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WORKING PAPER

Promoting the Dialogue:
Climate Change and America's Air Forces

By Will Rogers

Center for a
New American
Security

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Cover Image

An A-10C Thunderbolt II during the first flight of an aircraft powered solely by a biomass-derived jet fuel blend.

(SENIOR MASTER SGT. JOY JOSEPHSON/U.S. AIR FORCE)

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Climate change could have significant implications for U.S. air missions, which are critical to America's ability to protect the homeland, project power and ensure access to the global commons.[1] In the short term, the Air Force and Navy are determining how to consider climate change in their energy strategies, both to ensure more dependable access to and more efficient use of fuel, and to meet energy and greenhouse gas (GHG) reduction requirements set by the president, Congress, Department of Defense and state governments. In the mid to long term, climate change has the potential to affect air forces more directly by changing operating and strategic environments. For example, environmental changes could affect installations or equipment, or they may generate destabilizing conditions that could reshape the international security environment. To date, however, analysts have not fully explored what these effects could mean for U.S. air forces specifically.

Currently, the air forces are split in how they consider the short- and long-term implications of climate change and how they prioritize energy and climate change concerns. The Navy, for example, has been proactive in tying its energy conservation and diversification efforts to national climate change goals to reduce GHG emissions. It recognizes its own role in mitigating climate change and believes that climate change will affect its operating environment in observable ways in the near future.[2] In contrast, the Air Force is committed to reducing its demand for energy and increasing use of alternative fuels, but has been primarily concerned with ensuring access to fuel for mission effectiveness purposes, with less direct focus on how reducing GHG emissions will affect its operating environment or capabilities.

In June 2009, the Center for a New American Security initiated its "Promoting the Dialogue" project to study how climate change could affect the various military services and how these services are planning to adapt to those impacts. In accordance with the 2008 National Defense Authorization Act, which required the Department of Defense to consider the impact of climate change on its "facilities, capabilities and missions," the air forces have started to consider how climate change could affect their ability to operate in a changing security environment. Through extensive research and personal interviews with Navy and Air Force officials, this working paper synthesizes how America's air forces are considering climate change in their near- and long-term planning and identifies the role energy concerns play in the services' decision-making calculations. While the majority of this working paper will focus on the Air Force, observations about Navy aviation offer a point of comparison.

CLIMATE CHANGE AND ENERGY STRATEGY: U.S. AIR FORCES TODAY

The most immediate effect of climate change on U.S. air forces is the consideration of climate change in the services' energy security strategies. While energy and climate change are related concerns (86 percent of U.S. greenhouse gas emissions stem from energy use[3]), there is an ongoing tension within most of the military services on how to strike a balance between the desire for energy security (i.e., assured access to fuel in order to promote mission effectiveness) and national climate change goals. However, this tension derives, in part, from a false dichotomy between energy security and climate mitigation efforts perpetuated by the services. There is an often-cited concern by the services that energy conservation and efficiency practices and alternative fuel development that promote mission effectiveness may be at cross-purposes with meeting GHG reduction targets. But the two are not mutually exclusive. In fact, as this paper intends to demonstrate, the air forces have indicated through their various conservation and efficiency practices and overall energy strategies that there are areas where these concerns can be linked and even mutually reinforced.

Indeed, linking energy security and climate change can have near- and long-term implications for mission effectiveness. In the near term, reduced energy demand and employment of more fuel-efficient aircraft have the potential to give air forces longer endurance (i.e., the ability to refuel less often and stay in combat maneuvers longer) and reduce logistical constraints (e.g., not having to scale back operations because of access to fuel). In the long term, linking energy and climate change offers an opportunity to strengthen mission effectiveness by limiting the amount of GHG emissions that would contribute to global climate change, which in turn could have strategic and operational implications due to changes in the physical, social, cultural and political environments.

Energy security and climate change increasingly have become linked at the highest levels of national policy; this linkage now extends to the Department of Defense. Energy concerns have long topped the agenda for the Department of Defense, the single largest consumer of fuel in the U.S. government. Yet as the 2010 Quadrennial Defense Review (QDR) explicitly states, climate change, energy security and economic growth are "inextricably linked." Recognizing this linkage signals a preference for investments in energy sources and technologies that both promote improved energy assurance and reduce GHG emissions (such as greener alternative fuels and new aerospace designs that consider fuel efficiency as part of key performance parameters). Though the explicit linkage of energy security and climate change is new, requirements from the president and Congress increasingly promote GHG considerations alongside energy decisions. For example, President Barack Obama signed Executive Order 13514 in October 2009, which requires all federal agencies to establish GHG emissions reduction targets and to factor these into long-term planning and purchasing.[4] To align with the president's national climate change priorities, the Department of Defense issued an instruction to reduce GHG emissions by 34 percent for non-combat activities at its domestic installations by 2020.[5]

For the air forces in particular, aviation fuels are one of the most important areas where efforts to address energy concerns also create potential opportunities for the department to meet GHG reduction targets. With aviation fuel consumption constituting nearly 62 percent of DOD's total fuel demand, the Navy and Air Force have both given serious consideration to improving energy security in order to improve mission effectiveness, reduce costs and ensure access to fuels by combining alternative energy technologies with efficiency and conservation efforts.[6] The Navy, for example, has tested biofuel blends in its F/A-18 Super Hornet engine with the intent of conducting a test flight on Earth Day – April 22, 2010.[7]

Meanwhile, the Air Force recently conducted a successful test flight of a biofuel blend in both engines of an A-10 Thunderbolt II – the first time a military or civilian aircraft has been tested with biofuel blends in both engines.[8] However, the Navy and Air Force may continue to have a difficult time translating how these efforts contribute to national climate change goals.

This problem stems, in part, from the difficulty in quantifying how much those energy security efforts reduce GHG emissions. Indeed, this difficulty is a part of the frustration the services share about attempting to tie their energy security efforts to climate change priorities. To date, it is not clear to what extent alternative fuels could reduce GHG emissions compared to conventional petroleum-based fuels; estimates vary widely based on the data and models used. Measuring the lifecycle production of alternative fuels is complex and not well defined. (For example, analysis of algae-based fuel must include the total GHG emissions from developing an algal pond, processing the algae, extracting the oil from the algae, synthesizing the biofuel and shipping the fuel off for consumption.) There is no U.S. government baseline to measure the lifecycle production process for alternative or renewable fuels. The Environmental Protection Agency (EPA) recently released a lifecycle analysis on renewable fuels, while the Navy's Office of the Assistant General Counsel (Installations and Environment) is developing its own lifecycle analysis to help the Navy meet its environmental requirements with fuels that reduce its carbon footprint. Because the Federal Aviation Administration (FAA), the Air Force and industry producers have not adopted a single baseline or methodology for calculating GHG emissions, they may generate inconsistent and incomparable data that makes quantifying their efforts more difficult. Developing a U.S. government baseline should be a priority interagency effort among the Department of Defense, Department of Energy and Environmental Protection Agency.

An F/A-18 Super Hornet from Air Test and Evaluation Squadron (VX) 23 at Patuxent River, Md. The Super Hornet, with the green insignia and the U.S. Navy Energy Security logo, will be testing a drop in replacement biofuel made from the camelina plant on Earth Day 2010. (NOEL HEPP/U.S. NAVY)

Given the challenges and ongoing tensions within the air services on how to approach and quantify energy security and climate change efforts, it is important to understand how the Navy and Air Force have each taken steps to tackle these issues and the reasoning behind their efforts.

The Navy

In 2009, the Navy established two task forces, Task Force Energy and Task Force Climate Change, to study these issues.[9] The Chief of Naval Operations charged Task Force Energy with exploring options to bolster the Navy's energy security, efficiency and environmental stewardship. Task Force Climate Change was charged with assessing the Navy's preparedness in responding to climatic changes and providing science-based projections for such changes. However, as conversations with Navy officials confirmed, leaders in both task forces engage each other regularly and work across the two task forces to advance the Navy's objectives: creating an implicit understanding that energy security and climate change can and should be considered in tandem in order to ensure the Navy's success in its mission. Indeed, as of late, the link between climate change and energy has been made explicit

and embraced by Navy Secretary Ray Mabus. "The global implications of expanding demand and continued reliance on fossil fuels are significant," Mabus told an audience at the Defense Attachés Association Annual Conference in November 2009. "The stock of proven fossil fuel reserves worldwide is finite, costs will almost certainly continue to go up, and the current way we extract and use fossil fuels too often harms the environment and contributes to climate change."[10]

As a result of this high-level commitment, the Navy has been proactive in balancing energy security with climate change mitigation in its approach to achieving energy security. Aviation fuels account for approximately 42 percent of the Navy's total fuel consumption; the Navy has been working to reduce that through efficiency in its aircraft performance and through alternative fuel development – particularly in the F/A-18 Super Hornet, the most ubiquitous fixed-wing aircraft in the Navy's fleet.[11] According to Mabus, the Navy is working to improve the F404 F/A-18 engine's efficiency by 3 percent, to be operational by 2015.[12] Speaking before the Naval Energy Forum in October 2009, Mabus said these engine improvements "could save us 127,000 barrels of fuel per year, amounting to $15 million for the Fleet per year at today's fuel prices."

When it comes to aviation fuels, the Navy has been forward-leaning in terms of testing and evaluating biofuel blends in its F/A-18 Super Hornet engine as well. Mabus announced at the Naval Energy Forum that by 2020, 50 percent of the Navy's tactical vehicles and shore installations, including its aircraft, will be fueled using alternative sources of energy. It is unclear what percentage of the Navy's aircraft will use alternative sources of fuel to help meet this benchmark, but by shifting to a biofuel blend, the Navy is positioning itself to take advantage of potential GHG emissions reductions compared to conventional petroleum-based fuels. Indeed, it is the Navy's history and leadership on energy innovation – specifically nuclear propulsion – that helped trigger experimentation with alternative aviation fuels that may promote energy security and mitigate climate change. Speaking before the Naval Energy Forum, Mabus said, "We are a better Navy and a better Marine Corps for innovation; we have led the world in the adoption of new energy strategies in the past. This is our legacy."[13]

The Air Force

In contrast, the Air Force is prioritizing assured access to fuel supplies and has not as strongly or directly linked its efforts to achieve energy security with the goal of climate change mitigation. Moreover, due to other pressing institutional challenges, the Air Force has simply devoted less attention to the issue of climate change to date.

In the last several years the Air Force has undergone a period of introspection and institutional transformation in order to address a crisis of identity: in the words of Air Force Chief of Staff General Norton Schwartz, "what it is" versus "what it should be."[14] A spate of incidents over the last several years, including the breach in U.S. nuclear weapons security that led to the forced resignations of Air Force Chief of Staff General T. Michael Moseley and Air Force Secretary Michael W. Wynne in June 2008, brought unwelcome attention to the service.[15] As a result, in September 2008, General Schwartz, speaking before the Air Force Association's annual conference, said that the Air Force is "taking a hard look at what we do, how we do it and why."[16] In addition, the current conflict landscape has helped shepherd the Air Force through its evolution from a purely *air* force to one that is increasingly exercising "control and exploitation of air, space and cyberspace."[17] The wars in Afghanistan and Iraq have been "simultaneously conducted hand-to-hand, and at global distances" and are "characterized by face-to-face meetings with other cultures, yet also by electrons traveling through satellites 22,000 miles overhead."[18] For example, new technological advancements in unmanned aerial vehicles have allowed the Air Force to carve out a niche role in today's counterinsurgency operations and missions.

Whereas the Air Force has devoted less attention to climate change, as a result of recent institutional shifts and focus on force structure, it has focused intently on assuring access to fuel, which is considered a more immediate challenge to personnel, equipment, policies and mission effectiveness. The ability to project power globally depends on assured access to energy. The service's outsized dependence on energy means that, for every 10-dollar increase in the price of a barrel of oil, the Air Force increases its annual fuel cost by 619 million dollars.[19] As the single largest consumer of fuel within the Department of Defense, utilizing approximately 64 percent of DOD's fuel budget, energy security and cost volatility are, not surprisingly, major concerns for the Air Force.[20] Furthermore, the need to transport, store and deliver aviation fuel to aircraft in flight and to bases deep inside active combat zones constitutes a significant logistical risk. In fact, one Air Force official said that even if fuel were free and carbon emissions were nil, fuel would still constitute a major vulnerability given the long logistics tail necessary to support air operations in remote operating theaters and over long distances through the air. Given these considerations, it is understandable that the Air Force has primarily approached energy by balancing best business practices with operational security, leaving climate impacts mostly aside.

However, there are opportunities for the Air Force to integrate energy and climate goals, as seen in the Air Force's 2010 energy plan. Goals include increasing supply, reducing demand and changing the culture – including a goal to "reduce consumption of aviation fuel by 10% by 2015 against a FY2006 baseline."[21] According to the 2010 QDR, "By 2016, the Air Force will be postured to cost-competitively acquire 50 percent of its domestic aviation fuel via an alternative fuel blend that is *greener* [author's emphasis] than conventional petroleum fuel."[22] The emphasis on greener fuels lies, in part, with the Air Force's previous experience with testing and evaluating coal-to-liquid fuels which, without large-scale carbon capture, are likely to increase greenhouse gas emissions compared to petroleum-based fuel. (As mentioned earlier, there is no baseline for lifecycle GHG emissions, but the EPA, at the time, had projected coal-to-liquid fuels to contribute more than 100 percent of the emissions of conventional gasoline without carbon capture and sequestration.) Nevertheless, in the near to long term, the Air Force will continue to collaborate with the national labs and look for private sector partnerships to develop greener substitutes, including plans to test blends of algae-based biofuel in its aircraft, as recently demonstrated with the successful testing of biofuels in both engines of the A-10 Thunderbolt II.[23] While these efforts may be aimed at increasing energy security and maximizing mission effectiveness, and not directly linked to reducing GHG emissions, these efforts ultimately could help the Air Force achieve broader emissions reduction targets.

In the short term, the Air Force's most successful efforts to reduce GHG emissions and mitigate climate change are likely to come from the same measures that boost its mission effectiveness: reducing demand for energy through conservation and efficiency efforts.

NOT JUST BIOFUELS: ENERGY EFFICIENCY, CONSERVATION AND ALTERNATIVES IN THE AIR FORCE FLEET

In the short term, the Air Force's most successful efforts to reduce GHG emissions and mitigate climate change are likely to come from the same measures that boost its mission effectiveness: reducing demand for energy through conservation and efficiency efforts such as partnering with the commercial aviation industry, training pilots in flight simulators instead of fuel-guzzling aircraft and investing in adaptive wing and alternative propulsion technologies. In fact, the commercial sector is likely to help hasten the Air Force's efforts to integrate energy performance with its broader emissions reduction targets. While the drafters of the 2010 QDR expect that the Air Force's testing and standard-setting in alternative fuels will "[pave] the way for the much larger commercial aviation sector to follow," the Air Force has a rich history in learning lessons from the larger commercial aviation industry and is poised to take advantage of the conservation and efficiency practices advanced by the commercial sector.[24]

There are numerous instances in which the Air Force has learned important lessons from the commercial aviation industry and then leveraged those lessons successfully to reduce its own energy demand and, as a consequence, reduce GHG emissions. Useful lessons in energy conservation and efficiency have been drawn from the commercial airline industry by the Air Mobility Command (AMC), the Air Force's major command leading airlift and refueling operations (i.e., strategic airlifters like C-5s, C-17s; tactical airlifters like the C-130; aerial refuelers like the KC-10 and KC-135). Today, AMC operations consume approximately 44 percent of the Air Force's total fuel consumption.[25] In October 2008, the command stood up a Fuel Efficiency Office (FEO) to explore options to reduce its total energy demand. According to FEO Chief Colonel Kevin Trayer, the Air Force is integrating lessons learned from the commercial sector into its own practices.[26] The Air Force is also leveraging the experiences of its reservists and national guardsmen, some of whom are employed by commercial carriers.[27]

In another example of learning from industry practices, the Air Force has streamlined training with flight simulators and brought in commercial airline pilots to advise the service on fuel savings, including scaling up use of flight simulators.[28] Most of the major shifts in training started with heavy-lift aircraft like the C-17, with pilots certified after 70 hours in a high-fidelity simulator and four hours of real cockpit time.[29] While shifting training in fighter jets to simulators will be much slower due to the difficulty of simulating real-life conditions of aerial combat, the Air Force is looking to reduce the number of real cockpit hours combat pilots need to certify by substituting additional simulator training. Importantly, this will require improvements in the Air Force's simulators in order to ensure that increasing their use does not reduce training or readiness. The cumulative effects of these reduced flight requirements cut fuel usage significantly.

The Air Force is also cooperating with the FAA to develop a satellite-based system of air traffic management, known as the Next Generation Air Transportation System, to replace today's ground-based system of air traffic control.[30] This system will increase the capacity and efficiency of air travel while reducing the environmental impact of the aviation industry and allowing it to develop more precise, direct jet routes and approaches, which in turn help to reduce fuel burn and GHG emissions.[31] In addition, the Air Force and the National Aeronautical Space Administration are conducting aircraft trial tests using adaptive wing technology that would cut drag and offer potentially 30 percent fuel savings on subsonic commercial aircraft.[32]

Secretary of Defense Robert M. Gates sits in the cockpit of a flight simulator at Warrior Hall Flight School XXI Simulation Complex at Hanchey Army Airfield, AL . Today, the Air Force is streamlining training in flight simulators to reduce fuel demand. (U.S. AIR FORCE MASTER SGT. JERRY MORRISON/U.S. DEPARTMENT OF DEFENSE)

Air Force Research and Development, in partnership with leading aerospace agencies, is developing opportunities in alternative propulsion that will bolster mission effectiveness. The Air Force has several ongoing initiatives to develop potentially game-changing propulsion systems, including: INtegrated Vehicle ENergy Technology (INVENT); Highly Efficient Embedded Turbine Engine (HEETE); and ADaptive Versatile ENgine Technology (ADVENT). Each of these programs is intended to increase aircraft endurance, range and/or fuel efficiency. For example, the Air Force Research Laboratory's INVENT program aims to extend the range and endurance of aircraft 10 to 15 percent, while increasing power and thermal capacity 10 to 30 percent by integrating new power and thermal management systems in existing tactical, unmanned and long-range aircraft.[33] Meanwhile, the HEETE program focuses on embedded technologies that will also increase aircraft endurance and range for a variety of Air Force platforms. For this program, General Electric is working with the Air Force to develop an ultra-high-pressure ratio compressor and new thermal management systems that could improve fuel burn by 25 percent.[34] Finally, the ADVENT program is a research effort to study variable-cycle technologies that would give pilots the flexibility to change operational requirements (e.g., switching from tactical maneuvers to long-range flight in the same aircraft) while accommodating lower fuel requirements for the aircraft.

Overcoming Institutional Impediments

Despite the important lessons the Air Force has learned from commercial carriers and its ongoing partnerships with the aerospace community, institutional impediments prevent the Air Force from taking full advantage of advancements made in fuel conservation, efficiency and aerospace design. Today, one of the greatest challenges facing the Air Force is the difficulty in recapitalizing its aircraft fleet.[35]

Airlines can quickly recapitalize their fleets either by replacing aging aircraft with more efficient, off-the-line models or by just replacing outdated engines with more fuel-efficient ones. Indeed, there are financial incentives for commercial carriers to do so since aircraft improvements that result in better fuel efficiency strengthen their bottom line. By contrast, the Air Force fleet cannot recapitalize as quickly, in part due to budgetary limitations. Air Force platforms are procured with the intention of lasting decades and funding is authorized according to those timelines.

The other challenge facing the Air Force lies in fuel data collection and analysis. According to one Air Force official, the Air Force is behind the commercial airline industry when it comes to analyzing its own fuel consumption. Airlines use state-of-the-art information technology systems to analyze fuel data in real time. For example, when a commercial aircraft lands, the carrier can assess in real time the aircraft's departure overfuel (i.e., how much excess fuel the aircraft is carrying for the flight that it did not use). Carriers can then make the necessary corrections to optimize fuel conservation for its aircraft fleet. The Air Force, however, still records and inputs this information manually, requiring more time to analyze data and make corrections to optimize aircraft performance. A 2007 Air Force Audit Agency report found that the Air Force does not have an effective or efficient method for obtaining reliable aviation fuel consumption data.[36] As DOD Inspector General Claude Kicklighter reported to Congress in 2007, "[Air Force] Auditors concluded that the Air Force could better optimize aviation fuel use through centralized visibility and implementation of a formalized fuels management program with clearly defined policies and procedures, goals, metrics and incentives."[37]

Energy Investments at Air Force Installations

Air Force officials are making significant investments in better efficiency, conservation and renewable energy programs at domestic installations. While there are tangible benefits in reduced GHG emissions, Air Force installation officials are reducing their energy consumption and developing alternative on-base energy sources, in large part to meet energy requirements and mandates at the state and federal level. Some installation commanders may also be concerned with energy assurance and look for opportunities to reduce energy dependence on the domestic electric grid. They do this out of concern that missions could be more vulnerable when installations are tied to what has been described as a brittle domestic energy grid.[38] These efforts are aimed at mitigating that vulnerability and ensuring mission effectiveness.

Regardless, in the last several years the Air Force has been making steady investments in energy efficiency at its facilities and implementing renewable energy projects in order to reduce its energy demand and strengthen energy security. Energy use at Air Force facilities accounts for approximately 15 percent of the service's total energy consumption.[39] According to its 2008 Infrastructure Energy Strategic Plan, the Air Force reduced its total facility energy consumption by 30 percent between 1985 and 2005; it is poised to reduce its facility energy demand by another 30 percent by 2015.[40] But in order to accomplish that goal the Air Force plans "to get more aggressive."[41] In 2009, the Air Force reduced its energy intensity (i.e., the amount of energy used per gross square foot) by 13 percent from a 2003 baseline established by the Energy Policy Act of 2005.[42] According to a June 2009 Air Force Energy Program Policy Memorandum, the Air Force aims to continue to "procure energy-efficient products and vehicles" and plans to "[d]esign new buildings that are 30 percent better than American Society of Heating, Refrigerating & Air Conditioning Engineers (ASHRAE) standards" in order to achieve its objectives for reducing its total energy demand.[43]

The Air Force is also making significant investments in renewable energy programs, with 34 on-base renewable energy projects in operation.[44] Today, the

Air Force operates the largest solar array in North America at Nellis Air Force Base (AFB), Nevada, generating approximately 14 megawatts of energy, or 25 percent of the base's total energy demand.[45] According to President Obama, the Nellis solar array will "reduce harmful carbon pollution by 24,000 tons per year, which is the equivalent of removing 4,000 cars from our roads."[46] Meanwhile, the Air Force plans to expand its solar energy portfolio with a 3,200-acre solar power project at Edwards AFB, California, which is slated to generate approximately 600 megawatts and would surpass Nellis AFB as the largest solar project.[47] Continuing its investment in renewable energy projects is likely to pay significant climate dividends by reducing the Air Force's carbon footprint while achieving its own energy security objectives. Indeed, given the recent DOD instruction to reduce GHG emissions by 34 percent from non-combat activities at its more than 300,000 domestic installations by 2020, the Air Force would do well to consider explicitly linking energy security with climate change to take full credit for the work it is already doing to meet the department's goals.[48]

Despite these investments, however, there are no financial incentives for Air Force base and installation commanders to scale up these conservation, efficiency and renewable energy programs beyond what they need to do to meet their own installation's energy requirements. Indeed, the lack of incentives is a point of frustration for some Air Force officials who would like to reinvest money saved from reduced energy consumption in better base infrastructure and training platforms, such as state-of-the-art flight simulators. However, money saved from reduced energy consumption is not considered money saved, but rather a cost avoidance (i.e., the money was authorized by Congress, but because it was not used it does not need to be allocated). In fact, there may even be a disincentive for Air Force commanders to scale up these programs since it could result in budget cuts in the next fiscal year if Congress adjusts for (or cuts) the money the Air Force did not need for purchasing fuel or electricity.

CLIMATE CHANGE AND JOINT AIR POWER: FUTURE CHALLENGES AND OPPORTUNITIES

While it is clear that energy security will continue to sculpt how the air forces integrate climate change considerations into their strategic and operational planning, less clear are the mid- to long-term implications that climate change will have on air forces. While the Department of Defense anticipates increased requests to conduct humanitarian assistance and disaster relief (HA/DR) operations in response to increased and possibly more severe natural disasters resulting from climate change,[49] current climate science has yet to offer the level of detail or fidelity that would be necessary to fully elucidate the impacts of climate change on the air operating environment. Potential effects could include, for example, more turbulent air, changes in bird migration, increased low-level fog density and more intense and potentially frequent storms at air force and naval installations.

Conversations with Air Force officials show that they are acutely aware that climate change could alter the strategic environment by necessitating more frequent responses to natural disasters and relief missions, circumstances in which the air forces already play a critical role.[50] Domestically, air missions were a critical part of the joint operations in the wake of Hurricane Katrina. The Air Force played a significant role in search-and-rescue, evacuation and relief drop missions, for instance. Air Force helicopters and fixed-wing aircraft flew 648 and 4,095 sorties respectively, rescuing 4,322 stranded people and evacuating 26,943 displaced persons from the affected region.[51] Air missions were also essential in responding to the December 2004 Indian Ocean tsunami and the October 2005 earthquake in Pakistan. Most

While the Air Force is resilient and capable of adapting to changes as needed, it will still need better climate science and future projections to generate more useful planning documents.

recently, the air forces have played a crucial role in U.S. response efforts to Haiti following the January 12, 2010 earthquake. While the temblor was not a climate-induced disaster per se, the resulting air missions performed in Haiti are likely to be replicated in similar disaster response missions where millions of lives are affected and where air force assets can provide critical information to joint and interagency efforts. For example, with the U.S. Air Force taking a lead in military space missions, Air Force Intelligence, Surveillance and Reconnaissance (ISR) agencies provided joint and interagency partners with unclassified high-altitude surveillance imagery to assist in recovery and relief operations in Haiti.

Even while the Air Force "recognizes the importance of addressing climate change, and supports all DOD and administration objectives in tackling this global problem," it has yet to fully conceptualize the effects that climate change may have on its strategic and operating environments.[52] Similar to the challenges facing the other services, Air Force officials are not clear about how climate change could affect their facilities, capabilities and missions in ways that go beyond their capacity to adapt. For example, it is not clear if there is a threshold in the number of HA/DR missions it could be tasked with responding to that would force the Air Force to fundamentally reorient the service for long-term responses to climate change (i.e., it is unclear how many HA/DR missions would be equivalent to the resources, capabilities, and forces need for Air Force operations in Iraq or Afghanistan). Nevertheless, while the scale and types of missions are distinct and require different resources, Air Force officials are confident that those types of disaster relief missions will not approach the scale of operations in Iraq and Afghanistan and that they will be able to adapt to changes in the strategic environment as needed.

The Need for Further Climate Science

While the Air Force is resilient and capable of adapting to changes as needed, it will still need better climate science and future projections to generate more useful planning documents.

Indeed, Air Force leadership needs to systematically study how and if climate change will affect its operating environment given current and advancing scientific projections. It is still unclear if and how climate change will affect atmospheric chemistry in ways that compromise current and future Air Force platforms, facilities and operations. This lack of understanding is rooted, in part, in the lack of fidelity in the kinds of information that the Air Force – or any of the military services – would find useful. As a forthcoming CNAS report will show, there is a serious "translation" problem between what the effects of climate change mean for the Department of Defense and the various military services, Combatant Commands and defense agencies.[53] Numerous conversations with government officials, including those in the Air Force, indicate a lack of "actionable" data, or scientific data that can be used to make clear policy decisions, to help defense officials make decisions that relate to climate change – especially at the operational level.

To quantify the effects of climate change on their operating environment, Air Force officials have expressed interest in a base-by-base assessment of how climate change will affect facilities and

operations at specific locations. For example, a base-by-base assessment could analyze whether climate change will cause changes in fog density that could disrupt low-level flight operations. In particular, climate-induced bird migrations could cause more frequent bird strikes during low-level flight operations. The Air Force's Bird/Wildlife Aircraft Strike Hazard Team already studies how to preserve war-fighting capability by reducing wildlife hazards with aircraft, and the Department of Defense has members on the Bird Strike USA steering committee to study this very issue. There is a developing need to study climate-induced shifts in bird migrations and what that could mean for strikes on aircrafts. A base-by-base assessment would help identify hazard areas and sites where flight operations need to be more closely monitored to prevent accidents.

RECOMMENDATIONS

The Air Force should fully integrate energy security and climate change into its future planning efforts. While there are clear indicators where the Air Force can better align energy and climate change efforts – and indeed is enacting short- to near-term testing with biofuel blends in its aircraft fleet – it is not clear if these efforts will be fleeting or are intended to reduce GHG emissions over the near to long term. Until the Air Force has fully developed an understanding of the implications of climate change, there may not be a vested interest in developing a long-term strategy that fully and effectively integrates energy security and climate change mitigation. Indeed, adopting a long-term strategy that integrates these two related concerns has long-term (if uncertain) benefits for mission effectiveness. These could include longer, less energy-intensive missions and reduced GHG emissions that contribute to global climate change, which could have strategic and operational implications, as outlined above. What is more, integrating the two could also have immediate, positive consequences. The Air Force would demonstrate that its goals align more broadly with DOD's vision for energy security and climate change – as articulated in the 2010 QDR – and the president's national climate and energy goals. The Air Force would also improve its public image on these issues by taking full credit for the climate change mitigation efforts already undertaken through its extensive, cross-cutting energy security strategy.

The Department of Defense should systematically study what incentives would encourage Air Force, Navy and other service-level commanders to implement conservation and efficiency practices and invest in renewable energy programs at the base and installation level. For example, today's "cost avoidance" structure is a disincentive for many of the services to invest in renewable energy programs. Reduced energy costs do not translate into real dollars that commanders can invest in other programs. In fact, those commanders could see budget reductions since they did not use all of the money authorized to them. Properly aligned incentive structures have the potential to generate tremendous benefits in reduced energy demand and alternative energy production. The Air Force has already demonstrated the benefits of large scale conservation, efficiency and renewable energy programs.

Congress should examine how to better ensure that the Air Force and Navy can take advantage of advances in energy efficiency and conservation, including improved engine models and structural enhancements made by the commercial sector. Perhaps the most immediate gains could come from investments in a fuel data collection system that allows the Air Force and Navy to analyze fuel data and make corrections in real time.

Finally, the Air Force should develop a research agenda that studies a range of potential short- and long-term operational and strategic challenges linked to climate change. The Navy's Task Force Climate Change is a model that could be replicated. Task Force Climate Change has

considered several key questions about the implications of climate change for the Navy that are intended to make senior leaders more comfortable in dedicating operation and maintenance resources to study and respond to climate change.[54] Air Force strategists should develop similar questions aimed at determining which specific effects current climate science models indicate are likely to occur; where the Air Force can build synergies with the climate science community to help improve its understanding of climate changes, including potential changes to atmospheric chemistry that could have implications for the Air Force (and Navy); how these impacts could affect the Air Force's ability to conduct missions at the strategic and operational level; what trade-offs are involved with focusing time and funding on climate change; and what interagency and joint partnerships would further its understanding of, and preparation for, climate change.

CONCLUSION

U.S. air forces have yet to fully develop an advanced understanding of the complex consequences of climate change. However, understanding how climate change could affect air forces in the short to long term will offer them an opportunity to prepare for changes in the strategic and operating environments in anticipation of potential challenges that could threaten mission effectiveness. It is clear, and not at all unexpected, that energy security remains a priority for the air services. While the Navy's history and leadership have positioned it to be more forward-leaning in tying its energy security initiatives to climate change, the Air Force continues to maintain separate energy security and climate change strategies. It should link the two together to take full credit for climate mitigation efforts tied to its robust energy security strategy.

The Air Force has made great strides in adopting conservation and efficiency practices within its aviation platforms and installations and integrating aerospace advancements into its existing fleet. But institutional challenges surrounding recapitalization of its fleet and its inefficient fuel optimization data collection and analysis system inhibit the Air Force's ability to reap the total benefits of these practices. Meanwhile, the lack of incentives to scale up on-base renewable energy programs needs to be resolved.

Though the Air Force is confident in its ability to adapt to changes in the security environment, it has not fully conceptualized how difficult it may be to adapt to potential climate changes. At the operational level, current climate science can not yet adequately explain how climate change will affect the air forces' platforms and installations. As posited earlier, climate change could potentially affect the operating environment with more turbulent air, changes in bird migration, increasing fog density and more intense and potentially frequent storms at air force and naval installations. Better assessments and models will increase the understanding of the operational implications of climate change for all air forces. The Navy's adoption of the inextricable link between energy and climate change and its process of integrating these issues into its planning and making leaders more comfortable about dedicating finite resources to study these issues could serve as a useful model for the Air Force. Indeed, the Air Force has a vested interest in developing a more robust understanding of the effects climate change could have on its facilities, capabilities and missions.

ENDNOTES

1 The term "U.S. air forces" generally refers to the U.S. Air Force and the U.S. Navy, as many of the issues outlined may apply to each of them. However, most observations relate to specific services and are noted as such. A recent brief on climate change and maritime missions also covers U.S. Navy issues on this topic.

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