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Biofuels, Neither Saviour nor Scam

The Case for a Selective Strategy

Suzanne Hunt

Many people had never heard of biofuels two years ago, yet now they are receiving a lot of publicity—much of it negative. Initially, political and business circles touted the potential benefits of biofuels; it was a speechwriter's dream. Here was an energy source that promised jobs, rural revitalization, and greater independence from foreign oil producers.

At a time of growing anxiety over global warming, biofuels promised a clean, liquid transport fuel that would help reduce levels of greenhouse gas emissions. According to the Intergovernmental Panel on Climate Change Fourth Assessment Report in early 2007, an estimated 1.8–4 degree Celsius rise in global temperatures is likely by the end of the century, if no dramatic change in energy supply and use occurs globally. The report further confirmed that, given the current state of scientific knowledge, it is 90 percent certain that the emissions caused by humans are responsible for the increasing warming of the planet's surface. Studies of climate patterns conclude with increased certainty that a continuing rise in greenhouse gas levels in the atmosphere will most likely result in a variety of alarming—and quite possibly catastrophic—climate impacts.

In European Union member states, Japan, and a number of other countries that have signed the Kyoto Protocol, concern about climate change has been a powerful policy driver for the biofuels industry. (Currently, transport fuels account for about a quarter of energy-related greenhouse gas emissions.)

Meanwhile, with soaring gas prices and U.S. troops engaged in a war overseas, biofuels promised the added benefit of a secure, domestic energy source. The global transport system is almost entirely dependent on petroleum derivatives, and thus highly vulnerable. Leaving aside the complicated question of peak oil, a number of factors increasingly make reliance on petroleum a risky proposition: petro-states such as Iran and Venezuela may threaten to cut production, continued conflict in the oil-rich Middle East may impede the flow of oil, and low global refining capacity creates dangerous bottlenecks in the current fuel system that leaves us susceptible to natural disasters and malicious attacks.

Add to this a moral component: the world is all but certain to struggle with the intertwined challenges of energy security and climate change, but it is humanity's poor who will suffer most, as they tend to live in regions most vulnerable to extreme weather events, often lack the means for secure shelter and transport, and are most affected by increased food prices and shrinking energy supplies. Globally, some 2.4 billion people rely on traditional biomass sources (firewood, oil, coal) for energy; and some 1.6 billion lack access to electricity. Without new energy solutions, 1.4 billion people will still lack electricity by 2030, the majority living in South Asia and sub-Saharan Africa. Some regions, notably

the Caribbean, are almost completely dependent on imported petroleum for all of their energy needs. In these regions, even small amounts of domestically-produced biofuels can help diversify fuel options, thereby reducing risk and vulnerability.

With all these potential benefits, the biofuels market has grown by leaps and bounds over the past few years. There were some voices of caution during this giddy growth period, but they were largely unheeded. Just as popular sentiment had moved behind biofuels, it abruptly shifted course at an equally dizzying pace. The speed of the sea change in public opinion was shocking. Biofuels went from national savior to deadly scam in a matter of months. As wheat, corn, and rice prices reached new peaks this spring, the food riots that spread through poorer countries in Asia, Africa, and the Caribbean have been increasingly linked in public debate to biofuels.

Biofuels are neither a panacea nor a scourge. It is a valid concern that increased farming and production of biofuels are beginning to add pressure to stressed natural systems and failing social systems. It is clear that we need to develop energy alternatives, and quickly. The first and generally most cost-effective option is, and always should be, to reduce the consumption of petroleum through much more aggressive efficiency requirements, the development of light-weight materials for cars and trucks, improved battery technologies, new energy storage mechanisms, and the promotion of public transport. Biofuels belong within this portfolio of solutions. In total, biofuels today account for less than 2 percent of liquid transport fuels. This may seem like a small share, but biofuels have met about 30 percent of the growth in global demand for liquid transport fuels over the past three years. That is a significant contribution to the balance of the market.

In the European Union, for example, the 27 member states are currently required by law to meet volumetric biofuels targets. A target approved in 2003 stipulated that 5.75 percent of member states' fuel supplies must be composed of biofuels by 2010; this was followed in 2007 by a blending mandate calling for renewable fuels to make up 10 percent of transport fuel supply by 2020. But if the member states revoke this requirement, as a growing chorus suggests—rather than attaching sustainability standards—they will have no influence over how biofuels are produced.

With biofuels, as with all energy resources, there are trade-offs and risks, but there are also opportunities. The challenge today is to deal rationally with this energy source by developing effective safeguards against the risks and capitalizing on the social and environmental opportunities.

A Biofuel Primer

The two most common biofuels today are ethanol (made from starchy crops like sugarcane and corn) and biodiesel (which is generally derived from vegetable oils or animal fats). Ethanol is either blended with gasoline in low concentrations as an oxygenate or used at higher concentrations in Flex Fuel Vehicles (FFVs) that are designed to run on either unleaded gasoline or any blend of up to 85 percent ethanol. In the United States today, about half the gasoline sold at the pump is already 10 percent ethanol. Biodiesel can be used in diesel engines in either its pure form or as a blend with conventional diesel fuel. While these fuels hold significant potential to reduce greenhouse gas emissions and curb the global appetite for carbon-based petroleum products, there is now some concern over the emissions produced in the growing and refining of these fuels, as well as land-use issues, and their complex effect on food and grain prices.

But a second generation of advanced biofuels holds enormous potential to break through some of the key limitations of current fuels.[1] Advanced biofuels (biobutanol and synthetic diesel, for example) and other biofuels derived from switchgrass, garbage,

and algae are now under development in America, Europe, China, and elsewhere. Meanwhile, new conversion technologies are expected to expand production potential by allowing for the use of an array of non-food biomass sources, which will greatly improve net greenhouse gas emissions and generate other positive environmental impacts.

Ethanol use, today's principal biofuel, has grown by some 12 percent annually over the past seven years, more than doubling its production. Still, biofuels currently account for less than 2 percent of global transport fuels and well below 1 percent of world agricultural land. Most ethanol is produced in the United States and Brazil, which together account for three-quarters of world output. In Brazil, ethanol comprises nearly 50 percent of the fuel at the pump. The United States produces more ethanol than Brazil, but total percentage at the pump domestically is still less than 5 percent, due to our massive fuel consumption. Biodiesel production has grown by 700 percent since 2000—largely in Europe—but total volume is still only about 10 percent of global ethanol production.

In the broader scope of global biomass utilization, liquid biofuels for transportation are but a tiny fraction of the whole. The majority of organic matter (or biomass) is used for animal feed, food, consumer goods, and building materials, with only a small percentage devoted specifically toward energy generation—and even less used to produce liquid biofuels.[2] Still, there is considerable concern over the global rush to produce biofuels and it is critical to disaggregate the true issues from the din of the debate.

Concern #1: Food Prices

Perhaps the most emotionally charged aspect of the developing debate concerns the link between biofuels and food prices. While many have been quick to blame biofuels for current high commodity prices, the true picture is inherently more complex. As a report by the International Energy Agency notes, "it is true that increased use of biofuels has contributed to recent increases in grains and vegetable oils. But other factors, such as recent droughts and surging demand for meat and milk products in Asia have probably played a significantly larger role." A closer look at current key drivers of food prices is instructive.

For a start, soaring petroleum prices have contributed to record-high fertilizer and diesel prices for farmers, with spillover increases in the costs of production, packaging, and distribution that continue along the chain from farm to supermarket. Further, there has been a shift towards high-protein diets in fast developing countries, notably China and India. Meat production has thus increased, and as livestock numbers have swelled, greater inputs of feed and grain are required. It is commonly forgotten that approximately 40 percent of the world's grain is used to feed animals, not people. Add to this relatively low inventories of key commodities such as wheat and corn—in part due to severe droughts in major wheat producing countries, such as Australia—and it is easy to see why the global market now faces low supply and high demand. Finally, as the majority of commodities are traded in U.S. dollars, a weakened currency has made imports more expensive. Speculation in the oil market (and some believe in the food commodity markets) is also driving up prices.

But to fully disentangle the biofuel reality from the current debate, it is also important to differentiate between commodities. Many of the recent food riots across the globe have been in protest of spiking rice prices. Rice, though, is not used to make biofuels, nor is the land in which rice is grown generally suitable for such biofuel crops as corn and soy. Of the 13.2 billion hectares of the global total land area, 1.5 billion hectares are used to produce arable crops and 3.5 billion hectares are used as pasture for meat, milk, and wool

production. Crops currently used specifically for biofuels utilize about 25 million hectares of land worldwide, only about 0.5 percent of agricultural acreage. In Brazil, for example, ethanol produced from sugarcane (which constitutes nearly 50 percent of total gasoline demand) is grown on just 1 percent of the 320 million hectares of arable land and pasture.[3]

In the U.S. market, about 25 percent of corn production currently is used for ethanol, slightly more than the amount of corn that the United States exports. Globally, ethanol and biodiesel production now consume about 4 percent of the world's grain. This would suggest that biofuels produced from food crops have a similarly small influence on grain prices, a fact recently seconded by economists at the U.S Department of Agriculture.[4] Currently, there is little flexibility in commodity markets, and, with inelastic supply and demand curves, short-term disproportionate impacts and price fluctuations are increasingly common. As the National Resource Defense Council's Nathanael Greene put it, "economic modeling confirms that biofuels are a modest part of the food price picture." Nevertheless, although analyses show that currently biofuels are not a significant cause of food price increases, rapid growth in grain use for biofuels in the future may become an important factor.

Concern #2: Land-use

One of the latest rounds in the biofuels debate centers on greenhouse gas emissions from indirect land-use changes. Currently, biofuels are made predominantly from food crops. But while biofuels account for a small fraction of total agricultural acreage, new fields and land are being cleared to produce biofuels and meet market demand. Increased cultivation adds pressure to already stressed ecosystems, requiring more land, water, and other natural resources. Perhaps the most urgent risk is the threat posed to native ecosystems, such as forests, that store massive amounts of carbon. In addition to disturbing wildlife, soils, and hydrological and nutrient cycles, the conversion of rainforest and native prairies to agricultural land releases enormous amounts of carbon—both from burning vegetation to clear fields and from tilling soil.

While current policy mechanisms are relatively efficacious in mitigating the direct impacts of biofuels production (for example, water pollution regulations on agricultural production in the United States would also apply to biofuels production), indirect impacts present a significant challenge, both to scientists and policymakers. Take one example: if American farmers begin to plant more corn for biofuels and less soy, it is likely that the global soy price will rise, creating added incentive for farmers in other parts of the world to increase soy production. Increased production can be achieved by increasing yields, expanding into new land, or substituting for other crops. The effects can be deleterious: increased pesticides and chemical inputs, wholesale clearing of land and native forests for biofuel feed-stock cultivation, and crop displacement can dramatically increase greenhouse gas emissions. Thus, the calculus for assessing the indirect impact of, say, the growth in U.S. corn production for ethanol on global agriculture—and the associated greenhouse gas emissions—are enormously complex.

Recent articles in the authoritative journal *Science* on greenhouse gas emissions from land-use change caused indirectly from biofuels production have received wide attention. These articles have argued that virtually all biofuels produced today will result in more, not less, greenhouse gas emissions than the current use and production of fossil fuels. This has focused attention on a key issue, but it is important to realize that this field of research is very new—these studies are among the first ever peer-reviewed articles attempting to quantify greenhouse gas emissions impacts of indirect land-use

changes. As such, many of the underlying assumptions are being questioned and the adequacy of the models and datasets used are being challenged. Numerous research efforts are underway around the world to better understand these land-use and greenhouse gas emission dynamics.

Thus, while biofuels offer significant potential for greenhouse gas emission reductions, there are risks. Even among current types of biofuels there exists a wide range in net emissions impacts. Some may indeed generate net increases in greenhouse gas emissions. Thus, it is critical that, as our understanding progresses, we begin to take a full life-cycle account of biofuel agriculture and production, including direct and indirect land-use changes, feed-stock type, agricultural practices, energy replacement options, conversion and refining processes, and end use. Putting aside for a moment the potential greenhouse gas emissions from indirect land-use change, conventional corn-based ethanol is believed to produce roughly 15–35 percent net greenhouse gas emission reduction; soy-based biodiesel results in a net greenhouse gas emission reduction of 30–50 percent; cellulosic ethanol generates net greenhouse gas emissions reductions of 70–90 percent; and Brazilian sugar cane ethanol reduces net greenhouse emissions by 80–90 percent. These are considerable gains.

Moving Forward

As petroleum-based fuels still dominate global markets, alternative sources require a significant push in order to gain a foothold. Biofuels are multi-sectoral products that require a much higher degree of logistical coordination and more sophisticated planning. They must integrate into agricultural and forestry systems with appropriate agronomic and harvesting practices. They require appropriate collection, production, distribution, and end-use infrastructure (i.e., compatibility with automobile engines and manufacturer warrantees, ability to blend with other fuels, appropriate fuel pumps, distribution systems, pipelines, etc.). But this is the simple stuff. Biofuels production affects the transport and energy industries, agriculture and rural development, and global trade—all of which make the policy environment inherently complex. And, as public pressure is stoked by an increasingly shrill debate, the political stakes of biofuel policies are raised.

In much of the developing world, biofuels industries are in their nascent stages and regulatory regimes have yet to be developed. We can, however, use lessons learned in the handful of countries that maintain well-developed biofuels industries. While experiences in Brazil, the United States, and Europe over the past few decades are not necessarily transferable to other regions, they can be instructive. Voluntary or mandatory blending targets have been a powerful means of instigating and accelerating the development of biofuels industries. Mandates have been accompanied by various combinations of tax incentives, preferential government purchasing, and other price supports. For example, in the much studied Brazil experience, the government is requiring that the state oil company, Petrobras, preferentially purchase biodiesel feed-stock from small farmers. Government-supported research and development, grants, loans, guarantees, and other direct financial supports have also played an import role in biofuels development. And public-private partnerships have proven very effective. In the United States, for example, the Department of Energy spent roughly $1 billion in 2007 with the goal of helping companies develop next-generation biofuels technologies and bring processes and products to the market.

The risk that biofuels production will cause environmental harm has prompted a range of sustainability assurance efforts. Individual government efforts in Europe (especially in the Netherlands, the United Kingdom, and Germany) have lead to more coordinated effort including proposed EU-wide mandatory sustainability requirements

for biofuels. In 2005, the advanced industrial nations comprising the Group of Eight (G8) called for the creation of a Global Bioenergy Partnership (GBEP) to facilitate international collaboration on bioenergy and energy security, food security, and environmental sustainability. While achieving consensus among the member governments of GBEP has been difficult, the development of a sustainability assurance framework is underway. Notably, GBEP's greenhouse gas accounting task force has provided a vital forum for scientists and governments from member countries to share strategies to measure and account for the greenhouse gas emissions implications of biofuels. These efforts have informed new proposed European legislation that will likely feature a list of compulsory "sustainability criteria," including land-use and biodiversity requirements: for example, biofuels and other bioliquids would not be made from "raw materials obtained from land with recognized high biodiversity value" or from land with high carbon stocks. At the time of writing, a 35 percent or higher greenhouse gas emissions reductions requirement for biofuels was also being debated.

Sustainability is also being discussed is the International Biofuels Forum (IBF), a collaboration platform for the world's biggest biofuels producers and consumers: Brazil, China, India, South Africa, the United States, and the European Union. These nations are beginning to turn their attention to the need to develop sustainable biofuels. However, their efforts to date have primarily focused on international biofuel market development and the harmonization of technical standards and codes.

In addition to the ongoing multilateral discussions, a number of bilateral agreements have been signed between countries to advance biofuels development. The United States and China, Germany and China, and the United States and Brazil, have all signed bilateral memorandums of understanding related to the sustainable development of biofuels, and to foster collaboration around advanced production and market expansion. But there are as yet no international, multilateral binding regulations for biofuels that address such potential negative social and environmental impacts of biofuels as habitat conversion, water and air pollution, and land-use conflicts.

The primary concern is that, without international standards and cooperation, a biofuels free-for-all could develop that would pay little regard to sustainability and environmental concerns. Due to the rapid growth of the biofuels industry, and in the absence of strong national or international policy frameworks, a number of approaches to building a robust and sustainable global industry have been suggested, including several non-traditional policy options. One option is the creation of a multilateral environmental agreement (MEA) for biofuels. However, given the non-binding nature of such agreements, the standards are not likely to be rigorous. Another way forward would be to integrate sustainable biofuel standards into existing international systems like the International Standards Organization (ISO) which has traditionally focused on certifying technical standards for industry but has some sustainability focused initiatives. The European Standardization Organization (CEN) is exploring the role that ISO might play in sustainability assurances for biofuels and has recently launched its own EU "Sustainable Bioenergy Standards" initiative.

Adding to the effort, in March 2008, a Sustainable Biofuels Consensus was developed by a group of global specialists at the Rockefeller Foundation Bellagio Center in Italy. These experts crafted a vision for the sustainable production, use, and trade of transport biofuels and made a number of specific recommendations to policymakers. (Full disclosure: I was among the specialists invited to contribute to the Bellagio group.) The Consensus recommends better integrating and coordinating national policy frame-

works; rigorously assessing and mitigating negative impacts of biofuels trade, use, and production; building a system to reward positive impacts and investments; encouraging informed dialogues to build consensus for new projects; increasing investment in research, development, and demonstration; and making sure that trade policies and climate change policies work in concert.[6] It is an ambitious but hopeful agenda.

The U.S. Biofuels Agenda

In Washington, the bioenergy bonanza has led to a series of new legislation regarding biofuels, but little in the way of comprehensive sustainability requirements. The Renewable Fuel Standard (RFS), made law with the signing of the Energy Policy Act of 2005, called for the addition of more than 7.5 billion gallons of ethanol and biodiesel to the U.S. fuel supply by 2012.[7] (The ethanol industry has expanded so rapidly, however, that it is expected to exceed the 7.5 billion gallon target by late 2008.) Subsequently, in an early 2007 executive order, President George W. Bush called for 35 billion gallons of biofuel production by 2017. This was superseded, at the close of 2007, by congressional passage of the Energy Independence and Security Act (EISA) which created an expanded RFS and called for 36 billion gallons of "renewable fuel" by 2022.[8]

The 36 billion gallon RFS mandate does not include comprehensive mandatory sustainability standards; however, it does include requirements that biofuels meet certain emissions reductions levels compared to gasoline and diesel fuels. But this science is still quite new: the Environmental Protection Agency is currently in the process of drafting new rules and must soon decide on greenhouse gas accounting methodologies. The federal EISA does require that indirect land-use impacts be included in life-cycle (i.e., production, transport and use) calculations. However, all biofuel facilities built before the law was written are grandfathered in, and do not have to meet these life-cycle greenhouse gas emissions reductions.

Complicating the picture, a national regulatory framework for biofuels is mired in a legislative morass. Biofuels subsidies (like the volumetric ethanol excise tax credit) and new proposed agricultural legislation will have a significant impact on biofuel production, as crop subsidies traditionally contained in the Farm Bill directly affect volume and prices for key biofuels feed-stocks. The existing farm legislation was adopted in 2002, and efforts to pass a new bill in 2007 failed. By spring 2008, Congress had finally passed a new Farm Bill and overrode a veto by President Bush, who cited opposition to increased subsidies for farmers at a time of spiking food prices.

Nonetheless, various American states are moving forward, promoting aggressive and innovative biofuels-related policies. Many have approved blending mandates that require a certain ratio of biofuels to fossil fuels, and some states, like Minnesota, are developing independent sustainability standards. As the fifth largest economy in the world and an acknowledged leader in environmental policy, California's biofuels regulations should be given extra attention. In 2007, Governor Arnold Schwarzenegger's executive order established a Low Carbon Fuel Standard (LCFS) for transportation fuels in California, calling for a 10 percent reduction in carbon-intensity by 2020. This was the first significant policy in the United States designed specifically to reduce greenhouse gas emissions from transportation fuels and stimulate innovation in new, low-carbon fuels. The order requires companies that provide fuel in California to supply a mix of fuels that meet a declining standard of greenhouse gas emission intensity. The standard measures life-cycle emissions, including all emissions from fuel consumption and the intermediate steps of processing and production. While the standard mandates reductions, it allows choice: fuel providers may blend a low-carbon ethanol into

gasoline products or, say, purchase credits from power utilities to supply lower-carbon electricity for electric vehicles.

A similar rigorous standard is under serious discussion in several U.S. states, and is part of several measures before Congress. The California initiative has even been used as a model for recently proposed revisions to the Fuel Quality Directive in the European Union which would require mandatory monitoring and reporting of life-cycle greenhouse emissions from fuels as of 2009, and life-cycle greenhouse gases emission reductions of 1 percent per year from 2011 to 2020.

While there is undoubtedly progress toward opening up transport fuel markets to low-carbon transportation fuel, conflicting interests have prevented an efficient, comprehensive, long-term national policy. With commodity prices at historic highs and biofuels providing new markets for agricultural producers, many argue that there has never been a better time for comprehensive reform of agricultural support policies in the United States, and in Europe as well. Thus far, however, there has been considerable resistance to reform. Those benefiting from the current supports for petroleum, coal-to-liquid fuel technology, and agricultural commodity payments, for example, are fighting hard to keep these market-distorting supports in place.

But though legislation is in the works to enforce sustainability standards, the key component is incentivizing the market for green fuels. If we are serious about transitioning to a national low-carbon fuel system that does not threaten the stability of the global climate, we must begin rewarding domestic clean energy sources, healthy food, clean air, productive soil, intact ecosystems, and must create financial disincentives for highly concentrated, vulnerable, petroleum-reliant energy systems, and highly polluting fuels.

The federal RFS is a big step in the right direction. Performance-based policies (like California's Low Carbon Fuel Standard) can help accomplish this goal. But, realistically, we will need a combination of less prescriptive, more effective, and innovation-fostering policies at the national level. Yet we must first remove or revise policies which create perverse fiscal incentives in existing markets. As such, it would be prudent to phase out subsidies for less-sustainable biofuels (such as conventional corn-starch ethanol) and refocus on incentives to bring second-generation biofuels to market (such as cellulosic ethanol made from corn cobs, or synthetic diesel made from municipal waste). These fuels have greater production potential, more benign environmental impacts, and can be made from feed-stocks that do not compete for prime agricultural land.

The Big Picture

The task of incorporating land-use impacts into regulatory and policy frameworks is a huge challenge. Indirect impacts from biofuel production can be destructive on a global scale, but how can we hold individual producers accountable for indirect impacts over which they have no control? And, if we must put in place wide-ranging policy frameworks, how do we design them so as to not strangle a promising industry?

One of the most important responsibilities is to make sure that we are considering biofuels in a broad context. The global agricultural frontier has been expanding rapidly, as forests are exploited and razed for marginal farmland or low-value pastureland. Indeed, according to the Intergovernmental Panel on Climate Change, agriculture is responsible for an estimated 14 percent of global greenhouse gas emissions, while deforestation, much of it carried out to clear land for agriculture, accounts for another 17 percent. While biofuels are not the cause of these worrisome trends, we must make sure this new fuel source becomes part of the solution, not the problem. Biofuels are increasingly being seen as the culprit, but

these are broader, long-term challenges that require much more comprehensive solutions.

It is generally assumed that, as new and tougher limits on greenhouse gas emissions are enacted by governments, new market opportunities for environmental action—especially carbon emissions reductions and sequestration—will be created. (Sequestration refers to activities that remove carbon from the atmosphere.) Most emission reduction efforts to date have focused on energy providers and heavy industry. Because the agriculture sector has never been asked to reduce its greenhouse gas emissions, there exists a lot of "low-hanging fruit"—inexpensive, attainable gains—such as the implementation of advanced tillage and other agronomic techniques that build carbon in the soil, and the reduction of chemical nitrogen fertilizer use. These practices can help ensure that future biofuels production and agriculture meet sustainability targets. Increasingly, agricultural groups recognize this opportunity and are lobbying for favorable policies, such as carbon credits for sustainable agriculture practices that can be traded for profit on the open market. Reliable verification systems must be developed so that farmers, agricultural companies, and landowners get credit for true emissions reductions and sequestration. With further development of financial incentives to reduce greenhouse gas emissions, one can envision a myriad of win-win situations, and better financial opportunities for farmers.

Agriculture needs to be better integrated into domestic climate policies and included in international negotiations. Payments for avoiding deforestation could monetize environmental services and incentivize the preservation of natural ecosystems (forests, wetlands, and prairies). This may be more effective than mere punishment and summary legislation. In other words, we need to change the harsh reality that until these resources are more valuable intact than destroyed, the razing will continue.

Building a clean energy infrastructure, promoting greenhouse gas reductions, and ensuring plentiful and cheap food are daunting challenges, but they also present opportunities for new markets, new technologies, and new product development. Biofuels will play a role in a resilient, clean energy future, but we need smart policies and responsible, sustainable business practices.

The most egregious scam on the American people is not biofuels. Rather, it is the myopic debate that distracts from the larger issues at hand: our current agricultural, energy, and transport systems are failing and putting us at risk by threatening the global climate. Human innovation, forward-thinking legislation, and collective action will be our saviors, not the fuel flavor of the day. ●

Notes

1. Sugarcane-derived ethanol and biodiesel from palm oil are exceptional among first-generation fuels for greenhouse gas reductions and productivity.

2. Biofuels account for only a small fraction of total bioenergy use, most of which is derived from solid biomass (wood, dung, charcoal) burned for heat. Estimates are that 90 percent of the current bioenergy use is for such "traditional" applications.

3. By-products of biofuel crops are frequently used for animal feed, fertilizer, and electricity. In sugarcane ethanol production, for example, after sugar juice is extracted from the cane, the remainder (called bagasse) is burned to produce electricity.

4. A more complete discussion is available at www.ers.usda.gov/Publications/WRS0801/.

5. The Consensus is available at www.sef.org.nz/views/Sustainable_Biofuels.pdf.

6. Available at www.epa.gov/otaq/renewablefuels.

7. Available at http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.00006.