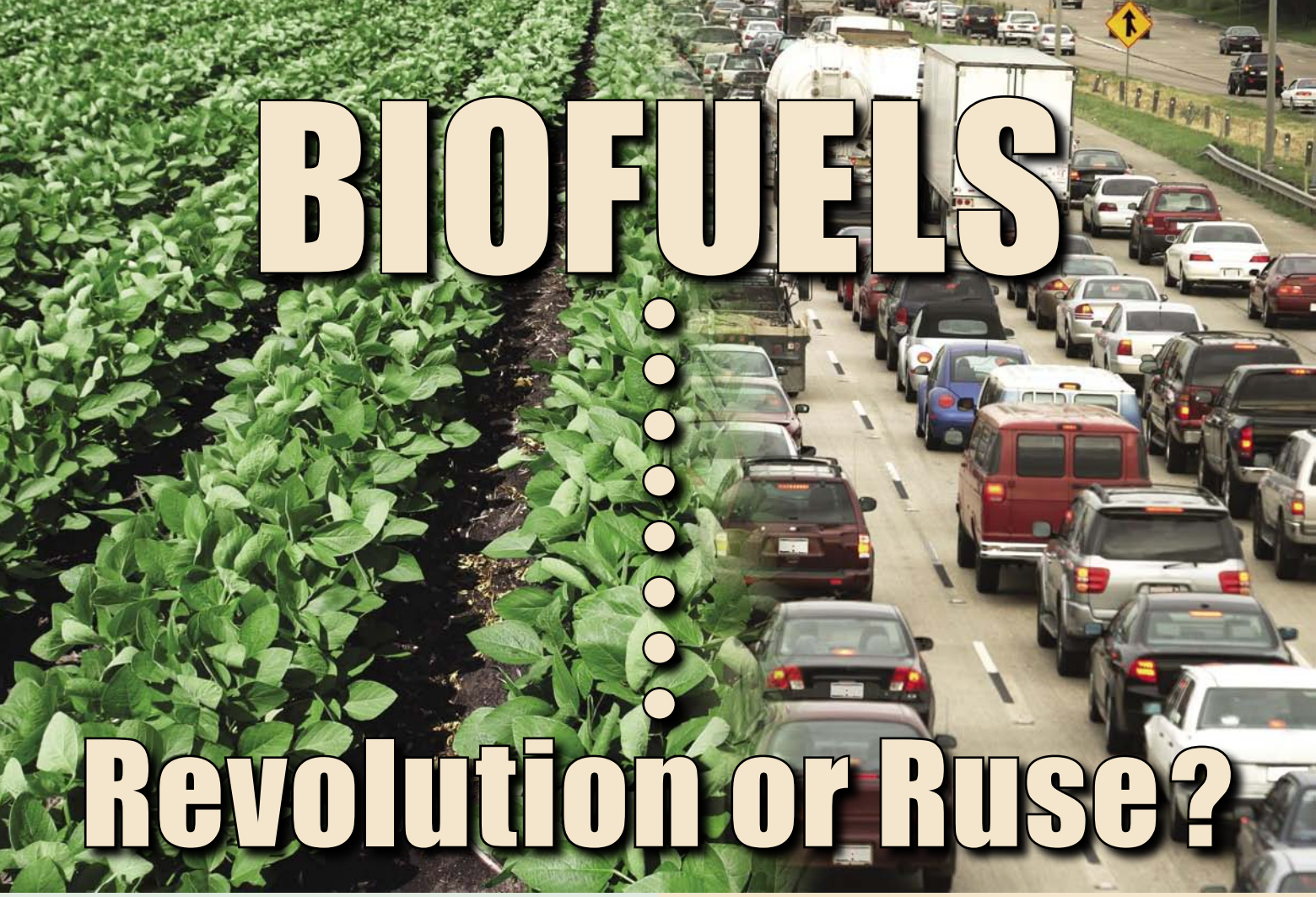


BIOFUELS
Revolution or Ruse?

David Max

Biofuels are concisely defined as "fuels, such as methane, ethanol, and biodiesel, that are produced from renewable resources, especially plant biomass and biobased industrial wastes." The biofuels that gain most of the headlines in the United States are biodiesel produced from soybeans, and ethanol produced from corn. Producing and using biofuels accomplishes multiple goals, including cleaner emissions, domestic energy security, and diversified energy production.

According to the National Renewable Energy Laboratory (NREL), biofuels contain significantly more energy than is used in their production. In contrast, both gasoline and diesel require more energy to produce than they contain.

Net Energy of Fuels

Fuel	Energy Out / Energy In Ratio	Percent Gain/Loss
Biodiesel	3.20	220%
Ethanol	1.40	40%
Diesel	0.89	-11%
Gasoline	0.85	-15%

Source: NREL

Richard Engel

In his book, *In the Absence of the Sacred*, author Jerry Mander claims that too little critical dialogue in society takes place over the introduction of new technologies. And what dialogue does take place is generally controlled by those with a vested interest in seeing the technology adopted. I'm afraid this scenario is being acted out once again in the realm of biofuels.

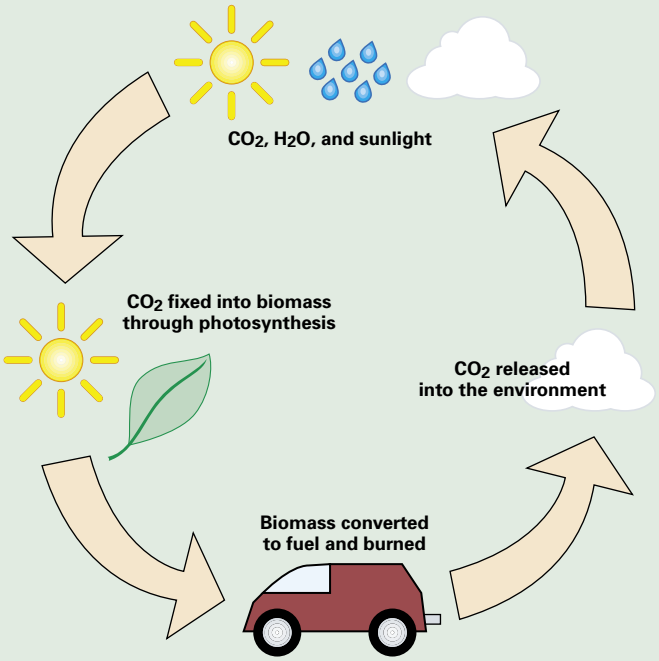
Many agribusiness interests, supported by some well-meaning environmentalists and renewable energy enthusiasts, are promoting biodiesel and other plant-derived fuels as a magic bullet that will enable a smooth transition out of the fossil fuel era. Biofuels certainly can offer some benefits, but serious problems may arise as we start using these fuels on a larger scale.

Much of the dialogue on the sustainability of biofuels derived from "virgin" plant feedstocks begins and ends with the issue of energy return on energy invested, or EROEI. This is the ratio of how much energy a fuel yields to the nonrenewable energy invested to create or obtain that fuel. An EROEI value of 1 means a fuel is just yielding back the invested energy. An EROEI less than 1, where more energy is invested than is derived, is not a sustainable long-term investment.

David Max, continued

Biodiesel and ethanol produce cleaner emissions than their petroleum counterparts. Carbon dioxide (CO_2), carbon monoxide, and particulate emissions are all reduced. Moreover, biofuels are CO_2 neutral—CO_2 released during combustion is equal to CO_2 sequestered by crops and biomass during the growth stage. While current petro-based agriculture emits CO_2 during production, using biofuels for crop production instead would create a completely CO_2 neutral process. None of this beneficial CO_2 recycling occurs when petroleum is burned and extracted.

The Biofuel Carbon Cycle



Unfortunately, existing biofuel production cannot meet transportation fuel demands. Using current feedstocks and production technologies, total biodiesel and ethanol production is less than 4 billion gallons per year. U.S. Department of Agriculture and Department of Energy research suggests that by using highly efficient cellulosic ethanol and planting more efficient forms of biomass, like high-yielding, low-input perennial switchgrass and by using crop residues, 30 percent of the gasoline we consume could be replaced by ethanol. Brazil replaces almost 40 percent of their total gasoline consumption with domestically grown and cheaper-to-produce ethanol from sugar cane.

By combining all available vegetable and animal waste fats, appropriate oilseed cultivation land, and higher yielding crops, present biodiesel production technologies could fulfill 20 percent of our diesel fuel needs. For example, mustard and canola yield higher oilseed per acre than soybeans.

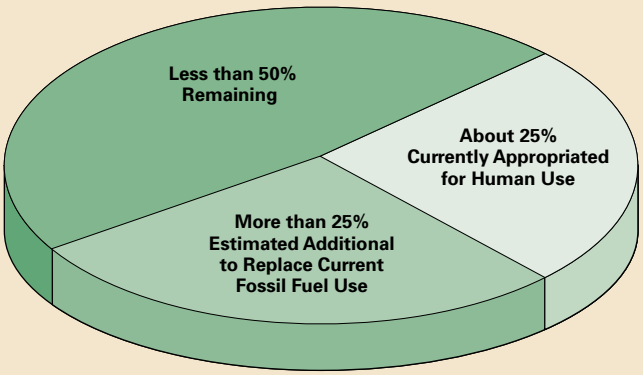
Richard Engel, continued

Prior to 1950, petroleum offered an impressive EROEI on the order of 100. Having retrieved the "easy" oil decades ago, petroleum's EROEI is now about 20 and falling. EROEI for biofuels varies widely depending on the feedstock, the extraction method, and other variables. I've recently seen estimates ranging from about 0.7 (definitely unfavorable) to more than 2 (pretty good). It appears likely that corn-derived ethanol has a favorable EROEI under certain conditions, but overall the energy balance for biofuels remains controversial.

Energy calculations do not tell the whole story about biofuels. Are the planet's non-energy resources—soils, land, water—capable of indefinitely supporting billions of humans dependent on biofuels? Each year, humans consume an estimated 20 to 30 percent of the planet's annual net primary productivity—what plants produce using the sun's energy. This is in addition to our rapid drawdown of the planet's "savings account" of fossil fuels.

Dr. Jeffrey Dukes, Assistant Professor of Biology at the University of Massachusetts–Boston, estimates that transferring our fossil fuel dependence entirely to plant sources would demand more than a quarter of our planet's annual plant growth, meaning that humans would be gulping down more than half of the planet's primary productivity each year.

Global Net Primary Production (NPP) from Photosynthesis



Consider freshwater, already widely predicted to be the most hotly contested resource of the twenty-first century. Humans currently appropriate some 26 percent of the global flows of freshwater, using about nine-tenths of this for agriculture. Could we tolerate a doubling of this resource use?

Global cropland resources may be even more strained, having shrunk by half to 0.23 hectare (about half an acre) per person over the past five decades. Apart from stresses due to population increase, the decline in per capita cropland is

David Max, continued

They are also great rotation crops for grains, improving the soil and breaking up pest cycles. With integrated crop management, the capture of biogas from waste agricultural residues, and wind production farms, we can grow clean energy for both rural and urban populations.

While cleaner emissions are a top priority, so is the efficient and appropriate use of land resources. According to research at NREL, the construction of high-oil-yielding algae farms to produce biodiesel feedstock has the potential to replace 100 percent of the petroleum fuel that we consume, while requiring less than 2 percent of the land space we currently use to produce all agricultural crops combined!

Researchers at the Massachusetts Institute of Technology (MIT) and within private industry are experimenting with methods of growing high-oil-content algae from flue gases emitted by fossil-fueled power plants. Incredibly, the algae reduce CO_2 emissions by 40 percent, and nitrous oxide emissions by 86 percent! Both oil and cellulose can be extracted from the algae, with the potential to produce 15,000 gallons per acre of both biodiesel and ethanol.

It has been said that the United States should be embarking on an "Apollo-like" push to research and finance renewable energy production and next-generation technology advances for efficient energy consumption. The expense and financing needed to construct this network would be enormous, but less than the total the United States has spent in Iraq. It would require innovation and research funding at universities and industry throughout the United States, and would have the potential to employ tens of thousands.

Consider the U.S. diesel passenger vehicle market, which is currently less than 4 percent of the total consumer market. In 1990, Europe's diesel passenger vehicle market was less than 10 percent. By 2005, it had grown to 50 percent. Why the popularity growth? Efficiency. Diesel engines are more efficient than gasoline engines in converting the energy contained in fuel into useable energy for the drivetrain.

Auto manufacturers have begun to see expansive new markets created by huge demand for hybrids and modern turbo-diesels in the wake of diminishing SUV sales. The Ford Expedition is on its way to extinction, and evolution has spawned Ford's first diesel-electric hybrid concept car, the Reflex. Volkswagen's latest prototype, nonhybrid diesel, the EcoRacer, is reported to get 69 mpg! Trucking companies are looking at diesel-hybrid systems that require higher initial investments, but offer significant fuel savings and cleaner emissions.

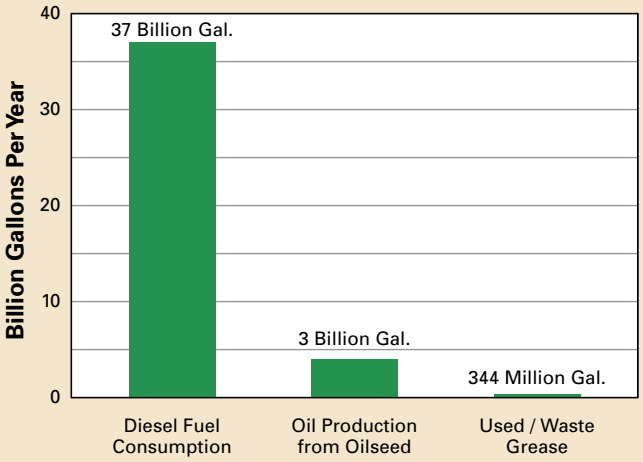
Biofuels hold the potential to offer cleaner emissions while using current fueling and vehicle infrastructure, despite obvious needs for increased efficiencies. Continued innovation in the production and utilization of these valuable resources can add multiple choices to our renewable energy portfolio. This could begin to not only move us away from fossil fuels, but also from fossil-fueled mind-sets.

Richard Engel, continued

driven by the abandonment of 20 million hectares (about 50 million acres) of cropland per year due to soil erosion and salinization. Where these croplands are replaced, it is generally through deforestation. Biofuels farming could greatly aggravate these conditions.

Many people tout biodiesel as a creative way of making use of used restaurant fryer fat. Yet in many communities, this "waste" is already being recovered to make products like soap, industrial chemicals, and animal feed. If such industries lose their feedstock to biodiesel production, they'll just turn to agricultural or petroleum sources, canceling any net gain in waste diversion or resource conservation. Growth potential for waste-derived biodiesel is also very limited. If we turned all of our waste fryer fat into biodiesel, we would meet less than 1 percent of current diesel fuel demand for transportation.

U.S. Diesel Consumption vs. Alternative Oil Supplies



Many biofuels enthusiasts wisely acknowledge that plant-derived fuels cannot replace petroleum on the scale we use today. They foresee biodiesel and ethanol playing minor roles as part of a portfolio of renewable technologies.

This is a healthy outlook, and we need to question biofuels policies that seek to make plant-derived energy a one-to-one replacement for fossil fuels or that send us back down the same road of dependence on unsustainable or imported energy sources. In November 2005, the United States received its first tankerload of foreign biodiesel, made from virgin Ecuadoran palm oil. Weren't we looking for *alternatives* to imported oil?

I'm willing to become a biofuels advocate if some emerging technology like cellulosic ethanol, derived from switchgrass, or algae-derived biodiesel proves feasible and sustainable on a large scale, but for now, I remain a skeptic. In seeking a measured approach to biofuels, I'll close by quoting environmental guru David Brower: "All new technologies should be assumed guilty until proven innocent."

Rebuttal by Richard Engel

During the several weeks since I started researching and preparing for this debate, some interesting experiences in the course of my daily work have got me rethinking biofuels. I participated in a conference call with biofuels researchers and a team who are trying to commercialize algae-derived biodiesel to fuel a major metropolitan bus fleet. I met with a former co-worker now engaged in the same MIT CO_2-capture project David cites. These ideas may someday prove technically and economically feasible, and I support continued biofuels research.

However, we need to keep our expectations realistic. Converting every acre of land in the United States to soybean production would replace barely half of our current gasoline and diesel fuel consumption.

The most important work in transportation energy really needs to happen on the demand side. When I see massive pickup trucks rumbling around town with one occupant and no cargo, many of them sporting pro-biodiesel bumper stickers, I think, "What's wrong with this picture?" We need to shift our emphasis to tried-and-true strategies like ride-sharing, using mass transit, building efficient vehicles, and creating walkable communities. If we put as much effort into these demand-side solutions as we do into clean fuels and other high-tech supply-side approaches, "peak oil" will be nothing to panic over.

A sustainable large-scale program for biofuels would have to:

- Use waste materials (such as crop residues and waste oil) as feedstock. Dedicated agriculture for energy crops produces too many negative impacts, including wildland habitat loss, displacement of essential food and fiber crops, and increased strain on already over-allocated soil and water resources.
- Be domestically based. The additional energy and emissions from transporting biofuels globally may cancel their benefits. Besides, ending dependence on foreign energy is purportedly one of the main drivers for biofuels development.
- Be linked with a serious plan to reduce overall fuel demand using the above strategies, among others.

I don't wish to suggest that there's no future for biofuels. But we must choose our path carefully to ensure biofuels live up to their proponents' claims of sustainability.

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Rebuttal by David Max

There are no magic bullets for replacing fossil fuel infrastructure worldwide. Instead, we must diligently and sustainably create a diverse renewable energy matrix to gradually wean ourselves from our overdependence on oil. Petroleum infrastructure has taken the last 50 to 100 years to create. Given the increasing speed of technological development (production and conservation), it could take another 30 to 50 years to transition to renewable energy resources.

I question the net energy gain/loss studies that Richard quotes; specifically, those that claim biofuel production is a net energy loser. Those studies were largely funded by the petroleum cartel, which has a vested interest in downplaying biofuels.

The agricultural production of biofuels has offered a starting point for the renewable fuel portion of the matrix, although admittedly, growing genetically modified, monoculture crops for biofuel feedstocks might offer less-than-desirable long-term sustainability. In building a renewable biofuel infrastructure, we must consider *all* of our options and, over time, move toward the most sustainable, long-term feedstock production methods. We need methods that not only consider net energy gains, but also the overall impact to our environment, placing economic value on soil and water conservation.

As consensus on world peak oil discoveries draws closer, all options to create locally distributed energy should be critically considered, with preference given to the most economical, sustainable, and cleanest technologies. Before (and after) this debate, I've strived to answer the question of what is truly sustainable. Industry across the globe must begin to move forward in a sustainable pattern. Otherwise, we will soon tip the scales of our own propagation, and that is only if Mother Nature doesn't do it for us first. Biofuels are not without their problems, and we should not throw caution to the wind. But we need good options for today, and also for the day after tomorrow.

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