American jobs–we invest more at home when we send less money overseas. When we set high standards and send clear market signals, American investors have supported great technological leaps, producing millions of jobs here at home. We can learn important lessons from California's 35-year run of setting the highest energy efficiency standards. Higher efficiency standards have pushed the state into a leadership position in clean technology and new energy systems—at a time when the global market for these products and services is on the rise.

America's innovative skills and technology leadership have helped us immeasurably. A shift away from oil—and the new and higher standards that will facilitate such a shift—can help us enhance those skills and retain that leadership.

Military Implications: Reshaped deployments & battlefield efficiency

Formulated in response to the oil shocks of the 1970s, the Carter Doctrine (announced in 1980 by President Carter) states that any attempt by outside powers to gain control of the Persian Gulf region would be viewed as an assault on the vital interests of the U.S. and would be repelled by any means necessary, including military force [10]. This abiding doctrine of U.S. security policy continues to shape our foreign policy engagements and our military deployments. Maintaining America's access to overseas oil has had, and continues to have, a profound impact on our military strategy.

An F-14/D Tomcat of the U.S. Navy carrier USS Abraham Lincoln provides tanker escort—REUTERS/STR New

The U.S. currently spends billions of dollars each year on military operations in the Persian Gulf region. Based on a literature review in CNA's 2010 report, An Economic Impact Assessment of Maritime Oil Chokepoints, the average estimate of the annual

military cost of protecting oil traffic in the Arabian Gulf was $74 billion [11]. Several other studies have found that the reduction of U.S. demand for foreign oil would reduce the strategic importance of the oil flows in that region for the U.S. economy [12].

It is our view that there are several other strategically important reasons for maintaining a significant military presence in the Middle East beyond protecting oil routes—we do not necessarily believe that reduced oil consumption would automatically lead to the return of troops stationed in the region. However, it is clear that by reducing U.S. demand for oil, and thereby reducing U.S. economic vulnerability to supply and price shocks, the United States would increase its options in military presence, operations, and costs in that region.

If we make the U.S. less sensitive to interruptions of overseas oil supplies, we reduce the potential urgency of our military response to closures of critical ocean chokepoints. For example, industry and government projections indicate that over the next fifteen years several nations—including China and India—will be increasingly reliant on oil imports, including imports from the Persian Gulf region. If we begin to act now to make the U.S. economy less sensitive to turbulent oil prices (while other countries grow more sensitive), our leverage will increase when asking other countries to supplement, or cooperate with, U.S. forces in assuring the flow of oil through the region. The U.S. will, in our view, be relieved of some of the military and economic burden of protecting those sea lanes, and be able to focus resources elsewhere. This would also support a broader notion of shared global security, with regional challenges addressed with strong collaboration among allies.

There may be additional benefits to the military as well. If the U.S. achieves a 30 percent reduction in our use of oil for transportation, it will be because we have become smarter about our energy use. The reduction will have come, at least in part, because we developed and deployed technologies to increase our efficiency, and perhaps because we have increased our use of alternative fuels. These kinds of economy-wide improvements can benefit front-line military personnel, because these private sector lessons can be quickly deployed within DOD. The technology behind more efficient cars and trucks, more flexible fuel vehicles, and more efficient batteries, may lead directly to more efficient battlefield vehicles. Our experiences transporting fuel in Iraq and Afghanistan offer proof that an economy and industry oriented toward greater fuel efficiency could share significant operational benefits with our military.

Finally, in an era of reduced domestic spending and flat or decreasing defense spending, funds not spent on fuel can potentially be spent to develop new capabilities or greater capacity to respond to the threats of the future. Less money for fuel can mean more money for other important priorities. (Here, we again offer a reminder that all DOD efforts should focus on effective expeditionary operations. Using DOD resources only to spur private sector development of alternative fuels may have the effect of reducing funding for our forward operating defense efforts.)

Geostrategic Implications: Stability strengthens our hand

Predicting the geostrategic effects of a reduction in U.S. oil imports is a challenge. Clearly, there are uncertainties about other countries' future energy policies, and there are obvious challenges associated with predicting the technologies, alternative fuels, or changes in behavior by which U.S. consumers may reduce their consumption of oil. A case can be made that, even with a dramatic drop in U.S. use, global demand for oil will remain high for decades. If oil consumption in the United States and Europe drops, nations such as China and India will demand more oil as their people increasingly become car owners [13]. Even if, over the next 15 years, alternative fuels and hybrid and electric

LIEUTENANT GENERAL RICHARD C. ZILMER, USMC (RET.)
Former Deputy Commandant for Manpower and Reserve Affairs, Headquarters Marine Corps

Lighter, faster, safer

In a conversation about energy efficiency, retired Marine Corps General Richard Zilmer raised a point about nomenclature. He said the terminology could be important, because political differences can easily end conversations that should continue. But, not surprisingly, he still got right to the point.

"This whole idea of green energy is critical," Zilmer said. "And it's interesting that it somehow gets branded as being on one side of the political aisle. It's not left or right. It's smart. At least that's how I see it."

Zilmer is well known for his 2006 statements about the value of greater fuel efficiency on the battlefield. The plea came in the form a Universal Needs Statement, a document used to quickly source equipment that may be readily available in standard commercial markets.

…inefficient fuel use here at home makes all of us—all Americans—less safe.

"When I was in Iraq, I had some very smart guys working on our technologies, and they were thinking through what we needed," Zilmer said. "They saw this massive requirement for fuel to run vehicles and generators, and that was causing us to have our fuelers on the road all the time. And these were the roads being mined or planted with IEDs."

Zilmer said the challenge, then and now, was to use less power or find a way to get power from alternative sources.

"We wanted to get to solar power and wind power," he said. "In Iraq, you had a lot of sun and high winds, and you could generate enough electricity to meet a lot of your needs."

When Zilmer noted the increased use of solar and wind power by Marine expeditionary forces in Afghanistan, he was asked if use by the Corps could change the reputation of green fuels. Zilmer first made it clear that the Marines were not alone.

"The Navy is doing great stuff," said Zilmer. "So is the Air Force, and so is the Army. And the services aren't waiting for the answer to come from above. The Marine Corps isn't doing this because the DOD is telling them, or because the Energy Department is suggesting it. It's happening because clean energy is smarter and leaner."

Zilmer said that this notion of the military value of efficiency could conceivably help shift public perceptions.

"Everything about our culture in the Marine Corps is to be expeditionary," Zilmer said. "Lighter, faster and more lethal on the battlefield—that's always the goal. If we're not carrying as much bulk liquid, and if we don't have to slow down to fuel up vehicles and generators, then we're better off."

"It's always been this way," said Zilmer, referencing *A Soldier's Load and The Mobility of a Nation*, the publication by Army historian S.L.A. Marshall. "It's a never-ending journey that we're on to find a way to be lighter, faster and more lethal. If the extra weight doesn't help you, get rid of it."

Zilmer expressed frustration with the lack of public focus on energy issues. He said the stakes are high.

"Inefficient fuel use on the battlefield makes our troops less safe. We know that," Zilmer said." And inefficient fuel use here at home makes all of us—all Americans—less safe. We know that, too. There is a direct connection between America's fuel use and America's safety. This is what I want more people to understand."

"It's only a matter of time before the next energy crisis. And the one after that. And the one after that. My fear is that we'll kick this down the lane until we face a crisis that is absolutely unavoidable. And then the solutions will be harder and more expensive."

cars are developed and brought to market much faster than expected, they would still likely account for less than 15 percent of global fuel use. As such, even with a 30 percent reduction in U.S. transportation oil use and oil imports, oil producing countries will still have growing markets for their oil, though the price of that oil may be less than it would be otherwise.

Changes in U.S. consumption would also not alter the sourcing of the world's oil. According to the U.S. National Intelligence Council, by 2025, six countries—Saudi Arabia, Iran, Kuwait, the UAE, Russia, and Iraq—will likely account for almost half of total world oil production. The Persian Gulf region will still dominate global production, and we believe that turbulence there will continue to impact global markets. Furthermore, we believe other countries with good prospects for increased oil production, like Nigeria and Kazakhstan, pose high risks of political instability. This will make markets volatile, and also increase the chances that oil will be used as an instrument for coercion, via market-rattling threats, delivery shut-offs, and embargoes. Thus, for many ill-managed countries, oil will likely remain a curse as well as a blessing.

The chief advantage the United States would gain from reduced reliance on oil and greater fuel diversity would be reduced vulnerability to supply shocks, and therefore, improved flexibility in choosing our international partners. OPEC's production cut of 1973-1974 shocked America into recognizing the dangers of concentrated supplies. Since then, new oil fields have opened around the world, nations have created strategic reserves, and the global supply system has become more resilient. Nevertheless, concerns over changes in oil supply and control have tethered us to the region, and largely account for our complicated relations with Saudi Arabia and other Arab autocracies. Greater fuel diversity, combined with the reduced use of oil, will increase our diplomatic options and will allow us to engage globally from a position of greater strength.

A decline in U.S. oil consumption and imports, and rising demand elsewhere, will spawn new patterns in the global energy markets. While the United States will gain strategic flexibility, other nations, including China and India, are likely to rely further on imported oil. China's already far-flung investments in pursuit of greater, and more assured, access to oil (in the Middle East, Central Asia, Africa, and South America) will likely expand. Beijing may compete increasingly with New Delhi for those supplies, as much or more so as with Europe or the United States. On the other hand, China and India are also investing enormous sums in new transport technologies and alternative fuel sources. It is fair to say that the future of the global oil market will be shaped more by events, technologies, and consumer tastes in those countries than by those in the United States.

Depending on the alternative fuels that substitute for oil (in the U.S. and in other countries), it is likely that U.S. trading ties and, to some extent, strategic interests will shift. To the degree that consumers choose natural gas, this shift would be less pronounced because most nations with large gas reserves—including Russia, Iran, Qatar, Venezuela, and the United States—are also major oil producers. If ethanol comes to satisfy a more significant share of the U.S. fuel market, leading producers like Brazil would become closer strategic partners. We can envision scenarios, for example, in which U.S. strategic ties to Saudi Arabia and other oil producers in the Middle East loosen, while ties with growing energy producers in the Americas—including Brazil, Canada, and Mexico—grow stronger. Indeed, regardless of what the alternative fuel profile of the United States may be ten years from now, a significant reduction in oil consumption would most likely

GENERAL GORDON SULLIVAN, USA (RET.)

Former Chief of Staff, U.S. Army

Energy, climate & security

While the first CNA Military Advisory Board report focused on climate change as a national security threat, it barely touched on climate science. One reason, as expressed by the Board's first chairman, retired Army General Gordon R. Sullivan, was that the scientific details weren't necessary. What mattered most what that the propensity of scientific evidence was strong enough that the Board believed the U.S. should plan as if it was real.

"We do have climate change," Sullivan said. "Whether you agree on exact future projections or not, the fact is something is going on. You see evidence of it every week.

"The famine in Somalia continues, and it's leading to refugees being displaced into Kenya, Tanzania and elsewhere. That's the kind of thing we talked about in the first report. Climate changes lead to national economic and health crises; as people cross borders into places where they may not be welcome, an issue affecting one country starts to affect an entire region. And tensions grow from there. It's not just weather, it's security."

Even if you're a budget hawk, you have to consider climate change

Sullivan agrees that a focus on points of agreement – such as the need to reduce America's use of oil – may be key to developing American leadership in alternative fuels and energy technologies. But he also said that much more space in the national dialogue should be dedicated to the topic of climate change.

"There is something very distressing about the present state of play in Washington," Sullivan said. "You have individuals who, for one reason or another, will say, 'No, I don't have time to talk about climate change.' Or they'll say it's a hoax, or that they have more important issues. I find that appalling.

"Energy, climate and security – these are legitimate issues that need to be addressed. But you've got people who will categorize the climate issue, and other issues, with pejoratives. They're dismissive, and with their threats, they take these hugely important issues off the table. We do that at great risk."

It's not just weather, it's security

Sullivan noted that a great deal of the national political dialogue focuses exclusively on the federal deficit, to the exclusion of other issues.

"In some cases, they're saying they don't have time to talk about climate change because they are focused on the budget," Sullivan said. "I'm not sure the budget is more important than the climate. But even if you're a budget hawk, you have to consider climate change, because it will have an impact on our financial viability. Take food production. You had drought across the southwest all summer. The wheat crop gets hurt, and that affects America's position as an exporter of grain. In the long-term, these kinds of climate changes would affect the balance of trade."

Sullivan also noted the impact of imported oil on our balance of trade.

"Again, you see the connection here," Sullivan said. "If you care about our fiscal situation, you want to reduce our use of oil. These things are connected. But we can only see those connections if we have thoughtful and respectful discourse about our national challenges."

ensure closer strategic ties with stable democracies including Canada, Brazil, and Mexico. It would also increase energy integration with our neighbors, who could be both suppliers and consumers, over whom we have much more influence, and with whom we have deeper partnerships and more in common than with oil producing countries in the Middle East.

Indeed, we expect that as fuel types and supplies become more diverse around the world, regions and countries will develop different fuel use profiles based on geographic, geological, and climatic variations. For example, methanol and grass-derived biofuels may dominate in North America, electric vehicles and vehicles using bio-diesel may be much more prevalent in Europe, traditional gasoline and algae-based biofuels may rule in East Asia and central Africa, and biofuels from sugar and cellulose as well as electric vehicles may be most common in South America.

The United States stands to gain not only from reducing its reliance on oil, but from becoming a more active producer and consumer of alternative fuels and a partner in those efforts with key allies. By shifting to low-carbon alternatives, we stand to gain from the growing global push for carbon emissions regulations instead of being penalized by it. Key democratic allies in Europe, the Pacific, and the Americas currently lead these efforts. Because the United States is one of the world's largest producers of greenhouse gas and lacks a national plan to reduce emissions, other countries view us as part of the problem, not the solution. Greater U.S. partnership, innovation, and even leadership in this area could solidify our bonds with these allies and help build new ones with the energy leaders of the future.

Increased public and private investment in future fuels and fuel technologies will also create new opportunities for the United States to engage developing country partners. The growing use of alternative fuels, especially those that involve advanced technologies and special raw materials, will create new markets for minerals, biomass, waste, and other materials that will provide economic opportunities to developing countries. By leading these developments and taking strategic advantage of these commercial and diplomatic opportunities, the United States will be better positioned to build new partnerships in Asia, the Americas, and Africa.

Environmental Implications: Reduced emissions as a spinoff benefit

The American and global scientific communities assert with high confidence that the warming of the earth's atmosphere over the last sixty years is caused, in large part, by human activity. In May 2011, the National Research Council (NRC), an agency of the National Academies of Science, released the last in a series of five major reports on climate change that were requested by Congress [14]. The NRC said, "Climate change is occurring, is very likely caused primarily by human activities, and poses significant risks to humans and the environment. These risks indicate a pressing need for substantial action to limit the magnitude of climate change" [15]. The reports project that a business-as-usual approach to energy would result in average global temperatures much higher than anything experienced by human civilizations, increased extreme weather events, and other impacts [16]. As noted in our first Military Advisory Board report, such changes would represent a threat multiplier in every global region.

Noting the political divisions in the United States over climate change, we choose not to dwell on climate science in this report, and to focus instead on this point of agreement: Even if greenhouse gas reductions are not the goal for our recommended path, they would surely result from it. If a 30 percent reduction in U.S. oil consumption in the transportation sector came from conservation and CO_2-neutral alternatives, it would lessen total global greenhouse emissions by

nearly 5 percent [17]. We could make similar calculations in reconsidering how we power and heat our homes and businesses to further lower our carbon footprint.

Other environmental impacts can affect national security as well. Oil spills can cause major impacts along coastal regions. Prolonged drought and excess heat or cold events can cause economic downturns, civil unrest, and mass migrations. Severe weather events can destroy key infrastructure components, which in turn can cripple regional economies.

Environmental security involves protecting a nation's access to, and the potential use of, its resources, both now and in the future. When considering alternatives to oil, we must balance our current needs with the needs of future generations of Americans. Not only do we think it unwise to burn all of America's limited known oil reserves in the near future, we also believe that any new technology to access petroleum for energy use must proceed cautiously, with full consideration of the risks of each alternative, and of the environmental costs of business as usual. For example, many will argue that the one-time use of a barrel of oil for transportation today will prove to be far less valuable than using the same barrel of oil for plastics, lubricating materials, or other substances in our future. By burning the oil today, we preclude such options from being available tomorrow. Similarly, we should not allow the few who may object to the prospect of energy being drawn from unconventional areas—the "not in my backyard" crowd—to stand in the way of national security and the reduction of our dependence on oil. From an energy standpoint, there will need to be shared sacrifices in ensuring our national security.

Chapter 2

Alternatives to Oil

The Obvious Value of Efficiency

A significant portion of our analysis was examining the possible national security implications of replacing oil with various alternative transport fuels. Most of this report focuses on petroleum used for ground transportation since ground transit accounts for 80 percent of the petroleum used in the U.S. transportation sector.

Before getting to that more directly, though, we note that the United States could accomplish a significant portion of a 30 percent reduction in oil use simply by being more efficient with our use of oil. There are several areas where dramatic efficiency gains are possible: engine and vehicle design and technology, infrastructure improvements and transportation reforms, and changes in the behavior of drivers and other consumers [18].

…the United States could accomplish a significant portion of a 30 percent reduction in oil use simply by being more efficient…

The internal gas-burning combustion engine has been the choice of manufacturers and consumers for many generations of vehicles and trucks. Though the use of alternative fuels and engine types offers many advantages, the fact remains that modern gasoline and diesel fuels provide exceptional energy density (that is, power per weight and volume), and modern vehicle engines are remarkably convenient, safe, reliable, and powerful. Given the dominance in the U.S. market of the internal combustion engine and consumer preference for this traditional technology, we believe the dominant means of using energy in transportation in the United States will, for some time, continue to be internal combustion of gasoline and diesel refined from oil. It stands to reason, then, that notable reductions in demand for those fuels in the near term would result from continuous, though incremental, improvements in vehicles that use internal combustion engines.

When consumers and government regulators have demanded improved gas efficiency, manufacturers have provided those improvements. As the government continues to press U.S. car manufacturers to meet higher standards for gas efficiency, there is every reason to believe that manufacturers will, to a large degree, be able to do so. We wholeheartedly support such a policy, expecting that important advances in materials and technologies will be part of advances in vehicle efficiency and will have wide-ranging applications in other markets. Our nation's competitiveness will likely be advanced on many commercial fronts as a result.

Historically, a divide has existed between our country's energy and transportation policies. At present, our national goals for energy use are not fully compatible with our existing transportation infrastructure. Our national and local transportation policies tend, in most cases, to emphasize efficient flow of a maximum number of cars and trucks. They tend not to focus on efficiency in the use of gas. As an example, increased traffic back-ups lead to increased idling of vehicles—an inefficient use of fuel that offsets some of the fuel economy gains of recent years. Here, we see opportunity for policy innovation. Over the long term, national and local governments must provide or encourage new and better infrastructure to allow different and more dramatic efficiency gains, including national dis-

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Former Vice Chief of Naval Operations

Small steps, big impacts

Having served as Vice Chief of Naval Operations, retired Admiral John Nathman knows the Pentagon can play an important role in helping the U.S. reduce its use of oil.

"There are lots of things DOD can do to help alternative fuels get to market," Nathman said. "Rapid prototyping, rigorous testing, trying things out in extreme conditions—those sorts of things. If the Navy is using a blended fuel and it's good enough to land an F-18 on a carrier at night, then you've made a big leap. You've shown that the fuel can hit the highest quality standard, and that can help in bringing it to market."

Nonetheless, Nathman cautions against expecting the DOD to drive the commercialization of new fuels. While he wants DOD to continue pushing for alternatives, he says greater gains may be made with large numbers of small steps.

"I think we should be talking to the American people about what they can do right now. You can wait for the ideal legislation or regulations, but there is so much we can do on our own."

If the country used 20% less fuel based on behavioral changes…it would absolutely have an impact.

As an example, Nathman referenced the Pentagon's Slug Line.

"You go outside and there are lines for all the different places people live," Nathman said. "You find two people going your way, they hop in your car, and now you get to use the HOV line on I-395. It saves a ton of time, and you've taken two cars off the road."

After noting that the three people carpooling would have cut their combined fuel use by two-thirds, he pointed out another layer of savings.

"When cars are stuck in traffic and they're going 15 miles an hour, they're horribly inefficient," he said. "They're built for higher speeds, so you waste fuel at that pace. That's a big part of this. You've got to take some of those cars off the road to make the system operate more efficiently.

"So the Slug Line works. And it's something you can do anywhere. You start in your neighborhood, where it's safe. You use social media to find people who might rideshare. You talk to employers about having slightly less rigid schedules so people can work at different times."

He said small steps at the local level could add up to a major impact.

"If you don't want big government, you still need to do something about this problem. You can work with your neighbors to drive less. This is a great use of social media—you could replicate the Pentagon's Slug Lines in any neighborhood in America using Facebook, twitter, or text messaging. If you're going to be using Facebook to post pictures of your cat doing loops, why can't you use that social networking in a positive way? I'm not opposed to cats doing loops, but I'm definitely in favor of cutting oil use. And social media can help us do that."

Nathman challenged, "If the country used 20% less fuel based on behavioral changes—and here I'm talking about you, me, the next guy, the person next to that guy all making changes—it would absolutely have an impact. We would be importing less. And the people who want to mess with the market and manipulate prices would have a lot less power."

tribution systems for ethanol fuels and hydrogen, electric battery recharging stations, and improved systems of high-speed rail transport and inland waterways.

Given that around 80 percent of fuel is used for ground transportation, we believe meaningful fuel savings could be realized by changes made by American consumers and users of oil. Some aspects of the modern American suburban lifestyle are extremely inefficient in terms of energy use. The nation needs to look at situations such as individuals commuting alone for 20 miles or more, and consider the multiple economic, social and environmental costs of such a trip. (Our overseas deployments often brought us to dense urban settings in foreign lands where vast numbers of residents commuted short distances on scooters and cycles that achieve 80 miles per gallon and more. We are reminded that there are many ways to get from here to there, and American energy and national security could be more secure if we reconsidered such options.) Of course, decisions about lifestyle must be left to individuals as they face their own tradeoffs and prices, but federal, state, and local policies can help shape those decisions. Future energy and transportation policies should contribute to improved efficiency. It matters to our national security.

A Range of Viable Options

The strategic benefits—and potential costs—to the United States of reducing its oil use by 30 percent depend in large part on the means by which we reach these reductions. As noted above, a significant share of this reduction could come through improved efficiency in our national use of oil: more efficient vehicles, advances in hybrid technologies to capture wasted braking and other energies, better driving practices, and lifestyles changes. We believe that efficiency alone will not be sufficient to achieve this important goal. We will also require a dramatic increase in America's use of alternative transport fuels.

Ultimately, many of the costs and benefits to America associated with using less oil will depend upon the fuels that U.S. drivers will use in its stead, as well as the sources of those fuels. This section reviews the alternative fuel types that appear to be the most likely candidates for broad public consumption. We outline our view of the most prominent advantages and disadvantages of each, in terms of their economic and technical viability, and, most importantly, the longer-term strategic and security implications of their commercial-scale production and consumption.

Most of this report references the fuels used for ground transportation for some simple reasons. Ground transit accounts for 80 percent of the petroleum used in U. S transportation. Making a shift in this sector would involve modifying or complementing a vast distribution system and could require some action by virtually all Americans of driving age. Reducing oil use by the aviation sector will also be no small challenge, but at least changes in distribution will involve fewer players.

While our work has focused on how a shift in fuels used by American society would affect our security, we begin by highlighting the unique fuel needs of the Department of Defense.

First and foremost, there is no substitute for performance, speed, lethality and security on the battlefield. We would hold to this position even if it meant a national energy policy that called on the civilian sector to rely on alternatives in order to free up traditional fuels for military application. (We do not think it will come to this, but the primacy of military missions for DOD defends the logic behind the statement.) Our goal is for a military that is light, fast, and expeditionary. If future alternative fuels can help take us there, so much the better.

Second, DOD's fuel mix must consider the availability of alternative fuels in far-away places. If our supply

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GENERAL ROBERT MAGNUS, USMC (RET.); *Former Assistant Commandant of the Marine Corps*

Security in diverse supplies

In every meeting of the current Military Advisory Board, various individuals have stressed the value of having diverse fuel supplies. They say this would strengthen our economy; they also make the case that it can strengthen our military.

In one conversation, retired Marine Corps General Robert Magnus acknowledged the complexities of cost and timing, but also offered a simple framework for a transition.

"You can pursue efficiencies in how we use our current fuels," General Magus said. "You move toward the cleaner fuels within the suite of fossil fuels. And you pursue non-fossil sources. You do all of those things. You move along this progression.

"Obviously, we want to make a transition. I don't know what the right pace is, but I do know we can achieve a balance. With the economy the way it is, and with our security situation the way it is, I want to engage with a full range of options. I want that today, and I also want that in the future. I want half a dozen sources of energy. I want them in secure markets. That's a stronger position for us—economically and militarily."

"We need a flexible source of energy that is resilient, and that means diversity"

Magnus noted that alternative fuels are already being used by combat troops—while also noting that these instances are still rare.

"The Third Battalion, Fifth Marines were at the far reaches of the supply chain," said Magnus. "They needed fuel for vehicles, computers, batteries, air conditioning—you name it. They deployed company-size wind power for generators. They didn't throw away their diesel generators, but they reduced strain on the supply chain. They had power when they needed it. Some of the systems were damaged by enemy combat, but still worked fine. That's good information."

Retired Air Force General Ronald Keys agreed on the need to shift away from our current reliance on petroleum.

"The path we're on is unsustainable. That's clear," said Keys. "In the long term, you do run out of oil. In the short to long term, you erode your leadership in the world and your ability to choose the best foreign policy. And you expose yourself to short-term supply shocks and unstable prices, which cause big economic turmoil. It's just not working."

His solution also involves a wide range of fuels.

"We need a flexible source of energy that is resilient, and that means diversity," said Keys. "It's like stocks. You don't want all your stocks in the same company or same commodity. You don't want to trade in one vulnerability for another one that is just as uncontrolled and volatile. It has to be a balanced approach."

Asked if the US military culture would accept alternative fuels, Keys said the focus on drop-in fuels (those that can be mixed or interchanged with the standard JP-8) was essential, and added that DOD is way ahead.

"They want to avoid supply and logistics issues when they are deployed so they will want to take a 'flex fuel' approach, but alternative fuels are definitely in their future."

"The Air Force has qualified all of their major aircraft on a 50-50 blend of JP-8 and Biofuel. Additionally, the Thunderbirds and Blue Angels are flying on the same blend. So they've proved it works for very high performance. The people who have flown it with this new mix say there is no difference—and if the engines don't cough, they don't care. The pilot's view: If you light the wick, and the flame comes out—it works! Now the market has to broaden and the price has work its way down."

lines take us all the way back to the U.S. for our fuel needs, we increase the risk to our troops. If we make the material and hardware changes to accommodate alternative fuels, we must ensure that those fuels are available, from our allies or others around the globe, when and where we will require our troops to fight. We must accept that some of these alternatives may work for stateside installations, but not for tactical vehicles and aircraft.

Some alternative fuels are drop-in fuels, allowing our vehicles to use these alternatives domestically, and as a direct substitute for traditional petroleum-based fuels in deployed locations. These drop-in fuels can be derived from various alternative fuel sources, such as the Fischer–Tropsch fuel blends being tested by the U.S. Air Force, or the camelina biofuel blends used by the Navy's F-18 Green Hornet. The F-18 engine, like most of the other jet engines used by all the military services, requires little or no modification to accept either drop-in alternative fuel or regular petroleum-based products. In this manner, drop-in fuels can be used for both stateside and tactically deployed vehicles and aircraft.

Finally, before looking at the suite of alternative fuels for America's domestic transport, we offer an additional comment on oil. In the near-term, an increase in domestic oil production could help make America more secure. However, increased production alone is not a long-term fix—it is like a bandage applying pressure to a wound, but not fundamentally healing it. For this reason, any increase in domestic production should be viewed within the context of an aggressive plan to reduce overall oil use. Reducing overall oil use, while increasing domestic production, is a powerful one-two punch in the effort to improve our national security.

The alternative fuels presented below are not in any order of preference.

Biofuels

Biofuels—chiefly ethanol (made from types of starch and sugar) and biodiesel (made from vegetable and animal oils)—have, for years, been produced and consumed around the world as fuel additives and, less often, as stand-alone fuels. In the United States today, most light duty vehicles are burning gasoline that has been blended with up to 10 percent ethanol. The United States and Brazil currently lead the world in the manufacture and use of ethanol. France, Sweden, and Germany are major producers of biodiesel. These technologies continue to advance in efficiency, raising the possibility of future mass production of fuel from cellulose (e. g., grasses, wood, sawdust, etc.), algae, manure, and municipal or industrial waste. In 2008, biofuels accounted for less than two percent of the world's transportation fuels, but their use is growing dramatically [19]. Part of their attractiveness is that the processes of their conversion into portable forms of energy generally emit much lower levels of CO_2 and other greenhouse gases than result from the conversion of gasoline. This relative advantage is especially pronounced in the case of cellulosic and advanced biofuels [20]. Governments around the world have encouraged the development, manufacture, and use of biofuels because doing so simultaneously reduces reliance on oil, boosts farmers' incomes, and decreases greenhouse gas emissions.

Under the U.S. Energy Independence and Security Act of 2007, the U.S. government has defined a Renewable Fuel Standard (RFS) that mandates, out to 2022, the increasing use of renewable fuels as gasoline additives in the United States. The trend in these standards is to keep the volumes of corn-based ethanol and biodiesel roughly constant, while increasing the level of cellulosic ethanol (for example, from switchgrass) and, more slowly, advanced non-cellulosic ethanol (for example, from algae).

Front Range Energy ethanol plant Windsor, Colorado. REUTERS/Rick Wilking

The technologies for producing basic biofuels and for using them in conventional engines are well proven, though the production of advanced biofuels from algal oil poses challenges at commercial scale. The delivery, storage, and use of biofuels in traditional pipes, valves, and tanks are somewhat complicated by the corrosiveness of the materials. Also, their use in higher concentrations in traditional vehicles requires engine modifications.

A major challenge to the expansion of the use of biofuels in the United States is the lack of sufficient regional collection and production centers and distribution systems. For biofuel use to rise to levels sufficient to make a dent in U.S. oil imports, U.S. farmers must be incentivized to collect and deliver dedicated crops and crop refuse to production centers efficiently enough not to interfere with their usual harvesting and cropland management requirements.

The shift away from food crops to cellulose and other source materials

The key problem that the biofuels industry currently faces, globally and in the United States, is the scarcity of agricultural land not already dedicated to the production of food, livestock feed, hay, forestry, and biofuels. Surface water for irrigation is scarce in many regions, and underground reserves are in decline across the United States. Without dramatic changes in agro-technology or land use policies, these scarcities could mean that significant increased production of crops for biofuels would reduce, to some degree, the production of crops for food [21].

While other countries produce biofuels from non-food crops, such as rapeseed or sugar cane, in the United States, our ethanol is derived primarily from corn. In 2011, over one-third of all the corn grown in the United States is likely to go to the production of ethanol [22]. Critics of current U.S. policies that subsidize ethanol blame the rapid rise in U.S. ethanol production for the surge in food prices nationally and around the world [23]. Proponents of corn based ethanol counter that rising food prices are caused by increased energy costs.

Because of this debate and ensuing policy decisions, most experts believe that biofuels will only reach their potential as economically and environmentally efficient substitutes for oil if they increasingly come from non-crop materials, particularly crop or wood refuse, grasses that grow abundantly on non-arable land, waste, or algae. Cellulosic ethanol has been produced in the U.S. only in low volumes due to financing problems [24]. The U.S. government currently supports research and development programs in cellulosic biofuels, and is revising upward the amount of cellulosic (non-corn based) ethanol mandated in its Renewable Fuel Standards program.

Another problem is that rising prices for crops—for food or for biofuels—raises the incentives for farmers and industries around the world to clear land and forests for more planting. This can be counterproductive, because even though biofuels emit less greenhouse gases in their energy cycle than does oil, the clearing of trees and forests to plant source material could result in the release of as much or more greenhouse

gases than is saved [25]. Without effective land use policies and regulations, a dramatic increase in the use of food-crop or cellulosic biofuels could conceivably increase regional or global greenhouse gas emissions.

Although not yet proven at commercial scale, the production of biofuels by algae farms offers advantages in higher potential efficiency, CO_2 recycling, and less land requirements. However, this production method has yet to be proven at scale and, depending on the farming method, it too could bear significant environmental costs due to its need for significant amounts of water. There is the potential for algae to be grown in oceans or bays, where water use would be less controversial. And there is extensive research into growing algae crops in closed or semi-closed systems where evaporation is greatly minimized and water use substantially lower than open algae farms.

Diversity via biofuels would help stabilize global energy markets

The U.S. should be aggressive in diversifying its sources and options for transportation fuels. Broadening our fuel choices, especially with domestically produced advanced biofuels, would improve U.S. energy autonomy and security. Because biofuels can be produced from a wide range of materials using relatively simple technology, other nations would likely follow suit and increase their domestic production of biofuels while increasing the diversity of their fuel choices, and enhancing their economic resilience. An expanded global capacity to produce, deliver, and use biofuels derived from various types of biomass would increase fuel diversity and resilience worldwide, improving general economic stability.

Presumably, countries with vast and diverse territories that already sustain large-scale agriculture (e.g., the United States, Canada, Russia, Brazil, and Argentina) are likely to gain the most economic and strategic benefit from increasing use of biofuels. In a world where demand for food and fuel are both likely to be high, the concentration of grain production in these breadbasket regions could have significant strategic effects. However, each country's biofuels production would likely reflect its biomass profile. Countries with vast stretches of cropland would produce their fuels from grains, grasses, and crop refuse; others from wood or wood pulp; still others from algae farms. Such diversity would strengthen the resilience of the global market, reducing energy insecurity and potentially fostering the proliferation of other specialized goods and services.

Phosphorus supplies pose a potential problem

Some research suggests that, in a future where global agricultural production must triple or quadruple in order to feed and to provide fuels for a rapidly growing global population, the mineral phosphorus, critical to modern agriculture and a non-renewable resource, could become scarce and valuable. Phosphorus can be found and mined in many countries, but its largest concentrations appear to be in Morocco and China [26]. It is conceivable that, if the United States were to become more reliant on foods and biofuels produced with massive amounts of phosphorus (as U.S. large-scale farming tends to operate today), this could present a strategic problem.

The global production capability of phosphorous is uncertain; however, increased demand would likely raise the price and this market stimulus could cause increased phosphorus production. Moreover, much of the current use of phosphorus is wasteful, and large amounts run off into streams and waterways. Engineered farming methods could significantly reduce the demand for phosphorous, and recycling out of lakes and other waterways may someday be feasible. We do not see phosphorus as a strategic impediment to increasing biofuel production.

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DOD's role in developing alternatives

Retired Air Force Lieutenant General Lawrence Farrell sees a limited, but important, role for the Pentagon in helping develop alternatives to petroleum.

"I like relying on markets to do what they do well," said Farrell. "For many years, market forces have inspired initiative, innovation, and creativity. I want to keep those forces intact. But one thing DOD can do well is to be a sort of forcing function. The Pentagon can say, 'This is the direction we're going, guys.' You let the market know that there will be a consistent demand."

"We only get the optimum benefit for the dollars spent if we have consistent standards"

Changes may be required before the Pentagon can send the kinds of clear signals Farrell says are needed.

"We need to make sure the Pentagon can effectively engage in long-term purchasing," Farrell said. "Investors want to know how they'll get paid back. If you want to rely on private money to develop alternatives to oil—and I think that's the right approach—those investors need to understand there is a strong prospect of return. So you need this."

Retired Air Force Lieutenant General Kenneth Eickmann believes energy issues should be more visible within the DOD.

"For too long, energy issues have been assumed away," Eickmann said. "With respect to war games, until recently, you could always assume that whatever fuel you want or need is going to be there. We can't do that anymore. And the same is true in society—we shouldn't be taking our fuel for granted."

"With greater visibility should come better coordination within DOD, particularly if one of the goals is to send strong market signals," he added.

"We only get the optimum benefit for the dollars spent if we have consistent standards," Eickmann said. "Decisions made at the base level reflect the base commander's assessment of needs—but those may not match the overall Department's assessment of critical needs."

In addition to better coordination within DOD, Eickmann sees real value in better coordination among the military and other institutions. As commander of the Oklahoma Air Logistics Center at Tinker Air Force Base just outside Oklahoma City, Eickmann saw first-hand the benefits of collaboration. A devastating fire at Tinker in 1984 led the city and base to explore ways to coordinate responses in the event of future disasters. When the Oklahoma City bombing took place in 1995, the two were able to collaborate fully and enhance the effectiveness of their emergency response efforts. The unique level of cooperation between the city and the base led the city to build a new power plant on the base.

"Tinker uses 40 megawatts of power, and 80 megawatts are now generated on the base," Eickmann said. "If there is a grid failure, the base still has power. The base made the land available and provides security. The city gives the base first priority for the power and a reduced rate. As a result, the city benefits and the base has energy security for its critical national and homeland defense missions. I believe this agreement is a direct result of the base-community relations that started with the initial fire."

Natural Gas

Natural gas exists in underground deposits around the world, often alongside crude oil. In the United States, most natural gas is used to generate electricity. However, many fleets of buses and delivery or commercial heavy duty vehicles run on compressed natural gas or even, in some cases, on liquid natural gas which requires specialized insulated tanks. There are roughly 110,000 natural gas vehicles in use in the United States, and about 13 million worldwide [27]. Natural gas vehicles tend to be more expensive in the United States than ordinary cars or hybrids, but the cost of fuel equivalent in energy to a gallon of gasoline is just under $2, so savings in operations can be substantial.

The United States has abundant natural gas reserves, and an infrastructure for the delivery and storage of natural gas already exists. At present, the United States has about 1,500 natural gas fueling stations that require high-pressure compressors, but small compressors appropriate for private homes are also in service. The advanced and proven quality of this fuel suggests that natural gas offers a ready alternative, especially in the short term, to oil. Nevertheless, the expansion of the use of compressed natural gas as a transportation fuel would require a major retooling of both cars and fuel station infrastructure.

Natural gas offers significantly lower emissions of most greenhouse gases and volatile organic compounds than does gasoline (though natural gas engines do emit high levels of unburned methane, a potent greenhouse gas). The collection and use of natural gas would also reduce the common practice, at least in many countries, of burning off natural gas at the wellhead of oil wells.

Reason for environmental caution

There is concern that the practice of hydraulic fracturing, which involves the pumping of fluids into geologic formations at high temperatures and pressures and is necessary for the further expansion of U.S. natural gas production, could pollute underground water reserves. To the degree this proves true (the issue is currently under study) and the industry cannot remedy the problem, this could limit the viability of extraction in fields across the United States. Also, the surface runoff from gas wells has, in some cases, been linked to groundwater contamination. Clearly, responsible industry practices and effective regulation are in order.

Natural gas is an attractive alternative fuel option for U.S. policymakers because it promotes energy self-sufficiency and raises relatively few geopolitical concerns. Most of the natural gas consumed in the United States is domestically produced, and our leading source of imports is Canada. Between the United States and Canada, natural gas reserves are abundant enough to sustain, if required, a significant increase in their use. Even if further imports were necessary, liquid natural gas is abundant and relatively inexpensive on the world market, and major producers include several nations that are reliable partners of the United States.

On the other hand, because natural gas is generally found alongside petroleum, a dramatic increase in the global demand for it would most likely continue bringing profits and influence to the governments and state-owned companies of nations including Russia, Iran, Saudi Arabia, and Venezuela. Greater global use of natural gas would increase fuel diversity, but influence from gas and oil production would still be concentrated in some of the same unreliable world actors as today. We note again that most natural gas consumed in the U.S. is produced domestically, and our leading source of imports is Canada; with this in mind, it is likely that the influence on the U.S. from unreliable actors would be significantly reduced if we shifted to greater use of natural gas.

Propane

In many respects, propane is similar to natural gas and shares its advantages as a potential domestically available alternative fuel. Propane is an energy-rich gas that is found mixed with natural gas and oil. Propane and other liquefied gases, including ethane and butane, are separated from natural gas at natural gas processing plants, or from crude oil at refineries.

In the U.S., most propane is used in the chemical industry or for home heating rather than for transportation. At present, around 350,000 U.S. vehicles run on propane, most of them forklift trucks and other indoor industrial vehicles [28]. The propane industry includes a highly developed delivery infrastructure, with approximately 4000 public refueling stations in the United States. Like natural gas, propane emits significantly less greenhouse gases than gasoline.

The most prominent challenges to increasing propane use as a transport fuel are the need for engine conversions in order to run on propane, and the lack of propane refueling stations in many areas of the country. In most cases, as with natural gas-fueled vehicles, propane-driven fleets of vehicles are refueled at local, dedicated refueling centers. Propane is a high-energy fuel source, but it is less dense than gasoline, so propane tanks must be filled more frequently than those in gasoline-powered engines in order to achieve the same range.

Because propane is a by-product of oil and gas production and is abundantly available within the United States, increasing its use would raise few strategic or security concerns. Approximately 90 percent of the United States' propane supply is produced domestically, while 70 percent of the imports are from Canada and Mexico.

Solids to Liquid Hydrocarbon Fuel

The Fischer-Tropsch (F-T) synthesis process used for creating liquid hydrocarbons from coal, natural gas or biomass was developed in Germany in the 1920s. During the Second World War, Germany successfully used this process to produce approximately 100,000 bbd/day of liquid fuel when Axis access to petroleum was restricted by Allied forces. Similarly, in response to an embargo on its oil, South Africa adopted the process in the 1950's; today F-T synthesis, using mostly coal, provides that country's diesel fuels and aviation-grade kerosene and chemicals. In Malaysia, F-T production using natural gas produces a variety of diesel fuels and other products.

There are two leading technologies for converting coal into transportation fuels and liquids. The original process, indirect coal liquefaction (ICL), gasifies coal to produce a synthetic gas (Syngas) and rebuilds small molecules in the Fischer-Tropsch process to produce the desired fuels. Direct coal liquefaction (DCL) breaks the coal down to maximize the proportion of compounds with the correct molecular size for liquid products. The conversion efficiency of DCL is greater than that of ICL and requires higher quality coal; however, DCL currently exists only in the laboratory and at pilot plant scale. China's first two coal-to-liquid plants, which will use the DCL process, are still under development.

The F-T method begins with the conversion of the feedstock material—such as coal, natural gas or biomass—to a gas containing carbon monoxide and hydrogen. This gaseous mixture, often referred to as Syngas, is next sent to a chemical reactor where it is converted to a mixture of liquid hydrocarbons. These liquid hydrocarbons can be processed into fuels that can easily substitute for petroleum-based fuels. For example, F-T fuels have been demonstrated in diesel engines, jet aircraft engines, and even missiles. The

fuel truck that refueled the B-52 for the first Air Force F-T flight test was running off the same fuel it put in the aircraft. Syngas nearly replicates the performance of petroleum fuels and thus can be used as a "drop-in" replacement requiring few infrastructure or lifestyle changes for the consumer.

There are no full-scale F-T plants operating in the United States. While F-T is considered a mature and established technology, the production facilities are expensive to build, operate, and maintain.

F-T processing presents various environmental problems

A significant liability with the F-T process is that it exhausts considerable amounts of carbon dioxide (more than the refinement of petroleum-based fuels). These gases must be sequestered, dealt with in some other manner, or eventually released into the atmosphere. When the carbon dioxide released in production of the fuel is added to CO_2 released by burning synfuels, the lifecycle carbon footprint (if all the CO_2 is released) exceeds that of fuels refined from crude oil by a factor of two [29]. Carbon sequestration offers a possible answer to reducing F-T's carbon emissions to a level only slightly exceeding the lifecycle emissions of conventional petroleum. However, these techniques and technologies are so far unproven. Nevertheless, there is another environmental benefit of F-T processes: they produce lower levels of particulate matter, including sulfur oxides, in the energy cycle than does gasoline.

Current F-T processes also demand enormous volumes of water for the preparation of coal, both for the actual F-T processing to function, as well as for cooling. Disposal of contaminated water is an additional problem. It would appear that resolving these problems would add significant cost to any F-T plant project in the United States. Some of these issues can be avoided if natural gas is used to produce the fuel, instead of coal.

Blended F-T fuels, which include fuels from refined biomass, potentially offer a partial solution to environmental concerns. Although one approach is to produce F-T fuels and biomass fuels and then blend them, the more plausible approach is to introduce biomass in the F-T process itself to reduce the CO_2 produced in F-T production. Life cycle emissions from blended F-T fuels could be less than half those of petroleum-derived fuels, assuming the carbon sequestration can work and that biomass is grown sustainably.

The development of an F-T industry in the United States could allow the exploitation of abundant domestic reserves for transport fuels, reducing reliance on imported petroleum, and increasing U.S. energy resilience and security. It would not involve the import of any sensitive or scarce inputs. Although most consider the construction and operations of large-scale F-T plants cost prohibitive, using natural gas and excess biomass could significantly lower operational costs. With a solution in place to lower the overall carbon dioxide produced by F-T process and rising oil prices, we believe this source of alternative fuel can be competitive.

Hybrid and Electric Car Technology

The same technology found in the electric batteries we use every day in small electronics can be, and are being, used to power vehicles. Vehicles that operate only on electricity are silent, emit virtually no pollutants or greenhouse gases, and dramatically improve energy efficiency by running on electricity generated on an economic scale in power plants (with emissions controls) instead of in small combustion engines. Largely because electric or hybrid vehicles allow limited emissions and are energy efficient, the United States gov-

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Making the shift *now*—on our terms

On a project considering the relative value of alternative fuels, retired Vice Admiral Lee Gunn didn't start with the long list of potential replacements to oil. He instead took steps to simplify the discussion, taking it to a higher plane.

"Energy can be considered to come in two forms," Gunn said. "While it all originates with the sun, in one way or another, we can see it as either stored energy or continuous energy.

"In talking about continuous energy, I don't mean continuously available at the light switch, or continuously available in a battery. I'm referring instead to the primary external source—the sun—that continuously impinges on the surface of the earth and its atmosphere. It keeps the planet warm and it provides us with energy options for human work. That energy source is continuous. It's always there."

Stored energy is the carbon-based material buried beneath the earth's crust. These are the energy sources—coal, oil and natural gas—that have been the primary drivers of our economy for the last two centuries.

"Stored energy has been very efficient and relatively cheap," Gunn says. "But one of the characteristics of stored energy is that it's finite. The timing is up for debate, but we should at least acknowledge that it's finite. At some point, we have to move away from stored energy and toward continuous energy. We have to move away from fossil fuels and toward renewable sources. If we have to do this anyway, then why not begin that shift on our own terms? If we choose to shift now, we can control the pace and timing. We can be the ones who develop the best technologies."

Gunn said there are other reasons for shifting away from petroleum use.

"There is a strong relationship between our use of fossil fuels and the acceleration of climate change," Gunn said. Referencing CNA's 2007 report on climate change and national security, he made a direct connection. "This is a security issue. Moving away from fossil fuels is an important step in reducing the security threats related to climate change."

"There is a strong relationship between our use of fossil fuels and the acceleration of climate change"

He also challenged the way petroleum is used almost exclusively for transportation.

"Petroleum is inherently valuable," Gunn said. "It has many uses that are beneficial to human beings well beyond its use in transportation. It's a very good lubricant. It's a constituent of plastics and composites. It has real value as an ingredient in products that are lasting. When we use oil for a single use—one trip to the store, one trip across the water—we tend to ignore the opportunity costs."

He added, "we should weigh the ever-increasing risks of production and transportation against the potential future value of petroleum for uses other than transportation. Just because technology is making supplies of petroleum and other stored energies more readily accessible to us today, it doesn't diminish their value, or potential value, for future uses."

Toyota Plug-in Hybrid—REUTERS/Denis Balibouse

ernment supports research and development in these technologies and offers considerable subsidies for purchases by consumers. The Obama administration aims to put one million electric or hybrid vehicles on the road by 2015.

Hybrid cars have both an electric motor and an internal combustion engine that is powered by gasoline or diesel fuels. When stopping, the braking energy reverses the power flow, turning the electric motor into a generator that recharges the batteries. Plug-in hybrids can be recharged prior to use, most advantageously during the night when electricity supply is high and prices are low.

Pure electric cars have operational ranges that vary, with current technologies, between 40 to over 100 miles. They generally require several hours to recharge; such a lengthy charge cycle is especially common at in-home outlets. Recharging stations are not available for longer trips—without infrastructure changes, electric cars may be most suitable for commutes. (If recharging stations are built, they could lead to problematic recharging during peak power consumption periods—though price incentives can be used to direct recharging to low power consumption periods.) The viability of pure electric cars may ultimately depend on the development of more potent, lighter batteries, which would allow for longer trips. At present, plug-in hybrid technology may be the most promising platform, given the extended range of these vehicles. With the relatively low cost of electricity in the U.S., powering a vehicle with electricity is far cheaper than powering a vehicle with gasoline, so the operating costs over an electric or hybrid vehicle's lifetime are becoming economical for a large portion of the market. As gas prices rise, we expect these vehicles to become ever more common on U.S. roadways and driveways.

Plug-in hybrids and the domestic electricity grid

One concern regarding the increased use of plug-in hybrid electric vehicles, especially if the increase is rapid, is that recharging batteries could put greater demand on power grids that are already stressed. This should not slow down the trend toward more electric vehicles. According to industry officials, if one assumes that most batteries are charged at night, when supplies are highest, even adding 15 million plug-in hybrid electric vehicles would be within the capacity of the existing power grid. While we are concerned about weaknesses in the U.S. national power grid, in our view, the power industry and government have numerous instruments for encouraging consumer power usage during off-hours, particularly differential pricing. Rather than seeing these issues separately, we see them both as reinforcing a key national security need outlined in our second report: upgrading a fragile national electrical grid.

Supplies of key inputs lithium and rare earth elements (REEs) are uncertain

It is legitimate to question whether the mineral lithium, fundamental to the lithium-ion batteries that are cur-

GENERAL PAUL J. KERN, USA, (RET.)

Former Commanding General, U.S. Army Materiel Command; Chairman, CNA Military Advisory Board

Everything's on the Table

When retied Army General Paul Kern talks about the steps necessary to reduce U.S. consumption of oil, he starts with economic policy.

"In all of our discussions, we kept coming back to economic issues," said Kern, referencing the CNA Military Advisory Board, which he chairs. "We concluded very early that oil is a global commodity, priced on the global market. No matter how much more we produce here in the U.S., we can't control the price of oil. So if we continue using as much as we do now, we'll continue to be vulnerable to price spikes and supply interruptions."

He was clear in saying the Military Advisory Board did not believe it should pick winners among the alternatives to oil or recommend a specific economic policy. But there was general agreement that high-level economic policies were necessary for a shift away from oil.

"If you want to unleash the power of the private sector, you need to send clear market signals," Kern said. "And that requires a long-term economic strategy."

Kern outlined a range of options that he said are representative of what should be on the table in a serious discussion of energy and security.

"Incentives have played a significant role in how we develop resources in the U.S.," he said. "With ethanol, the incentive was the tax break for corn farmers. That made a difference. It moved us in the intended direction. You can argue about ethanol, but the fact is, the incentives worked. The sector grew. So you can start there."

A second option also involved incentives, but rather than focusing on a single fuel or technology, the incentives could encourage a mix of technologies.

"We ran across people using fuel cells charged by wind energy to produce methanol," Kern said. "They essentially found a way to store wind energy in a liquid form. They've got a long way to go, but it was a reminder that if we choose the incentive route, we may want to take steps to incentivize collaboration."

Kern said a third option might involve using a tax to set a floor for the price of gas and diesel.

"The purpose is to eliminate the economic fluctuations that have stopped us from focusing on alternatives to oil," said Kern. "We've gotten excited about alternatives in the past, then the price of oil drops significantly, and the investment dollars go away. That kills innovation."

A fourth option, according to Kern, could be a tax on carbon. He said such a tax could be configured so funds circle back to the people hardest hit. He also stressed that a carbon tax could be designed to be revenue neutral.

"There are many options here," Kern said. "My own view is that everything should be on the table. We cannot be afraid to talk about incentives, regulations, government intervention and, yes, even tax on carbon. I don't know which of those options is best, but I do know we should be willing to consider all of them. I don't think it's reasonable to reject things out of hand for reasons of ideology or politics. This is more than energy policy that we're talking about—it's national security policy."

Kern said America's economic power and capacity for innovation was a key to its military successes.

"We're still ahead," said Kern, "but these things can turn quickly. If we choose to innovate—if we push ourselves to be the ones to develop new energy sources and technologies—we can stay ahead in ways that really matter."

Kern stressed the need for a consistent economic policy, and noted savings that can come from small steps.

"A lot of this comes down to individual steps," Kern said. "Designers in so many industries can make small improvements in engine efficiencies. Those decisions aren't always visible, but they add up. And the choices we make as we live our daily lives are equally important. Do we need to drive to the store or can we get there some other way? Can we rideshare? If we're buying a car, how much emphasis will we put on fuel economy? These things add up."

rently the dominant battery technology, is sufficiently abundant to support rising global demand for lithium battery-powered vehicles. Although lithium is present around the world, it is found in concentrations that allow commercial extraction in Australia and only a few countries in North and South America. As with phosphorus (a key input for the cultivation of biofuel source materials), the degree to which lithium could become a strategically valuable mineral in the future is debatable. We do not judge the issue of lithium availability as a matter of strategic concern because, as prices rise, the production of lithium will almost certainly rise around the world, manmade substitutes could increasingly become available, and lithium recycling is possible.

A greater concern, in our perspective, may be that critical components of advanced batteries include certain rare earth elements (REEs), which are expensive and environmentally hazardous to produce. Currently, China produces almost 90 percent of the world's commercial REEs, including those used in advanced batteries, and therefore controls the global price. In 2010, China used this domination to restrict the exports of REEs to Japan in a move to strengthen its position in a dispute over maritime territorial rights. This is indeed a cause for concern. However, we are encouraged that if the global demand for these elements were to increase dramatically, producers around the world would be motivated to make new investments in production outside of China. In our opinion, future secure access to REEs is rightfully an area of concern for the U.S. government, especially as electric car and battery technologies become areas of intense international industrial competition.

Hydrogen Fuel Cell Technology

Hydrogen as a fuel can be used by modified internal combustion engines or as fuel cells which power engines electrically. There are various ways of producing hydrogen. The most common method is extraction from fossil fuels. The techniques used to extract hydrogen from fossil fuels include steam reforming, partial oxidation, and gasification. Most of these techniques employ high temperature reactions that involve a catalyst. A disadvantage of these techniques is that they often produce carbon dioxide, a greenhouse gas. Alternatively, hydrogen can be produced by electrolysis—running electricity through water—which does not produce any greenhouse gases. Commercially, both methods are expensive and are currently only performed on a small scale.

Members of the CNA Military Advisory Board inspect an electric car.—K. Duggan, CNA.

The storage of hydrogen, which would be necessary for its use in fuel cells powering modified internal combustion engines, presents several challenges. For hydrogen to be used in an internal combustion engine, it must be in liquid form, which involves intense compression in fuel tanks. Also, one key byproduct of internal combustion engines—carbon monoxide—affects hydrogen fuel cells by binding to the catalysts within, reducing the efficiency of the hydrogen-catalyst interaction. Also, many hydrogen fuel cells involve extremely advanced carbon nanofibers, metal hydrides, or glass microspheres, all of which require further development before widespread commercial use in the transportation sector would be feasible.

Research is currently being performed on all aspects of fuel cells, such as their membranes, catalysts, electrodes, diffusion layers, and the production of the hydrogen that is contained in the fuel cells. The technology of fuel cells is changing rapidly, but, at present, just the cost of producing sufficient hydrogen for widespread fuel cell use is prohibitive. Moreover, the cost of creating a hydrogen supply infrastructure nationwide would be exorbitant, perhaps in the hundreds of billions of dollars. For these technological and cost reasons, most industry experts believe that hydrogen fuel cell vehicles will not be widely available until 2020, at the earliest. Still, mass vehicle hydrogen fuel cell demonstrations are taking place in Germany, Japan, and Korea, and several hundred hydrogen fuel cell-powered vehicles are operating in the United States [30].

The cleanest transport energy available

In terms of low environmental impact and greenhouse gas emissions, hydrogen fuel technology seems most promising. The main byproduct of the hydrogen fuel cells is water, causing virtually no environmental impact. Hydrogen that is produced by electrolysis and then captured in fuel cells releases negligible amounts of greenhouse gases (though the production of the required electricity would most likely involve emissions). Hydrogen that is produced from fossil fuels to be used in modified internal combustion engines is less clean because it involves the release of carbon dioxide.

Once the technological and market challenges related to hydrogen fuel cells are overcome, we foresee few geopolitical impacts beyond the reduced need for oil-based fuels. The key inputs—electricity, water, perhaps small amounts of hydrocarbons—are abundant. Fuel cells and the electric engines they power could be produced domestically without critically scarce imports.

Methanol

Methanol, also known as methyl alcohol or wood alcohol, is a colorless liquid that is slightly less flammable than gasoline. Methanol may be produced from fossil fuels such as natural gas and coal or from renewable resources such as agricultural products, municipal waste, and biomass, and by combining hydrogen with excess carbon dioxide.

Efficient transportation fuel

Methanol gained popularity in the United States as an alternative fuel during the oil crises of the 1970s. In the 1990s, it was successfully introduced into approximately 15,000 vehicles as a flex fuel and is used as an additive to gasoline to improve fuel efficiency in the U.S. and Europe. Today, methanol is considered a viable and emerging transportation fuel. It can be used directly as vehicle fuel or converted into gasoline or Dimethyl Ether (DME), a fuel regarded as clean-burning for diesel and petrol engines [31]. It has a higher energy density than hydrogen, but a lower energy density than gasoline or diesel fuel [32]. On an energy-equivalent basis, the production of methanol is an estimated 30 percent lower than that of natural gas conversion to diesel fuel. Furthermore, greenhouse gas (GHG) emissions from natural gas derived methanol are more than 50 percent lower than natural gas conversion to diesel fuel.

Methanol also holds potential as a hydrogen carrier for fuel cell vehicles. Unlike most fuel cells that are powered by hydrogen, direct methanol fuel cells (DMFCs) are powered by pure methanol that is mixed with steam and fed to the fuel cell anode. Since methanol has a higher energy density than hydrogen, it may be easier to store, transport, and supply. However, research and development of DMFCs lag behind that of other alternative fuel types by an estimated three to four years [33].

Low production costs

Methanol is typically produced using natural gas and coal as feedstocks. U.S. industries currently tend to favor natural gas as a feedstock because it is readily available and is associated with low production costs. Progress is also being made on the production of methanol from renewable resources such as wood, municipal solid waste, agricultural waste, and gases. The U.S. has sufficient feedstock of natural gas and coal to facilitate a transition from non-renewable to renewable methanol. In addition, several studies have found that a light-duty, tri-flex-fuel vehicle running on gasoline, ethanol, and methanol would be an efficient interim option that would cost the American consumer only $100 to $200 more than an ethanol-gasoline flex-fuel vehicle. Over time, methanol could lead the industry as a carbon-neutral, alternative fuel [34].

As with other fuels, increasing the production of methanol carries some risk. It would require some investment to modify existing engines to run methanol. In addition, thermo-chemical plants used to generate renewable methanol are almost twice as expensive as bio-chemical ethanol plants [35], and require substantial amounts of water. Perhaps the greatest challenge to using methanol as a transportation fuel is preparing the current, petroleum-based fueling infrastructure for methanol, including pumps and fueling stations [36].

Environmental benefits

Depending on the feedstock, emissions from methanol are comparable to or lower than those of natural gas. Methanol produced from renewable resources has the lowest overall emissions, assuming small Indirect Land Use Change [37]. "Well-to-wheels" GHG emissions for methanol derived from natural gas are comparable to those from gasoline and slightly lower for CO_2, but somewhat higher if methane is included [38]. Methanol from coal, which is mostly produced in China, nearly doubles the carbon intensity compared to gasoline, whereas methanol produced using salvaged CO_2 could be completely carbon neutral.

Geostrategic implications

Globally, there are over 90 methanol plants producing more than 100,000 tons of methanol for use as chemical manufacturing feedstock or transportation fuel [39]. China currently leads world production. The United States currently imports most of its methanol from the Caribbean and South America because foreign production tends to be less expensive.

Methanol can be produced relatively simply from coal and natural gas, and from a range of other source materials as well, including biomass and human and animal waste. If governments were to encourage the addition of methanol as a transport fuel, either into gasoline-based blends, or as a stand-alone fuel, or if drivers were to favor methanol as a fuel, its supply (from various source materials) should be relatively inexpensive and reliable. Once car fleets around the world are modified to run on methanol or methanol blends, most countries and regions should be able to produce sufficient methanol so that supply controls and chokepoints would not occur. This additional diversity and flexibility in international or national fuel markets should reduce oil prices and improve stability.

Summary Table:

The chart below offers a simplified summary of various alternatives to oil, briefly noting the technical and economic challenges associated with each, as well as the different security concerns that may be raised with the increased use of each fuel. The alternative fuels are listed alphabetically and not in any order of preference.

Chart 1: Summary of the features and prospects for various alternative fuels

	Algae-based biofuels	Cellulose-based biofuels	Compressed natural gas	Electric vehicles	Fischer-Trophsch derived fuels
Economic security	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs and new industry.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs and new industry.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs, depending on competitiveness of U.S. auto makers.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs.
Geo-political security	Fuels can be produced in non-agricultural areas, diversifying supplies. Rising demand for phosphorus could complicate pricing, supplies.	Benefits accrue to U.S. and other grain producers. Production from indigenous biomass sources can diversify and stabilize global supplies.	Global gas reserves are plentiful, including within the United States. Gas reserves tend to occur alongside petroleum reserves, so many oil producers would benefit.	Current advanced batteries require lithium and some rare earth minerals, the supplies of which could become constrained due to market or political forces. Some substitutes available.	Coal and gas reserves are relatively plentiful around the world.
Environmental security	Relatively low GHG emissions. Total GHG impact depends on type and means of algae cultivation, input supplies. Could require intense use of phosphates, CO2, and water.	Relatively low vehicle GHG emissions. Cultivation requires fewer inputs than food crops (could be waste). Grasses, crop residues affect land values less than food crops.	Burns cleaner than oil, but releases much more GHG than ethanol. Large-scale gas extraction has environmental hazards similar to oil drilling.	EVs emit no greenhouse gases. Total impact would depend on source for electricity.	Requires CO2 sequestration, or another means of reducing or storing CO2 to keep GHG emissions at acceptable levels. Coal-burning F-T plants require large volumes of water.
Military implications	Sound for permanent installations in the continental U.S. (CONUS). Good potential for expeditionary use.	Sound for permanent installations, CONUS. Good potential for expeditionary use.	Sound for permanent installations, CONUS. For expeditionary use, volatility a challenge.	Sound for permanent installations, CONUS. Poor for expeditionary use because of limited, unreliable electric capacity at front lines.	Sound for permanent installations, CONUS. Good potential for expeditionary use.
Technical or economic challenges	Technology unproven at commercial scale. Costs uncertain. Could be mixed into gasoline, or dropped in as alternative without major engine alteration. 5-10 years to commercial availability	High initial facility costs. Uncertainty about optimal source materials. Requires modified delivery and storage systems. Can be mixed into gasoline, or dropped in as alternative without major engine alteration. 0-5 years to commercial availability	Best for fleets with central refueling points. Wider delivery systems require special compression systems. High potential as source material for further refinement into fuel via F-T process or into methanol. Lower GHG than gasoline. 0-8 years for wide commercial availability	Already commercially available, but cost of vehicles high. Designing smaller, more powerful, affordable batteries is the key challenge. Recharging at massive scale could increase pressure on U.S. energy grid. 0-5 years for wide commercial availability	Technology proven and commercially operative in other countries. Costs of new F-T plants are extremely high, though lower if source material is natural gas (instead of coal). 0-5 years for wide commercial availability

= Good = Area of concern = Area of higher risk

Food crop-based biofuels	Traditional gasoline	Hydrogen fuel cells	Methanol	Propane
Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs.	Reliance on gasoline contributes to trade deficit. Subsidies to oil and gas include military protection of supply chain, limited taxes, emergency funds for oil spills, and use of public lands.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs and new technologies could have spillover effect for new industries.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs. Energy density is half that of gasoline–more refuelings.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs.
Benefits accrue to U.S. and other grain producers, mostly stable democracies. Food vs. fuel tradeoff for grains could cause global political rift. Rising demand for phosphorus could complicate pricing, supplies.	Reliance on gasoline restricts foreign policy, underpins enduring military engagement in the Middle East, and profits countries and groups who oppose U.S.	Offer prospects for abundant transport fuels. Enormous start-up costs may limit technology to wealthy countries.	Methanol is relatively easy to produce from gas, coal, or nuclear power and blends with traditional gasoline. Production possible around the world, which would diversify global energy supplies.	Global gas reserves are plentiful, including within the United States. Gas reserves tend to occur alongside petroleum reserves, so many oil producers would benefit.
Relatively low vehicle GHG emissions. Rising cropland values can lead to deforestation. Cultivation can require intense use of energy, phosphates, and water, increasing "well-to-wheel" GHG impact.	Burning gasoline from oil using internal combustion engines emits significantly more GHGs than any alternative fuel produced from natural gas or biomass or from gas-powered electricity plants.	Offer cleanest known technology, with no emissions. Total impact would depend on need for electricity and its source.	Diversification of fuel supply reduces price volatility and vulnerability to shocks. Domestic production would create jobs and new technologies could have spillover effect for new industries.	Propane burns cleaner than oil, but releases much more GHG than ethanol.
Sound for permanent installations, CONUS. Good potential for expeditionary use.	Optimal power per weight, but costs for delivery in expeditionary use can be very high.	Volatility a challenge. Additional weight and size for fuel tank unsuitable for expeditionary use.	Sound for permanent installations, CONUS. Good potential for expeditionary use, but twice as many fuel convoys.	Volatility a challenge. Additional weight and size for fuel tank unsuitable for expeditionary use.
Technology established. Less efficient than biofuels from cellulose. As stand alone fuel requires modified delivery and storage. Can be mixed into gasoline, or dropped in as alternative without major engine alteration.	Technology established. High price volatility controlled by cartel. Mostly imported. Poses significant national security vulnerability. High GHG.	Commercially available, but in small numbers and at high cost. Weight and size of fuel tanks presents design challenges. Would require new hydrogen delivery infrastructure.	Technology is established from natural gas and coal, under development from biomass. High start-up costs for new plants. Can be mixed into gasoline, or dropped in as alternative without major engine alteration.	Less efficient per volume than gasoline, requiring frequent fuel tank replenishment. Most efficient for specialized fleets of small vehicles. Requires compressed storage and delivery. High GHG.
0-5 years for wide commercial availability	Widely available now	5-15 years for wide commercial availability	0-5 years for wide commercial availability	Widely available now

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

Former Deputy Chief of Naval Operations for Warfare Requirements and Programs; Vice Chairman, CNA Military Advisory Board

Setting the highest standards

"It's ambitious, but we can do it," said retired Vice-Admiral Dennis McGinn. "America knows how to turn a challenge into an opportunity. We are innovators."

The challenge is our country's dependence on oil. The opportunity is making our cars and trucks more fuel-efficient—which is where the global market is going anyway, according to McGinn. He said America can achieve much higher corporate auto fuel economy (CAFE) standards—and certainly the 54.5 mpg by 2025 standard put forward recently by the Administration. He quickly checks off a list of reasons justifying that target.

"Our oil addiction weakens our leverage in dealing with regimes that do not always have our best interests at heart," McGinn said. "It forces us to fund with petrodollars, nations hostile to the U.S. The volatility of the oil market whipsaws our economy. Burning oil worsens the effects of climate change. And massive oil spills and mining disasters constantly remind us of the high costs of producing fossil fuels in our own backyard."

"What kind of gas mileage and choices do American drivers deserve?"

McGinn said a vital step toward ending our oil addiction involves setting high fuel efficiency standards. Once that's done, a market-driven dynamic works to satisfy consumer needs and to meet our larger economic, environmental, and security needs.

"Given that our oil addiction is such a serious problem, it might seem surprising that something as simple as better gas mileage can help," McGinn said. "But gasoline accounts for about 45% of the oil we use in the U.S."

McGinn talked about the important role government standards have played in making American cars safer and more efficient. As examples, he pointed to government requirements for seatbelts, airbags, catalytic converters and increased fuel economy that the auto industry at first opposed but then exceeded brilliantly.

"54.5 miles per gallon by 2025 is very doable," McGinn said. "Engineering experts say we can get most of the way there by simply deploying a mix of better-designed traditional gasoline-powered cars and more cars using proven alternative technologies like hybrid gas-electric engines. If you add in some forward- looking options, like plug-in hybrids and electric vehicles, it would take us over the top. And the companies themselves would decide on the exact mix of models that would allow them to meet the average fuel economy standard of 60 mpg."

McGinn pointed out that automakers are already selling cars that meet or exceed the proposed standards—they just aren't selling those cars here in the U.S. He said this begs an obvious question.

"What kind of gas mileage and choices do American drivers deserve?" McGinn asked. "I don't think we Americans have ever thought that gas-guzzling was a national value. We deserve cars that hit the highest standards anywhere in the world. We have high quality and safety standards, just as we should. We should also have the highest fuel economy standards. That's leadership. And that's America's role- we can do it!"

Conclusion

A Call to Action:

Efficiency, Diverse Fuels & Shared Responsibility

Three things strike us as we review our discussions. First, during the nine months of work we have spent deliberating, conferring with energy and policy experts, and tasking our research team, it became quite evident that we can make great progress toward a 30 percent reduction in oil use through efficiency. Indeed, it is baffling that our nation has not pursued these gains aggressively. But here we are—and we have the compelling need to act. The pursuit of energy efficiency should not be viewed only as an environmental measure. It should be viewed as a step toward greater security. If we commit aggressively to efficiency, we will be more secure as a nation. Period.

Efficiency improvements would not require radical change. As Energy Secretary Steven Chu has put it so eloquently: "Energy efficiency isn't just low-hanging fruit; it's fruit on the ground." It's all right there for us.

…we see fuel diversity as an opportunity. Diverse fuel supplies can be a new strength

Second, rather than force the selection of a single fuel—the silver bullet—we are encouraged by the diversity of alternatives to oil. Many alternatives have promising attributes; many can play a role in reducing our reliance on oil. Given our original problem of an overreliance on a single type of fuel, we see fuel diversity as an opportunity. Diverse fuel supplies can be a new strength.

The ideal replacement for 30 percent of our country's oil is not one particular type of new fuel. Instead, it is a set of several new fuels, technologies, vehicle types, and driver practices. This is true at least in the short-term; over time, market-driven innovations will alter the affordability of various options. Coordination is essential—diversity cannot interfere with interstate mobility.

The Chevy Avalanche flexible fuel vehicle (FFV).
REUTERS/Keith Bedford

The challenges in developing these fuels are real. Even the most technologically proven alternatives, such as ethanol and fuels derived from F-T processes, face economic challenges in that they may require significant up-front investments. Some, like propane or F-T derived from coal, require new, unproven technologies such as carbon sequestration, to provide few, if any, benefits in terms of reduced environmental and greenhouse gas impacts.

In our view, the most promising alternative fuels in the short- to medium-term—given the need to balance economic, environmental, geopolitical, and military security concerns—are methanol, biofuel ethanol, electric vehicles (with clean electrical generation), and natural gas. All are proven, currently commercially available technologies. Methanol, ethanol biofuels, and electric motors offer the advantage of easy, incremental introduction into the market without disrupting the gas-powered systems that currently dominate the marketplace. However, this narrowing of preferred fuels in the short- and mid-term is not intended to restrict development of other alternatives. In our view, the further development and use of the full suite of alternative fuels will contribute to diversifying the national and global fuel markets, thereby improving economic and geopolitical stability.

…we call on all Americans to help us on a path to greater security

Third, we see the need for urgent collective action. Throughout this report, we have called on America's leaders to direct a shift away from oil and toward greater security. But our political leaders take direction from the American people. And so it is that we call on all Americans to help us on a path to greater security.

Individual Americans—as consumers and as voters—should understand that our ability to move freely in the future is being constrained by the ways we move about today. We should all understand that our choices in the future are being limited by the energy choices we make today. We can move about differently. We can make different energy choices. If our leaders don't take the necessary steps to make us more secure, we can make different political choices.

We have choices—perhaps more than many Americans realize. We can substantially reduce our reliance on oil. We can, and we must.

Biographies

GENERAL PAUL J. KERN, USA, (RET.)

Former Commanding General, U.S. Army Materiel Command; Chairman, CNA Military Advisory Board

General Paul J. Kern is a Senior Counselor at The Cohen Group, which provides global business consulting services and advice on tactical and strategic opportunities in markets around the world. He holds the Class of 1950 Chair for Advanced Technologies at the United States Military Academy and is a member of the National Academy of Engineering.

Kern was Commanding General, Army Materiel Command from 2001-2004, and Senior Advisor for Army Research, Development, and Acquisition from 1997-2001. He was commissioned as an Armor Lieutenant following graduation from West Point in 1967 and served three combat tours – two in Vietnam as a platoon leader and troop commander, and the third in Desert Shield/Desert Storm as Commander of the Second Brigade of the 24th Infantry which played a pivotal role in the historic attack on the Jalibah Airfield, allowing the 24th Infantry Division to secure objectives deep inside of Iraq. He was also the division's Assistant Division Commander after its redeployment to Ft. Stewart.

In the 1990s, Kern served as 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. In June 2004, at the request of Secretary of Defense Donald Rumsfeld, Kern led the military's internal investigation into the abuses at the Abu Ghraib prison in Iraq.

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).

He holds master's degrees in both Civil and Mechanical Engineering from the University of Michigan, and he was a Senior Security Fellow at the John F. Kennedy School at Harvard University.

GENERAL JAMES T. CONWAY, USMC (RET.)

Former 34th Commandant Of The Marine Corps

Previous high level assignments included President of the Marine Corps University, command of a (20,000 Marine) Division, and commander of 90,000 U.S. and British forces during the invasion of Iraq. Prior to becoming the Commandant, served as the J-3 Joint Staff, or senior operations officer in the U.S. military, where he oversaw the war efforts in Iraq and Afghanistan.

As Commandant, served as the senior uniformed Marine responsible for the organization, training, and equipping of over 250,000 active duty, reserve, and civilian personnel serving in the United States and overseas. Managed a USMC annual budget on the order of $40 Billion. As a member of the Joint Chiefs of Staff for four years, functioned as a military advisor to the Secretary of Defense, the National Security Council, and the President. Retired from active duty in late 2010 after 40 years of service.

During his tenure the USMC experienced the growth of 27,000 additional personnel, major military construction efforts at bases and stations throughout the United States, and the integration of multiple next-generation weapons systems into the inventory. He initiated new programs for the care of wounded warriors and brought Marine Corps family programs onto a war-time footing. General Conway is best known for his out-going manner, pragmatic approach, and effective communication skills.

He attended Southeast Missouri University; the Seminar XXI M.I.T. Fellowship Program, and the JFK School of Government, Harvard University, Seminar of International Relations.

Married to Annette for 41 years, they have three children: two sons who are serving as majors in the Marine Corps, and a daughter, married to a Marine Cobra pilot. He enjoys fly-fishing, hunting, golfing, kayaking, and grandchildren.

LIEUTENTANT GENERAL KEN EICKMANN, USAF (RET.)

Former Commander, Aeronautical Systems Center, Wright-Patterson AFB

Ken Eickmann is the Deputy Director of the Center for Energy Security at the University of Texas in Austin. He is also the State Vice Chairman for the Texas Engineers Taskforce on Homeland Security.

From 1996-1998, Eickmann served as the Commander, Aeronautical Systems Center, Wright-Patterson AFB, where he led the nation's largest center of excellence for research, development, and acquisition of aircraft, aeronautical equipment, and munitions. In that capacity, he managed more than 2,800 programs, executed an annual budget of more than $11 billion, and employed a workforce of approximately 12,000 at 35 locations worldwide.

General Eickmann was the Commander of the Oklahoma City Air Logistics Center and Installation Commander of Tinker Air Force Base from 1994-1996; Deputy Chief of Staff for Logistics and Chief of Staff for Air Force Materiel Command from 1992-1994; and DCS Logistics, Headquarters Pacific Air Forces from 1990-1992. From 1967 to 1990, General Eickmann's assignments centered on his expertise in research, development, acquisition, and logistics.

He is a recognized expert in propulsion technology and has published several papers in technical journals in the U.S. and overseas. He is a registered Professional Engineer and a certified acquisition professional in Acquisition Logistics (Level III), Program Management (Level III), and Systems Planning, Research, Development and Engineering (Level III).

He chaired a General Officer Red Team formed to review Logistics Transformation efforts of the U.S. Air Force, and served as a member of a National Research Council committee formed to provide an independent evaluation of the feasibility of achieving the science and technology requirements implied in the National Aerospace Initiative. In addition, the General recently chaired three committees for the National Academy of Sciences and the National Research Council focused on propulsion technology and how to reduce U.S. dependence on foreign sources of fuel.

Eickmann has received many awards, including the Distinguished Service Medal with Oak Leaf Cluster. The State of Oklahoma declared July 11, 1995, as "General Ken Eickmann Day" in recognition of his leadership and assistance to Federal and State rescue and recovery efforts following the April 19, 1995, bombing of the Alfred P. Murrah Building in Oklahoma City. He was presented with the Order of the Sword by the enlisted men and women of Air Force Materiel Command in 1998. In 1999, he was honored as a Distinguished Graduate of The University of Texas at Austin College of Engineering

The General is a member of the faculty at UT Austin. He holds a bachelor's degree in Mechanical Engineering from UT Austin, a master's degree in Systems Engineering from the Air Force Institute of Technology, and is a graduate of the University of Michigan School of Business and the John F. Kennedy School of Government, Harvard University. His professional military education includes Squadron Officer's School, Air Command and Staff College, Air War College, and the Industrial College of the Armed Forces.

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

Former Deputy Chief Of Staff For Plans And Programs, Headquarters U.S. Air Force

Lt. Gen. Lawrence P. Farrell, Jr., USAF (Ret.) became the President and CEO of NDIA in September 2001. 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 Forces 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, 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, Hill Air Force Base, Utah.

General Farrell has had in-depth business development experience, having served on various business strategy groups for such companies as LABBLEE Corp, Raytheon, Labat-Anderson Inc., KPMG, Huber Corp, The Boeing Company, and Philadelphia Electric Company. He has also served on a number of study groups supporting The United States Air Force, The Rand Corporation, and The Logistics Management Institute. In addition, he has been a member of the advisory boards of UNISPHERE Inc., BAE Systems Simulation and Training, Miltope Group Inc., Learning Byte International, and The Camber Corporation. He currently serves on the Boards of Global Healthcare Exchange, Advanced Technology Institute, and the National Center for Defense Manufacturing and Machining.

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

A native of Montgomery, Alabama, he is married to the former Victoria Leigh Kruzel of Richmond, Virginia. They have a son, Major Sean Farrell; a daughter, Kelly Farrell Lowder, and 4 grandchildren.

BRIGADIER GENERAL GERALD E. GALLOWAY, JR., P.E., PH.D., USA (RET.)

Former Dean of the Academic Board, U.S. Military Academy

Brigadier General Gerry Galloway is a Glenn L. Martin Institute Professor of Engineering and an affiliate professor of Public Policy at the University of Maryland, College Park. A civil engineer, public administrator, and geographer, he has served as a water resources and flood mitigation consultant to a variety of national and international government and business organizations, is a member of the Louisiana Governor's Advisory Commission on Coastal Protection, Restoration and Conservation. He serves as co-chair of the experts group on policy for the U.N. World Water Assessment Program and as a consultant to The Nature Conservancy on its Yangtze River Program. He is also a member of the National Academy of Engineering, a fellow of the National Academy of Public Administration (NAPA), and a member of the Board of Trustees of the Natural Heritage Institute.

Galloway was a principal investigator for FEMA the 2006 study of the adequacy of the National Flood Insurance Program's one percent flood standard, and also chaired for FEMA an Interagency National Levee Policy Review Team. In 2006-2007, he led an expert panel examining flood challenges in California's Central Valley. From 2007 to 2008 he was the Maas-White Scholar at the U.S. Army Corps of Engineers Institute for Water Resources. From 2007-2009, he was a member of a NAPA Panel examining for DOD joint land use issues. He was a Presidential appointee to the Mississippi River Commission from 1988 to 1995, and from 1994 to 1995, was assigned to the White House to lead a committee in assessing the causes of the 1993 Mississippi River Flood.

During a 38-year career in the military he served in various command and staff assignments in Germany, Southeast Asia, and the United States, retiring in 1995 as a brigadier general. He is a graduate of the U.S. Military Academy and holds master's degrees from Princeton and Pennsylvania State Universities, and the U.S. Army Command and General Staff College, as well as, a doctorate in Geography from the University of North Carolina at Chapel Hill.

Galloway is an Honorary Diplomate of the American Academy of Water Resources Engineering, a Distinguished Member and Fellow of the American Society of Civil Engineers, a Fellow of the Society of American Military Engineers, and a member of Association of American Geographers. In 2007, he served as president of the American Water Resources Association. He has served on eight committees of the National Research Council and is a member of its Water Science and Technology Board and its Disasters Roundtable.

VICE ADMIRAL LEE F. GUNN, USN (RET.)

Former Inspector General of the Department of the Navy; Vice Chairman, CNA Military Advisory Board

Vice Admiral Lee Gunn is President of CNA's Institute for Public Research, which provides high-level research and analysis services to federal, state, and local government agencies, and non-commercial clients working in the areas of education, health research and policy, organizational learning and effectiveness, air traffic management, safety and security, and other domestic issues.

Gunn is also President of the American Security Project, Chair of the Board of Advisors of the Naval Postgraduate School, and an Advisor to the Global Perspectives Initiative at the University of Central Florida. From 2001-2006, Gunn was President of the Surface Navy Association and continues to serve as a member of its Executive Board.

Gunn served for 35 years in U.S. Navy. His last active duty assignment was Inspector General of the Department of the Navy where, with his Marine deputy, he was responsible for the Department's overall inspection program and its assessments of readiness, training, and quality of service.

Serving in the Surface Navy in a variety of theaters, Gunn rose through the cruiser/destroyer force to command the Frigate USS Barbey, then commanded the Navy's anti-submarine warfare tactical and technical evaluation Destroyer squadron, DESRON 31. He later commanded Amphibious Group Three, comprising 19 ships, 12 other, separate commands, and 16,000 Sailors and Marines.

As Commander of PHIBGRU THREE he served as the Combined Naval Forces Commander, and Deputy Task Force Commander of Combined Task Force United Shield, which conducted the withdrawal of U.N. peacekeeping forces from Somalia in 1995 – the only amphibious withdrawal operation under fire conducted since the Korean War. He has received the Distinguished Service Medal, the Defense Superior Service Medal, six Legions of Merit, two Meritorious Service Medals, the Navy Commendation Medal (with Combat Distinguishing Device), the Navy Achievement Medal, the Combat Action Ribbon, and numerous theater and service awards.

Following his active-duty career, Gunn was tasked by the Chief of Naval Operations to lead an Executive Review of Navy Training – a nine-month examination by experts from the uniformed Navy, the Department of the Navy's civilian corps, and the business and education communities, which yielded recommendations that continue to be implemented and are revolutionizing training and learning for Navy men and women.

Gunn holds a bachelor's degree in Experimental and Physiological Psychology from the University of California, Los Angeles, and a master of science degree in Operations Research from the Naval Postgraduate School in Monterey, California.

GENERAL RONALD E. KEYS, USAF (RET.)

Former Commander, Air Combat Command

A member of CNA's Military Advisory Board, General Ron Keys is founder of RK Solution Enterprises, an independent consulting firm, providing clients with guidance on advanced technologies, marketing, strategic planning, and policy development. He is a senior advisor to the Bipartisan Policy Center (BPC) on policy initiatives related to national energy, transportation, and security issues, as well as those related to fragile states, and Iran policy. He is the BPC advisor to the Hamilton-Kean 9/11 Commission National Security Preparedness Group, leads the BPC National Security Speaker Series, and is technical advisor to the BPC's Cyber Shockwave Security simulation project.

He is also a member of the Embry-Riddle Aeronautical University Board of Directors; a Senior Mentor to STRATCOM cyber exercises, experiments, and space command-and-control projects, and advises the U.S. Air Force on energy security, unmanned aerial systems, irregular warfare, cyber organizational strategies, and rated management issues.

Keys retired from the Air Force in November 2007, after completing a career of more than forty years. His last assignment was as Commander of the Air Force's largest command—Air Combat Command, comprised of 1,200 aircraft, 27 wings, 17 bases, and 105,000 personnel in 200

operating locations worldwide. Under his leadership, ACC organized and stood up the Air Force's first Unmanned Aerial Vehicle (UAV) Wing and first Network Warfare Wing.

He has received two Defense Distinguished Service Medals, two Distinguished Service Medals, two Legions of Merit, two Distinguished Flying Crosses, and seventeen Air Medals. He was the 2007 recipient of the H. H. Arnold Award – the Air Force Association's most prestigious annual award, honoring the military member who had made the most significant contribution to national defense – and upon his retirement was selected as the first recipient of the Air Force Reserve Officer Corps' AFROTC Distinguished Alumni Award.

He has participated in the National and International Security Seminars; Harvard University's John F. Kennedy School of Government; and the Center for Creative Leadership's "Leadership at the Peak" program in Colorado Springs, Colorado.

Keys holds a bachelor of science degree from Kansas State University and a master's degree in Business Administration from Golden Gate University.

ADMIRAL T. JOSEPH LOPEZ, USN (RET.)

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

Admiral Joe Lopez is president of Information Manufacturing Corporation (IMC), an information technology service integrator with major offices in Fairfax, Virginia.

Lopez's assignments included both Commander in Chief of U.S. Naval Forces, Europe and Commander in Chief Allied Forces, Southern Europe (1996-1998). In 1996 he commanded all U.S. and Allied Bosnia Peace Forces from his headquarters in Sarajevo. He served as the Senior Military Assistant to the Secretary of Defense in 1990-1992 and commanded the United States Navy Sixth Fleet in 1992-1993.

Lopez is one of only two flag officers in the history of the U.S. Navy to have achieved four-star rank after direct commission from enlisted service, and is the recipient of 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.

Following his retirement from the Navy, Lopez joined Brown & Root Services (BRS) and became Chief Operating Officer, directing all government activities worldwide from offices in Washington, D.C., London, U.K., and Canberra, Australia. He is a member of CNA's Board of Trustees, and a member of the Boards of the U. S. Naval Postgraduate School, the National Defense University, the National Youth Science Foundation, and the Armed Forces Benefit Association.

He holds a bachelor of arts (Cum Laude) in International Relations, a master of science in Management and 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.

GENERAL ROBERT MAGNUS, USMC (RET.)

Former Assistant Commandant of the Marine Corps

General Robert Magnus retired from military service in 2008. His last assignment was as Assistant Commandant of the Marine Corps (September 2005 - 2 July 2008).

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 Cen-

ter, 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.

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.

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

Former Deputy Chief of Naval Operations for Warfare Requirements and Programs; Vice Chairman, CNA Military Advisory Board

Vice Admiral Denny McGinn is Chief Executive Officer at RemoteReality, a position he assumed in January, 2008, after five years with Battelle Memorial Institute, the world's largest nonprofit independent research and development organization. While at Battelle, he was a corporate officer and led the energy, transportation and environment division. Additional assignments with Battelle included serving as vice president of strategic planning and national security business development, and as a director on the Board of Brookhaven National Laboratory.

Prior to joining Battelle, McGinn served 35 years with the U.S. Navy as a naval aviator, test pilot, aircraft carrier commanding officer, and national security strategist. His last assignment was Deputy Chief of Naval Operations for Warfare Requirements and Programs at the Pentagon, where he led the development of the U.S. Navy's future strategic capabilities. He also commanded the U.S. Third Fleet, which is responsible for some 50 million square miles of the eastern Pacific Ocean. As Third Fleet Commander, he was recognized for leading great advances in operational innovation, the rapid prototyping of sea-based information technology, and international naval force experimentation and coordination.

McGinn serves as a director on the board and strategic architect of the National Conference on Citizenship, as a senior policy advisor to the American Council on Renewable Energy, and a senior fellow for international security at the Rocky Mountain Institute. He is actively engaged in national forums to highlight the close link between energy and international security and the imperative for innovative government policies, focused investments, and effective deployment of technology to create a high-quality, sustainable global environment.

McGinn has previously served as chairman of the U.S. Naval Institute Board of Directors, and served for three years as a commissioner on the National Commission on Disabled Veterans' Benefits in Washington, D.C.

He received a bachelor of science degree in Naval Engineering from the U.S. Naval Academy, attended the national security program at the Kennedy School of Government, Harvard University, and was a Chief of Naval Operations strategic studies fellow at the U.S. Naval War College.

ADMIRAL JOHN B. NATHMAN, USN (RET.)

Former Vice Chief of Naval Operations

Admiral John Nathman is a member of CNA's Military Advisory Board. He retired from the United States Navy in May 2007. Prior to his retirement, he served as the nation's 33rd Vice Chief of Naval Operations (August 2004 - February 2005) and, from February 2005 until his retirement in 2007, commanded all U.S. Fleet Forces.

Nathman has served in a variety of sea, shore, and joint assignments, and has flown more than 40 types of aircraft. As a carrier pilot, he 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. In 1987, he reported to the USS Nimitz (CVN 68) 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. In

1991 he served briefly in the Pentagon as the Director for Navy Fighter Requirements before returning to the Nimitz as her Commanding Officer from 1992-1994.

After his selection to Flag rank in 1994, 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 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. In August 2000, he was promoted to Vice Admiral and commanded Naval Air Force, U.S. Pacific Fleet and was later designated the first Commander.

Nathman has received four Distinguished Service Medals, four Legions of Merit, the Defense Superior Service Medal, Bronze Star with Combat V, Defense Meritorious Service Medal, three Meritorious Service Medals, two Navy Commendation Medals with Combat V, and the Air Force Achievement Medal, in addition to numerous campaign and unit awards.

Nathman graduated with distinction from the United States Naval Academy in 1970. In 1972 he received the Naval Training Command's Outstanding Pilot Graduate Award while earning a Master of Science degree in Aerospace Engineering. In 1976, he graduated with distinction from the U.S. Air Force Test Pilot School at Edwards Air Force Base, after which he served as an instructor pilot at TOPGUN and oversaw the advanced tactical training of naval aviators. From 1982-1984, Nathman was the senior naval test pilot flying all MiG aircraft with the 4477 Test and Evaluation Squadron at Nellis Air Force Base and Tonopah, Nevada.

GENERAL GORDON SULLIVAN, USA (RET.)

Former Chief of Staff, U.S. Army

General Gordon Sullivan is President of the Association of the United States Army (AUSA). He is also Chairman of the Board of Trustees of Norwich University a director of the Institute of Defense Analyses, and the Chairman Emeritus of the Marshall Legacy Institute.

From 1991-1995, Sullivan served as the 32nd Army 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 transitioned the Army from its Cold War posture.

He was Army Vice Chief of Staff from 1990-1991, Army Deputy Chief of Staff, Operations and Plans from 1989-1990, and Commander, 1st US Army Infantry Division (Mechanized) from 1988-89. From 1987-1988, he served as Deputy Commandant, U.S. Army Command and General Staff College, Fort Leavenworth, Kansas; and, from 1983-1984, was Assistant Commandant, U.S. Army Armor School, Fort Knox, Kentucky. His overseas assignments included four tours in Europe, two in Vietnam, and one in Korea. He served as Chief of Staff to the Secretary of Defense during the Administration of President George H. W. Bush. He is the co-author, with Michael V. Harper, of *Hope Is Not a Method* (Random House, 1996), which chronicles the enormous challenges encountered in transforming the post-Cold War Army, through the lens of proven leadership principles and a commitment to shared values.

Sullivan has received the Army Achievement Medal, the Army Commendation Medal, the Bronze Star, Combat Infantryman Badge, Defense Distinguished Service Medal, the Distinguished Service Medal, the Legion of Merit, and the Purple Heart. For his work with AUSA, he also received the United States Military Academy's 2003 Sylvanus Thayer Award.

Sullivan holds a bachelor of arts degree in History from Norwich University and a master of arts degree in Political Science from the University of New Hampshire. 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.

LIEUTENANT GENERAL RICHARD C. ZILMER, USMC (RET.)

Former Deputy Commandant for Manpower and Reserve Affairs, Headquarters Marine Corps

Lieutenant General Richard Zilmer retired from Active Duty in January of 2011, following over 36 years of commissioned service. Among a variety of professional and volunteer activities, Zilmer presently sits on the Board of Directors for The Hershey Trust Company, Board of Managers for the Milton Hershey School, and the CNA Military Advisory Board.

During his military career, Zilmer served in a variety of operational and staff assignments throughout the United States, the United Kingdom, Germany, and Japan. His operational commands consisted of Commanding Officer First Battalion, First Marines, Commanding Officer 15th Marine Expeditionary Unit, Commanding General Multinational Forces -West (Anbar Province, Iraq), and Commanding General III Marine Expeditionary Force, Okinawa, Japan. Zilmer served combat tours during Lebanon Peacekeeping Operations, Operation Desert Storm, and Operation Iraqi Freedom. Zilmer's staff assignments included multiple Washington DC tours at Headquarters Marine Corps, Deputy J-3 for Operations at the United States European Command, Presidential Support duties at Camp David, Maryland, and Senior US Marine Representative to the Royal Marines in Poole England. His final assignment was Deputy Commandant for Manpower and Reserve Affairs, Headquarters Marine Corps.

A native of Reading, Pennsylvania, Zilmer presently resides with his wife Lorie and youngest son in the Pocono Mountains of eastern Pennsylvania. Lieutenant General Zilmer graduated with a bachelors degree in Secondary Education from Kutztown University in 1974, and holds a master of arts degree in National Security and Strategic Studies from the College of Naval Warfare. He has also studied at the Penn State Executive Programs and the Kenan-Flagler School of Business at UNC.

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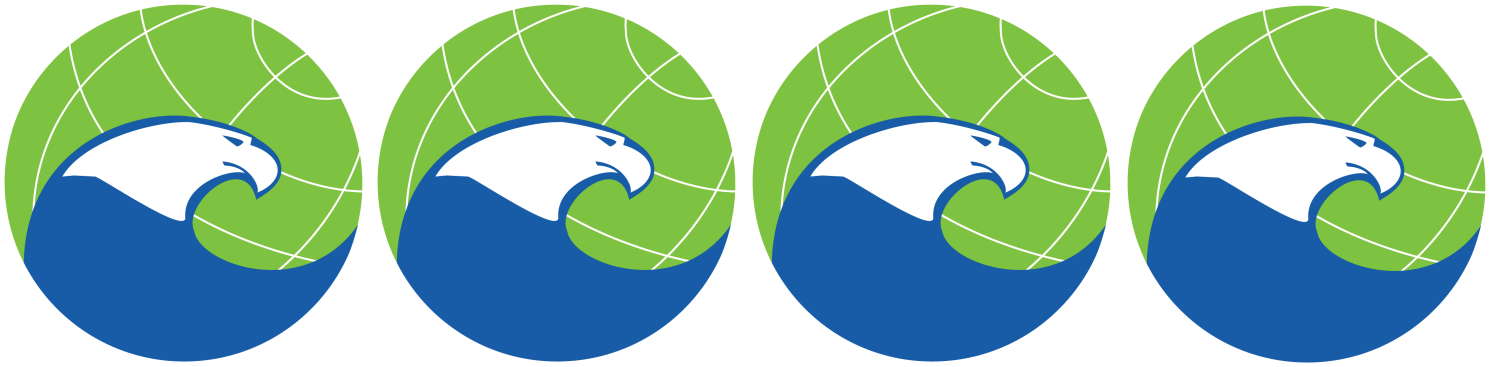
Shown above and on the inside front cover: Two war efforts posters seen during World War II showing how little has changed.



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