Powering America's Economy:

Energy Innovation at the Crossroads of National Security Challenges

July 2010

CNA
ANALYSIS & SOLUTIONS

CNA is a not-for-profit company which serves the public interest by providing in-depth analysis and results-oriented solutions to help government leaders choose the best course of action in setting policy and managing operations. CNA: Nobody gets closer—to the people, to the data, to the problem.

APPROVED FOR DISTRIBUTION: July 2010

Sherri Goodman
Executive Director, CNA Military Advisory Board
Senior Vice President, General Counsel, and Corporate Secretary, CNA

The sponsors for this project were the Bipartisan Policy Center and the Energy Foundation.

Printed on: Green Seal® Certified 30 percent post-consumer fiber paper stock.

To the Reader

Since 2006, the CNA Military Advisory Board (CNA MAB) has gathered periodically to examine the critically important and interconnected issues of national security, energy security, and climate change. Our membership includes retired flag and general officers from the Army, Navy, Air Force, Marine Corps, National Guard, and Coast Guard.

This report marks our third publication. Our first, the April 2007 report *National Security and the Threat of Climate Change*, identified climate change as a "threat multiplier" to existing security risks in some of the most volatile regions in the world, and it also discussed how "climate change, national security, and energy dependence are a related set of global challenges" [1]. Our second publication, the May 2009 report *Powering America's Defense: Energy and the Risks to National Security*, identified America's energy policies and practices as serious and urgent threats to national security—militarily, diplomatically, and economically [2].

In the first half of 2010, the CNA MAB reconvened to further consider the challenges and opportunities that America faces in order to transition to clean energy technology (that is, low carbon energy technology), even as the United States and the world's major economies begin to emerge from a great recession. Specifically, we examined how America's national power could face significant future challenges due to the vulnerabilities of the nation's current energy posture. Furthermore, we looked at the opportunities presented to the United States, relative to collaborators and competitors, by moving toward a clean energy economy. We examined how the Department of Defense (DOD) could play a key role by altering its research and development enterprise to accelerate the development of innovative clean energy technologies.

To this end, we were briefed by a number of talented speakers and experts, including current and former senior officials from DOD and the Department of Energy (DOE), current and former U.S. climate negotiators, defense officials charged with incorporating energy and climate change into national security strategy, active-duty military officers responsible for energy transformation, intelligence officials, private sector energy technology innovators, and specialists in the emerging clean energy economies of nations around the world.

This report, which serves as a follow-on white paper to *Powering America's Defense*, contains the findings and recommendations resulting from our deliberations. We hope that they will provide a useful contribution to the public debate and policy formulation on these critically important national security issues.

General Gordon R. Sullivan,
USA (Ret.); *CNA MAB Chairman*

Vice Admiral Dennis V. McGinn,
USN (Ret.); *CNA MAB Vice Chairman*

Admiral Steve Abbot,
USN (Ret.)

Admiral Frank L. "Skip" Bowman,
USN (Ret.)

Major General Russell Fuhrman,
USA (Ret.)

Brigadier General Gerald E. Galloway, Jr.,
USA (Ret.)

Vice Admiral Lee F. Gunn,
USN (Ret.)

General Paul J. Kern,
USA (Ret.)

General Ronald E. Keys,
USAF (Ret.)

Admiral T. Joseph Lopez,
USN (Ret.)

General Robert Magnus,
USMC (Ret.)

Admiral John B. Nathman,
USN (Ret.)

Vice Admiral Roger T. Rufe,
USCG (Ret.)

Lieutenant General Clyde A. Vaughn,
USA (Ret.)

General Charles F. "Chuck" Wald,
USAF (Ret.)

Military Advisory Board (MAB) Members

CNA MAB Chairman: General Gordon R. Sullivan, USA (Ret.)
Former Chief of Staff, U.S. Army

CNA MAB Vice Chairman: Vice Admiral Dennis V. McGinn, USN (Ret.)
Former Deputy Chief of Naval Operations for Warfare Requirements and Programs

Admiral Steve Abbot, USN (Ret.)
Former Deputy Commander, Headquarters U.S. European Command

Admiral Frank L. "Skip" Bowman, USN (Ret.)
Former Director, Naval Nuclear Propulsion Program

Major General Russell Fuhrman, USA (Ret.)
Former Deputy Commanding General, U.S. Army Corps of Engineers

Brigadier General Gerald E. Galloway, Jr., USA (Ret.)
Former Dean of the Academic Board, U.S. Military Academy and Dean of the Faculty and Academic Programs, Industrial College of the Armed Forces

Vice Admiral Lee F. Gunn, USN (Ret.)
Former Inspector General, Department of the Navy

General Paul J. Kern, USA (Ret.)
Former Commanding General, U.S. Army Materiel Command

General Ronald E. Keys, USAF (Ret.)
Former Commander, Air Combat Command

Admiral T. Joseph Lopez, USN (Ret.)
Former Commander-in-Chief, U.S. Naval Forces Europe and of Allied Forces, Southern Europe

General Robert Magnus, USMC (Ret.)
Former Assistant Commandant of the U.S. Marine Corps

Admiral John B. Nathman, USN (Ret.)
Former Vice Chief of Naval Operations and Commander of U.S. Fleet Forces

Vice Admiral Roger T. Rufe, USCG (Ret.)
Former Commander, Coast Guard Atlantic Area and Maritime Defense Zone Atlantic

Lieutenant General Clyde A. Vaughn, USA (Ret.)
Former Director, Army National Guard, National Guard Bureau

General Charles F. "Chuck" Wald, USAF (Ret.)
Former Deputy Commander, Headquarters U.S. European Command

CNA MAB Executive Director:
Ms. Sherri Goodman
CNA Senior Vice President, General Counsel, and Corporate Secretary

CNA MAB Study Team:
David M. Catarious, Jr., Ph.D.
CNA Research Analyst

Marcus D. King, Ph.D.
CNA Research Analyst

Acknowledgments

We are thankful to several people for their support of this effort. This report benefited greatly from the insights of the speakers that appeared before the CNA Military Advisory Board as well as from Mr. John Alic (Consultant), Ms. Kate Brandt (Department of the Navy), Ms. Morrow Cater (Cater Communications), Col Robert Charette (U.S. Marine Corps), Ms. Constance Custer (CNA), Ms. Karin Duggan (CNA), Dr. Ronald Filadelfo (CNA), Ms. Kate Gordon (Center for American Progress), Dr. Holmes Hummel (U.S. Department of Energy), Mr. Richard Kidd (U.S. Department of Energy), Mr. Randy McLean (Defense and Security Technology Accelerator), Ms. Barbara McQuiston (formerly with DARPA), Ms. Kelly Merkel (U.S. Marine Corps), Ms. Sarah Minczeski (CNA), Ms. Elana Mintz (CNA), Dr. Erin Rebhan (CNA), Mr. James Robbins (Business Cluster Development), Dr. Daniel Sarewitz (Arizona State University), Mr. Joseph Satriano (OSD Power Surety Task Force), and Ms. Linda Schuck (California Institute for Energy and Environment, University of California Energy Institute). We are also especially grateful for the efforts of Ms. Brenda Mitchell at CNA.

We would also like to thank the following people for appearing before the CNA Military Advisory Board (MAB) (in alphabetical order):

Ms. Carol Browner, Director, White House Office of Energy and Climate Change Policy

Dr. Robert Corell, Director of the Global Change Program, The H. John Heinz III Center for Science, Economics, and the Environment

Dr. Heidi Cullen, Director of Communications, Senior Research Scientist, Climate Central

Rear Admiral Philip Cullom, USN, Director, Fleet Readiness Division; Director, U.S. Navy Task Force Energy

Ms. Amanda Dory, Deputy Assistant Secretary of Defense for Strategy

Major General Richard Engel, USAF (Ret.), Director, Climate Change and State Stability Program, National Intelligence Council

Dr. Ralph Espach, Research Analyst, CNA

Mr. Thomas Hicks, Deputy Assistant Secretary of the Navy, Energy

Dr. Kristina Johnson, Under Secretary, U.S. Department of Energy

Mr. Larry K., Climate Change Center, Central Intelligence Agency

Dr. Henry Kelly, Principal Deputy Assistant Secretary, Energy Efficiency and Renewable Energy, U.S. Department of Energy

Mr. David King, Director, Energy Program Management Office, U.S. Air Force

Dr. Steve Koonin, Under Secretary for Science, U.S. Department of Energy

Dr. Michael Levi, David M. Rubenstein Senior Fellow for Energy and the Environment and Director of the Program on Energy Security and Climate Change, Council on Foreign Relations

Dr. Joanna Lewis, Professor of Science, Technology and International Affairs, Georgetown University

Mr. Frank Loy, Former Under Secretary of State; Former chief U.S. climate change negotiator

Dr. Mike MacCracken, Chief Scientist for Climate Change Programs, Climate Institute

Mr. Peter Mackenzie, China Analyst, CNA

Dr. Jeff Marqusee, Executive Director, Strategic Environmental Research and Development Program (SERDP) & Environmental Security Technology Certification Program (ESTCP), Office of the Secretary of Defense

Mr. Alan Miller, Principal Climate Change Specialist, International Finance Corporation

Mr. Kevin Moran, Bipartisan Policy Center

Mr. E. Thomas Morehouse, CNA

Rear Admiral Neil Morisetti, UK Foreign and Commonwealth Office (FCO) Special Envoy for Climate Change and Security

Dr. Jonathan Pershing, Deputy Special Envoy for Climate Change, U.S. Department of State

Mr. John Podesta, President & CEO, Center for American Progress

Mr. Nigel Purvis, Founder and President, Climate Advisers

Dr. Dorothy Robyn, Deputy Under Secretary of Defense, Installations and Environment

Ms. Susan Rochford, Senior Vice President, Council on Competitiveness

Mr. David Sandalow, Assistant Secretary for Policy and International Affairs, U.S. Department of Energy

Rear Admiral David Titley, Oceanographer and Navigator of the U.S. Navy; Director, U.S. Navy Task Force Climate Change

Mr. Shawn P. Walsh, Director, Army Energy Policy

Mr. Julian L. Wong, Senior Policy Analyst, Energy & Climate, Center for American Progress

Mr. Terry Yonkers, Assistant Secretary of the Air Force, Installations and Environment

Contents

i To the Reader

iii Military Advisory Board (MAB) Members

iv Acknowledgments

vii Executive Summary

1 Challenges and Opportunities

2 *Voices of Experience:* On Local Impacts of a Global Issue
General Gordon R. Sullivan, USA (Ret.)

5 *Voices of Experience:* On the Value of Strategic Leadership
General Charles F. "Chuck" Wald, USAF (Ret.)

7 *Voices of Experience:* On Stepping Up
Vice Admiral Dennis V. McGinn, USN (Ret.)

9 Propelling Innovation

11 *Voices of Experience:* On Leadership and a Culture of Responsibility
Admiral Frank L. "Skip" Bowman, USN (Ret.)

16 *Voices of Experience:* On Evolutionary and Revolutionary Energy Solutions
General Robert Magnus, USMC (Ret.)

20 *Voices of Experience:* On the Need for Creative Energy Solutions
Brigadier General Gerald E. Galloway, Jr., USA (Ret.)

21 Conclusion

23 Biographies

33 References

Executive Summary

In this report, the CNA Military Advisory Board (CNA MAB) explores the growing challenges presented by the links that tie the nation's current energy posture to its economy and national security. We address the potential opportunities that could result from the transition to a clean energy technology-based economy and the key role that the Department of Defense (DOD) can play to support innovation and commercialization of clean, low carbon energy, thereby directly contributing to America's future economic competitiveness and bolstering national security.

The specific questions addressed in this report follow:

- What are the key links between national security, energy, and the economy?
- What are the national security challenges and benefits of developing a clean energy economy in the United States?
- How can DOD contribute to America's economic and national security while addressing its own energy challenges?

Our findings and recommendations follow.

Findings

Finding 1: America's energy choices are inextricably linked to national and economic security.

America's national security and economy depend heavily on fossil fuels. While these fuels directly supported the nation's economic growth and military power in the twentieth century, they have not come without cost. The environmental and health implications of fossil fuel use have been apparent for decades, and the risks to the nation's future national security and economic well being are becoming clearer by the day. The nation's heavy use of fossil energy leaves America unacceptably vulnerable to hostile nations and is detrimental to American foreign policy. Economically, the nation's heavy oil dependence diverts hundreds of billions of dollars out of the economy each year and leaves American businesses and governmental agencies vulnerable to unpredictable price volatility. In the case of oil, unless the nation significantly decreases its dependence, declining supplies combined with increasing global demand will have severe impacts on the American economy and our ability to remain militarily strong.

Economically, the nation's heavy oil dependence diverts hundreds of billions of dollars out of the economy each year and leaves American businesses and governmental agencies vulnerable to unpredictable price volatility.

Finding 2: The clean energy technology revolution presents great challenges and great opportunities.

Transitioning away from fossil fuels will be difficult. Significantly altering fossil fuel consumption in the United States will require new approaches to the nation's current methods of producing, delivering, and using energy. It will require developing alternative sources of energy and greatly increasing energy efficiency; it will require the long-term commitment of the United States government and American citizens.

However, the necessity and benefits of the transition are compelling. Not only will overall national security improve, but so will the foundation upon which it rests: economic security. The sheer scale of the needed changes represents an enormous economic

opportunity. Other countries (notably China, Spain, Germany, and the United Arab Emirates) have already recognized these economic benefits and are taking aggressive action to ensure the clean energy technology opportunity is not missed; the United States must seize the moment and lead.

Finding 3: Energy business-as-usual is not a viable option for the United States.

Continued over-reliance on fossil fuels will increase the risks to America's future economic prosperity and will thereby diminish the military's ability to meet the security challenges of the rapidly changing global strategic environment. By taking bold leadership actions now, the nation can turn the growing energy and economic challenges into great opportunity.

Finding 4: The Department of Defense can be a powerful catalyst of energy innovation.

Because of its size, the considerable amount of energy it consumes, and its extensive experience in technological innovation, DOD is uniquely positioned to spur clean energy innovation. By harnessing the leadership characteristics inherent in its military culture, leveraging its organizational discipline, fine-tuning technology development and energy acquisition processes, and cultivating strategic relationships within the federal interagency network—particularly with the Department of Energy (DOE)—DOD can be a key player in moving America forward in the clean energy technology revolution.

By taking bold leadership actions now, the nation can turn the growing energy and economic challenges into great opportunity.

Recommendations

In light of these findings, we offer the following recommendations:

Recommendation 1: The United States government should take bold and aggressive action to support clean energy technology innovation and rapidly decrease the nation's dependence on fossil fuels.

The problems that the nation faces as a result of its heavy dependence on fossil fuels are serious and increasing. Such large-scale challenges will require large-scale solutions. To successfully meet these challenges, United States policy-makers must provide a clear and predictable market signal for investment, development, and scale-up of clean energy technologies. To be effective, such a price signal must account for the enormous costs and risks already associated with the nation's fossil fuel dependence. The right national energy policy would level the energy development playing field and provide the much-needed foundation to unleash the full force of American innovation and investment leadership.

Recommendation 2: The Departments of Defense and Energy should more closely align their energy-related research and development activities, funding priorities, and intellectual capital.

The Department of Energy has a robust research and development base for energy technologies, and DOE's knowledge base represents a largely untapped resource for DOD. In addition, DOD could be of great value to DOE because of its large-scale ability to demonstrate, test, fund, and field new energy technologies. By clearly aligning DOD and DOE goals and talented personnel at the strategic, operational,

and tactical levels, clean energy technologies could be greatly accelerated through the innovation pipeline.

The two Departments should define a structural alignment to facilitate the sharing of information and development of research priorities. By properly aligning DOD and DOE's assets, funding, and intellectual capital, the Departments could act to achieve their strategic energy missions in a more effective and efficient manner. Key components of this alignment include focusing on national and military energy security goals, identifying partnerships between Departments, and connecting warfighters to technology researchers. While some information sharing and collaboration already exists between the Departments, these arrangements are typically ad hoc and are principally the result of enterprising individuals, unaided by a joint vision of meeting national energy security needs with advanced technical excellence.

DOD is uniquely positioned to spur clean energy innovation.

Specifically, DOD and DOE should

- Establish a structured means of information sharing for energy-related research and development. Achieving this strategic and operational alignment would permit the Departments to better meet their own objectives and speed the development of innovative energy technologies.

- Formally establish organizational relationships in order to ensure the efforts continue beyond the tenure of individual champions. The Secretaries of each Department should take a leadership role in ensuring that the appropriate levels of alignment are achieved.

- Formalize the role of DOD's installations and tactical forces as primary test beds for products developed in DOE's Innovation Hubs and the Advanced Research Projects Agency-Energy (ARPA-E).

Concurrent with establishing the much needed alignment with DOE, DOD should also establish better coordination and alignment with other energy-related research and development interagency organizations, specifically NASA, the Department of Transportation, and the Department of Agriculture.

In pursuing its most urgent energy vulnerabilities, DOD should take steps to ensure that it receives input from all innovators, including those in the smallest companies.

Recommendation 3: The Department of Defense should partner with private sector innovators and establish an Operational Energy Innovation Center.

In pursuing its most urgent energy vulnerabilities, DOD should take steps to ensure that it receives input from all innovators, including those in the smallest companies. However, information and communication barriers, largely related to the size disparity of the organizations, impede such collaboration. One potential avenue to connect DOD to innovators is through technology incubators, which provide the expertise needed to get small innovators firmly established. By cultivating a partnership, DOD could provide the testing data and initial market necessary to commercialize new clean energy technologies. Furthermore, to address its most urgent energy concerns, DOD could combine the innovators from nascent businesses with researchers from larger private firms, universities, and national laboratories in an Operational Energy Innovation Center, modeled on DOE's Innovation Hubs. The Center could be funded through a competitive Operational Energy Innovation Fund.

Recommendation 4: The Department of Defense should require widespread sharing of energy information in its research and development enterprise.

The Department of Defense has a well-established and well-funded research and development base, but its complexity results in duplication of effort, inefficient use of taxpayer dollars, and delays in developing and deploying beneficial technologies. The system's complexity also creates barriers within the research community as well as between researchers and warfighters.

While DOD has achieved important milestones in developing clean energy technologies, it could speed these technologies through the innovation pipeline by requiring widespread sharing of information about energy requirements and technology needs. By establishing this structured means of sharing information about funding and results of energy research and development, DOD's constituent agencies and the military services could better leverage the funding they expend and help to accelerate the testing and deployment of innovative energy technologies. Achieving transparency of information is a critical step in delivering the technologies that DOD requires onto its installations and into the battlespace.

Recommendation 5: The Department of Defense should include acquiring clean energy technologies as a priority in its installation acquisition strategy.

The Department of Defense can support the deployment and commercialization of clean energy technologies by prioritizing them in its installation acquisition strategy. Currently, two mechanisms that improve energy efficiency and support conservation are used to fund the acquisition of technologies: Energy Savings Performance Contracts (ESPCs) and the Energy Conservation Investment Program (ECIP). Under the current design, however, these mechanisms support the purchase of older, well-established energy technologies. To help provide an initial market for new clean energy technologies, DOD should incentivize the purchase of clean energy products over older energy technologies.

Specifically, in the ESPC program, DOD should mitigate the financial risk to energy-providers that experiment with cutting edge energy technologies by guaranteeing a minimum return on investment commensurate with what would be returned by mature and aging technologies. In addition, the ECIP program should be directed to give first preference to the energy technologies that are emerging on the market from federal energy-related research and development programs. Such improvements would not only strengthen DOD's energy posture, but it would also provide early support to the private sector companies that produce these technologies.

Chapter 1

Challenges and Opportunities

The Costs of America's Energy

Hydrocarbons are the foundation of today's energy supply in the United States. As shown in Figure 1, approximately 84 percent of the total energy consumed in this country is derived from fossil fuels. Nearly 51 percent of the nation's electricity is generated from coal, and another 17 percent comes from natural gas. Ninety-five percent of the transportation sector is fueled by petroleum [3].

Figure 1: American energy consumption by energy source in 2007 [3].

Fossil Sources: Petroleum 39.17%, Natural Gas 23.28%, Coal 22.43%, and Coal Coke Net Imports 0.02%

Non-Fossil Sources: Nuclear Electric Power 8.29%, Biomass 3.54%, Hydroelectric Conventional 2.41%, Geothermal Energy 0.34%, Wind Energy 0.34%, Eletricity Net Imports 0.10%, Solar/Photovoltaic Energy 0.08%

Fossil fuels, especially coal and oil, have helped build the nation. For much of the twentieth century, these energy sources were affordable, accessible, and relatively abundant. However, America's heavy reliance on fossil fuels comes at a cost that is not fully reflected in the amount paid at the gas pump or on an electric bill. Most directly visible are the environmental and health costs. Beyond that, however, there are less obvious but equally important costs to national security and economic stability. Ignoring the true costs of fossil fuels is a growing risk to America's economy and national security.

Although coal is in abundant supply domestically and is an important component of economic activity in several regions of the United States, it emits toxins such as mercury and arsenic when burned; it is also the fossil fuel that emits the heaviest concentrations of climate-altering greenhouse gases. And while plentiful, it is becoming more difficult and expensive to extract. Accidents such as the December 2008 multi-million dollar coal slurry spill in Tennessee or the tragic April 2010 mine explosion in West Virginia underscore the steep human and environmental costs of this energy source. Despite these very real costs, the nation's consumption of coal has been constantly rising since 1980, and it is projected to increase over the next three decades [4].

Like coal, oil has clearly contributed to America's prosperity, but it has also done so at a real cost with growing risks. Oil presents its own environmental problems, both in terms of greenhouse gas emissions and regional impacts as evidenced by the April 2010 oil rig explosion and environmental disaster in the Gulf of Mexico. Furthermore, the United States now relies on other countries for nearly three out of every

America's heavy reliance on fossil fuels comes at a cost that is not fully reflected in the amount paid at the gas pump or on an electric bill.

GENERAL GORDON R. SULLIVAN, USA (RET.)

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

On Local Impacts of a Global Issue

For General Gordon Sullivan, New England's lobster fisheries and the Gulf of Mexico oil spill underscore the far-reaching challenges of energy and climate change.

"My paternal grandparents moved from Maine to Quincy, Massachusetts, because of the demise of the sardine fisheries in the Gulf of Maine," General Sullivan says. "I have seen the Massachusetts fishing fleet—New Bedford, Cape Cod, Boston, Gloucester—essentially disappear. Much of the food, the fish, and the local customs are gone, and the economic losses have been significant."

General Sullivan is concerned about the deterioration of New England lobstering and its connection to climate change: "Two decades ago, lobsters from the waters off Massachusetts, Connecticut, Rhode Island, and the Long Island Sound accounted for as much as 25 percent of New England's lobster catch. Today, the area accounts for only 5 to 7 percent. And the lobster population—35 million in 1990—has dropped to 13 million. All the articles I've read suggest that the waters off the coast are warming up, and the lobster population is moving into deeper, colder water. Of course, other issues have also affected lobsters: the 1996 oil spill, pesticide runoff, overfishing. People are worried about the long-term economic impacts."

We must do something imaginative and courageous if we are to remain secure and economically powerful.

General Sullivan says that "for most people in America, the lobster problem is a sideshow—an environmental, climate-based shift in the breeding ground. But this is a complex crisis because there are environmental, economic, and cultural consequences."

Turning to an article about the April 2010 oil spill in the Gulf of Mexico, General Sullivan says, "And then I see this picture in the paper of a wave that looks unlike any wave I've ever seen—it's brown with black greasy dots. We are about to feel the impact of an uncontained contamination of the Gulf's ecosystem and, potentially, the Gulf Stream. A whole culture is being destroyed, and I don't think any amount of money will replace it. This event shows us the dangers of relying on extreme industrial methods to secure petroleum in our own backyard. We had better figure out what we're going to do about fossil fuels going forward.

"And it's not just in New England and the Gulf—the Chesapeake watermen are a dying breed, as are those who fished the Carolinas. America will survive the collapse of our fishing industry, just as it weathered the demise of our textile industry and manufacturing sectors, but it seems to me that the destruction of natural systems as a result of uncontrolled exploitation of natural resources will have profound social, economic, and life science implications.

"It may take economic incentives to reduce pollution from energy sources. It may take a shift to nuclear energy, an area where we have had serious discussions. The Navy powers some of our biggest and most effective warships without a problem, and many of our closest allies have done it. This is a time for the country to come together and do something. Americans need clean, large-scale sources of energy.

"It is relatively easy to attribute environmental damage to our insatiable demands for energy, but it is not so easy to shift America's energy sources to ones that are cleaner, thus protecting our environment and limiting our reliance on foreign energy sources. The DOD-DOE partnership, which has been successful in the past, could be instrumental in the move away from fossil fuels if there is a willingness to empower this team to seek clean, renewable, and economical sources of power for domestic use. We need to develop clean energy sources as a source of strength and positive growth, rather than allow the United States to become a post-industrial society, dependent upon other nations for energy."

"This is the time for big ideas and innovation," says General Sullivan. "At this point, continuing to take partisan positions just for the sake of it is unacceptable. We need to come up with solutions to meet U.S. requirements for power and to provide a good quality of life for our children and grandchildren, or we're going to leave a legacy that none of us will like."

five barrels of oil it consumes [4]. This heavy dependence presents severe geostrategic and economic challenges and, if it is not changed, puts America at even greater risk in the future.

- *Geostrategic challenges*: Reliance on foreign oil presents geostrategic challenges to the nation. Oil funds some nations, notably Iran and Venezuela, whose objectives often run contrary to those of the United States. None of this is new: guaranteeing access to petroleum has been at the top of the American foreign policy agenda for decades. In 1980, for example, President Carter declared that American military forces would protect the Persian Gulf "from outside attempts to gain control" [5]. American actions abroad are, by necessity, conducted within this geostrategic context.

Without stable and predictable energy prices, business leaders, farmers, and especially large industries cannot effectively plan, hire, and remain competitive in a global market.

- *Economic impacts*: As of this writing, the full economic impacts of the Deepwater Horizon oil disaster to states along the Gulf Coast are not yet fully known, but they will no doubt be extraordinarily high and persist for many years. Further, oil imports are a huge drain on the nation's economy. Despite the severe economic recession, the United States transferred an estimated $386 billion overseas to purchase oil in 2008 and over $350 billion in 2009. Finally, and perhaps most significant from an economic security perspective, the unpredictable volatility of oil prices sends ripple effects through American businesses and government agencies stretching from the federal to local level. Without stable and predictable energy prices, business leaders, farmers, and especially large industries cannot effectively plan, hire, and remain competitive in a global market. The economic costs of the nation's energy choices affect jobs, American livelihoods, and the ability of the United States to compete in the global marketplace. America's global leadership, militarily and diplomatically, is directly affected by its economic strength.

The nation's fossil fuel dependence also directly affects the military. The Defense Science Board examined the Department's energy challenges in 2008 and concluded that DOD's energy inefficiency and reliance on oil created many serious challenges to military effectiveness, including the following [6]:

- *Cost*: Like the rest of the country, heavy dependence on oil has significant economic repercussions in DOD. Given the size of DOD and its rate of energy consumption, the effects are especially significant. In 2008, approximately $20 billion of DOD's budget was spent on energy, of which $3.8 billion purchased electricity for installations [7]. Over the past two decades, the Navy's expenditure on energy has increased 500 percent [8]. When the price of fuel spikes (as it will continue to do), it sends a readiness shock wave through DOD's budget. Every $10 increase in the price of a barrel of oil costs the Department $1.3 billion. That money comes at a direct and serious cost to other warfighting readiness priorities.

- *Tactical vulnerability*: The burden of delivering fuel supplies to the battlefield reduces combat effectiveness and creates tactical vulnerabilities.

- *Grid vulnerability*: At home, military installations are nearly completely dependent upon a commercial electric grid that is vulnerable to cyber attacks and natural disasters [6]. The grid is becoming an even greater liability because U.S.-based military installations are increasingly being called upon to support real-time combat operations overseas (such as piloting Predator drones or processing battlefield intelligence) [9].

The Benefits of Changing Course

The nation needs to reduce its dependence on coal and oil not only for environmental reasons, but also for its national and economic security. However, rapidly transitioning energy use in the United States is a daunting task for several reasons:

- Our nation has a huge infrastructure investment in fossil fuels. Entire industries are created around extracting and distributing fossil fuels. The nation's electrical generation and distribution system developed over the course of an entire century, and it represents over a trillion dollars of legacy capital investment. Buildings, responsible for 48 percent of the nation's energy consumption, can last for 50 to 100 years [10]. Transitioning the transportation sector will require replacing or modifying a fleet of 250 million vehicles and 240,000 aircraft that have operational lifetimes measured in decades [11].

- There is also a great deal of consumer lifestyle inertia. Energy is so intertwined with American lifestyles and standard of living that change will certainly be difficult. With ready access to technologies and fuel sources that can keep homes at 70 degrees and commutes comfortable, it will be difficult to introduce technologies that accomplish the same tasks but at an initially higher cost.

- Perhaps most daunting is the simple physical and economic reality of energy sources. For much of the past century, when the nation's energy infrastructure was constructed, fossil fuels were the cheapest and most readily available energy source. Because of this long lead time, fossil fuels enjoy an important advantage, and without technological breakthroughs and support from policies, renewable energy sources simply cannot compete with fossil fuels in the short term relative to cost per unit of energy produced.

Like the rest of the country, heavy dependence on oil has significant economic repercussions in DOD.

However, while the challenges of this transition may be great, the full costs of fossil fuels should compel the nation to search for more reliable, sustainable, and cleaner sources of energy. Moving away from fossil fuel-based energy will not only create a cleaner and healthier future for America, but it will also strengthen the economy and make the nation more secure and prosperous. As President Obama noted in his 2010 State of the Union address, "*The nation that leads the clean energy economy will be the nation that leads the global economy and America must be that nation*" [12].

A U.S. Army attack helicopter providing protection for a British convoy in Helmand Province, Afghanistan in August 2008. Courtesy of U.S. Marine Corps, photo by Cpl. Chad J. Pulliam.

Policy-makers have recently begun to signal an increasing interest in developing America's clean, low carbon energy economy. For example, in January 2007, the Bush Administration issued an order to federal agencies, instructing them to increase their focus on clean energy, specifically calling for more energy efficiency in building standards, adoption of new renewable energy sources, decreased emissions of greenhouse gases, and reduction in petroleum fuels consumed [13]. In October 2009, the Obama Administration issued an Executive Order that made the government's energy- and greenhouse gas-focused goals more aggressive, stating federal leadership was required "in order to create a clean energy economy that will increase our Nation's prosperity, promote energy security, protect the interests of taxpayers, and safeguard the health of our environment" [14].

Policy-makers have recently begun to signal an increasing interest in developing America's clean, low carbon energy economy.

Congress has also given attention to energy-related legislation in recent years, the most significant of which being the "American Recovery and Reinvestment Act of 2009" (ARRA). While focused on stimulating the U.S. economy as a whole, the ARRA also constituted the largest one-time investment in renewable energy in American history. Through the ARRA, the DOE received $26.6 billion for advanced energy programs and innovation [15]. In addition, DOE announced that it would invest another $23 billion by 2012 in hopes of doubling both renewable energy generation and advanced energy manufacturing. The Department of Energy also intends to leverage $43 billion in private sector investment [16].

Recognizing the potential economic benefits of the clean energy economy, some businesses in the United States have begun to look at the clean energy market sector. In fact, by 2007, even without the benefit of large-scale policy support, the clean energy industry contributed more than 770,000 jobs to the American economy [17]. Business leaders have signaled their desire for the country's political leaders to arrive at a comprehensive energy policy to allow them to better plan their long-term financial investments and more aggressively develop this emerging economic sector [18].

Other Nations are Pursuing Clean Energy's Economic Benefits

The opportunities of the clean energy revolution have not gone unnoticed by other nations. In recent years, while still investing heavily in fossil-intensive energy infrastructure, China has emerged as a world leader in clean energy technologies, becoming the largest manufacturer of wind turbines and solar panels [19, 20]. Inexpensive manufacturing coupled with protectionist policies, a long-term strategic view, and massive government investment have helped to build the Chinese clean technology manufacturing base to the detriment of its competitors [21, 22]. In 2009, the clean energy investments in China were more than $34 billion, nearly twice that of the United States [23].

The Chinese government's position on clean energy is clear. A Chinese official, cited by Thomas Friedman in a January 2010 column from the *New York Times*, stated: "China was asleep during the Industrial Revolution. She was just waking during the Information Technology Revolution. She intends to participate fully in the Green Revolution" [24].

Several European countries have also established themselves as leaders in clean energy technologies. Spain, for example, is home to some of the world's most successful renewable energy companies, and they have experienced explosive growth. Spain has a renewable energy capacity of more than 30 percent, as compared to 4 percent in the United States [24]. Likewise, Germany has focused its large industrial

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

Former Deputy Commander, Headquarters U.S. European Command

On the Value of Strategic Leadership

For much of his time in the U.S. Air Force, when General Chuck Wald wasn't flying F-16s, he focused on planning and strategy for the air campaign into Afghanistan, for the Joint Staff, for the Air Force as a whole, and for U.S. European Command. He understands that having a strategy in place to meet an objective is critical to achieving the desired end state.

It was at European Command, working with General James Jones, USMC (Ret.), where General Wald first focused on energy security. "We were looking for what creates threats and problems for our allies," he recalled. "The top threat we found was extremism and associated access to weapons of mass destruction, followed by nuclear proliferation writ large. After that, we listed energy security. Energy security *is* a national security issue. That being the case, we needed to be concerned with the status of energy availability in our theater; we needed to start thinking about what to do if we had major energy disruptions."

We need to remain competitive in the world as we move toward a future of green, sustainable energy…The biggest motivation to do it is national security.

Since retiring from the Air Force, General Wald has been deeply involved with the issue of energy security. He is concerned about the nation's energy strategy and believes that the nation's oil dependence, national debt, and national security concerns are interconnected. General Wald sees clean energy technologies as a release valve on these interconnected pressures: "We need to remain competitive in the world as we move toward a future of green, sustainable energy. That will keep our debt from growing. Importing less oil means fewer foreign policy impacts and more assured energy for what we need. The biggest motivation to do it is national security."

Some of the top business leaders in the United States are concerned about the nation's lagging position and the lack of policies to support the clean energy economy. "I hear that fear all the time," said General Wald. "That's the theme of so many discussions: the world is moving on. In energy, there's a need to compete economically. Everything's driving to clean energy in a big way. The technology is there, but you need a market signal."

"To get to that end state, there is no doubt that we need the political will," he continued. "And we can get there through a combination of innovation, policy, and regulation. We need a friendly environment for businesses to invest."

When discussing clean energy technology developments around the world, General Wald is particularly impressed by the United Arab Emirates (UAE) and Abu Dhabi's Crown Prince Mohammed bin Zayed. Abu Dhabi is aiming to become the Silicon Valley of clean alternative energy, and their signature effort is Masdar City. This 100 percent carbon neutral city will support 40,000 citizens over 2.3 square miles and produce zero waste.

"Masdar City is a classic example of what the future will bring," he said. In describing why a country that possesses some of the world's largest oil and natural gas reserves would pursue such a project, he cites the economic opportunities that clean energy provides: "The real motivation is diversification. The Emirates strategy is to bring in technology to diversify their economy and to build job opportunities for their people."

General Wald credits Abu Dhabi's leadership, saying, "Mohammed bin Zayed is easily one of the top three leaders in the world. They make a lot of money on oil, but I think he sees the fact that oil won't be there forever, and he cares about his people and their children. He sees the writing on the wall that clean energy will be a product with a market value. There will be a price of some sort on carbon eventually. I think they're showing responsibility. He's demonstrating leadership from a practical economic standpoint and a more altruistic standpoint."

sector on the manufacture of wind and solar technologies. Renewable energy now comprises 29 percent of Germany's installed power capacity [23]. Sparked by the oil crises of the 1970s, France focused its national strategy on deploying nuclear electrical generation throughout the country; as a result, it now generates more than three-quarters of its electricity from carbon-free nuclear power [25]. The European Union has established a strong framework of policies and institutions, including putting a price on greenhouse gas producing carbon fuels, and a Europe-wide carbon trading market, which has aided the development of clean energy technology. Policies that encourage the adoption of renewable technology at the household level have successfully incentivized the deployment of clean energy technology across Europe.

Inexpensive manufacturing coupled with protectionist policies, a long-term strategic view, and massive government investment have helped to build the Chinese clean technology manufacturing base to the detriment of its competitors.

Abu Dhabi, within the United Arab Emirates (UAE), is perhaps the most striking example of a country that sees the huge potential of the new energy economy. Despite being a member of the Organization of Petroleum Exporting Countries (OPEC) and possessing nearly 10 percent of the world's proven oil reserves, it has launched initiatives that could position it as a world leader in renewable energy technology. Abu Dhabi's aim is to attract investors and entrepreneurs in order to become the Silicon Valley for clean, renewable, and alternative energy [26].

We do want to stress the fact that the work being done by other nations to develop and deploy clean energy technologies is a positive development. Mitigating climate change is not a zero sum game: each nation has different strengths and weaknesses, and collaboration, trade, and technology sharing will be necessary. In fact, the United States benefits in many ways from the progress being made overseas [27].

However, as it stands today, the United States is at risk of falling behind. While some steps have been taken, the nation has not made a serious, comprehensive commitment to move away from fossil fuel energy, and policies have not supported the large-scale research, development, and deployment of clean energy technologies necessary to lead in the rapidly emerging multibillion dollar global market. As stated by CNA MAB member General Chuck Wald, "A better and cleaner world is a good thing. But who's going to be the leader when we get there?" [28].

Businesses in the United States recognize the risks of losing a competitive edge. General Electric's Jeff Immelt has urged "strong action" by the government to support clean energy technology development, saying, "Let's not take this growth industry and give it to every other country in the world but the United States" [29]. Others have voiced similar sentiments. In a report by the American Energy Innovation Council, a group of American executives expressed their concern with the nation's lack of commitment to energy innovation [30]. Referring to the clean energy technology market as the "next industrial revolution," We Can Lead, a coalition of over one thousand businesses nationwide, recently issued the statement: "Today the United States is falling behind in the global race to lead the next industrial revolution. U.S. businesses need strong policies and clear market signals to deploy capital, harness innovative technologies, and compete in the global marketplace" [31].

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

Former Deputy Chief of Naval Operations for Warfare Requirements and Programs; CNA MAB Vice Chairman

On Stepping Up

Vice Admiral Dennis McGinn, co-chairman of the CNA Military Advisory Board, became interested in energy issues during the first OPEC oil embargo in the 1970s. "I was a young lieutenant," Admiral McGinn recalls, "fresh from two combat deployments, and, along with all Americans, I found myself sitting in gas lines waiting for hours to fill up the tank in my car. It was a wake-up call. It was not a good national security position for the country to be in. We were relying too heavily on imported oil. I realized then how vulnerable we really were, and I haven't lost focus on the critical link between energy and America's economy and national security."

We need policies that fully recognize the high costs and growing risks that the nation faces because of our over-reliance on fossil energy.

In fact, during the year since the publication of the CNA Military Advisory Board report, Powering America's Defense, Admiral McGinn spent a lot of time traveling around the United States talking about the convergence of national security, climate change, and energy security. Admiral McGinn has presented these issues to people across the country, jointly with retired Senator John Warner (R-VA).

"I've visited over half of the United States talking about these challenges," Admiral McGinn says, "and people across the country are concerned about our growing dependence on foreign oil, especially the burden that our energy posture places on men and women in uniform. People are really thoughtful; they really get it. These are serious and complex problems. Our energy challenges are not going to get smaller or go away by themselves; we need to step up and do something about them. And they aren't going to be solved solely in Washington, Houston, Detroit, or on Wall Street. They will be solved by all of us, recognizing that just as Americans before us have risen to great challenges, we must do the same today. Through our innovation, determination, and hard work, we can turn adversity into opportunity. Taking serious steps now to move away from so much dependence on fossil fuels and investing in clean energy technologies will make America much more secure and prosperous."

Admiral McGinn continues: "Many of the national security problems that we see in energy security and climate change are rooted in America's huge reliance on fossil fuels; some have called it an addiction. We need policies that fully recognize the high costs and growing risks that the nation faces because of our over-reliance on fossil energy—quite simply, we need to put a price on carbon that accounts for the true costs we are already bearing. The right policy would provide a steady and predictable market signal to unleash the tremendous power of American innovation and the power of free-market capital. It won't be easy, but the costs and challenges we face by taking deliberate actions now to move away from fossil fuels will be far less than those we will most certainly face if we continue along the energy path we're on now."

Admiral McGinn is often asked about which technologies the nation should look toward. "Energy efficiency, for sure, but I believe that there is no one perfect new energy solution—we need a silver buckshot approach because there's not a silver bullet," he says. "For example, I know, based on my Navy experience, that we can safely run and increase the capacity of our nuclear power industry. But that, too, needs to be evaluated objectively on its merits, including costs, risks, and benefits. The cost of renewing our nuclear energy infrastructure is high. It may be exactly the right thing to do, but, as with all energy approaches, we ultimately need to let the market decide. Similarly, we also know that we can't simply drill our way out of this growing and long-term energy crisis. While we will continue to need fossil fuels, even as we develop alternatives, business-as-usual is not the answer. What is most needed now, as we begin the transition to a new clean energy economy, is the market certainty created by a visionary and bold long-range energy policy. That will be a huge step in the right direction. So, America, let's get started."

The United States must play on its strengths…it can lead in the realm of developing cutting-edge technologies and innovation in research and development.

The Way Ahead

The United States must play on its strengths. While it cannot compete with many nations in low cost manufacturing, it can lead in the realm of developing cutting-edge technologies and innovation in research and development. To seize a portion of the economic benefits of the emerging clean energy economy, the government must align policies, incentives, and funding to lead the nation to an energy secure future.

The federal Government's investments in clean energy technologies represent a significant effort, but they are not sufficient to stimulate the kind of private sector investment necessary to create a robust clean energy economy. Consistent and long-term policies and price signals are critical in order to make certain that research and development continues in the United States.

Contributions from many government and private sector organizations will be necessary. However, we believe that one organization can be a clear leader. Given its size, the amount of energy it consumes, and its proven record in innovation, DOD can provide the testing ground and the economies of scale necessary to begin the innovation that could ultimately change the course of the country. In the next chapter, we look at how DOD can take on this pivotal role.

Chapter 2

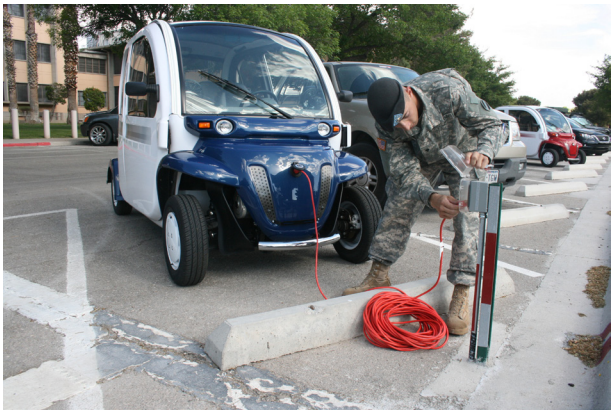
Propelling Innovation

The Department of Defense: An Innovative Culture

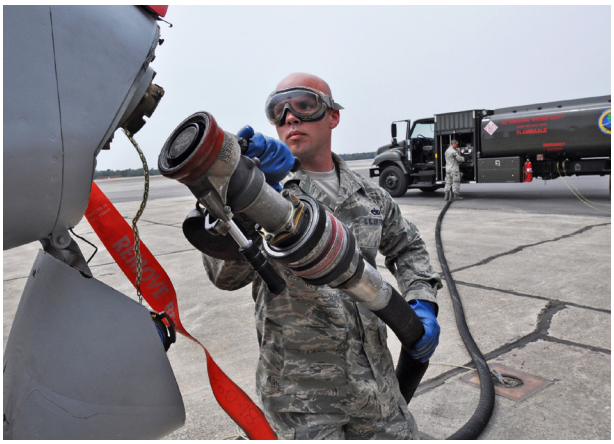
Defense leaders recognize the threat of its energy posture, and it is taking steps to confront the issue. Speaking on energy, Dr. Dorothy Robyn, DOD's Deputy Under Secretary of Defense (DUSD) for Installations and Environment stated that "mission assurance and cost avoidance are becoming a priority for the Department in addition to environmental and regulatory compliance." In February 2010, DUSD Robyn noted to Congress that "renewable energy is key to energy security," particularly when paired with micro-grids and energy efficiency improvements [9].

Recent actions by DOD and the military services confirm their dedication to changing how they use energy.

Recent actions by DOD and the military services confirm their dedication to changing how they use energy. Operationally, the deployment of foam insulation on tents in Afghanistan and Iraq has resulted in significant reductions in the diesel fuel burned by power generators for air conditioning [32]. The Navy and Air Force have both demonstrated jets that use new blends of biofuels [33, 34]. By 2016, the Navy hopes to deploy the "Great Green Fleet," an aircraft carrier strike group powered entirely by nuclear and biofuels [35]. The Marine Corps has mobilized Marine Energy Assessment Teams to analyze energy and water use on forward operating bases, and the Marines are also exploring potential solutions at experimental forward operating bases at Quantico, Camp Pendleton, and Twenty-Nine Palms. The Army is a leader in pursuing alternatives to traditional non-tactical fleet vehicles, acquiring 4,000 neighborhood electric vehicles in 2009; the Army also plans to deploy smart grids on tactical command posts and forward operating bases within five years [36].

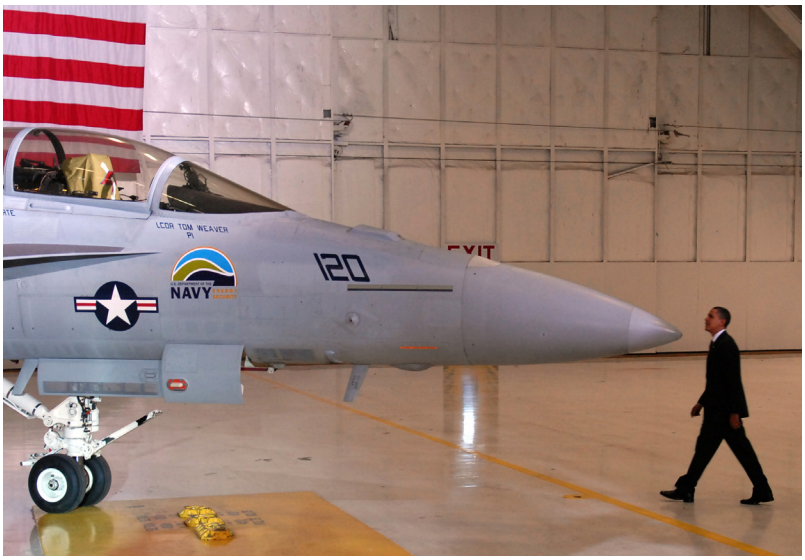


Fort Bliss' command sergeant major's electric car being charged on base. Courtesy of Fort Bliss Public Affairs, photo by Major Deanna Bague.



On 25 March 2010, the Air Force fueled and flew this A-10C Thunderbolt II with a 50/50 blend of bio-derived and conventional jet fuel, making it the first military or civilian aircraft to fly with biofuels powering each engine. Courtesy of the U.S. Air Force, photo by Samuel King, Jr.

The Defense Department's interest in changing its energy posture is evident. However, to solve all of its energy vulnerabilities, DOD will have to continue to come up with innovative solutions. So for the innova-



President Obama at Andrews Air Force Base, Maryland, on March 31, 2010, with the U.S. Navy's Green Hornet F/A-18, the first Navy fighter plane to fly on a biofuels blend. Courtesy of U.S. Navy, photo by Mass Communication Specialist 2nd Class Clifford L.H. Davis.

tor, the demand signals are clear and the opportunities are enormous; this is true not only because of the signaled interest but also because of the sheer size of the organization. Consider this: DOD uses nearly 1 percent of all energy consumed in the United States, making it the nation's largest single user of energy; its share accounts for approximately three-quarters of all energy consumed by the U.S. government [37]. So, by focusing on improving its energy posture, DOD can begin the push toward a clean energy economy.

Because of its experience in technology innovation, DOD is in a position to help drive this change—for itself and for the nation as a whole.

DOD also brings significant experience to the conversation on innovation. Several widely adopted technologies, including the jet engine, gas turbines, solid state electronics, and the internet were pioneered by the United States military [38]. Global positioning satellite (GPS) technology was developed through research performed by the Defense Advanced Research Projects Agency (DARPA) and other government sponsors [39]. The military—particularly the Navy and Army—also played a pivotal role in what is arguably the largest energy revolution of the twentieth century: nuclear power.

However, the energy challenges facing the nation today are of a magnitude not seen before. Fundamentally, then, this means that the way in which technologies move through the innovation pipeline—from research and development to commercialization—must be made more efficient. Because of its experience in technology innovation, DOD is in a position to help drive this change—for itself and for the nation as a whole.

Accelerating DOD's Energy Innovation Pipeline

Broken down into its most simplified parts, the innovation pipeline consists of research, development, demonstration, and deployment, and before new technologies can be commercialized, they must move through this pipeline. The process is complex; each stage has varying financial, intellectual, and facility requirements. Consider funding, for example: while the initial dollars may come from government sources, latter stages require funding through corporate and venture capital as well as from traditional investment and lending institutions [40]. In terms of facilities, initial research may be performed in a university laboratory, but testing prototypes requires a more operational setting and producing the final product

ADMIRAL FRANK L. "SKIP" BOWMAN, USN (RET.)

Former Director, Naval Nuclear Propulsion Program and former Deputy Administrator for Naval Reactors, National Nuclear Security Administration

On Leadership and a Culture of Responsibility

In his former position as the director of the Navy's nuclear propulsion program, Admiral Skip Bowman served as the third successor to the legendary Admiral Hyman G. Rickover, the father of the nuclear Navy. In that role, Admiral Bowman concurrently held the position of deputy administrator for naval reactors within the Department of Energy's National Nuclear Security Administration.

After reviewing and synthesizing the findings of the CNA MAB's three studies, Admiral Bowman stated, "Energy innovation is an urgent national security imperative to address the dual issues of climate change and energy security—we need to get going, to move out of the box. The U.S. military certainly has a tradition of driving technology innovation when we really need it. I worry that the proper urgency isn't shared across our government, across all sectors. The Department of Defense can play a key role in these efforts, with the Department of Energy and others, to place this imperative on a faster track."

Admiral Bowman feels that efforts to confront these challenges within the Departments of Defense and Energy must be better coordinated—under a single leader—in order to reach solutions more quickly. He stated, "Simply put, there are natural synergies in our broad government that, if brought together under a single leader, could properly address energy innovation and work a viable path to address climate change, energy independence, and ultimately national security. While many parts of DOE and DOD are pursuing these intertwined issues, without better coordination, synthesis, and a common goal, I fear we will not reach the desired end. We need a single leader coordinating the efforts."

Admiral Bowman believes that successfully coordinating efforts between the Departments requires establishing a pervasive culture of accountable leadership at all levels and a concerted focus on goals. When discussing the importance of accountability and responsibility, Admiral Bowman recalled Admiral Rickover's thoughts on the subject: "Responsibility is a unique concept: it can only reside and inhere in a single individual. You may share it with others, but your portion is not diminished. You may delegate it, but it is still with you. You may disclaim it, but you cannot divest yourself of it. Even if you do not recognize it or admit its presence, you cannot escape it. If responsibility is rightfully yours, no evasion, or ignorance, or passing the blame can shift the burden to someone else. Unless you can point your finger at the person who is responsible when something goes wrong, then you have never had anyone really responsible."

Energy innovation is an urgent national security imperative to address the dual issues of climate change and energy security—we need to get going, to move out of the box.

As a critical aspect of leading organizations to focus on the problem at hand, Admiral Bowman discussed the importance of ownership at every level: "Rickover said that a person needs to look after his work as if it was his own business and his own money. If he considers himself to be a temporary custodian, or the job to be a temporary stepping stone, actions won't take into account the interests of the organization nor achieve the established goals."

In recalling the strength of culture in the Navy's nuclear program, Admiral Bowman again pointed to the legacy of Admiral Rickover: "I had two DOE labs reporting directly to me," said Admiral Bowman. "The culture in those labs was every bit the culture that you'd find at naval reactors headquarters and at sea. All felt the same culture and sense of ownership."

The strength of Admiral Rickover's legacy is clear in Admiral Bowman. "Even though I never reported to the Admiral directly," Admiral Bowman said, "there was never a minute throughout those 38 1/2 years where I didn't feel that I was reporting directly to him, including those years after his death when I was sitting in his chair."

USS *George Washington*, the Navy's first nuclear-powered fleet ballistic-missile submarine, was commissioned in 1959. Courtesy of U.S. Navy.

often requires large-scale, complex manufacturing capabilities. Because the transitions from one stage to the next are often fraught with problems, many technologies ultimately perish in what has come to be known, especially in relation to the transition between the demonstration and deployment phases, as the "Valley of Death."

The Department of Defense has proven itself time and again a useful partner in helping to pull good ideas through the innovation pipeline. Not only is it well versed in the research and development phase of technology development, supporting more basic and applied research and development than any other federal agency besides the National Institutes of Health and the National Science Foundation [41], but it is also accustomed to working with universities and private industry in testing and evaluating technologies.

By fine-tuning processes and strengthening partnerships, DOD can improve its research and development efficiency, ultimately pulling innovative technologies through the pipeline more quickly.

In the following sections, we look at four ways that DOD can begin improving the processes already in place:

- Requiring widespread sharing of energy research and development information
- Aligning DOD and the Department of Energy (DOE): energy-related research and development activities, funding priorities, and intellectual capital
- Partnering with innovators and establishing an Operational Energy Innovation Center
- Deploying emerging clean energy technologies: acquisition strategy on installations

The first section looks broadly at the innovation pipeline, recognizing that information sharing and careful planning will have an impact on every stage from research to deployment. The second and third sections discuss how building partnerships could improve efficiency in certain stages of innovation, and the last section considers the deployment phase specifically.

Requiring widespread sharing of energy research and development information

The total funding for DOD's research, development, testing, and evaluation (RDT&E) in FY2010 was $80.5 billion, meaning that the research and development enterprise within DOD received more funding than the entire operating budgets of any other federal agency besides the Department of Health and Human Services [42]. Of the $80.5 billion, $13.5 billion was directed at early stage activities: basic research, applied research, and advanced technology development.

To execute its research and development agenda, DOD distributes funding to a variety of institutions. Each of the services has its own research laboratory (the Naval, Army, and Air Force Research Laboratories). An array of Defense-wide agencies also expend research and development dollars; in FY2010, four of them were funded with more than a billion dollars each—the Missile Defense Agency, DARPA, the research activities within the Office of the Secretary of Defense (OSD), and the Chemical and Biological De-

fense Program. Five additional agencies also received more than $100 million to support research and development [43]. The Defense Department's focus falls most heavily on weapons systems, with only a fraction being directed toward projects with energy innovation as their primary objective.

Of DOD's research and development investments made in energy since 2008, the largest single expenditure (accounting for more than $67 million expended) was made by DARPA in pursuit of a liquid fuel to replace the petroleum-based jet fuel used by the military services. The biofuels research program offers a useful window into the complexity of DOD's research and development enterprise. The Defense Advanced Research Agency's partners have included U.S. Pacific Command, the Defense Energy Support Center (of the Defense Logistics Agency), the Departments of Energy and Agriculture, and private firms [44]. The length of this list is not unusual. Generally speaking, any research and development within DOD, whether directed through the military services, service research laboratories, or defense agencies, results in a web of interconnections with many other partners, including universities, federally funded research and development centers, DOE's national laboratories, and defense firms.

Tracking the flow of funding through each of these actors is, to say the least, a difficult and time-consuming task. The sheer volume of funding, number and variety of organizations involved, number of individual decision-makers, and assortment of channels through which the funding can flow make the DOD's research and development enterprise extremely complex. The complexity of the research and development system also contributes to separating the end users of technology (i.e., the warfighters) from those who perform the research and development; as such, the needs of the forces are not necessarily clearly known, nor are they always met in an efficient manner. In Congressional testimony, the Director of DARPA stated that processes of separating technology users from those who construct requirements and acquire technologies is a rigid process that does not afford flexibility in terms of speed or design [45].

Thus, while the research and development enterprise contributes to making the military forces more effective, its complexity and lack of transparency introduces inefficiency; this inefficiency, in turn, results in a significant slowing of the innovation process in all stages of the pipeline. Furthermore, resulting from the lack of transparency, the services and other components within DOD are often unable to see the research and development efforts being pursued elsewhere. In one example, we learned that a military service had recently approached DARPA with a technology need, only to discover that DARPA had developed the technology ten years earlier.

To provide power to Marines in the field, the Office of Naval Research developed this 300-watt photovoltaic battery system, known as the Ground Renewable Expeditionary Energy System (GREENS). Courtesy of U.S. Navy, photo by John F. Williams.

Such lack of visibility and information flow regarding research and development projects leads to delays in adopting useful military technology, duplication of effort, inefficient use of taxpayer dollars, and a greatly increased potential for the loss of relevant technologies in the pipeline. A structured and defined means of sharing information regarding energy-related research and development activities would strengthen the process, eliminating waste and redundancies while improving efficiency.

Aligning DOD and the Department of Energy (DOE): energy-related research and development activities, funding priorities, and intellectual capital

The Department of Energy is the country's largest source of science and technology funding directed specifically toward energy. In FY2010, from its total budget of $26.4 billion, DOE expended nearly $2.3 billion on energy research and development, and another $4.4 billion on research and development in basic sciences [46, 47]. Many of the technologies in DOE's research and development program are similar to those of interest to DOD, including hydrogen technology and fuel cells (funded in FY2010 at $174 million), biomass and biorefineries ($220 million), solar energy ($247 million), and facilities and infrastructure ($63 million). The Department of Energy's research and development agenda is executed by nearly 30,000 scientists and engineers at universities, in the private sector, and at a collection of 24 DOE-funded national laboratories and research facilities [48].

Since 2009, DOE has undergone some structural changes to help foster innovation and commercialization in the renewable and alternative energy sectors. One of the most high profile of these changes was the establishment of the Advanced Research Projects Agency—Energy (ARPA-E). Based on the model of DARPA, ARPA-E examines areas of research that are high-risk but high-reward. In 2009 and 2010, ARPA-E received $500 million in funding. While the research being pursued at ARPA-E, the national laboratories, and other sponsored locations is not necessarily directed toward defense applications, the knowledge assets could be of immense value to DOD. By the same token, the end-user, mission focus of DOD could provide invaluable direction for much of the research and development work being done by DOE, with the added benefit of creating an accelerated innovation cycle.

Because of its ability to produce rapid prototypes within its own research and development infrastructure, DOD can help DOE evaluate its research and determine the technical risks. Understanding these risks in the earlier phases could save time and money and help ensure that only those technologies with the highest probability for commercialization are advanced.

A structured and defined means of sharing information regarding energy-related research and development activities would strengthen the process, eliminating waste and redundancies while improving efficiency.

Furthermore, DOD's physical equipment, numerous installations, and operational needs offer fertile ground for culling data. In particular, installations, which are often a microcosm of American cities, provide a unique and readily available test bed for DOE research. Spread across the world, military installations offer an array of 300,000 buildings and 200 other structures, covering four times the square footage of the Wal-Mart enterprise [49]. Data collected from DOD tests of DOE research and development products would allow developers to more rapidly obtain confidence in what works on a commercial scale. In

the words of Dr. Dorothy Robyn, DOD is "beautifully situated to be a proving ground" [50].

…to date the relationship between DOD and DOE has been largely ad hoc, usually the result of particularly enterprising individuals.

The Defense Department's testing capabilities would be particularly valuable for evaluating efficient heating, ventilation, and cooling systems. Because consumers already have technology to keep their homes at a constant temperature, it is often difficult for commercial companies to defend expending funds on testing these products. The first users of such technology would have to be willing to pay more than what the commercial marketplace would be willing to spend. However, as DOD expends nearly $4 billion on installation energy and is searching for means to reduce its greenhouse gas emissions (per Executive Order and legislative mandates), it is in DOD's interest to be the first testers and adopters, ultimately distributing the most successful and highly efficient technologies across its vast infrastructure. This, in turn, would help to bring down production costs and deliver these products to commercialization.

Consider another example of the potential benefits of a DOD/DOE partnership: Even with its substantial funding, ARPA-E has not been able to fund all the research that it deemed worthy of further exploration. In its initial call for proposals, ARPA-E received more than 3,700 responses [51]. A team of over 1,500 scientists, convened by DOE, determined that more than 300 of these were viable and worth pursuing; however, funding was only available to cover 30 of them. The 270 unfunded, but thoroughly vetted, projects may have strategic or operational value to DOD, and DOD, therefore, may be willing to fund some of them.

The two agencies already cooperate for mutual benefit in some areas. For instance, since 2008, the National Renewable Energy Laboratory (NREL) and the military services have been jointly pursuing net zero bases—that is, bases that produce as much energy as they consume. In other instances, DOE has placed energy advisors at some of DOD's Combatant Command headquarters. Through these advisors, DOE and DOD have uncovered large areas of common interest. However, to date the relationship between DOD and DOE has been largely ad hoc, usually the result of particularly enterprising individuals.

A solar field belonging to the 180th Fighter Wing, Ohio, Air National Guard, a project funded by DOD's Defense Research and Development Program. Once completed, this field will allow the fighter wing to save approximately 37.5% on its annual electric bill. Courtesy of U.S. Air Force, photo by Master Sgt. Beth Holliker.

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

On Evolutionary and Revolutionary Energy Solutions

"Evolutionary and revolutionary" is how retired Marine Corps General Robert Magnus describes the solutions necessary to address the strategic vulnerabilities that result from the nation's heavy use of fossil fuels. Evolutionary solutions are required to address near-term challenges, while revolutionary solutions are required for the long term.

"All four Services and the defense labs are working on things that are evolutionary—like efficiency—and revolutionary—like biofuels," General Magnus explains. "The Navy has delivered a hybrid electric system for large deck amphibs. It has a highly efficient gas turbine that will use 40 percent less fuel over its lifetime. This is a major evolutionary step for fossil-powered surface combatants in terms of both efficiency and cost savings."

General Magnus is not the only Marine in recent years to take an interest in energy. At the end of 2009, General James Conway, Commandant of the Marine Corps, sent out two teams to take a look at how energy and water were being consumed at forward deployed locations. In addition to initiatives on its bases, including installing photovoltaic solar panels on buildings, with the potential to meet up to 20 percent of electric power needs, and the use of natural gas for non-tactical vehicles, Marines are using generators on light and medium trucks to produce electricity when the vehicles are stationary at expeditionary locations. The Marine Corps is also developing energy efficient field shelters with embedded solar panels to reduce heat from direct sunlight while generating electricity from photovoltaic cells. Larger photovoltaic systems are expected to produce more electricity, reducing the need for electric generators that run on fossil fuels. Water purification systems are being developed to make locally available water potable; this will reduce the need for convoy delivered bottled water and the trucks and fuel necessary for the delivery. The Marine Corps expects to meet the Commandant's goal to cut fossil fuel use by 40 percent within 10 years.

General Magnus continues: "Society also needs to make these evolutionary and revolutionary changes. As our economic output increases, we cannot afford to have a parallel increase in our need for fossil fuel, with its implications for energy security and costs. And, while DOD is an important part of the Nation's move toward evolutionary efficiencies and revolutionary energy sources and systems, DOD must lean heavily not only on its own and DOE's labs, but also on private companies and large energy consumers in order to generate the practical ideas and investments that will improve efficiencies and reduce costs of non-fossil energy sources and impacts on our environment. Department of Defense's mission is to always be ready to meet national defense needs at home and overseas."

"Evolutionary and revolutionary" …describes the solutions necessary to address the strategic vulnerabilities that result from the nation's heavy use of fossil fuels.

General Magnus believes strong incentives may be necessary. "I would be in favor of a market mechanism to reduce the use of fossil fuels, provided that the revenue specifically targets further efficiencies and revolutionary energy programs," says General Magnus. "If we're going to increase the costs of energy, then everyone should benefit. We need to make sure that our energy strategy encourages us to be more productive and more prosperous."

General Magnus is glad to see the Marines and the other Services confront their energy issues: "Somebody has to get started, and it makes sense for the military because they have the most interest in terms of blood, time, and money."

Clearly, a formalized partnership between these two organizations would be mutually beneficial. However, to achieve such a partnership, DOD and DOE must align goals and personnel at the strategic, operational, and tactical levels within their organizations. Strategically, the Secretaries and Under Secretaries of each Department should agree on the goals and desired outcomes and appoint a leader who will be responsible to the American public and Congress for success. Setting the appropriate strategy will provide the other portions of the Departments with the necessary direction and support. Operationally, the civilian leadership of the services that are tasked with energy as a priority should align their activities with the overall strategy of DOD and identify specific partnerships within DOE. Tactically, military personnel and researchers must be linked to guide the technology development, achieve more complete understanding of needs and operational constraints, and perform the actual demonstrations, tests, and evaluations.

In addition to DOE, there are several other federal agencies with expertise in next generation energy technologies—including NASA, the Department of Transportation, and the Department of Agriculture. As in the case of DOE, DOD already has some connections with these agencies. For example, the Department of Agriculture and Department of the Navy collaborate on biofuels research and development. Pursuing appropriate alignment of energy expertise with these agencies would also provide opportunities to accelerate the testing, development, and deployment of innovative energy technologies.

Partnering with innovators and establishing an Operational Energy Innovation Center

While DOD has been a significant player in the development of numerous widely used technologies (jet engine, gas turbines, solid state electronics, the Internet, etc.), much of the innovation that occurs in the United States happens in the private sector in small start-up companies. And it is widely noted that these businesses are also engines of economic development [52]. By taking steps to support these innovators, DOD could obtain technologies which otherwise may not see commercialization and help build the nation's economy.

…DOD and DOE must align goals and personnel at the strategic, operational, and tactical levels within their organizations.

However, while many of the most exciting innovations occur within nascent businesses, there are several barriers that divide DOD from these innovators. On the supply side, the production capabilities of these small, newly formed businesses may not be able to keep up with the large volume of orders that are often made by the government and military. Furthermore, the process of responding to government requests is also arduous and time-consuming, two factors that companies with only a few employees cannot overcome. Finally, many small companies believe that they don't have a chance of competing against large, well-established firms, and they choose to put their resources and time elsewhere. On the demand side, DOD does not have the resources to reach out to individual members of this community. The size of DOD, the various types of technology that it pursues, the number of ventures that do not succeed on the supply end, and the sheer number of participants involved makes outreach to small start-ups nearly impossible.

But what if these smaller companies were given a leg up in terms of resources? Technology incubators do just that. Designed to support fledgling companies through their first year or two of existence, these incubators provide guidance on how to commercialize products, obtain funding from angel investors or venture capitalists, and turn their ideas into functioning

businesses. Some of the incubators are physical, allowing companies to share office space and administrative support; others are virtual, providing only guidance. Many of the best and potentially viable technology companies, including clean energy technology companies, reside in the 1,100 business incubators operating in the United States [53].

A second avenue for pursuing partnerships with small businesses is through regional innovation centers or clusters. These centers foster innovation by first connecting researchers together to create teams and then by putting those teams in contact with people and resources that can help their product succeed. These centers also help to connect developers of technology with end users, providing opportunities for products to be demonstrated, tested, and eventually commercialized.

The Department of Defense and the intelligence community already has some contact with innovation clusters and centers (though not necessarily those focused on clean energy technologies). The Defense and Science Technology Accelerator (DSTA), founded in 2006, is located in Fayetteville, North Carolina, in close proximity to Fort Bragg. The mission of DSTA is to deliver technology to the warfighter (particularly special operations), while providing economic development in the area around Fayetteville. An initiative of a state economic development center in North Carolina helped to found DSTA.

Various parts of DOD and the intelligence community have also interacted with the Chesapeake Innovation Center (CIC), located in Maryland [54]. This center is both a technology incubator as well as an innovation center. One of CIC's first clients was the National Security Agency (NSA), for whom CIC vetted hundreds of companies and technologies that the NSA did not have the capacity to examine. One of CIC's primary roles is to connect technology innovators with government clients, facilitating a relationship beneficial to both sides that would likely not have been possible without CIC's assistance.

A partnership between DOD and either an incubator or a center offers similar opportunities to those discussed in the previous section: working with these umbrella organizations, DOD could identify those start-ups whose products may be of potential significance and arrange to be the first demonstrators. By serving in that role, DOD could provide small businesses with testing and operating data that may otherwise be beyond their reach. These data can help prove technologies and move these products through the pipeline and toward commercialization. And DOD is able to do this more efficiently because the small organizations are collected together in something akin to the one-stop-shop.

Furthermore, DOD could go one step further and establish its own energy innovation center, aimed at developing solutions to address its most critical energy vulnerabilities. There is precedent. In December 2009, DOE announced its plans to form three Energy Innovation Hubs. Operating similarly to private-sector innovation centers, the DOE Hubs are designed to bring together multi-disciplinary teams in order to achieve greater efficiency in all stages of the pipeline from basic research to commercialization.[1] In this scenario, DOD could ensure that the technologies being researched and developed are tailored to its particular energy needs. Furthermore, a DOD energy innovation center could serve as a central information clearinghouse, which would, as discussed above, limit redundancies, save taxpayer dollars, and reduce inefficiencies in the innovation pipeline.

1. The three Energy Innovation Hubs are "Fuels from Sunlight," "Modeling and Simulation for Nuclear Reactors," and "Energy Efficient Building Systems Design."

Deploying emerging clean energy technologies: acquisition strategy on installations

In our final discussion, we consider the end of the innovation pipeline—deployment—and we look at how fine-tuning the incentives might help pull more innovative, new energy technologies through the pipeline.

Energy use at installations is governed under a stricter rubric than operational energy: a variety of regulatory and legislative mandates have steered DOD toward lowering energy consumption, increasing use of renewables, and promoting conservation and energy efficiency. However, the adoption of new clean energy technologies is still hampered in key installation acquisition programs.

To help achieve its energy goals, DOD often employs two mechanisms: the Energy Conservation Investment Program (ECIP) and Energy Savings Performance Contracts (ESPCs). The ECIP program is backed by Congressional appropriations (through military construction funding), and it is designed to allow installations to purchase technologies that save money through conserving energy [55]. The program is viewed widely as being successful, cited as saving more than two dollars for each dollar invested. ESPCs are contracting vehicles that allow DOD to invest in energy-related improvements without expending funds appropriated by Congress. Through ESPCs, DOD partners with private firms that make the energy improvements; in return, the firms' investments are paid back through the energy savings.

While these programs have improved installation energy use, as they are currently structured, they favor older technologies that are well-established on the commercial market. This is especially the case for ESPCs, which are inherently risk averse. The private sector firms that enter into these contracts only do so if they are guaranteed to make a profit; as such, the energy improvements are done so with tried-and-tested technologies whose payback schedules and energy savings are well-defined. Many of these investments are also made with small profit margins. As such, companies are not willing to take risks on these contracts by using new and perhaps unproven technologies.

Altering these programs to reduce the advantages provided to already commercialized products will encourage the acquisition of more innovative technologies on installations. One change could include a guaranteed return on investment (similar to that given on older technologies) for those developers proposing cutting-edge technologies. Another change could include giving first preference to innovations that come from public/private partnerships (incubators, energy hubs, etc.). Given DOD's size and the fact that installations mirror U.S. infrastructure, the use of innovative technologies on its installations provides a clear demand signal to the developer.

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

Former Dean of the Academic Board, U.S. Military Academy and Dean of the Faculty and Academic Programs, Industrial College of the Armed Forces

On the Need for Creative Energy Solutions

Brigadier General Gerald Galloway has the pragmatism of a soldier, the systems perspective of an engineer and logistician, the worldview of a geographer, and the curiosity of an academic. Throughout his career, he has used these skills to find solutions to such complex issues as providing logistical support to large Army operations and analyzing how to support people and the natural environment when flooding disasters occur.

General Galloway believes that energy is at the heart of the challenges in military logistics and operations: "Most people don't recognize the logistics demands that follow a modern Army as it deploys to the far reaches of the world. Tactical operations require support from staging areas and forward bases and bring with them very large supply requirements, with ammunition and fuel at the forefront. The challenge is to find ways to minimize the energy footprint in the theater. This is a problem that can be reduced, but it can't be completely eliminated. Ultimately, you still need fuel to power and sustain forces."

In the 1950s and '60s, DOD was looking for ways to take care of its bases and provide power that didn't require constant refueling and so it turned to small nuclear plants.

Providing reliable, deployable power has long tested the military. General Galloway cites the historical willingness of the Army to be creative in findings solutions to those challenges, specifically in its use of nuclear energy. "Going way back, there have been a number of initiatives," he recalls. "In the 1950s and '60s, DOD was looking for ways to take care of its bases and provide power that didn't require constant refueling and so it turned to small nuclear plants. The Army's Nuclear Power Program progressed to the point where they actually built eight small nuclear plants and operated them around the world."

It was a mission-motivated solution, General Galloway explains. "They were driven by the need to power Air Force distant early warning sites—called the DEW line—to monitor if Soviet bombers were coming over the Pole. They also supported Navy operations at McMurdo Station, Antarctica, and Army activity at Camp Century, Greenland. Those sites required power, but getting fuel to them was difficult. Small nuclear reactors were a solution to that problem." The Army also began to think about moving these to theaters of operation to provide constant power to rear area operations.

The reactors operated across a diverse set of mission requirements. "Recognizing the need for mobile power, they even put one on a ship that could be towed to disaster sites in order to provide power for communities," says General Galloway. That reactor, aboard the *Sturgis*, provided power to the Panama Canal for nearly ten years in the 1960s and 1970s. "After that, because of national concerns with nuclear safety and cost of the program, it went dormant. It wasn't the right thing to do in the 1970s."

Based on the progress made in technology, and on the findings of a study he chaired for the National Academies, General Galloway believes it may be time for the Army to revisit the initiative and consider paradigm-shifting technologies like small, modular nuclear reactors. "In 1999, our report on logistics for the future Army recommended looking once again into small nuclear plants. It found that now there are additional benefits, like producing hydrogen for fuel cells. Today, small nuclear reactors are being marketed in the U.S. It's probably time to think more about this," General Galloway says. "No one's envisioned bringing them out in combat zones, but they could provide energy in theater at large staging areas."

General Galloway sees a special role for DOD in demonstrating these reactors in the United States. "The challenge at many military facilities is that they're tied to the grid. We've seen the grid go down. At the same time, energy demands are rising. Putting a small reactor on a military installation not only provides a reliable and sustainable power source and a test bed to define its long-term utility, but also places the plant in a secure location. Within the United States, it's hard to find a more physically secure place than a military installation," says General Galloway. "If the tests go well on bases in the United States, these small reactors could be used to support overseas military operations or disaster recovery activities."

Chapter 3

Conclusion

Economic strength is fundamental to America's national security. For this reason, a strong and focused commitment to innovation in clean energy technologies, in a comprehensive and effective manner, must become a national security priority.

…DOD can propel the nation toward a clean energy economy, helping turn what could be a crisis into the next great American opportunity.

"We must develop clean energy that can power new industry, unbind us from foreign oil, and preserve our planet. We must pursue science and research that unlocks wonders as unforeseen to us today as the microchip and the surface of the moon were a century ago. Simply put, American innovation must be a foundation of American power. Because at no time in human history has a nation of diminished economic vitality maintained its military and political primacy." President Obama, Convocation speech at the United States Military Academy, 22 May 2010.

While the United States has begun to take small and somewhat diffuse steps toward mitigating the challenges of energy security, climate change, and national security, the nation's overall response has been disjointed. Other nations, including China, Germany, Spain, and the United Arab Emirates, have implemented national policies that have put them at the forefront in developing and deploying these technologies. And while the United States may not be able to compete in low-cost manufacturing, the nation remains powerful and unique in its ability to innovate.

Numerous examples from recent history illustrate how the military's need and support for specific technologies have resulted in large-scale technological breakthroughs that transform the civilian sector. The development of nuclear power, jet engines, and the Internet can be counted among them. So, as energy continues to come to the fore as a critical vulnerability in current military operations, the nation can expect DOD to be relentless in its pursuit of innovative solutions that address energy issues.

The Defense Department's stake in a sustainable, efficient, and clean energy economy is high. But, the organization, as we have seen, is also uniquely positioned to take up a leading role in moving toward the solution. Its size, its heavy consumption of energy, its infrastructure composition, and its experience in moving innovation through the pipeline are all powerful signals to would-be innovators. Moreover, by fine tuning already existing processes and by building partnerships in both the public and private sectors, DOD can further spur innovation and, as a result, the clean energy economy. So, by looking for solutions to its own energy issues, DOD can propel the nation toward a clean energy economy, helping turn what could be a crisis into the next great American opportunity.

Biographies

GENERAL GORDON R. SULLIVAN, USA (RET.)

Former Chief of Staff, U.S. Army; Chairman, CNA Military Advisory Board

General Sullivan is the President and Chief Operating Officer of the Association of the United States Army, headquartered in Arlington, Virginia. Since assuming the presidency in 1998, General Sullivan has overseen the transformation of the Association into a dynamic 100,000+ individual and 500+ sustaining member organization that represents Soldiers, families, and the defense industry.

His responsibilities as President and Chief Operating Officer encompass both daily business operating and strategy planning for the largest Army-oriented non-profit association. The Association promotes and advocates programs for Soldiers and their families, creates opportunities for Army-Industry and professional dialogue, advocates public awareness of Army and national security issues through its educational mission, and maintains an outreach program to national leadership on critical issues pertinent to Army readiness.

General Sullivan was born in Boston, Massachusetts, on 25 September 1937 and raised in Quincy. He was commissioned a second lieutenant of Armor and awarded a Bachelor of Arts degree in history from Norwich University in 1959. He holds 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.

General Sullivan retired from the Army on 31 July 1995 after more than 36 years of active service. He culminated his service in uniform as the 32nd Chief of Staff—the senior general officer in the Army—and a member of the Joint Chiefs of Staff.

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. He is the Chairman of the Board of Trustees of Norwich University and the Marshall Legacy Institute, and was formerly a director on the boards of Newell-Rubbermaid, Shell Corporation, Institute of Defense Analyses and General Dynamics.

General Sullivan is married to the former Gay Loftus of Quincy, Massachusetts; they currently reside in Alexandria, Virginia. He has three children and three grandchildren. He is an avid reader, amateur historian, active sailor, and sport fishing enthusiast.

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 Renew-

able 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 STEVE ABBOT, USN (RET.)

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

Admiral Steve Abbot is President and Chief Executive Officer of the Navy-Marine Corps Relief Society, a private, non-profit aid society dedicated to assisting Sailors, Marines, and their families. Until June 2003, he was Acting Homeland Security Advisor to the President, having served as the Deputy Homeland Security Advisor under Governor Tom Ridge.

Abbot's last military assignment was Deputy Commander-in-Chief, U.S. European Command, Stuttgart, Germany. He oversaw the daily activities of a Unified Command with an area of responsibility encompassing 89 countries and more than 13 million square miles.

Born in Pensacola, Florida, Abbot graduated from the United States Naval Academy in June 1966. His graduate work includes studies at Oxford University, as a Rhodes Scholar, and at Harvard University in its Program for Senior Officials in National Security. He also completed U.S. Air Force Test Pilot School and Naval Nuclear Power training.

In his 38-year career in the Navy, Abbot's assignments included service as Commanding Officer of the USS *Theodore Roosevelt* (CVN 71) from February 1990 until August 1992 (a period that included Operation Desert Storm), service as the Theodore Roosevelt Battle Group Commander while assigned as Commander, Carrier Group Eight, and as Commander, Joint Task Force 120. He also served as Commander of the U.S. Sixth Fleet and Commander, Naval Striking and Support Forces, Southern Europe during which he was Joint Task Force Commander of Operation Silver Wake, the non-combatant evacuation of Albania.

Abbot and his wife, Marjorie, live in Arlington, Virginia. They have three sons, LCDR Spencer Abbot assigned to the Agency for International Development in Washington, D.C., Sebastian Abbot with the Associated Press in Islamabad, Pakistan, and LCDR Matt Abbot on duty with the staff of Strike Group NINE in Everett, Washington.

ADMIRAL FRANK L. "SKIP" BOWMAN, USN (RET.)

Former Director, Naval Nuclear Propulsion Program; Former Deputy Administrator for Naval Reactors; National Nuclear Security Administration

Admiral Frank "Skip" Bowman is President of Strategic Decisions, LLC, in Maryland, serves on the board of directors of Morgan Stanley Mutual Funds, the National Security Advisory Council of the Center for U.S. Global Engagement and on the MIT Nuclear Engineering Visiting Committee. He is co-chair of a National Academies/Naval Studies Board investigating the Implications of Climate Change on Naval Forces, is an advisor to the Penn State Nuclear Engineering Department, and serves on the board of the Armed Services YMCA of the USA. He is also a member of the American Nuclear Society and serves on the BP America External Advisory Committee.

Bowman served for more than 38 years in the U.S. Navy, rising to the rank of admiral. He was director of the Naval Nuclear Propulsion Program, the third successor to Adm. Hyman G. Rickover in that command, and was concurrently deputy administrator-Naval Reactors in the National

Nuclear Security Administration at the U.S. Department of Energy. In these dual positions, he was responsible for the operations of 103 reactors aboard the Navy's aircraft carriers and submarines, four training sites, and two Department of Energy laboratories. As a flag officer Bowman served on the Joint Staff as Director of Political-Military Affairs and as the Chief of Naval Personnel. At sea, he commanded the nuclear submarine USS *City of Corpus Christi* (SSN 705) and the submarine tender USS *Holland* (AS 32).

Following his Navy career, Bowman served as President and Chief Executive Officer of the Nuclear Energy Institute.

Bowman, a native of Chattanooga, is a 1966 graduate of Duke University. He earned a dual master's in Nuclear Engineering and Naval Architecture/Marine Engineering at the Massachusetts Institute of Technology in 1973 and was elected to the Society of Sigma Xi. He is a member of the National Academy of Engineering and a recipient of the Robert S. Landauer Memorial Lecture Award for distinguished contributions to the field of Radiological Physics and Radiation Health Protection.

In 2003 Bowman was awarded an honorary Doctor of Humane Letters degree from Duke, and in 2006, was knighted by Britain's Ambassador to the U.S. as Honorary Knight Commander of the Most Excellent Order of the British Empire upon the appointment and approval of the Queen of England. He has also received the Officier de l'Ordre National du Mérite from the French Government.

MAJOR GENERAL RUSSELL FUHRMAN, USA (RET.)

Former Deputy Commanding General and Acting Chief of Engineers, U.S. Army Corps of Engineers

Major General Russ Fuhrman is a Senior Vice President with Parsons Brinckerhoff (PB). He also serves as the Principle in Charge (PIC) of Potomac Crossing Consultants (PCC), a general engineering consultant providing support to the Federal Highway Administration, Maryland State Highway Administration and Virginia Department of Transportation in the construction of the Woodrow Wilson Bridge – a $2.5 billion program to rebuild four interchanges and a signature bridge across the Potomac River, south of Washington, D.C., on 7.5 miles of the Capital Beltway (Interstate Route 95/495). Prior to his current role as Principle in Charge, Fuhrman spent over five years as Executive Project Manager for the construction phase of the Woodrow Wilson Bridge Program.

Potomac Crossing Consultants, a joint venture of Parsons Brinckerhoff and two other engineering consultants, provides program management services including planning, design and construction management, project controls, environmental and congestion management, and public and community affairs management.

Fuhrman joined PB in 2001 after a 32-year Army career of hands-on engineering and construction experience in the United States and abroad. He rose to the rank of Major General in the U.S. Army Corps of Engineers and retired in January 2001 as the Corps' Deputy Commanding General and Acting Chief of Engineers. His private sector career has also given him extensive experience in program, facilities, and construction management, including management of a complex, $90 million fast-track design-build program to construct 11 cable landing stations in North and South America.

Fuhrman graduated from the United States Military Academy in 1968 and received his master's degree from Pennsylvania State University in 1974. He is a registered Professional Engineer in Virginia and a member of the National Academy of Construction.

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

Former Dean of the Academic Board, U.S. Military Academy and Dean of the Faculty and Academic Programs, Industrial College of the Armed Forces

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 and 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 in 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 to 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 he 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, and 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, Department of the Navy

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 to 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 the 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, composed of 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 UCLA and a Master of Science degree in Operations Research from the Naval Postgraduate School in Monterey, California.

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

Former Commanding General, U.S. Army Materiel Command

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 to 2004, and Senior Advisor for Army Research, Development, and Acquisition from 1997 to 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 Fort 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 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 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, composed 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 to 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 State 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 U.S. 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 Center, Joint Staff; Executive Assistant to the Director of the Joint Staff; Head, Aviation Plans and Programs Branch; Assistant Deputy Chief of Staff for Aviation; Assistant Deputy Commandant for Plans, Policies, and Operations; and Deputy Commandant for Programs and Resources.

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.

ADMIRAL JOHN B. NATHMAN, USN (RET.)

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

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 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. He returned to the *Nimitz* as her Commanding Officer from 1992 to 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 the *Nimitz* Carrier Strike Group and Battle Force FIFTY in the Persian Gulf, and subsequently served as Director, Air Warfare in the Pentagon. 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, Naval Air Forces.

Nathman's awards included 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, and two Navy Commendation Medals with Combat V, 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 to 1984, Nathman was the senior naval test pilot flying all MiG aircraft with the 4477 Test and Evaluation Squadron at Nellis Air Force Base.

VICE ADMIRAL ROGER T. RUFE, USCG (RET.)

Former Commander, Coast Guard Atlantic Area and Maritime Defense Zone Atlantic

Vice Admiral Roger Rufe is a 34-year veteran of the United States Coast Guard and currently serves as President of the National War College Alumni Association Board of Directors.

During his career with the USCG, Rufe served as captain of five Coast Guard cutters and, as a flag officer, held the Pacific and Atlantic Area commands, as well as commands with responsibility for Coast Guard operations in Alaska and the Southeast U.S. and the Caribbean. He was vice chairman of the National Response Team, chief of the Coast Guard Congressional Affairs Office, representative to the North Pacific and Mid-Atlantic Fisheries Management Councils, and delegate to Marine Environment Protection Committee of the International Maritime Organization.

After retirement from the Coast Guard, he served for seven years as President and CEO of The Ocean Conservancy, a national non-profit environmental advocacy organization that promotes science-based ocean conservation and protection of marine wildlife. While at The Ocean Conservancy, he held leadership positions on several non-profit Boards and commissions involved in ocean policy.

In July 2009, Rufe completed a three year Secretarial term appointment as the Director of the Department of Homeland Security (DHS) Office of Operations Coordination and Planning. As Director, Rufe was responsible for integrating operations across the Department's component agencies as well as coordinating with state, local, tribal, and other federal departments which have a role in

preventing, preparing for and responding to acts of terrorism, natural disasters and other emergencies. He was also responsible for interagency disaster and emergency management planning.

Rufe is a graduate of the U.S. Coast Guard Academy, holds a master's degree in Public Administration from New York University, and is a graduate of the National War College and the Naval War College.

LIEUTENANT GENERAL CLYDE A. VAUGHN, USA (RET.)

Former Director, Army National Guard, National Guard Bureau

Lieutenant General Clyde Vaughn retired as the Director of the Army National Guard in July 2009 after nearly 40 years of service to the Guard and the U.S. Army.

As Director of the Army National Guard—a force of over 350,000 Soldiers in the 54 states, territories, and the District of Columbia—Vaughn guided the formulation, development and implementation of all programs and policies affecting the Guard. He built an innovative and highly successful recruiting program; undertook the changes necessary to raise ARNG readiness levels to all-time highs; enabled the ARNG to meet all wartime and deployment requirements, deploying over 300,000 soldiers; guided the deployment of ARNG soldiers to Katrina/Rita and the Southwest Border; and developed several innovative programs such as the Afghanistan Agriculture Development Teams.

Vaughn was commissioned through the Missouri National Guard Officer Candidate School program in 1974 and served in a wide variety of command and staff positions as a traditional Guardsman and on active duty. He also served extensively in Central and South America on several deployed Task Forces.

His general officer assignments were as Deputy Director of Operations, Readiness, and Mobilization & Deputy Director of Military Support under the G3 of the U.S. Army; Deputy Director of the Army National Guard; Assistant to the Chairman of the Joint Chiefs of Staff for National Guard Matters; and Director of the Army National Guard from June 2005 to July 2009.

Vaughn has received the Army Distinguished Service Medal with Oak Leaf Cluster, the Defense Superior Service Medal, and the Legion of Merit with four Bronze Oak Leaf Clusters.

He holds a Bachelor of Science degree from Southeast Missouri State College and a MPA from Shippensburg University. His professional military education includes the United States Army Command and General Staff College, and the United States Army War College.

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

Former Deputy Commander, U.S. European Command

General Chuck Wald is a director and senior advisor to the Aerospace & Defense Industries for Deloitte LLP. He is a specialist in weapons procurement and deployment, counter terrorism, and national energy and international security policy. At Deloitte he is responsible for providing senior leadership in strategy and relationships with defense contractors and Department of Defense (DOD) program executives. Prior to joining Deloitte, Wald was the Vice President, International Programs for L-3 Communications Corp., based in Washington, D.C.

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

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

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

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

He holds a Bachelor of Arts degree from North Dakota State University and a1982 Master of Political Science degree in International Relations from Troy State University. His professional military education includes Squadron Officer School and Air Command and Staff College, Maxwell AFB, Alabama; National War College, Ft. Lesley J. McNair, Washington, D.C.; and the Program for Senior Officials in National Security, Harvard University, Cambridge, MA.

References

[1] CNA Military Advisory Board. National Security and the Threat of Climate Change, Apr 2007, accessed 22 Jun 2010 at http://www.cna.org/reports/climate

[2] CNA Military Advisory Board. Powering America's Defense: Energy and the Risks to National Security, May 2009, accessed 22 Jun 2010 at http://www.cna.org/reports/energy

[3] Energy Information Administration, Department of Energy. "U.S. energy consumption by energy source." www.eia.doe.gov Official Energy Statistics from the U.S. Government, accessed 22 Jun 2010 at http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table1.html

[4] Energy Information Administration, Annual Energy Outlook 2010, 11 May 2010, accessed 22 Jun 2010 at http://www.eia.doe.gov/oiaf/aeo/index.html

[5] President Jimmy Carter's Address to a Joint Session of Congress on the State of the Union, 1980. Accessed 22 Jun 2010 at http://www.jimmycarterlibrary.org/documents/speeches/su81jec.phtml

[6] Defense Science Board. More Fight, Less Fuel. Feb 2008, accessed 22 June 2010 at http://www.acq.osd.mil/dsb/reports/ADA477619.pdf

[7] Office of the Deputy Under Secretary of Defense for Installations and Environment, Annual Energy Management Report, Fiscal Year 2008, 2 Jan 2009, accessed 22 Jun 2010 at http://www.acq.osd.mil/ie/energy/library/DoDenergymgmtrpt08.pdf

[8] Rear Admiral Philip Cullom. Presentation for the CNA Military Advisory Board, Alexandria, Virginia, 27 Apr 2010

[9] Dorothy Robyn. Statement given by Dorothy Robyn, Deputy Under Secretary of Defense for Installations and Environment before the House Armed Services Committee, Subcommittee on Readiness. Washington, DC, 24 Feb 2010

[10] Architecture 2030. "Building Sector, Energy, CO2 Emissions—Current Situation." www.architecture2030.org Climate Change, Global Warming, and the Built Environment—Architecture 2030, accessed 22 Jun 2010 at http://www.architecture2030.org/current_situation/building_sector.html

[11] Research and Innovative Technology Administration. "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances." www.bts.gov Bureau of Transportation Statistics, accessed 22 Jun 2010 at http://www.11.gov/publications/national_transportation_statistics/html/table_01_11.html

[12] C-Span. "State of the Union." Capitol Hill, The White House and National Politics, accessed 22 Jun 2010 at http://www.c-span.org/Executive/State-of-the-Union.aspx

[13] The President. Executive Order (E.O.) 13423, Strengthening Federal Environmental, Energy, and Transportation Management. Federal Register, 26 Jan 2007, accessed 22 Jun 2010 at http://edocket.access.gpo.gov/2007/pdf/07-374.pdf

[14] The President. Executive Order (E.O.) 13514, Federal Leadership in Environmental, Energy and Economic Performance. Federal Register, 8 Oct 2009, accessed 22 Jun 2010 at http://edocket.access.gpo.gov/2009/pdf/E9-24518.pdf

[15] Department of Energy. "Breakdown of Funding." www.energy.gov Department of Energy, accessed 22 Jun 2010 at http://www.energy.gov/recovery/breakdown.htm

[16] David Sandalow, Assistant Secretary of Energy for Policy and International Affairs. "Clean Energy Stimulus: One Year Later." Remarks at the Center for Strategic and International Studies, Washington DC, 17 Feb 2010

[17] Pew Charitable Trusts. The Clean Energy Economy, Repowering Jobs, Businesses and Investments Across America, June 2009

[18] U.S. Climate Action Partnership, accessed 22 Jun 2010 at http://www.us-cap.org/

[19] Keith Bradsher. "China Leading Global Race to Make Clean Energy." New York Times, 31 Jan 2010, accessed 22 Jun 2010 at http://www.nytimes.com/2010/01/31/business/energy-environment/31renew.html

[20] Kate Gordon, Julian L. Wong, and J. T. McClain. Out of the Running? How Germany, Spain, and China Are Seizing the Energy Opportunity and Why the United Sates Risks Getting Left Behind, Center for American Progress, Mar 2010

[21] Keith Bradsher. "China Racing Ahead of U.S. in Drive to Go Solar." New York Times, 25 Aug 2009

[22] Joanna Lewis. Presentation for the CNA Military Advisory Board, Alexandria, Virginia, 27 Apr 2010

[23] Pew Charitable Trusts. Who's Winning the Clean Energy Race? Growth, Competition and Opportunity in the World's Largest Economies: G-20 Clean Energy Factbook, 2010

[24] Thomas L. Friedman. "Who's Sleeping Now?" New York Times, 9 Jan 2010, accessed 22 Jun 2010 at http://www.nytimes.com/2010/01/10/opinion/10friedman.html

[25] World Nuclear Association. "Nuclear Power in France." www.world-nuclear.org World Nuclear Association, accessed 22 Jun 2010 at http://www.world-nuclear.org/info/inf40.htm

[26] "Masdar Plan." The Economist, 4 Dec 2008

[27] Asian Society Center on U.S.-China Relations, Center for American Progress, and Monitor Group. A Roadmap for UNITED STATES-China Collaboration on Carbon Capture and Sequestration, Nov 2009

[28] Meeting of the CNA Military Advisory Board, Alexandria, Virginia 27 Apr 2010

[29] Jim Efstanthiou Jr. "GE's Immelt Says U.S. Needs Strong Actions on Energy." Business Week, 02 Mar 2010, accessed 22 Jun 2010 at http://www.businessweek.com/news/2010-03-02/ge-s-immelt-says-u-s-needs-strong-actions-in-energy-race.html

[30] American Energy Innovation Council. A Business Plan for America's Energy Future, 2010

[31] We Can Lead. "Over 170 U.S. Companies Call on Senators to Get Energy and Climate Legislation 'Back on Track.'" wecanlead.org/ We Can Lead, 28 Apr 2010, accessed 22 Jun 2010 at http://wecanlead.org/newsroom/release0428.html

[32] Power Surety Task Force. "Projects Catalog." www.pstfonline.com Power Surety Task Force, accessed 22 Jun 2010 at http://pstfonline.com/Projects_Catalog.html

[33] Ray Mabus. Remarks by the Honorable Ray Mabus, Secretary of the Navy, Navy/Agriculture Memorandum of Understanding Signature Ceremony, Pentagon, Washington, DC, 21 Jan 2010

[34] Ian Graham. "Air Force scientists test, develop bio jet fuels." www.af.mil The Official Web Site of the U.S. Air Force, 30 Mar 2010, accessed 22 Jun 2010 at http://www.af.mil/news/story.asp?id=123197415

[35] Ray Mabus. Remarks by the Honorable Ray Mabus, Secretary of the Navy, Secretary of the Navy, Surface Navy Association National Symposium, Crystal City, Virginia, 13 Jan 2010

[36] Federal Energy Management Program. "Electric Avenue U.S. Army Charges Ahead in Using Electric Vehicles." www1.eere.energy.gov/femp EERE: Federal Energy Management Program Homepage, accessed 22 Jun 2010 at http://www1.eere.energy.gov/femp/pdfs/fedfleet_army_ss.pdf

[37] Brad Hancock. "Department of Defense Facilities and Vehicles Energy Use, Strategies and Goals: Program Overview." Presentation to the Quality Construction Alliance, 11 May 2009

[38] Daniel Sarewitz and John Alic. Innovation Policy for Climate Change: A Report to the Nation. Sep 2009

[39] Office of the Press Secretary, The White House. "Improving the Civilian Global Positioning System (GPS)," 1 May 2000, accessed 22 Jun 2010 at http://usgovinfo.about.com/library/news/aa050300b.htm

[40] Daniel Reicher. Testimony before the Senate Committee on Energy and Natural Resources, Hearing on Legislation to Improve the Availability of Financing for Clean Energy and Energy Efficiency, 15 Jul 2008

[41] American Association for the Advancement of Science. "R&D Budget and Policy Program." AAAS—The World's Largest General Scientific Society, accessed 22 Jun 2010 at http://www.aaas.org/spp/rd/

[42] Office of Management and Budget (OMB), The White House. "Summary Tables, Budget of the United States Government, Fiscal Year 2011," accessed 22 Jun 2010 at http://www.whitehouse.gov/omb/budget/fy2011/assets/tables.pdf

[43] Office of the Under Secretary of Defense (Comptroller), RDT&E Programs. Department of Defense Budget, Fiscal Year 2011, Feb 2010, accessed 22 Jun 2010 at http://comptroller.defense.gov/defbudget/fy2011/fy2011_r1.pdf

[44] Barbara McQuiston. "Power and Energy Related Programs." Presentation to Army Science Board, 10 Mar 2010

[45] Regina Dugan. "Statement before the Subcommittee on Terrorism, Unconventional Threats and Capabilities, House Armed Services Committee, United States House of Representatives," 23 Mar 2010, accessed 22 Jun 2010 at http://www.darpa.mil/Docs/DARPA2010CongressionalTestimonyHASC.PDF

[46] Department of Energy. "Budget & Performance." www.energy.gov Department of Energy, accessed 22 June 2010 at http://www.energy.gov/about/budget.htm

[47] American Association for the Advancement of Science. "Total research and development by Agency Congressional Action on research and development in the FY 2010 Budget," accessed 22 Jun 2010 at http://www.aaas.org/spp/rd/fy2010/total10c.pdf

[48] Department of Energy. "Labs & Technology Centers." www.energy.gov Department of Energy, accessed 22 Jun 2010 at http://www.energy.gov/organization/labs-techcenters.htm

[49] Office of the Deputy Under Secretary of Defense for Installations and Environment, Base Structure Report, Fiscal Year 2009 Baseline (a summary of DOD's real property), Aug 2009, accessed 22 Jun 2010 at http://www.acq.osd.mil/ie/download/bsr/BSR2009Baseline.pdf

[50] Dorothy Robyn. Presentation for the CNA Military Advisory Board, Alexandria, Virginia, 27 Apr 2010

[51] David Richardson. "New Agency Puts Clean Energy on Front Burner." Miller-McCune, 14 Mar 2010, accessed 22 Jun 2010 at http://www.miller-mccune.com/science-environment/new-agency-puts-clean-energy-on-front-burner-10852/.

[52] "Clusters and Cluster Development." www.isc.hbs.edu/index.html Institute for Strategy and Competitiveness, Harvard Business School, accessed 22 Jun 2010 at http://www.isc.hbs.edu/econ-clusters.htm

[53] National Business Incubation Association. "About NBIA." www.nbia.org National Business Incubation Association, accessed 22 Jun 2010 at http://www.nbia.org/about_nbia

[54] Chesapeake Innovation Center. "Chesapeake Innovation Center Factsheet." Aug 2007, accessed 22 Jun 2010 at http://www.cic-tech.org/CIC-FACT-Sheet-FINAL-Updated-8-07.pdf

[55] Office of the Deputy Under Secretary of Defense for Installations and Environment. "Facility Energy—Energy Conservation and Investment Program (ECIP)." www.acq.osd.mil Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, 26 Jan 2010, accessed 22 Jun 2010 at http://www.acq.osd.mil/ie/energy/ecip/ecip.shtml

CNA
ANALYSIS & SOLUTIONS

4825 Mark Center Drive • Alexandria, VA 22311-1850 • 703-824-2000 • www.cna.org