Department of Defense Rebuttal – Air Force *Strategic Studies Quarterly* Article, "Energy Insecurity: The False Promise of Liquid Biofuels"

The article titled "Energy Insecurity, The False Promise of Liquid Biofuels" highlights interesting but ultimately misleading opinions on the challenges the Department of Defense faces in harnessing energy innovation.

The Department of Defense invests in various energy supplies and technologies to advance military missions and improve defense capabilities. To that end, the Department spends about $15 billion a year on petroleum fuels for military operations – about 2% of our total budget – and more than $1 billion on initiatives to improve operational energy use. Almost all of those initiatives are aimed at reducing the amount of fuel required in military operations.

As one of the world's largest consumers of liquid fuels, the Department does have an interest in diversification of our supplies, especially for our legacy fleet of ships and planes, which will be with us for decades to come. Since 2003, DoD has made a small but important investment in alternative fuels, mostly R&D by the military Services to ensure that defense equipment can operate on a range of alternative fuels. The Department has a policy of only purchasing operational quantities of such fuels if they are cost competitive with conventional fuels. References to per-gallon prices DoD is paying for alternative fuels refers to small quantities of test fuel purchased as part of R&D programs. Additionally, the Department is only looking to purchase drop-in alternative fuels for tactical use, and not ethanol or biodiesel.

On questions about the future of commodity markets and properties of various fuels, DoD relies on the expertise of the Department of Energy (DOE), the US Department of Agriculture (USDA), and the private sector.

The July 2012 Department of Defense Alternative Fuels Policy for Operational Platforms Alternative Fuels Policy, which governs military investments in alternative fuels, and other materials about energy programs at the Department of Defense, including a DOE rebuttal of multiple factual inaccuracies in this article, are posted at www.energy.defense.gov.

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Department of Energy Bioenergy Technologies Office Comments on Air Force *Strategic Studies Quarterly* Article, "Energy Insecurity: The False Promise of Liquid Biofuels"

General Comments

Although the author has done an extensive literature reading in the biofuels area, the paper does not have any analysis of critical issues of energy systems including petroleum systems and biofuel systems. Instead, it is a summary of literature. Furthermore, the summary of biofuel literatures in this paper has been tailored with literatures with negative points of views and results for biofuels. There are equally important, if not more important, literatures with credible analyses and objective results of biofuels, which were either overlooked or ignored by the author.

The author used energy return on investment (EROI) as a key indicator to advocate if an energy system should be invested in or not. If energy choices are made simplistically on the basis of EROI, society would eliminate electricity generation systems, since generation of electricity causes significant energy losses (for example, coal-fired electric power plants lose two-thirds of energy inputs). While the author presented the definition of EROI in a formula, he did not specify what energy types to be included in EROI calculations. Furthermore, the author did not calculate EROI himself for key energy systems that he advocated or opposed. Instead, he cited EROI values from various publications without realizing or by ignoring that scopes and system boundaries in the different studies he chose to cite could be very different. For example, the EROI values of 8:1 cited by the author for petroleum fuels do not include petroleum energy contained in gasoline or diesel. However, some of the EROI values he cited for biofuel systems appear to include renewable energy contained in biofuels. This major inconsistency in the paper caused invalid conclusions in the paper based on cited EROI values. The problem is clearly shown in Figure 1 with counterintuitive results for some of the energy systems in the figure.

The author was confused with present purchase prices of certain fuels for fleet testing versus the long-term goals of government biofuel research and development (R&D) investment. The present purchase prices reflect current production at very limited scale and limited technology advancement. Government R&D investments are intended to overcome key technology barriers so that in the long term biofuels can become vital national energy options. If one uses the status quo to decide what society should or should not do, many technology innovations and civilization advancements would not have occurred.

The author did not go to the level of understanding of quantitative results and conclusions of many of the literatures cited in the paper. This misinterpretation by the author, which occurs throughout the paper, resulted in invalid conclusions. For example, he quoted the total energy use that includes the energy in the biomass for algae-based fuel systems from Frank et al. Algae may be inefficient in converting renewable energy from sunshine to liquid fuels, but the earth is not limited by the solar energy it receives. On the other hand, the earth does have a finite amount of petroleum resources. The author fails to address resource depletion issues in comparing the petroleum energy systems and biofuel systems.

The author used the term "perpetual motion machine" to characterize biofuel systems. Biofuel systems work in reality in contrast to that mischaracterization because the author failed to take into account the solar energy that is inputted into biofuel systems. That is, biofuel energy systems are designed to convert low-quality, somewhat unlimited, solar energy into liquid fuel energy.

Some of the studies cited in the paper are out of date. Many citations in the paper are from web postings, which formal journal papers would not be allowed to cite.

Specific Comments

p. 115, 2nd para. Based on the congressional definition of energy security cited here, prices are not included in the definition, but the author inserted prices into his interpretation.

p. 123, the biodiesel's low energy density relative to petroleum diesel is a fuel property issue, not an energy security issue. Otherwise, one might argue that hydrogen and natural gas, among many other fuels, would have severe energy security issues.

p. 123, it seems that the author was confused by assuming that biodiesel would be hydrotreated to produce renewable diesel. In practice, oils from vegetation and animal fats, among other feedstocks, are hydrotreated to produce renewable diesel without going through production of biodiesel.

p. 125, the last line. The statement of "corn ethanol lifecycle GHG emissions more than triple those of petroleum fuels" is with exclusion of GHG emissions of petroleum fuel combustion.

p. 134–36, the section on water problems of biofuels.

The author proposed a "peak water" theory parallel to "peak oil." This is misleading because petroleum oil is extracted from an existing reserve and is not renewable; therefore, there could be a peak. Water, as we see it in rivers or ground water, is a part of the global hydrologic cycle, in which water is input as rainfall or snowmelt, consumed in a form of evapotranspiration by plants or evaporation through lakes, seas, rivers, and human activities, and then back to the atmosphere. In this hydrologic cycle, only a small fraction of water is lost when incorporated into a solid form. For example, water could be trapped with oil sands in a large retention pond of an oil field. Separation of water from the oil sands slurry in the pond is expected to take 100 years.

Water consumption and water footprint. The author appears confused between two basic concepts: water consumption and water footprint and selectively compared results from one to the other. Water consumption refers to the water consumed through a particular production activity/process or a stage in product life cycle (often to a specific water resource) while water footprint represents water consumed through a product life cycle (often for all the water resources). The two have a distinctive system boundary, methodology, and targeted resource and carry different meanings. Therefore, results from water consumption cannot be compared with results from water footprint. In an attempt to compare water consumption between various fuels, the author cited petroleum gasoline water footprint (ref. 96) and biofuel water footprint (ref. 97). It is important to point out that reference 96 is not a water footprint but a water consumption study focusing on two main stages of fuel production – fuel resource extraction/growing and fuel processing/production – for both gasoline and biofuels (from corn and cellulosic) and estimated surface and ground water consumption. Reference 97 is a water footprint study that focuses on green water (rain fall), blue water (surface and ground water), and grey water – which is a volume equivalency of the water required to dilute a certain amount of residue N fertilizer in rivers, not physically based consumption – for fuel life cycle. A comparison between the two data sets is inconsistent and meaningless. In fact, the blue water consumption comparison data required for petroleum gasoline and biofuel obtained under the same methodology is available in reference 96: conventional gasoline water consumption: 2.2-4.4 L/L ethanol BTU equivalent (US conventional), 11-160 L/L ethanol (corn), and 1.9-4.6 L/L biofuel (cellulosic). Unfortunately, the author chose not to use the data sets that derived from the same methodology for comparison.

Seawater desalination and argument. The author presented that current biofuel production cannot provide enough fuel to operate a seawater desalination plant. First, the desalination process operates on electricity as a fuel source, not ethanol. Second, current desalination plants produce fresh water for agricultural irrigation for food and human consumption, not for biofuels. Let us assume that biofuel crop is irrigated with desalinated water – which is blue water consumption or blue water use in the water footprint methodology. The water produced from the plant, 126-970 L/L ethanol equivalent of energy input, would meet the irrigation and process water requirement for biofuels produced in the U.S. Based on above section (3) (ref. 96), 11-160 L of blue water would be needed to produce a liter of ethanol - for corn ethanol produced from the regions responsible for 90% of ethanol in the U.S. After irrigation and process water consumption, there is still 115-810 L of desalinated water in excess per L ethanol produced. Therefore, in the U.S. Midwest, under the base case and current conditions, corn ethanol is able to not only provide enough fuel to power a desalination plant to produce water for irrigating the crop, but also contribute leftover fuel to power the vehicles. This is totally opposite of the conclusion drawn by the author. The key reason for the difference is that the author used the water footprint methodology results, where in addition to irrigation and process water consumption, rainfall and grey water (dilution water for chemical fertilizer residue) are included. Note that desalinated freshwater satisfies irrigation water needs, but would not displace rainfall, which contributes to a significant portion of the water footprint.

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AUTHOR'S REBUTTAL RESPONSE: March 1, 2013

The rebuttals from OSD and DOE are most notable for the points they do not dispute. The arguments raised in my *Energy Insecurity* article can be categorized as,

<u>The Seven Deadly Sins of Biofuels</u>:

1. crippling ***fossil fuel dependence***,
2. ***deficient EROI*** at scale,
3. ***poor quality*** (energy density, power density, infrastructure and engine compatibility, need for hydrotreatment, etc.),
4. ***huge environmental impact*** (land and water footprint, nitrate poisoning (eutrophication) and agrichemical runoff, irreversible conversion of and damage to biodiverse habitat),
5. ***higher lifecycle GHG emissions*** (when properly counting land use change and all N_2O, CH_4, and CO_2),
6. ***increased global instability*** (food competition, "green grabbing" land confiscation, displacement of native populations, pseudo-slave labor),
7. ***decreased energy security*** (higher cost, greater price volatility, annual production with no reserves, vulnerable to weather and crop failures, etc.).

Each one of these arguments by itself is fatal to the claim of biofuels as promoting national security. The longer version of the paper adds to these fatal flaws the vulnerability of current and future increased dependence on imported agricultural minerals, the historical perspective of what low EROI, retrograde, biomass-based civilizations look like, and the nation's history of fruitless encounters with biofuels. Of all the evidence against biofuels presented in my article, the rebuttals question EROI and water footprint. However, they critique only my computational methodology, not the underlying fact of massive disadvantage to biofuels.

It surprised me to hear that DoE does not consider fuel price or fuel density to be related to national security. The cost of energy is directly linked to stability of supply and to overall economic health. Energy density affects the fuel economy of vehicles and thus the number and length of convoys needed to supply fuel to the troops on the battlefield. The higher price of biofuels leaves less of the nation's GDP for sustainment and growth, and the lower density of biofuels would require more fuel trucks on the battlefield subject to ambush and IED attack.

I must admit I was not able to follow the logic of how rain on crops in the US Midwest reduces the energy required to desalinate seawater in Saudi Arabia. It was also disheartening to have the Department of Energy confuse the thermal efficiency of a power plant for the EROI of a fuel. In contrast to both rebuttals, my article is an attempt to be straightforward and transparent so those interested in this issue will not be intimidated by jargon, but instead retrace my research for themselves.

The remaining criticisms simply misquote the paper. Careful readers—those truly willing to explore the 6,000 words of endnotes as well as the 9,600 words of the text—will discover how the government's own reports and university studies in peer-reviewed journals across the four disciplines of physics, chemistry, biology, and economics converge to paint a coherent and damning portrait of biofuels.

The best accuracy test of any theory or worldview is whether it is predictive. Since the final version of my article a month ago, two new studies documenting the environmental damage of biofuels within the United States have been released.[1] And the only US enterprise to ever sell cellulosic ethanol for EPA Renewable Fuel Standard RIN credits has filed for Chapter 11.[2] Now I leave it to the SSQ audience to dig deeper and decide for themselves—are Biofuels an empty promise?

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[1] See 1. Wright, C. K., and M. C. Wimberly. "Recent Land Use Change in the Western Corn Belt Threatens Grasslands and Wetlands." *Proceedings of the National Academy of Sciences* (February 19, 2013). doi:10.1073/pnas.1215404110; and 2. Faber et al., and Defenders of Wildlife. "Plowed Under." Environmental Working Group, February 2012. http://static.ewg.org/pdf/plowed_under.pdf.

[2] Susanne Retka Schill. "Western Biomass Energy in Chapter 11 Reorganization." *Ethanol Producer Magazine*, February 12, 2013. http://www.ethanolproducer.com/articles/9549/western-biomass-energy-in-chapter-11-reorganization.