Airman prepares to fuel A-10C Thunderbolt II with 50/50 blend of Hydrotreated Renewable Jet and JP-8; plane then flew first flight of aircraft powered solely by biomass-derived jet fuel blend (U.S. Air Force/Samuel King, Jr.)

Green Peace
Can Biofuels Accelerate Energy Security?

By John E. Gay

The evolution of liquid fuel for transportation has a long history of innovation that began with the steam engine. Initially, wood and coal were the primary fuel sources for propelling various vehicles both on land and at sea, but transferring them was dirty and strenuous and required extensive manpower. The discovery of liquid petroleum and the development of refinery processes quickly shifted transportation energy from coal and wood to liquid fuels. Petroleum offered double the thermal energy of coal and as a result boiler designs became smaller, enabling automobiles, ships, and railway locomotives to travel faster and farther. The transfer of liquid petroleum through pipes greatly reduced refueling labor and provided greater distribution options. As a result, petroleum quickly became the fuel of choice, initiated a global oil boom, and created competing interests among nations.

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Today, global economies as well as national security interests depend on domestic and imported oil. As that dependency grows, the fundamental stability of the global oil market is being stressed by inadequate investment in oil production capacity, persistent geopolitical instability, and rapidly growing demand in developing nations.[1] In addition, reliance on a single energy source for transportation fuel—petroleum—has economic, strategic, and environmental drawbacks. In response to these challenges, and controversially using Cold War authorities of the Defense

Production Act, a memorandum of understanding was signed between the Secretaries of Agriculture, Energy, and the Navy to each invest $170 million to jumpstart a biofuels industry and help lead the United States to energy independence.[2]

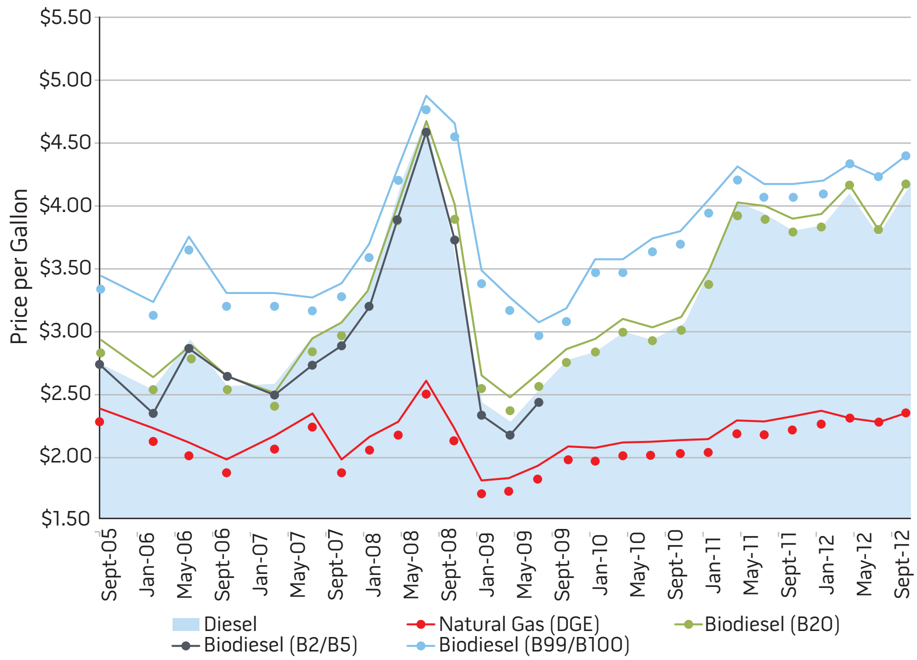
The 2007 National Defense Authorization Act set an aggressive goal for the military to produce or procure 25 percent of all its energy demands from renewable sources by 2025.[3]

Section 2852 of the 2007 National Defense Authorization Act calls for the Department of Defense (DOD) to establish goals regarding use of renewable energy to meet transportation needs:

The Secretary of Defense shall submit to the congressional defense committees the energy performance goals for the Department of Defense regarding transportation systems, support systems, utilities, and infrastructure and facilities . . . (c) Special considerations—For the purpose of developing and implementing the energy performance goals and energy performance plan, the Secretary of Defense shall consider at a minimum the following . . . (4) Opportunities to pursue alternative energy initiatives, including the use of alternative fuels in military vehicles and equipment, (5) Cost effectiveness, cost savings, and net present value of alternatives . . . and (8) the value of the use of renewable energy sources.[4]

In compliance with the law, the U.S. Army, Navy, Marine Corps, and Air Force have all expressed an interest in being early users of alternative fuels, although Congress did not require the use of alternative fuels in military tactical weapon systems. The Air Force played a lead role in evaluating and testing alternative fuels for military applications and set a goal to be prepared to acquire cost-competitive alternative fuel blends sufficient to meet 50 percent of its domestic aviation fuel requirements by 2016. Moving well beyond compliance with the will of Congress, Secretary of the Navy Ray Mabus established an aggressive energy strategy focused on replacing 50 percent of the Navy's energy consumption with biofuels by 2020.[5] The Army is evaluating the performance of alternative fuels in combat systems but has not yet formally established goals.[6]

Figure 1. Alternative Fuel Prices vs. Diesel



Source: Department of Energy, "Cities Alternative Fuel Price Report," July 2012, 15.

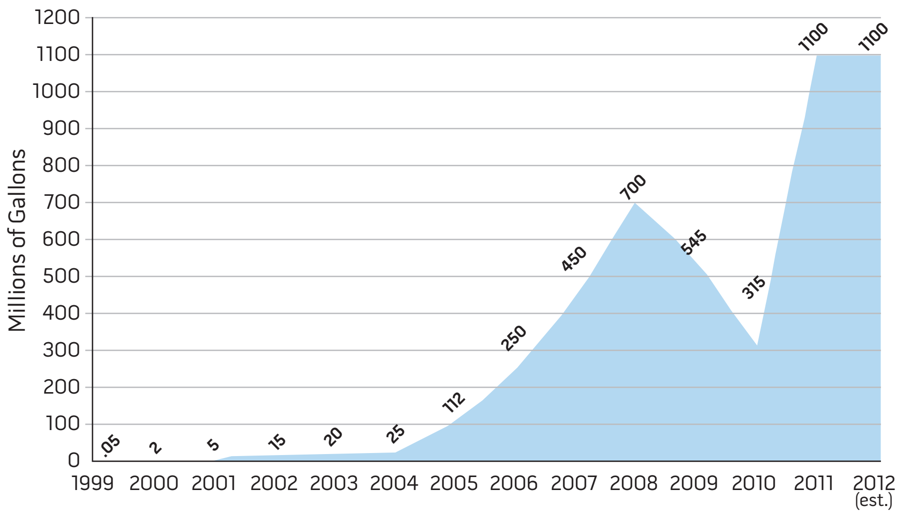
Can military research and investment jumpstart a biofuels industry and provide an alternative to imported foreign oil that is compatible, readily available, and affordable? This article explores the military application and feasibility of biofuels and offers reasons why biofuels will not lead the Nation to improved energy security.

Biofuels Defined

Biofuels are liquid fuels produced from agricultural or other biological materials, and such fuels have been around for more than 125 years. Some of the first automobiles and tractors were capable of running on biofuel, and the first commercial cellulosic ethanol plant opened in the United States in 1910. Biofuels production declined over time because it was expensive, inefficient, and ultimately unsustainable.[7] Corn-based ethanol reappeared in the 1970s after the oil embargo as a way for the United States to reduce its dependency on imported oil from the Middle East, and it attracted interest again in the 1990s as a renewable fuel to help reduce greenhouse gas emissions.[8] Today the most widely used biofuel, ethanol, is produced from the fermentation and distillation of sugar or starch-based crops such as sugar cane and corn. Biofuels also include biodiesel—mono-alkyl esters of long-chain fatty acids derived from vegetable oils and animal fats.[9] Biodiesel is renewable heating oil and a diesel substitute used in Europe, and it is gaining interest in the commercial market in the United States. Common feedstock for biodiesel fuels includes soybeans, rapeseed, canola, palm, other plants, and waste cooking oils and animal fats.[10]

Untreated bio-oil made from thermal processing of tree and plant cellulose is a complex mixture of oxygenated organic compounds with about 25 percent water that is difficult to separate. Bio-oil is not compatible with conventional fuel systems and engines and is unstable in long-term storage.[11] However, it can be stabilized and converted to a conventional hydrocarbon fuel by a complex sequence called hydrotreating.[12] Once hydrotreated, biodiesel is compatible with petroleum-based fuels and miscible in many different concentrations offering "drop-in" advantages without

Figure 2. U.S. Biodiesel Production



Source: National Biodiesel Board Annual Estimates

diesel motor modification. However, hydrotreatment is costly in energy, and some scientists doubt that there is a net energy gain in biofuels because more than 50 percent of the energy stored in feedstock plants comes from fossil fuels in the form of nitrogen fertilizers and pesticides; energy for tilling, harvesting, and transport; and the chemical conversion process.[13] Because a significant amount of fossil fuel is required in the life-cycle production of biofuels, the cost of processing biomass into ethanol or biodiesel is directly linked to the cost of fossil fuels. When the price of oil increases, so do the feedstock and production costs of biofuels. Biofuels and associated renewable energy credits are also part of the global energy trading market, and the biofuels price trends in the same direction as fossil fuels, as observed in figure 1. As a result, it is unlikely that the costs of biofuels will ever become more competitive than fossil fuels.[14]

Biofuels do not offer the same energy density as petroleum-based fuels. Ethanol contains 33 percent less energy per gallon than gasoline and biodiesels contain about 8 percent less energy than petroleum-based diesel fuels.[15] Lower energy density has a direct negative effect on battlefield energy security. That means operational vehicles using biofuels will travel less distance per tank of fuel, thus requiring more fuel to accomplish the same mission. This results in additional logistics requirements in the form of more fuel that will have to be delivered to the troops.

Energy Security

Energy security is having assured access to reliable supplies and the ability to protect and deliver sufficient energy to meet essential requirements.[16] Improving U.S. energy security is principally about reducing excessive costs to consumers resulting from disruptions in the oil supply. It also means having a robust supply portfolio.

In a 2011 speech on America's energy security delivered at Georgetown University, President Barack Obama echoed the conventional wisdom of biofuels:

> *The United States of America cannot afford to bet our long-term prosperity, our long-term security on a resource that will eventually run out, and even before it runs out will get more and more expensive to extract from the ground. We cannot afford it when the costs to our economy, our country, and our planet are so high, not when your generation needs us to get this right. It is time to do what we can to secure our energy future.*[17]

The transportation sector of the U.S. economy almost exclusively relies on petroleum converted by refineries to gasoline, diesel fuel, and jet fuel. That makes America most vulnerable to disruptions in the oil supply. The United States consumed more than 250 billion gallons of refined petroleum in 2011. Some 61 percent of its crude is imported, with 12.7 percent coming from the Persian Gulf.[18] In 2001 DOD consumed 5.2 billion gallons of refined petroleum products domestically and another 4.05 billion gallons overseas, or about 3.6 percent of the U.S. total of refined petroleum consumed.

Global economic growth has generated rapid increases in energy demand worldwide. Crude oil prices jumped from $60 a barrel in mid-2005 to a spike of $140 a barrel in mid-2008. More recently, from July 2011 to July 2012, the price of light crude fluctuated from under $80 a barrel to just over $110.[19] Steady petroleum price increases have supported the government's justification for investing in biofuels development.[20] As a result, the volume of biodiesel produced in the United States has steadily increased over the past 10 years, as observed in figure 2, but this is still only a very small fraction of the 202.7 billion gallons of petroleum consumed in the transportation sector in 2011.[21]

Despite the rising costs of crude, there is little hope that biofuels prices will ever be lower than the cost of petroleum. Even after the billions in government subsidies, the current price of corn ethanol is $.40 a gallon higher than regular gasoline for the same amount of energy in the gas tank.[22] Biodiesel prices range significantly higher. In 2009 the Defense Logistics Agency awarded small contracts for hydrotreated renewable HRJ-5 jet fuel that ranged from $66 to $149 per gallon.[23] Over the past few years, the Air Force and Navy have staged several aircraft and ship demonstrations using compatible drop-in biodiesel and bio–jet fuel as a tactical fuel. In 2011 the Navy spent $12 million for 450,000 gallons of hydrotreated renewable jet fuel and diesel oil made from chicken fat and algae to support an exercise in the Pacific Ocean. The biodiesel used by the Navy cost $26.75 per gallon, nearly 10 times the costs of petroleum-based diesel fuel. That same $12 million biofuels purchase could have paid for more than three million gallons of conventional diesel fuel, or the money could have gone to other critical military programs.[24]

In Afghanistan, fuel reaches the front lines via rail, trucks, and in some cases aircraft from Turkmenistan or Tajikistan. By some estimates 70 percent of the convoys in the theater of war involve "liquid logistics"—the delivery of fuel and water. By the time fuel reaches forward deployed troops, the fully burdened cost—the commodity fuel price plus the total cost of personnel and assets required to move and protect the fuel from the point it is received from the commercial supplier to the point of use—was estimated by the Marine Corps to range $9–$16 per gallon if delivered by land and $29–$31 per gallon if delivered by air. In early 2009 Ashton Carter, Under Secretary of Defense for Acquisition, Technology, and Logistics (AT&L), testified to Congress that protecting fuel convoys imposes a huge burden on combat forces and that by reducing fuel demand the Services could reduce logistics assets and operating costs and mitigate budget effects caused by fuel price volatility.[25] In addition, fuel convoys increase casualty risks for Servicemembers from enemy attacks, improvised explosive devices (IEDs), bad weather, and traffic accidents. According to the Center for Army Lessons Learned, there was one casualty for every 24 fuel convoys in Afghanistan and one for every 38.5 in Iraq.[26] Fuel convoys are extremely vulnerable to IEDs and are responsible for a large percentage of combat-related fatalities. Between July 2003 and May 2009, IEDs alone accounted for some 43 percent of U.S. fatalities in Iraq and 39.7 percent in Afghanistan.[27]

Liquid fuels, whether they are petroleum-based or biofuels, have to be transported on the battlefield at the same cost and risks to our Servicemembers. For this reason, the use of biodiesel does not offer a tactical advantage for enhancing energy security and may increase the risks and number of casualties due to its reduced energy density, which will require more fuel to accomplish the same mission.

In a 2011 report, the Federally funded RAND National Defense Research Institute concluded that there is no direct benefit to the Department of Defense for using alternative fuels rather than petroleum-derived fuels.[28] Biofuels do not offer a tactical military advantage, and unless their price becomes more competitive and the biofuels industry can scale up production, there is little chance the United States will significantly reduce its demand for petroleum-based fuels in the near future. The challenge of biofuels is production, not combustion.

Biofuels and Natural Resources

One of the biggest downsides to increasing production is that all biofuels compete with food agriculture for land, water, agrichemicals, and other farming resources. About 40 percent of the corn grown in America today is used to produce ethanol as a gasoline additive, and food crops such as soybean, rapeseed, and palm are used to produce biodiesels. The large percentage of farmland used to grow corn for ethanol has only replaced 6.5 percent of America's gasoline energy. The ethanol industry expanded based partly on expectations that gasoline consumption would keep rising and that ethanol's share of that growth would continue. Instead, gasoline demand for 2013 is projected to be 6.7 percent below its peak in 2007.[29] Agricultural markets are also volatile in price. When droughts, floods, or freezes affect crop production, food costs and biofuel prices climb together, which is particularly damaging to an economy.[30] For example, the 2012 U.S. Midwest drought forced many ethanol bio-refinery plants to close and demonstrates the insecurity of a biomass fuel supply and the effects on energy security.

Land. Today all biofuels produced in the United States and European Union (EU) are consumed domestically, but current production capacities in both regions are a long way from meeting their own future targets without importing biomass feedstock. The demand for biomass is growing at a time of massive competition for other land use including commercial forestry, food agriculture, industrial agriculture for textiles and chemicals, biomass for electrical power generation, and the expansion of urban areas.[31]

Available land to meet future biofuel demands is unevenly divided across the world. North Africa, South Asia, and Japan have very little arable land left for expansion, and almost half of the world's potentially available arable land is situated in only seven countries: Angola, Argentina, Bolivia, Brazil, Colombia, Democratic Republic of the Congo, and Sudan.[32] Also competing with the United States and European Union for land expansion are China, India, Japan, and South Korea. These nations continue to struggle to find additional agricultural land and are leasing land in other nations as well as trying to reclaim wasteland and saline land internally.[33]

One of the largest competing uses of land for biofuels production will be the food crops needed to feed a growing world population. The grain it takes to fill a sport utility vehicle tank with ethanol could feed one person for a year.[34] This is a major concern considering that according to the United Nations, the world's population is expected to increase from 7 billion in 2011 to 9.3 billion by 2050.[35] One estimate predicts that by 2020 an extra 200 to 500 million hectares of land will be needed for food, animal feed, and pasture to meet the nutritional needs of the global population.[36]

According to Nobel Laureate Michel Hartmut, the growth of plants for biofuels will undoubtedly lead to higher food prices, which will predominantly hit poorer people.[37] The global community has yet to address the key drivers of recent food prices, which have spiked three times in the last 5 years. Estimates suggest that the 2008 food crisis forced 100 million people into poverty and some believe biofuels were responsible for at least 30 percent of the global food price spike that year. ActionAid, an international nongovernmental organization, estimated at the time that 30 million more people went hungry as a direct result of biofuels.[38] Future estimates

Sailor presents samples of traditional F-76 diesel fuel and 50/50 biofuel blend to illustrate use of biofuels in support of Navy Secretary's goal to cut petroleum consumption in half by 2015 (U.S. Navy/Lolita Lewis)

suggest global food prices could rise by as much as 76 percent by 2020, pushing another 600 million into hunger if U.S. and EU biofuels goals are met and no other action is taken to prevent hunger.[39]

To meet the need for land, large-scale land acquisitions, frequently referred to as "land grabs," are taking place around the world. Land formerly used by independent farmers for their own subsistence is often confiscated by governments, with no respect for private land rights, and converted into plantations and crop monocultures. The agriculture products are exported to feed the energy and food demands of the industrialized world with little consideration for the local economies.[40] This practice creates escalating local food prices, food scarcity, and loss of job opportunities, forcing widespread displacement of populations.[41] Oxfam International, a confederation of 17 aid organizations operating in 90 countries, estimates that 567 million acres in the developing world have been sold, leased, licensed, or have been under negotiation to foreign corporations between 2000 and today.[42] According to the Renewable Fuels Agency, an estimated 500 million more hectares, roughly half the area of Europe, will be needed to meet the global biofuels demand by 2020. Land grabs are an example of how mandatory biofuels mandates are counterproductive to global security, to its supporting pillar of energy security, and to U.S. national security strategy.

Water. In addition to requiring more land, biofuels mandates add pressure to natural water resources. Large-scale industrial agriculture operations are often located in major river basins and consume massive amounts of water.[43] According to an Intelligence Community Assessment, numerous countries have already overpumped groundwater to satisfy a growing agricultural demand. This practice is counterproductive because degraded or depleted groundwater produces fewer crops, leading to food security problems and possible social disruption.[44]

A third of all Africans already live in water-scarce environments, and global climate change is likely to increase these numbers significantly. According to Citigroup's chief economist Willem Buiter, in the not-so-distant future water will become "the single most important physical commodity-based asset class, dwarfing oil, copper, agricultural commodities and precious metals."[45] Over the next 10 years, water problems will contribute to instability in regions important to U.S. national interests, and shortages and poor quality, when combined with poverty, social tensions, environmental degradation, and ineffectual government, will contribute to social disruptions that could result in failed states.[46] Biofuels mandates in Europe and the United States pressure agricultural expansion and stress natural resources. These practices are detrimental to energy security and could require U.S. military involvement in countries where there is currently little security threat.

Algae. Some scientists suggest algae may offer biofuels solutions that will not compete with food agriculture or scarce water supplies. Algae are a potential energy source that can be converted into biodiesel and bio–jet fuel, and on paper some scientists believe it could replace petroleum use altogether.[47] Algae have been studied for many years for production of hydrogen, methane, vegetable oils, hydrocarbons, and ethanol.[48] In 2006, after President George W. Bush declared that the United States was "addicted to oil," government algae research was resurrected and venture capital flowed into dozens of algae startups. Scientists and entrepreneurs have been trying to unlock the energy potential of algae for more than three decades. Some companies grow algae in ponds, others grow them in plastic and glass tubes called bio-reactors, and others keep their algae away from sunlight, feeding them sugars instead.[49] The National Research Council concluded that current technology scaled up to produce 39 billion liters of algae-derived biodiesel per year—5 percent of total U.S. transportation fuel needs—would require unsustainable levels of water and fossil fuel–based energy and fertilizer.[50] Today's technologies require between 3.15 and 3,650 liters of water to produce the amount of algae-biofuel equivalent to one liter of gasoline. As a comparison, petroleum requires 1.9 to 6.6 liters of water to produce one liter of gasoline.[51] Some argue that algae can be cultivated in salt water, but even salt water algae require all cooling water and evaporative make-up water to be fresh, or else salinity increases to lethal concentrations.

John Benemann, a biochemist who has spent more than 30 years working on algae, says, "algae biofuels cannot compete with fossil energy based on simple economics." Researchers at the Lawrence Berkeley National Laboratory estimate that biofuels grown from algae in ponds at scale would cost between $240 and $332 a barrel, considerably higher than current petroleum prices.[52] Algae is thus not a viable option to support energy security at this time.

Recommendations

Improving national energy security is principally about reducing the cost of energy to consumers and preventing disruptions in the oil supply. According to the 2010 National Security Strategy, the development of new sources of energy will reduce dependence on foreign oil and provide better energy security.[53] At this time, an investment in biofuels alone will not reduce America's thirst for foreign oil. The Nation must employ other alternatives, such as improving efficiencies, using new technologies to tap into domestic petroleum reserves, and developing better conservation practices.

Efficiency. Global consumption of petroleum will continue to grow about 1 percent per year and will remain the primary transportation fuel in the foreseeable future.[54] The United States is taking steps to produce more fuel-efficient automobiles by employing hybrid technology, developing lighter materials, and improving engine and transmission efficiency. Because of these initiatives, a reversing trend in domestic fuel consumption is expected by 2020. Some of these fuel-efficient technologies are compatible for use in military vehicles and can reduce the fuel needed on the front lines. Investing in fuel-efficient technologies thus enhances our energy security.

Conservation. Liquid fuels make up the majority of military logistics operations and require thousands of personnel at an enormous cost in both money and human life. Until a few years ago, military wargaming did not factor energy into the equation; it was simply assumed fuel would be available on time and where needed. Private industry case studies show behavior-based conservation methods often result in 20 percent or more in energy use reductions.[55] Even small consumption reductions can make a big difference in the logistics burden. Better planning, new doctrine, and conservation training can greatly enhance energy security for military operations.

Domestic Oil and Gas Production. Until quite recently, it appeared the United States was increasing its dependency on foreign oil imports, but today true energy independence has become a real possibility even without the development of alternative fuels. A dozen years ago, shale gas amounted to only 2 percent of domestic production; today it is 37 percent and rising. Natural gas is in such ample supply that its price has plummeted. This unanticipated abundance has ignited a new political argument about liquefied natural gas—not about how much the Nation will import but how much it should export.[56] According to a 2012 report published by Citigroup analysts, North America is "the new Middle East."[57] In 2011 the United States registered the largest increase in domestic oil production of any country outside the Organization of the Petroleum Exporting Countries, and net petroleum imports have fallen from 60 percent of total consumption in 2005 to 42 percent today.[58] Analysts and economists believe that North America can achieve energy independence by 2020. Domestic oil and natural gas production has surged because of new technologies such as hydraulic fracturing and horizontal drilling, which allow companies to tap hydrocarbons trapped in shale and other tight rock formations. Government estimates suggest that domestic production of petroleum will rise another 22 percent to 6.7 million barrels per day by 2020. While domestic production is increasing, better efficiency and conservation practices are on track to reduce the amount of fuel Americans consume by almost 10 percent.[59] Collectively these energy alternatives will greatly contribute to overall national energy security.

Conclusion

For the United States to achieve energy security, it must reduce its dependence on foreign oil. However, should the military—the branch of government responsible for national security—be responsible for investing its limited resources as a venture capitalist to jumpstart a biofuels industry and be forced to purchase fuels at 10 times the cost of readily available petroleum-based fuels? Not only does this not make good economic sense, but it also puts our national security at risk. Biofuels

Airman prepares to refuel F-16 Fighting Falcon, part of field service evaluation for biofuel operations (U.S. Air Force/Jeremy Lock)

mandates divert scarce military resources away from critical programs such as weapons modernization, maintenance, training, and readiness. America's military is the largest consumer of liquid fuels in the world, but it still only accounts for 3.6 percent of annual U.S. consumption. This low percentage is not enough to spark a biofuels industry and affect overall fuel prices.

As this article points out, biofuels are counterproductive to national energy security for four primary reasons. First, the cost of biofuels is directly linked to the cost of petroleum, so as the price of petroleum increases so do biofuel prices. Second, biofuels are not currently available in the quantities needed to meet military demand and it is unlikely the industry will ever be capable of producing a sufficient supply. Third, biofuels energy density is significantly less than fossil fuels, and less energy density means less fuel efficiency. Less fuel efficiency means more fuel convoys will be needed to meet the military's mission, increasing costs and risks to Servicemembers. The fourth and possibly most compelling reason is that the greater demand for biofuels feedstock will foster global threats and as a result may increase the likelihood that our nation may have to deploy forces to new threat areas. Our military depends on the best technology to defend the Nation, and for the aforementioned reasons petroleum will remain the optimal energy source for some time to come. **JFQ**

Notes

[1] Deloitte Development LLC, *Energy Security America's Best Defense: A study of increasing dependence on fossil fuels in wartime, and its contribution to ever higher casualty rates* (New York: Deloitte LLC, 2009), 4.

[2] Moshe Schwartz, Katherine Blakeley, and Ronald O'Rourke, *Department of Defense Energy Initiatives: Background and Issues for Congress* (Washington, DC: Congressional Research Service, December 2012), 18.

[3] National Defense Authorization Act for Fiscal Year 2007, P.L. 364, 109th Congress, *Department of Defense goal regarding use of renewable energy to meet transportation needs* (October 17, 2006).

[4] Ibid.

[5] U.S. Navy, *The Department of the Navy's Energy Goals*, available at <www.navy.mil/features/Navy_EnergySecurity.pdf>.

[6] James T. Bartis and Lawrence Van Bibber, *Alternative Fuels for Military Applications* (Santa Monica, CA: RAND, 2011), ix, available at <www.rand.org/pubs/monographs/MG969>.

[7] Thomas Pyle, "The Navy's Use of Biofuels Is Inefficient and Costly," *U.S. News and World Report*, July 19, 2012, available at <www.usnews.com/opinion/blogs/on-energy/2012/07/19/the-navys-use-of-biofuels-is-inefficient-and-costly>.

[8] Rick Newman, "More Evidence That It's Time to Dump Ethanol," *U.S. News and World Report*, July 31, 2012, available at <www.usnews.com/news/blogs/rick-newman/2012/07/31/more-evidence-that-its-time-to-dump-ethanol>.

[9] Energy Information Agency, "Biofuels in the U.S. Transportation Sector," February

2007, available at <www.eia.gov/oiaf/analysis-paper/biofuels_notes.html#133>.

[10] Ibid.

[11] A. Oasmaa and E. Kuoppala, "Fast Pyrolysis of Forestry Residue, 3, Stability of Liquid Fuel," *Energy & Fuels* 17, no. 4 (2003), 1075–1084.

[12] S.B. Jones et al., *Production of Gasoline and Diesel from Biomass via Fast Pyrolysis, Hydrotreating and Hydrocracking: A Design Case* (Richland, WA: Pacific Northwest National Laboratory, February 2009), 4.3.

[13] Michael Hartmut, "The Nonsense of Biofuels," *Angewandte Chemie International* 51, no. 11 (March 2012), 2516–2518, available at <http://onlinelibrary.wiley.com/doi/10.1002/anie.201200218/full>.

[14] "Biofuel markets and policy impacts," in *Biofuels: prospects, risks and opportunities*, The State of Food and Agriculture 2008 (Rome, Italy: Food and Agriculture Organization of the United Nations, November 2008), available at <ftp://ftp.fao.org/docrep/fao/011/i0100e/i0100e04.pdf>.

[15] U.S. Department of Energy, "Biodiesel Benefits and Considerations," February 2011, available at <www.afdc.energy.gov/fuels/biodiesel_benefits.html>.

[16] *Energy Security,* U.S. Code, Title 10, Chap. 173, Sec. 2924, Annual Department of Defense energy management reports, January 3, 2012.

[17] Barack Obama, "America's Energy Security," address at Georgetown University, Washington, DC, March 30, 2011, available at <www.whitehouse.gov/the-press-office/2011/03/30/remarks-president-americas-energy-security>.

[18] "U.S. Crude Oil Imports by Country of Origin," available at <www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbblpd_a.htm>.

[19] Energy Information Administration, "Spot Prices for Crude Oil and Petroleum Products," available at <www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm>.

[20] Rosamond Naylor and William Wrigley, "Biofuels, Rural Development, and the Changing Nature of Agricultural Demand," Center on Food Security and the Environment, Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century, April 11, 2012, 6.

[21] U.S. Energy Information Administration, "Refinery Sales Volumes of Other Petroleum Products," available at <www.eia.gov/dnav/pet/pet_cons_refoth_d_nus_VTR_mgalpd_a.htm>.

[22] "AAA Daily Fuel Gauge Report, Oil Price Information Service," *National Average Fuel Prices*, available at <http://fuelgaugereport.opisnet.com/index.asp>.

[23] Anthony Andrews et al., *The Navy Biofuel Initiative Under the Defense Production Act*, R42568 (Washington, DC: Congressional Research Service, June 22, 2012), 3.

[24] Pyle.

[25] Deloitte, 15.

[26] David S. Eady et al., *Sustain the Mission Project: Casualty Factors for Fuel and Water Resupply Convoys* (Arlington, VA: Army Environmental Policy Institute, September 2009), 6.

[27] Operation *Iraqi Freedom*, Operation *Enduring Freedom* Coalition Fatalities, available at <http://icasualties.org/OEF/Index.asp>.

[28] Bartis and Van Bibber, 83.

[29] Mark Peters, "Ethanol's Long Boom Stalls, Fuel-Additive Plants Close as Gasoline Demand Falls, Federal Mandates Are Met," *Wall Street Journal*, June 11, 2012, available at <http://online.wsj.com/article/SB10001424052702303395604577434782358634706.html>.

[30] Newman.

[31] Alan Broughton, "Sierra Leone—Land grabbing: A new colonialism," *Globalfaultlines*, available at <http://axisoflogic.com/artman/publish/Article_65146.shtml>.

[32] Renewable Fuels Agency, "Review of Indirect Effects of Biofuel, Evaluation of the drivers of land use change Review of future demand and supply of biofuels to 2020 and their impact on GHG-emissions," June 26, 2008, 28, available at <www.globalbioenergy.org/uploads/media/0806_AEA_-_Review_of_indirect_effects_of_biofuels.pdf>.

[33] Ibid.

[34] David Roberts, "Why the military is trying to reduce its fossil fuel use," July 30, 2012, available at <http://grist.org/climate-energy/why-the-military-is-trying-to-reduce-its-fossil-fuel-use/>.

[35] United Nations, United Nations Department of Economic and Social Affairs/Population Division, *World Urbanization Prospects: The 2011 Revision* (New York: United Nations, 2012), 1.

[36] E. Gallagher, *The Gallagher Review of the Indirect Effects of Biofuels Production,* Renewable Fuels Agency, UK, July 2008, 29, available at <www.unido.org/fileadmin/user_media/UNIDO_Header_Site/Subsites/Green_Industry_Asia_Conference__Maanila_/GC13/Gallagher_Report.pdf>.

[37] Hartmut.

[38] Tim Rice, "Meals per gallon, the impact of industrial biofuels on people and global hunger," ActionAid, available at <www.actionaidusa.org/eu/publications/meals-gallon-impact-industrial-biofuels-people-and-global-hunger>.

[39] Ibid.

[40] Broughton.

[41] Rice.

[42] Ibid.

[43] GRAIN, *Squeezing Africa Dry: Behind every land grab is a water grab*, available at <www.grain.org/article/entries/4516-squeezing-africa-dry-behind-every-land-grab-is-a-water-grab>.

[44] Maria Otero, Global Water Security, Intelligence Community Assessment, May 9, 2012, available at <www.state.gov/j/189598.htm>.

[45] Ibid.

[46] Schuyler Null, "Global Water Security Calls for U.S. Leadership, Says Intelligence Assessment," *NewSecurityBeat*, available at <www.newsecuritybeat.org/2012/03/global-water-security-calls-for-u-s-leadership-says-intelligence-assessment/>.

[47] Ibid.

[48] John R. Benemann, "Opportunities and Challenges in Algae Biofuels Production," 5, available at <www.fao.org/uploads/media/algae_positionpaper.pdf>.

[49] Marc Gunther, "Green Crude: The Quest to Unlock Algae's Energy Potential," *Yale Environment 360*, available at <http://e360.yale.edu/feature/green_crude_the_quest_to__unlock_algaes_energy_potential/2582>.

[50] Robert F. Service, "Large Scale Algae Biofuels Currently Unsustainable, New Report Concludes," *ScienceInsider*, October 24, 2012.

[51] Ibid.

[52] Gunther.

[53] The White House, *National Security Strategy* (Washington, DC: The White House, May 2012), 2.

[54] Pike Research, "Algae-Based Biofuels—Demand Drivers, Policy Issues, Emerging Technologies, Key Industry Players, and Global Market Forecasts," available at <www.pikeresearch.com/research/algae-based-biofuels>.

[55] John Laitner, Karen Ehrhardt-Martinez, and Vanessa McKinney, "Examining the Scale of the Behaviour Energy Efficiency Continuum," The Foundation of Future Energy Studies, 218–219, available at <www.mitenergyclub.org/assets/2009/10/25/LaitnerEA2009_EfficiencyBehaviorContinuum.pdf>.

[56] Daniel Yergin, "America's New Energy Reality," *Dallas Morning News*, June 9, 2012.

[57] Tim Mullaney, "U.S. Energy Independence Is No Longer Just a Pipe Dream," *USA Today,* May 2012.

[58] Yergin.

[59] Mullaney.