



**Doing Biofuels Right:
Making Sense of the Great Biofuels Debate**

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March 8, 2010

Acknowledgements:

The debate on biofuels in Ohio, the U.S. and worldwide has been polarized, with each side putting forth dueling scientists and advocates in what seems more like a contest to score political points than to deepen public understanding. Clean Fuels Ohio's mission is to advance cleaner domestic alternatives to petroleum-based fuels. Our mission is explicit about curbing climate change. We also work with industry groups where our mission and specific business interests are aligned.

In producing this white paper, our goal is to present a fair and candid assessment of the role of biofuels and to examine controversial issues. We debunk some misunderstandings, identify fair criticisms, and present both sides of certain debates where the jury is still out. The biofuels debate is a moving target. This paper is only a snapshot in time. Concerns today may change quickly based on new research or discoveries.

I'd like to thank Clean Fuels Ohio's Board of Directors, particularly Tom Fontana from Ohio Soybean Council, Chris Gawronski formerly of Mid-Ohio Regional Planning Commission and Gary Scherer of Circleville Oil, for their help in reviewing and providing guidance in the development of this paper. Our Board, like other groups, has engaged in a healthy dialogue over biofuels and I expect this to continue after this paper is released. I also owe thanks to Clean Fuels Ohio's staff, especially Andrew Conley and Micah Vieux. I'd also like to thank many experts who reviewed and provided comments, including Dr. Matthew Roberts at The Ohio State University, Stacy Noblet of the Department of Energy's Alternative Fuel Data Center, Kristi Moriarty from the National Renewable Energy Laboratory, and Nathanael Greene from Natural Resources Defense Council.

Introduction:

Rising energy costs, security, climate change and job creation are four interrelated challenges of our era. America's addiction to petroleum, especially for transportation, lies at the heart of them all.

In 2006 the U.S. spent an estimated \$309.4 billion dollars on imported oil and refined petroleum products. The loss for 2008 was estimated at \$480 billion based on an average \$100 per barrel crude oil price.¹ While petroleum fuel costs have abated due to the worldwide economic downturn, high and higher costs will return – emptying family wallets and draining jobs from our economy.

The environmental costs of petroleum use are also staggering. Nearly 80% of all airborne cancer-causing emissions come from diesel engines.² About 50% of smog-forming emissions³ come from on and off-road vehicles burning petroleum fuels.⁴ Roughly 32% of global warming pollutants in the U.S. come from motor vehicles⁵.

The share of the world's oil found in the U.S. is shrinking. The U.S. has about 2.4% of known reserves while members of the Oil Petroleum Exporting Countries have about 75.5%.⁶ Although huge reserves of petroleum-like sources such as oil shale and tar sands exist in North America, they are expensive to extract and refine. They also are even more heavily saturated with carbon than oil and therefore present increased concerns for climate change. The same is true of liquid fuels made from coal.⁷

Many have suggested that biofuels are a solution. Rather than import petroleum, perhaps we could fill our tanks from fuels produced on America's farms. In early 2006 following President Bush's State of the Union address during which he famously said that America is "addicted to oil," media hype about biofuels reached a peak. General Motors' launched its "Live Green – Go Yellow" campaign during the Super Bowl and Winter Olympics. This campaign, along with other media and political hype about biofuels, contributed to the impression among some that biofuels, especially ethanol, might soon end America's dependence on imported oil.

Some industry supporters fueled the hype. One ethanol supporter from Iowa suggested that "...U.S. energy independence...could become a reality if U.S. lawmakers find ways to expand demand for fuels blended with homegrown sources like corn..."⁸

These exaggerations gave biofuels critics an opening. In the backlash biofuels were accused of having a "negative energy balance"⁹, increasing smog levels¹⁰, causing starvation among the world's poor¹¹, causing prices of corn tortillas and other foods to skyrocket¹², increasing the price of fuels¹³, depleting water supplies¹⁴, destroying wildlife¹⁵, increasing global warming¹⁶ and more. Biofuels were called a scam and a boondoggle based on subsidies and tariff protections¹⁷. Many critics singled out ethanol made from corn as particularly bad while praising "2nd or 3rd generation" biofuels feedstocks¹⁸. Other critics suggest all biofuels in any quantities are bad.¹⁹

Many supporters have responded in kind by hunkering down behind their positions, refusing to acknowledge that any criticisms of biofuels are valid. As Senator Charles Grassley (R-Iowa) famously remarked in a Senate proceeding, "In other words, it is as the Campbell's soup advertisement of 25 years ago: everything about ethanol is good, good, good."²⁰ In this polarized climate, it has been hard for fair-minded people to sort out the facts.

The goal of this white paper is to explore selected controversial issues surrounding biofuels. Both advocates and opponents of biofuels make valid points, and both are guilty of exaggerations and fallacies. Clean Fuels Ohio believes that biofuels can play a positive role – providing parts of an overall mix of energy sources for our motor vehicles while mitigating climate change and other environmental impacts. We also believe that biofuels can be destructive in many ways if poor choices of production methods are chosen or appropriate roles and scale are misunderstood. The stakes are high. "Doing biofuels right" is an essential part of an overall strategy to increasing energy security, strengthening our economy and mitigating environmental damage, particularly climate change.

Biofuels and Climate Change:

Biofuels are made from vegetation that is planted, grown, harvested, and replanted in a time span ranging anywhere from days to decades in contrast to millions of years required for formation of fossil fuels. Carbon dioxide (CO₂), which is building up in the atmosphere and contributing to climate change, is released when any carbon-based material, including a biofuel, is burned. It also is released in the process of cultivating and harvesting crops and manufacturing fuels. However, CO₂ is also absorbed by plant biomass when it is grown.

The critical climate change factor is “net” CO₂ emissions, or total CO₂ emissions throughout the production and consumption life cycle minus the CO₂ removed by biomass when it is grown. Net CO₂ emitted is a more complete indicator of the climate impact of any fuel. Dr. Michael Wang at Argonne National Laboratory developed the GREET model to attempt to measure and compare net CO₂ impacts of various fuels. For ethanol made from corn, Wang’s model estimated that net CO₂ emissions are about 10-30% less compared with gasoline²¹. Relying on the GREET model, others have asserted that net CO₂ emissions have improved some in recent years as newer ethanol plans coming on line are more energy efficient.²² For biodiesel Wang calculated net CO₂ emissions about 80% less than petroleum diesel.²³

Within the last few years, a significant group of scientists have argued that Wang’s GREET model and various “net” carbon studies don’t tell the full story because they account only for “direct” land use of biofuels, not “indirect land use change” (ILUC) impacts. In an article published in *Science* in February 2008, Tim Searchinger from Princeton University asserted that increasing global demand for biofuels is triggering a global chain reaction destroying rain forests and other natural lands²⁴. These scientists have said that raising global demand for biofuels creates powerful economic incentives for land owners, particularly in less developed nations, to convert fallow lands such as rain forests and savannas into farm lands for energy crops or food crops.

As these carbon storehouses disappear, sometimes by being burned, massive amounts of CO₂ are released. The sugar cane, palm, soy, or other energy crops planted in their place do not compensate for the loss of these natural carbon storehouses. Thus, Searchinger and like-minded colleagues say that biofuels make climate change worse because of the combination of direct land use and indirect land use changes.

Recent policy action has ratcheted up the controversy even higher. In April 2009, the California Air Resources Board (CARB) approved a low carbon fuel standard (LCFS)²⁵ that included accounting for ILUC. As part of the newly expanded Renewable Fuels Standard (RFS2), which requires 36 billion gallons of renewable fuels by 2022, Congress required the U.S. Environmental Protection Agency to consider lifecycle CO₂ impacts as part of its RFS2 rules. The EPA’s proposed rules, like the CARB LCFS, also required an accounting of ILUC-driven net carbon impacts as well as direct CO₂ emissions and reductions²⁶.

Biofuels supporters within the academic community have said that the science behind ILUC is premature at best. In a 2008 letter to USEPA seven biofuels researchers and industry experts write, “We strongly believe that a requirement to account for indirect land use changes in the legislation was premature, as there are generally no accepted methods for determining indirect land use change, or for that matter, any indirect (market-driven) change, and there is no way to apply even current methods in any meaningful way to the choices a farmer makes.”²⁷

Some in the biofuels industry attacked the proposed rule and rule makers more directly, suggesting that the rules single out biofuels for special treatment by failing to account for indirect impacts from petroleum sources and other activities that impact land use such as timber harvesting, population increases, and not accounting for increases in agricultural productivity. Some have called for a broad scientific review.²⁸ Others have claimed that officials are politically motivated or beholden to oil interests^{29 30}.

It has been up to the U.S. EPA to try to sort this out – a difficult task because while the science has evolved, it is not settled. On February 3, 2010, the EPA announced its final RFS2 rule.³¹ RFS2 established production benchmarks for all renewable fuels, increasing national output from 12.95 billion gallons in 2010 to 36 billion gallons by 2022. The new rule also established a basis for determining which fuels would qualify for various categories based in part on their projected lifecycle net CO2 emission profile. To be classified as “renewable” and be included in the RFS2 regime a fuel must achieve at least a 20% net emissions reduction. To be considered “advanced” or “biomass-based diesel” the biofuel must curb net GHG emissions by at least 50%. To be considered “cellulosic” the biofuel must curb net GHG emissions by at least 60%. The rule requires increasing minimum volumes of biofuels to meet these higher net GHG reduction standards.

When EPA issued their Notice of Proposed Rulemaking for RFS2, some predicted that conventional ethanol and biodiesel would not qualify to be counted as part of the RFS2 system. However, EPA included both of these conventional biofuels. Biodiesel was given “advanced” biofuel status because the EPA judged that it had initially underestimated the nitrogen fixing properties of soybeans, among other reasons. Corn-based ethanol was given a mixed blessing of sorts. In their proposed rule, the EPA examined lifecycle GHG emissions from all corn-based ethanol production and found that corn ethanol has slightly higher GHG emissions compared with the baseline – gasoline in 2005. However, because all ethanol plants constructed prior to the passage of the 2007 Energy Independence and Security Act (EISA) were grandfathered into the rule, the EPA reworked its analysis to consider only new and future corn ethanol plants. The result was an average reduction in GHG emissions of 21%³², even considering ILUC impacts.

The EPA noted that since their initial rulemaking notice, some new data and new modeling techniques had caused increases to GHG emissions from biofuels, while other updated data and models had led to GHG reductions. In their final analysis, the combined data resulted in GHG emission reductions. Significant factors in this result included rate of crop yield improvements as a function of price, greater efficiency of dry distillers grains (a corn ethanol co-product), and less ILUC impacts resulting from more precise satellite imagery³³.

The reaction to the EPA's new RFS2 rule has been fascinating, yielding both supportive and critical assessments of the EPA. Focusing on the analysis of new ethanol plants, the National Corn Growers Association praised the EPA for acknowledging ethanol's "distinct advantage over gasoline" in greenhouse gas emissions³⁴; the Renewable Fuels Association criticized the EPA for using a 30-year timeframe for considering lifecycle GHG emissions rather than the 100-year window that RFA recommended. The EPA's rationale for choosing 30 years was based on the significant climate change impacts that are expected within 30 years or sooner.

Some conventional biofuels critics praised aspects of the EPA's rule. The rule can provide "greater energy independence, create good American jobs without sacrificing our health, climate or the environment," said Nathanael Greene of NRDC³⁵. However, many in the oil industry were critical of the new rule. The American Petroleum Institute asserted that RFS2 was unworkable and would result in higher consumer costs for fuel³⁶.

It may be too soon to tell, but perhaps the new EPA rule heralds a return to a more sensible, science-based dialogue on biofuels. The rule recognized that all biofuels, even those produced from conventional feedstocks have a valuable, while limited role to play in the effort to curb climate change. Yet, there are clear, significant differences between types of biofuels and sources of feedstocks to produce them, from a climate standpoint. ILUC must be considered as a factor. As several scientists writing to USEPA in support of inclusion of ILUC impacts said, "assigning a value of zero is clearly not supported by the science,"³⁷ taking a position contrary to industry protests that only direct emissions should be considered. However, some initial reports may have over-estimated ILUC impacts due to improper accounting of productivity factors and land use changes caused by other factors.

A major factor also considered by the EPA during RFS2 rulemaking was the manufacturing process, particularly the energy source used to produce the biofuels and the overall production efficiency. Typically, ethanol plants use natural gas as their energy source. As mentioned earlier, newer ethanol plants are considerably more energy efficient.³⁸ Technology advancements have driven efficiency increases. For example, the Corn Plus ethanol plant includes a biomass boiler that includes syrup (an intermediary product of ethanol production) as a feedstock to supply process steam.³⁹ A few ethanol plants, less than 10 of 197, are fueled by coal. Coal is more carbon rich than natural gas, so ethanol made by burning coal results in higher net or life cycle carbon emissions than using gasoline.⁴⁰ Use of coal to produce ethanol is a poor climate protection strategy unless the distillery incorporates a high level of effective CO₂ capture and storage (CCS). The Andersons' ethanol facility in Greenville, Ohio, which is not powered by coal but by natural gas, is currently experimenting with CCS technology.⁴¹

The Food-Fuel Debate:

Biofuels critics have widely claimed that using crops grown for human consumption, even indirectly, removes grains from the world food supply. This in turn leads to food shortages and

rising prices. The claim that biofuels production has increased food prices has received significant media attention. Defenders have countered that biofuels have had little or no impact on food supplies or prices. They argue that grain production levels and yields have increased, that the “farm value” portion of a typical grocery bill is relatively small, and that distillers grains are an important co-product of ethanol production which provide valuable protein for animal agriculture. Defenders of biofuels point to other factors, especially rising fuel costs, to explain the bulk of increasing food prices.

The arguments of both sides have some merits. Rising prices of farm commodities have increased the cost of grain exports and some domestic foods, especially certain meats and dairy. However, claims that biofuels have caused food shortages and major price spikes in groceries across the board are wild exaggerations.

According to the U.S. Department of Agriculture, more than 13.1 billion bushels of corn were harvested in 2007, setting an all-time record for corn production. The total in 2006 was 10.7 billion bushels. Thus, 2007 marked a 24% increase in U.S. domestic corn production⁴².

Ethanol accounted for about 21 percent of the total corn demand for 2007, up from 18.5% in 2006. Animal Feed accounted for 42 percent of demand in 2007, down from about 50%. This drop was due to distillers grains used for feed rather than corn. Production of distiller grains increased from 14.6 million tons in 2007 to 27 million tons in 2008. Food-related products such as corn sweeteners, cereal and tortillas accounted for about 10%. Nevertheless, in absolute numbers, corn consumed by animals increased by about 100 million bushels. Corn exports declined from 19% to about 17% but absolute export levels increased by about 180 million bushels. Exports of dry distillers’ grains, an ethanol co-product, also increased.⁴³

While percentages of overall corn production used for food-related purposes in the US and abroad are trending down, absolute amounts are actually increasing slightly. One factor is conversion of acres used to grow soybeans and wheat into acres for corn⁴⁴. Another factor is conversion of fallow lands into production⁴⁵. A third factor is increased yields per acre of corn. On average, corn yields have increased by 3.5 bushels per acre per year since 1995.⁴⁶ However, 1995 was a drought year; using it as a baseline may portray an overly optimistic prospect for future yields. Markets have responded to increasing demand for corn and corn by-products by producing more corn in absolute terms. Factors underlying increased production vary and some present other concerns that are addressed elsewhere in this paper⁴⁷. In the end, the claim that biofuels are starving the poor or displacing food with fuel is simply not true.

The National Corn Growers Association (NCGA) predicts corn yields to grow from 150 bushels per acre in 2006 to around 180 bushels per acre by 2015. If this projection holds up, ethanol production could increase to over 20 billion gallons without increasing corn acreage—or increasing the amount of corn for domestic or foreign food-related markets⁴⁸. Importantly, this production level would be 5 billion gallons more than required by the Renewable Fuel Standard. To place this in a bigger context, the land devoted to “coarse grains” including corn has declined 8% worldwide since 1980 as a function of increasing yields.⁴⁹

While increased production is likely, continuous steep rises are not guaranteed. Weather pattern changes, including the prospect of rising temperatures could have a dramatic effect on yield potential if hotter temperatures occurred during sensitive periods of crop development.⁵⁰

To place biofuels in their proper global perspective, biofuels production worldwide uses only about 4% of total grain supplies.⁵¹ The total net amount of cropland dedicated to American ethanol production was 0.6% of cropland worldwide.⁵²

Thus the relative impact of biofuels' demand on the supply of grains is small compared with increased demand for grain-fed meat.

The criticism that biofuels have increased food prices has gained significant media traction. Part of this can be attributed to a media campaign led by the Grocery Manufacturers Association and others to create a link between rising food prices and biofuels.⁵³ However, analyses of factors related to food prices yield different explanations and a more complicated picture of this debate.

A study by the Agriculture and Food Policy Center at Texas A & M University analyzed government, consumer, and agriculture prices as well as component elements of food costs to consumers. (Need citation for previous sentence) According to this analysis, the percentage of retail food prices attributable to farm commodities "has declined from 32 percent in 1970 to 19 percent in 2002."

According to the Agriculture and Food Policy Center, another key factor is that the farm share of retail food prices tends to decline as agricultural commodities are further processed into food products. Farmers in 2002 got an average of 20% of the price paid for fresh vegetables, but only 5% of bakery and cereal items. Generally, farm shares of consumer-purchased meats and milk are highest, but the majority of prices even of these items incorporate petroleum-fueled transportation, packaging, and non-farm labor-related costs.⁵⁴ Biofuels have impacted food prices to a degree, but they do not influence food prices as much as other factors.

A December 2007 report by Informa Economics found "a comparatively 'weak correlation' (about 4%) between corn prices and overall food costs."⁵⁵ A report by the Federal Reserve Bank of Kansas City in February 2008 listed robust food demand, record high crop prices, and accelerating costs for labor and energy as culprits for rises in food prices.⁵⁶

A study funded by Kraft Foods, a noted biofuels critic, cites various analyses that suggest ethanol's impact on corn commodity prices for the periods 2006-07 through 2008-09 could be between 25-60%.⁵⁷ However, as mentioned, the relative impact of field corn prices on the price of food people actually consume is much less.

In fact, a report released on April 9, 2009 by the Congressional Budget Office (CBO) concluded that "from April 2007 to April 2008, the rise in the price of corn resulting from expanded production of ethanol contributed between 0.5 and 0.8 percentage points of the 5.1 percent

increase in food prices measured by the consumer price index (CPI). Over the same period, certain other factors—for example, higher energy costs—had a greater effect on food prices than did the use of ethanol as a motor fuel⁵⁸.”

Have biofuels caused some increases in food costs? Yes. Have they been a major or significant factor? Based on the studies cited above, other factors, especially escalating transportation fuel and other energy prices, have been more significant. The reason for this is the relatively small portion of “farm value” (the share of food costs that farmers receive) that constitutes the consumer grocery bill. Interestingly, as both energy and commodity prices have declined during the recent economic downturn, grocery prices mostly have remained high⁵⁹.

Environmental Impacts of Biofuels Crop Production:

Defenders and critics of biofuels disagree about several different environmental aspects related to the production of feedstocks, in addition to the manufacturing and consumption of the fuels themselves. The climate debate has been addressed, but there are many other heated environmental topics to consider.

Critics of biofuels have suggested that the prices of commodity grains, driven by demand for biofuels, are encouraging farmers to opt out of the federal Conservation Reserve Program (CRP).⁶⁰ This program pays farmers to keep highly erodible and ecologically sensitive lands out of production.⁶¹ Defenders of biofuels admit that this has occurred, but downplay the overall impacts.

The CRP is generally acknowledged as a success story of U.S. agriculture policy.⁶² The program helps protect water quality, reduces runoff, cuts down overall carbon emissions from agriculture, and protects wildlife habitat. As corn prices rose in 2007, the rental rates offered by USDA to renew acreage in the CRP did not keep pace. Thus, farmers whose contracts were set to expire had an incentive to opt out of the program. From September 2007 to September 2008, CRP enrollments declined by 2.1 million acres.⁶³ It is not known how many of these acres went into corn production.

A related complaint from biofuels opponents is that increased corn production has led to increased use of pesticides and fertilizers, and that this has contributed to water pollution and damage to soils. Supporters counter that corn production has become more efficient in terms of units of chemical inputs per crop yield volume – even if total chemical inputs remain significant. Additionally, supporters point to the improved efficiency of nitrogen fertilizers.⁶⁴

In 2007, the total planted area in the United States was 93.6 million acres, up 19 percent from 2006 and at the highest level since 1944.⁶⁵ Corn tends to require higher levels of pesticides and fertilizer, especially when planting “corn after corn” rather than rotating corn and soybeans, which helps retain soil nutrients.⁶⁶ Farmers vary in their intensity of cultivation when growing corn. More intense cultivation leads to more soil erosion and runoff of chemicals. This runoff contributes to water pollution. Researchers have noted significant damage to the Gulf of

Mexico due to fertilizer runoff.⁶⁷ Runoff nationwide not only damages water quality, but can also lead to declines in sport fishing and commercial fishing revenues. Clearly, one of agriculture's biggest challenges is to make significantly more progress on implementing conservation practices to reduce farm-related runoff pollution into waterways.

The U.S. Department of Agriculture conducted a "Billion Ton Study," which projected the potential of generating one billion tons of renewable biomass from U.S. lands to produce biofuels and other bioenergy.⁶⁸ This projection is based on assumptions that significant amounts of harvested biomass from perennial crops, plus residual biomass from food crops and forests, can be removed from lands on a sustainable basis. However, there is significant disagreement about how much biomass, including crop "residues," trees and other materials can be sustainably removed without harming soils in the long term.⁶⁹ This is an extremely important research question. Answering it could point toward what crops to grow, in what quantities, over what time frame, and from which areas. We need to understand how much and what materials can be sustainably removed from the land.

The bottom line is that farming presents environmental challenges, whether farmers are growing crops for food, energy or both. It is unclear whether environmental impacts from increased cultivation of corn have been offset by improvements in farming practices.

Given the increased demands on commodity grains for food, fuel, and other bio-based products, many competing groups must work together to craft effective policy solutions based on scientific findings in order to achieve long-term sustainability. Biofuels and food processing industries, farmers themselves, environmental groups, and various experts need to work with political leaders on measures to increase agricultural productivity, conserve soils, protect water resources, produce an ample global food supply, and help our land make a sustainable contribution to meet our energy needs.

All parties involved need to recognize that policies which require sustainable practices might increase costs of fuels, food, or both products. Biofuels supporters must acknowledge limits on the capacity of the land and thus the role of biofuels in meeting global energy demand. Critics need to appreciate that current limits based on yields per acre, available feedstocks, agricultural science, growing methods, and fuel production techniques likely will change the capacity of biofuels to provide energy in future years.

Net Energy Balance of Biofuels:

Critics have argued that studies show ethanol has a "negative energy balance." In other words, the overall process of making ethanol consumes more energy than ethanol itself provides as a fuel. Proponents of ethanol and other biofuels counter that only one researcher, Dr. David Pimentel, whose work is suspect, found a negative energy balance. All other studies since the late 1990s have indicated that ethanol has a positive energy balance.

While ethanol energy balance has been a popular media topic, there is effectively no scientific debate. All other energy balance studies⁷⁰ of ethanol over the past ten years, US Department of Energy, US Department of Agriculture, Michigan State University, the Canadian Government, Institute of Local Self-Reliance and others, have come to the opposite conclusion, showing a modest positive energy balance.

Some researchers believe that energy balance is really a misleading concept because energy is only valuable for what value it actually can produce, and it can't produce that value until it is converted into the proper form.⁷¹

Environmental Impacts of Biofuels Manufacturing

Water Consumption

Biofuels opponents complain that ethanol production requires a very large amount of water, which has negative impacts on supply, especially in certain parts of the country. Water shortages, they contend, can lead to negative environmental and social consequences. Industry supporters downplay water consumption of ethanol compared with other types of energy production and assert that ethanol is becoming much more water efficient.

According to a study by the Institute for Agriculture and Trade Policy (IATP) the average ethanol plant requires 4.6 gallons of water to make one gallon of ethanol⁷². Ethanol plants have become more efficient in water use over the last several years. The newest ethanol plants have achieved an efficiency of 3 gallons of water for every one gallon of ethanol produced.⁷³ Some studies claim an extremely high level of water consumption when irrigation practices for corn are included⁷⁴. Water consumption to make ethanol either compares poorly or favorably with refining petroleum depending on what aspects of production are included. The oil refining process itself is much more efficient. About a half a gallon of water is used per gallon of refined product. However, in declining oil wells, a significant amount of water in the form of steam is sometimes used to force crude oil out of the ground. For these wells, it takes more like 10 gallons of water to produce one net gallon of refined product⁷⁵. The oil industry can also use techniques and materials that do not require as much or any fresh water to recover oil from declining wells, such as using salt water or waste water.

Water use is another limit of ethanol production. Water consumption may be less of an issue in places with fewer major draws on water supplies and/or more plentiful supplies. In locations with more water demands (particularly for agriculture) and less or declining supplies, the water demands of ethanol plants may create longer term water supply issues or at least competition for water, driving up its cost.

The IATP authors recommend strong local and state regulations to compel ethanol plants to be as water efficient as possible, and even to restrict ethanol production in dry places where water resources for agriculture and other uses are strained. Other recommendations included co-locating ethanol production and waste water treatment and/or livestock facilities.⁷⁶ The

ethanol industry and all biofuels production can become more efficient in their use of water. In order to provide a much larger portion of fuel demands over the long term, increased efficiencies will be demanded at every level.

Vehicle Emissions and Fuel Economy:

Tailpipe Emissions

Biofuels, especially ethanol, have received criticism for increasing some types of tailpipe emissions. Defenders of biofuels point to data showing decreases in emissions. The conflicting claims are confusing. Some of this is because emissions levels, in comparison with petroleum fuels, vary depending on the biofuel, the percentage of the biofuel in a given fuel mixture, and the specific emission in question (e.g. nitrogen oxides, hydrocarbons, carbon monoxide, etc). USEPA data indicate reductions generally across the board for ethanol blends, especially E85.⁷⁷ Some data sources disagree with EPA on E10 emissions of nitrogen oxides and volatile organic compounds.⁷⁸

Regarding biodiesel, there is consensus that any level blend will reduce particulates, hydrocarbons and toxics. Regarding NOx, data is contradictory. Some data suggest slightly elevated emissions and other data show NOx emissions are slightly reduced. Whichever is the case, the amount of difference is quite small. Overall, the emissions reduction benefits of biodiesel vary depending on blend percentage, but the fact that there are significant reductions of most emissions is indisputable.⁷⁹

Fuel Economy

According to a study by Consumer Reports mileage of a vehicle running on E85 is worse by 27%⁸⁰. A report from the Renewable Fuels Association stated "E85 contains about 73% to 76% the BTU content of gasoline. The actual impact on fuel economy can vary depending on the model of vehicle, vehicle driving patterns, driving conditions, driver input, state of tune of the vehicle and other factors. Some drivers and fleets have experienced fuel economy penalties below 10%, but most drivers will experience a larger miles per gallon drop, typically in the 20% range."⁸¹

Biodiesel studies have pointed out that pure biodiesel (B100) has 11% lower energy content than its petroleum equivalent and thus produces lower fuel economy.⁸² Supporters of biodiesel don't dispute the lower energy content but they point to experience among some fleets that blended biodiesel provides the same or even slightly higher fuel economy. Most of this anecdotal information is tied to use of B20 (20% blend). This may be based on higher cetane levels and/or the cleansing effect of biodiesel that can improve operating performance.⁸³ The data seem to suggest that, despite biodiesel's lower energy content, fleet fuel economy with blends of B20 and lower is virtually the same. Inconsistency of results may be attributed to differences in types of biodiesel, diesel blend stock, vehicle type, and condition.

The Sustainable Role of Biofuels Today and Tomorrow:

Hyperbole and oversimplification has characterized much of the discussion about biofuels over the past several years. While some biofuels utilizing newer production methods and advanced feedstocks are more beneficial than others, biofuels themselves are neither good nor bad. Their relative benefit or harm depends on the many factors discussed in this paper: feedstocks used to produce various biofuels, farming practices to grow feedstocks, manufacturing processes, competing uses of land, amounts of biofuels actually produced, water consumption, tailpipe emissions, and more.

It is safe to say that ethanol and biodiesel will be part of a broad transportation energy strategy. This strategy includes other non-petroleum energy options for transportation, technologies to increase vehicle efficiency, and strategies to reduce miles traveled by personal vehicles. Clean Fuels Ohio believes that biofuels can play a positive role for energy security, our economy and the environment. We believe that strong public policies are needed to mitigate negative environmental impacts that biofuels can cause. We believe that objective science and political courage on all sides is needed to cut through the polarized debate around critical issues such as ILUC and water quality impacts.

So-called “first generation” biofuels are made mainly in the U.S. from food-based agricultural commodities. Fuels from these first-generation feedstocks are unsustainable and destructive if produced at levels that can only be achieved by eliminating crop rotations, planting in environmentally sensitive areas, contributing to massive runoff pollution, consuming vast quantities of water, producing massive deforestation and crowding out crops to produce adequate food supplies. Corn and soybeans can be produced using environmentally sustainable farming practices, including low or no-till, sound crop rotation, and efficient use of fertilizers. Continual improvements in these practices can help sustain and increase yields. These increased yields can provide raw materials to produce relatively small, but significant quantities of biofuels from these feedstocks. How much is “significant?” This is a moving target, but based on what we know today, for corn-based ethanol (or butanol, a similar biofuel) it will likely be around 10-15 billion gallons per year, or about 7 to 10% of our current gasoline consumption.⁸⁴ For biodiesel it will likely be closer to 3 billion gallons per year, according to the Institute for Local Self-Reliance. This is about 6-7% of annual U.S. diesel consumption.⁸⁵ This level would require significant levels of non-vegetable oil, renewable feedstocks.

These levels are significant for two reasons. First, by cutting petroleum demand and consumption even slightly, they relieve price and supply pressure, which saves money for consumers and reduces the export of U.S. wealth abroad. Second, this level of production paves the way for production of more biofuels from next generation feedstocks. These include waste materials, grasses and algae among others. This is what some biofuels supporters mean when they say that “first generation” biofuels are transitional. Even with the new RFS2 rule, it’s unclear what level of future production these new feedstocks will actually yield.

No one knows today how much bio-based energy we can produce from these advanced feedstocks and improved methods of production. This will depend on technology advances and prices of conventional fuel sources. Estimates range from a few billion gallons to over 100 billion or more, if optimistic predictions about algae and other feedstocks and methods are assumed. If the more optimistic projections turn out to be correct, then the advanced biofuels industry will owe at least part of the credit for their success to corn, soy and other “food” based biofuels for charting the course, establishing quality controls, and gaining market acceptance.

Finally, let’s not forget about production of other biofuels such as bio-gas methane, a global warming pollutant 25 times more potent than CO₂ and which can be captured from many landfills, large animal agriculture operations, municipal sewage facilities, composting operations and other sources of anaerobic digestion. These renewable sources of methane can be used as compressed natural gas (CNG) or liquefied natural gas (LNG). While Europe has led the way in bio-methane production in recent years, Ohio is becoming a leader as the U.S. catches up.⁸⁶ The promise of bio-gas methane provides another reminder of the wide and exciting diversity of cleaner energy sources that can be developed.

As with most technologies, it is important to always bear in mind that biofuels are neither “good” nor “bad.” The essential question is how to “do biofuels right” and to make them sustainable, so that we can gain the benefits biofuels have to offer in terms of energy security, climate change mitigation, and economic prosperity while avoiding possible negative consequences.

¹ Jackson, James K. CRS Report RL34686: The U.S. Trade Deficit, The Dollar, And the Price of Oil, *Congressional Research Service*, September 29, 2008, p. 19. *(Depends on average barrel price: \$100/barrel = \$480B, \$110/barrel = \$528B, \$120/barrel = \$576B, \$130/barrel = \$625B). “WTI crude averaged \$100/barrel in 2008” Short Term Energy and Summer Fuels Outlook, *Energy Information Administration*, April 14, 2009, p. 1.

² Diesel Particulate Matter Health Risk Assessment, *California EPA Air Resources Board*, March 19, 2008, p. 3.

³ Nitrogen oxide and volatile organic compounds

⁴ Fact Sheet, *California EPA Air Resource Board*, January 23, 2004, p. 1.

⁵ Greenhouse Gas Emissions from the U.S. Transportation Sector, *U.S. EPA Office of Transportation and Air Quality*, March 2006, p. 9.

⁶ BP Statistical Review of World Energy June 2008, *Beyond Petroleum*, June 2008, p. 8.

⁷ Wilson, Janet and Simon, Richard, On D.C.’s Burner, Coal at the Pumps, *The Los Angeles Times*, May 10, 2007, p. A-26. CTL twice the amount of greenhouse gas as petroleum.

⁸ Baltimore, Chris, U.S. Needs More Incentives To Use Ethanol, *Reuters*, January 16, 2007.

⁹ Pimentel, David and Patzek, Tad W, Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower,” *Natural Resources Research*, Vol. 14:1, 65-76.

¹⁰ Jacobson, Mark, Effects of Ethanol (E85) Versus Gasoline Vehicles on Cancer and Mortality in the United States, *Environmental Science and Technology*, August 30, 2006.

¹¹ Brown, Lester R. Massive Diversion of U.S. Grain to Fuel Cars is Raising World Food Prices, *Eco-Economy Update*, March 21, 2007.

¹² Wroughton, Lesley, Update 3—Biofuels major driver of food price rise—World Bank, *Reuters*, July 28, 2008.

¹³ Mouawad, Jad, Oil Industry Says Biofuels May Hurt at Pump, *The New York Times*, May 24, 2007.

¹⁴ Brabeck-Letmathe, Peter, Biofuels and a Dwindling Water Supply, *The Boston Globe*, October 10, 2008.

¹⁵ Power, Stephen, If a Tree Falls in the Forest, are Biofuels to Blame? It’s Not Easy Being Green, *The Wall Street Journal*, November 11, 2008.

-
- ¹⁶ Eilperin, Juliet, Studies Say Clearing Land for Biofuels Will Aid Warming, *The Washington Post*, February 8, 2008.
- ¹⁷ Taylor, Jerry and Van Doren, Peter, [The Ethanol Boondoggle](#), *The Milken Institute Review*, First Quarter, 2007.
- ¹⁸ Motavalli, Jim, Solution or Distraction? An Ethanol Reality Check, *The New York Times*, May 14, 2006.
- ¹⁹ Righelato, Renton and Spracklen, Dominick V., Carbon Mitigation by Biofuels or By Saving and Restoring Forests, *Science*, August 17, 2007, Vol. 317. no. 5840, p. 902.
- ²⁰ Senator Charles Grassley (R-Iowa), Sources of Energy in America, *U.S. Senate*, Feb. 6, 2007; <http://www.c-spanarchives.org/congress/?q=node/77531&id=7531756>.
- ²¹ Wang, Michael, The Debate on Energy and Greenhouse Gas Emissions Impacts of Fuel Ethanol, *Argonne National Laboratory*, August 3, 2005.
- ²² Dr. Ken Cassman, University of Nebraska at Lincoln, 2008
- ²³ An Overview of Biodiesel and Petroleum Diesel Life Cycles, *U.S. Department of Agriculture and U.S. Department of Energy*, May 1998, p. 18.
- ²⁴ Searchinger, Timothy et al., Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change, *Science* 29 February 2008, Vol. 319. no. 5867, pp. 1238 – 1240.
- ²⁵ Rulemaking to Consider the Proposed Regulation to Implement the Low Carbon Fuel Standard, *California Air Resources Board*, Hearing April 23, 2009.
- ²⁶ USEPA, May 5, 2009: Renewable Fuel Standard Program (RFS2) Notice of Proposed Rulemaking
- ²⁷ Letter to USEPA Administrator Stephen Johnson from Dr. Bruce Dale, Michigan State University and four others, October 21, 2008
- ²⁸ “Leading Scientists Call for National Academy Review of Controversial Provision in the CA Low Carbon Fuel Standard,” *Energy Daily*, April 20, 2009
- ²⁹ “California Fuel Move Angers Ethanol Makers,” *New York Times*, April 24, 2009
- ³⁰ Huffington Post, “Time to Watch Those CARBs -- and Oils,” April 23, 2009
- ³¹ EPA, Renewable Fuel Standard Program, February 3, 2010: <http://www.epa.gov/oms/renewablefuels/index.htm>
- ³² Ethanol Producers Magazine: February 5, 2010: http://www.ethanolproducer.com/article.jsp?article_id=6329
- ³³ EPA Analysis of RFS2 Rule, Feb 2, 2010: <http://www.epa.gov/otaq/renewablefuels/420f10006.htm>
- ³⁴ NCGA President Darrin Ihnen, quoted in Domestic Fuel: <http://domesticfuel.com/2010/02/03/epa-rules-confirm-ethanols-environmental-advantages/>
- ³⁵ Nathanael Greene blog, February 3, 2010: http://switchboard.nrdc.org/blogs/ngreene/epa_publishes_final_rfsii_rule.html
- ³⁶ API Statement, February 3, 2010: <http://www.api.org/Newsroom/api-statemnt-rfs2.cfm>
- ³⁷ April 21, 2009 letter from 175 scientists to California Air Resources Board: http://www.ucsusa.org/assets/documents/clean_vehicles/call_to_action_biofuels_and_land_use_change.pdf
- ³⁸ Dr. Ken Cassman, University of Nebraska at Lincoln, 2008
- ³⁹ http://www.energydigital.com/Corn-Plus--More-than-ethanol_18852.aspx
- ⁴⁰ Wang, M, M. Wu, and H. Hong, “Life-Cycle Energy and Greenhouse Gas Emission Impacts of Different Corn Ethanol Plant Types,” *Environmental Research Letter*, 2: 024001, 2007.
- ⁴¹ Sutherly, Ben, Greenville Injection Project Could Have Global Implications, *The Dayton Daily News*, June 29, 2008.
- ⁴² Crops Production: 2007 Summary, *National Agriculture Statistics Service, USDA*, January 2008, p. 1.
- ⁴³ World Agriculture Supply and Demand Estimates, WASDE—463—Revised, *United States Department of Agriculture*, October 28, 2008, p. 2.
- ⁴⁴ Crops Production: 2007 Summary, *National Agriculture Statistics Service, USDA*, January 2008, p. 80-82.
- ⁴⁵ Taking acres out of the Conservation Easement program has increased supply of grains, mitigating the effect of biofuels on supply and price. However, removal of acres from this conservation program has caused environmental impacts. A strong biofuels policy should address how to restore acreage in conservation management, even if this slows the rate of biofuels growth in the near term.
- ⁴⁶ Corn Production Trends: 1991-2007, *National Corn Growers Association*, December 8, 2008.
- ⁴⁷ E.g. Potential climate and other environmental damage from cultivation of formerly fallow lands and suspending normal crop rotations.
- ⁴⁸ Corn and Ethanol: Green, Getting Greener, *The National Corn Growers Association, National Ethanol Conference*, February 26, 2008. (Ethanol production expected to reach 15.3 billion gallons by 2015).
- ⁴⁹ Ethanol Industry Outlook 2008, Renewable Fuels Association (quoting USDA data)

-
- ⁵⁰ Weather, Technology, and Corn and Soybean Yields in the U.S. Corn Belt, Michael A. Tannura, Scott H. Irwin, and Darrel L. Good, University of Illinois, 2008
- ⁵¹ Trostle, Ron, Biofuels and World Grain Markets, *Economic Research Service, USDA*, September 2008.
- ⁵² Ethanol Industry Outlook 2009, Renewable Fuels Association
- ⁵³ Palmer, Anna, Beating up on Ethanol: Glover Park Helps Frame the Debate, *Roll Call*, May 14, 2008.
- ⁵⁴ The Effects of Ethanol on Texas Food and Feed, *Agriculture and Food Policy Center, Texas A&M University*, p. 20-22.
- ⁵⁵ Analysis of Potential Causes of Consumer Food Price Inflation, *Informa Economics*, November 2007, pp. 4-5.
- ⁵⁶ Henderson, Jason, What is Driving Food Price Inflation, *Federal Reserve Bank of Kansas City*, February 2008.
- ⁵⁷ The Role of Biofuels and Other Factors in Increasing Farm and Food Prices, Keith Collins, Ph.D, 2008
- ⁵⁸ <http://www.cbo.gov/ftpdocs/100xx/doc10057/04-08-Ethanol.pdf>
- ⁵⁹ http://www.biodieselmagazine.com/article.jsp?article_id=3146
- ⁶⁰ Streitfeld, David, As Prices Rise, Farmers Spurn Conservation, *The New York Times*, April 9, 2008.
- ⁶¹ See <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp>
- ⁶² Lasseter, Teresa C., America's Conservation Program Turns Twenty, *Farm Service Agency, USDA*, 2006.
- ⁶³ Conservation Reserve Program Status—September 30, 2008, *Farm Service Agency, USDA*, September 2008.
- ⁶⁴ University of Nebraska at Lincoln LCA Report, 2009
- ⁶⁵ Crops Production: 2007 Summary, *National Agriculture Statistics Service, USDA*, January 2008, p. 1.
- ⁶⁶ Erikson, Bruce, Crop Input Prices for 2009: What Factors are at Work, What Might Be Expected, and Should Your Management Change? *Purdue University*, 2008.
- ⁶⁷ Winter, Allison, Farm Runoff in Nine States Linked to Gulf 'Dead Zone', *E&ENews PM*, January 30, 2008.
- ⁶⁸ Perlack, Robert D., et. al. Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion Ton Annual Supply, *U.S. Department of Energy, U.S. Department of Agriculture*, 2005.
- ⁶⁹ Greene, Nathaniel, et. al., From Plants to Power Plants: Cataloging the Environmental Impacts of Biopower, *Natural Resources Defense Council*, 2002.
- ⁷⁰ M.R. Schmer, K.P. Vogel, R.B. Mitchell, R.K. Perrin, Net Energy of Cellulosic Ethanol from Switchgrass, *U.S. Dept. of Agriculture*, November 21, 2007. Shapouri, et. al (1995) - USDA +20,436 (HHV); Lorenz and Morris (1995) - Institute for Local Self-Reliance +30,589 (HHV); Agri. and Agri-Food, CAN (1999) +29,826 (LHV); Wang, et. al. (1999) – Argonne National Laboratory +22,500 (LHV); Shapouri, et. al, Update (2002) – USDA +21,105 (HHV); Kim and Dale (2002) - Michigan State University +23,866 to +35,463 (LHV); Shapouri, et. al, (2004) – USDA +30,258 (LHV).
- ⁷¹ Thinking Clearly about Biofuels: Ending the Silly “Net Energy” Controversy, Dr. Bruce Dale, Michigan State University, 2007
- ⁷² Keeney, Dennis and Muller, Mark, Water Use by Ethanol Plants: Potential Challenges, *Institute for Agriculture and Trade Policy*, 2006, p. 4.
- ⁷³ Wu, May, Analysis of the Efficiency of the U.S. Ethanol Industry 2007, *Argonne National Laboratory*, April 21, 2008.
- ⁷⁴ R. Dominguez-Faus, Susan E. Powers, Joel G. Burken, and Pedro J. Alvarez, “The Water Footprint of Biofuels: A Drink or Drive Issue?”, *Environ. Sci. Technol.* 2009, 43, 3005–3010.
- ⁷⁵ Energy Demands on Water Resources: Report to Congress on the Interdependency of Energy and Water, *U.S. Department of Energy*, 2006, p. 21.
- ⁷⁶ Keeney, Dennis and Muller, Mark, Water Use by Ethanol Plants: Potential Challenges, *Institute for Agriculture and Trade Policy*, 2006, pp 5-6.
- ⁷⁷ EPA Fact Sheet EPA420-F-00-035 (Ethanol Emissions as Compared with Gasoline Emissions)
- ⁷⁸ Southeastern Michigan Council of Governments, 2005
- ⁷⁹ McCormick, R.L.; Williams, A.; Ireland, J.; Brimhall, M.; Hayes, R.R., Effects of Biodiesel Blends on Vehicle Emissions: Milestone Report: NREL/MP-540-40554, *National Renewable Energy Laboratory*, October 2006.
- ⁸⁰ The Ethanol Myth, *Consumer Reports*, October 2006.
- ⁸¹ “E85 Fuel Ethanol: Industry Guidelines, Specifications, and Procedures,” *Renewable Fuels Association*, March 2009, RFA Publication # 090301, pg. 15.
- ⁸² Biodiesel—Clean, Green Diesel Fuel. *National Renewable Energy Laboratory, U.S. DOE*, September 2001.
- ⁸³ Graboski, M.S. and McCormick, R.L. Combustion of Fat and Vegetable Oil Derived Fuels in Diesel Engines, *Progress in Energy and Combustion Science*, Vol. 24, No. 2, 1998, pp. 131-132.

⁸⁴ Biofuels in the U.S. Transportation Sector, *Energy Information Administration, Annual Energy Outlook 2007*, Washington, DC, February 2007.

⁸⁵ Kurki, Al; Hill, Amanda; Morris, Mike, Biodiesel: The Sustainability Dimensions, *National Sustainable Agricultural Information Service*, ATTRA Publication #IP281, 2006.

⁸⁶ Landfill gas from the Solid Waste Authority of Central Ohio's landfill in Grove City is being processed into pipeline quality bio-gas methane by Firm Green Energy using technology developed in Cleveland by Acrion Technologies.