ETHANOL ACROSS AMERICA

Issue Brief:

Environmental Impacts of Ethanol Production

Summer 2009 A Publication of Ethanol Across America

The goal is to break the stranglehold of imported petroleum by developing domestic, renewable energy. But can we achieve this objective while leaving a minimal environmental footprint? Can we keep biofuels clean and green? And can we avoid the oil-soaked sins of the past without setting unrealistic expectations for an evolving renewable energy industry that holds such great promise? The ethanol industry is already out in front of these issues.

The profound negative environmental impact of petroleum is well documented. Just ask a seagull that was around for the Exxon *Valdez* spill. Or the asthma victim who can't go outdoors thanks to air pollution. Add the crushing cost of imported oil and the incalculable human cost of military action to protect the sources of that oil, and it's obvious that there is no alternative to finding alternatives.

Ethanol has helped improve America's environment and energy security and added billions of gallons to our nation's fuel supply. On a gasoline equivalent basis, the U.S. ethanol industry supplies more fuel to America's fuel pool than the oil we import from Iran, Iraq or Venezuela. In fact, only Canada and Saudi Arabia supply more.

In spite of these unquestioned benefits, legitimate questions have arisen regarding the environmental impact of ethanol production as well as the production of feedstocks such as corn.

In truth, the unreasonable expectations placed on biofuels are an attempt to understate and ignore the environmental damage of petroleum, as well as to avoid the sins of the past. This has led to policies that set the bar very high for biofuels—especially in terms of greenhouse gas reductions. Under the terms of the most recent energy bill, next generation biofuels such as ethanol and biodiesel are tasked with being **five times better than the petroleum fuels they are replacing!** *(Guess what? Preliminary indications are that they can meet this aggressive expectation. See chart on page 2.)*

The ethanol industry has been in place for about 35 years. Yet more than half the ethanol plants in the U.S. are less than four years old. We are well into second and third generation technology that has dramatically improved efficiency, lowered energy and water demand, and further reduced the environmental footprint of biofuels production. The relative youth of the industry

(continued)

Inside

To Our Readers:

On behalf of the ***Ethanol Across America*** education campaign, I am pleased to present the latest in our highly successful Issue Brief series. *The Environmental Impacts of Ethanol Production* provides a common sense look at ethanol production in terms of the emissions from these facilities, their energy and water use, and some of the environmental considerations in the feedstocks used to produce America's most successful alternative fuel.

A central component of the ***Ethanol Across America*** campaign for the past decade has been our "three E" theme of connecting the dots between energy, environment, and economic development and how biofuels such as ethanol can play a critical role. With a global recession, increasing dependence on imported oil, and a universal recognition of the need to address climate change, the stakes have never been higher. The need to balance our production of energy with carbon reductions and environmental stewardship is shaping policies and programs at both the state and federal level.

Biofuels can not only meet this challenge but lead the way. For that to happen we must be operating from the right baseline, and one that is based on facts. You may be surprised after reading this brief: Surprised that ethanol plants today use less water than it takes to produce a gallon of gasoline–8 times less! Or that ethanol plants are among the most regulated stationary sources in the U.S., meeting all federal and state standards. Or even that energy consumption in ethanol plants has been reduced by more than 20% over a 5-year period according to the Department of Energy. The net value of ethanol's byproducts means that we can produce more food to feed the world, with less land and energy inputs than ever imagined.

So read on. Learn the facts. And we look forward to working with all of you who share our vision that we can have a robust economy, a secure supply of energy, and a safe environment with biofuels–the three E's.

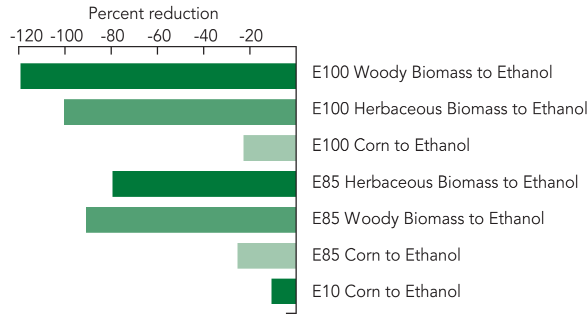
Douglas A. Durante, *Director*

"Our overwhelming dependence on petroleum, much of it from nations wishing harm to the United States, severely undercuts not only our economy, but our very security. Ethanol production from corn now, and cellulosic materials in the near future, must continue to play an important role in the overall response to our national energy security concerns."

Ethanol Across America Co-Chairmen U.S. Senators Ben Nelson (D-NE) and Richard Lugar (R-IN)

has enabled it to implement the latest designs, processes and protocols in order to minimize environmental impact. Unfortunately, many of the studies challenging the environmental benefits of ethanol production are based on first-generation technology and decades-old agricultural data—and don't begin to recognize or give credit for recent advancements in efficiency and engineering.

Greenhouse Gas Reductions Compared to Gasoline



Source: U.S. Department of Energy Office of Fuels Development and Congressional Research Service

Ethanol in every form, including that made from corn, lowers greenhouse gas (GHG) emissions compared to gasoline. If the goal is to reduce GHG, clearly ethanol is a better choice than continued reliance on petroleum based transportation fuel sources.

Seizing the opportunity to replace petroleum with renewable energy sources has never been more important. But it involves a balancing act that provides energy while protecting the air we breathe, the water we drink and the land on which we live and rely.

AIR

Improving the quality of the air we breathe is one of the most important benefits of biofuels such as ethanol. When added to motor fuel, fuel oxygenates such as ethanol help reduce the use of cancer-causing gasoline compounds such as benzene, toluene, xylene, and ethyl benzene. And the more ethanol we use in fuel, the lower the amount of these toxins per gallon. Oxygenates also help reduce the emissions of small particulates and soot from motor fuels—and reduce greenhouse gas emissions as well.

Historically, ethanol use has been a significant strategy in helping cities meet Clean Air Standards, helping reduce smog and the number of non-attainment days.

Managing Emissions from Ethanol Plants

By their very nature, virtually every manufacturing or processing facility transforms raw materials into a value-added product—and in that process, organic and chemical changes take place that result in emissions of some sort. Ethanol production is no different in that regard.

Process innovations in ethanol plant design are creating a clear trend toward enhanced emission control. Nearly 190 ethanol plants have been permitted for production in the U.S. These plants are required to meet stringent local, state and federal regulations during both construction and operation. Ethanol plants must stay within air emission limits specified in the permits or face fines or "cease operation" orders from environmental regulatory agencies.

Emissions from ethanol production may vary slightly depending on the process, design and feedstock. A variety of emission control technologies are used to control potential air pollutants from ethanol plants.

Dust control equipment monitors the presence of tiny particles (particulate matter less than 10 microns in diameter, PM^{10}) in the air created during the corn delivery, handling, milling and drying processes.

Volatile organic compounds (VOCs) are produced during fermentation, distillation and drying. Potential emissions of VOCs are measured and controlled through plant design regardless of the biofuel technology used.

Combustion from boilers in the plant generates carbon monoxide, nitrogen oxides, and sulfur oxides. If co-product drying is in place, carbon monoxide may also be a result. Again, technologies are in place to calculate and control emissions in compliance with applicable permits—all targeted to reducing the emission profile of these biorefineries.

Other emissions may result from activities outside the actual production process including:

- Hydrogen sulfide and VOCs released from the wastewater treatment process
- PM^{10} from the cooling towers
- Fugitive PM^{10} and VOC emissions from haul road traffic and equipment leaks, respectively
- PM^{10}, NOx, SOx, CO and VOCs from emergency equipment
- Potential VOC evaporative loss from wet distillers grains storage pile (if dryers are not in use)

Operating permits also prescribe controls and practices to mitigate these emissions and potential plant odors. Again, the permits require that ethanol plants stay within strict, prescribed limits in terms of emission—and there are severe and expensive consequences for not doing so.

One final note: The plume one occasionally sees rising from an ethanol plant is not smoke. It's simply steam resulting from the cooling process within the plant—water being returned to the atmosphere.

WATER

Concerns about increased demands on water supplies existed well before the advent of the ethanol industry. Growing population in cities, urban sprawl into rural areas, and increased agricultural and recreational demand have placed a premium on water.

As a relatively new industrial water user, ethanol production has been the focus of a disproportionate share of the water debate even though it ranks near the bottom of industrial water usage rankings *(See chart on page 5)*. Like all industries, ethanol producers are continually looking for ways to minimize impact on water supplies. Still, critics suggest that ethanol production—and the production of corn feedstocks—are consuming more water than they should. The fact is that both ethanol producers and corn farmers are using less than they did just a few short years ago.

The nation's corn crop returns more than 300 billion gallons of water per day to the atmosphere, more than 30 times more than is used on irrigated corn acreage.

Water to Grow Corn

Corn is currently the primary feedstock for ethanol production—and accounts for the largest volume of water required in the overall ethanol production cycle. While much of this water is returned to the atmosphere through plant evapotranspiration (4,000 gallons per acre per day!), corn (like all crops) must have water at critical times of its development.

Depending on soil type and growing conditions, a corn plant requires up to 14 inches of water to produce satisfactory yields. But here's the kicker: Some 90-93% of the nation's corn is not irrigated at all, but relies solely on rainfall *(USDA)*. This water falls from the sky—and when rain falls on a cornfield, it produces food, feed <u>and</u> fuel. (Compare that to what is produced when rain falls on a parking lot.)

Water use regulations, coupled with the increasing fuel costs to irrigate, are leading to innovation and dramatic increases in water efficiency on the 7 to 10% of corn acres that rely on irrigation. Sophisticated management and monitoring practices boost water efficiency and cut water consumption by up to half. Electronic monitoring of ground moisture levels and crop evapotranspiration are now commonplace and even required in some areas. This technology allows farmers to know how much water the crop is using and losing, which enables them to know exactly how much water is needed—as well as when and where.

Crop rotation and no-till practices allow soils to retain moisture and nutrients. Drought resistant corn hybrids are being developed that will reduce the amount of water needed to achieve optimum yields.

It is in farmers' best interests to use water as efficiently as possible—and they are implementing innovative methods that are having a dramatic effect on reducing water use without impacting yields.

Water Use in Ethanol Plants

Like virtually all manufacturing and processing facilities, ethanol plants use water to do what they do. Depending on plant design and process, water use ranges from 1.5 to 4 gallons for each gallon of ethanol produced. The overall industry average is between 3.0 and 3.5 gallons—down from nearly 6 gallons just a few years ago. Older plants tend to be toward the top of this range, but many are making significant investments in key processing equipment to reduce water demand. Newer plants have more sophisticated, water-conscious designs that put them at the lower end of the water demand scale. Additionally, the water discharged from ethanol plants is heavily regulated, assuring that water is environmentally neutral when it leaves the plant.

Water availability and allocation is a critical factor in siting an ethanol plant, a process that also involves government water agencies and municipalities.

In an ethanol plant, water is primarily related to energy production: the boiler system that drives the plant and the cooling of process water and equipment. The U.S. Department of Energy's National Renewable Energy Laboratory estimates 70% of the water demand at an ethanol plant goes to these functions, with the rest entering the fermentation process.

If distillers grains are dried, the water is returned to the atmosphere through evaporation. If the distillers grains are shipped wet to local livestock operations, the moisture in the product helps reduce additional water requirements of the animals.

Because the quality of water coming into a plant can vary, it's more efficient to focus on managing and reusing the wastewater generated during the ethanol process, which is more consistent and reliable. This is typically "blow down" residual water from boilers and cooling towers or from centrifuges that remove some water from wet distillers grains before shipment.

Some plants are implementing creative ways to reduce water usage including use of "gray" municipal wastewater, return of water to farmers for crop irrigation, management of mineral levels in water supplies—even the development of zero-discharge technology that eliminates waste stream disposal issues altogether. In many areas, ethanol plants must purchase water rights from other users in order to achieve a net-zero increase in water demand.

Gallons of Water Used in U.S. Industrial Applications

62,000	to manufacture one ton of steel
39,090	to manufacture a new car
4,400	to produce one pair of leather shoes
1,851	to refine one barrel of crude oil
1,500	to process one barrel of beer
150	to produce one average sized Sunday newspaper
24	to manufacture one pound of plastic
22	to refine one gallon of gasoline
12	to process one chicken
10	to process one can of fruit or vegetables
3	to process one gallon of ethanol

Source: Environmental Protection Agency

LAND

The environmental impact of ethanol production on land has focused primarily on the production of ethanol feedstocks, especially corn—not just how much is grown, but how it is grown.

"Sustainability" is a term coined in the United States in the late 1980s—and has come into popular use, especially in discussions of energy, the environment, population growth, and agriculture. The term has been co-opted by those concerned with the impact of farming on the environment and society—as well as by those who favor organic farming over larger-scale production agriculture.

These narrow definitions of "sustainability" typically ignore the factors of future economic and social needs that must be balanced with environmental stewardship and the long-term ability of agriculture to meet global demands for food, feed, fuel, and fiber.

U.S. corn farmers have harvested record yields in recent years, in spite of the fact that the amount of land planted to corn in the U.S. is about 30 million acres less than the peak in 1932. In other words, we're growing considerably more corn—on considerably less land!

Corn farmers understand that satisfying the demands of a growing world population cannot come at the expense of ecological health, human safety or economic viability. More than anyone, farmers understand that maintaining and fostering the quality of natural resources is absolutely critical to their success and that of future generations. For decades, farmers have adhered to the principles and pursuit of continuous improvement, greater efficiency and environmental responsibility.

Producing More Corn with Less Significant advances in corn production technology have dramatically improved yields while reducing inputs, labor costs, and environmental impact. This is a critical point in the discussion of indirect land use change (ILUC). *(See center spread regarding ILUC.)*

In 2006, corn farmers produced 372% more corn on 28% percent less acreage than in 1931. To produce an equivalent amount of corn using 1931 production practices would require 430 million acres—an area larger than the state of Alaska.

The introduction of biotechnology in corn hybrids in 1995 has had a dramatic impact on corn farmers' ability to grow more corn on fewer acres and to do so with fewer chemicals. Since pest resistance is genetically built into the plant, farmers applied 69.7 million pounds less of pesticides in 2005 and reduced production costs by $1.4 billion—thereby improving both the environmental and economic sustainability of corn production.

Precision agriculture technology allows farmers to use GPS-based data to eliminate overlaps when applying chemicals, fertilize at prescribed rates for specific sections of each field, and plant different populations of seed according to soil profiles.

All of these advancements are combining to increase per-acre yields, reduce energy inputs and continually improve environmental stewardship. And when one considers that many of these technological improvements have yet to be fully implemented in other nations with significant agriculture production such as Brazil and Argentina, concerns about the world's ability to grow more corn—and do it responsibly and sustainably—begin to fade away.

One more thing: The production of distillers grains (the livestock feed "leftovers" of corn ethanol production) reduces ethanol's environmental footprint by offsetting corn demand. Animal nutritionists confirm that for every two bushels of corn processed in an ethanol facility, approximately one bushel of corn is preserved and used to displace bulk corn as livestock feed. So more corn ethanol production can save energy and reduce emissions because multiple products are produced simultaneously from one raw material source—renewable, domestically grown corn.

Soil Management and Tillage Crops cannot be produced without disturbing (tilling) the soil in some way. Conservation tillage is a widely adopted category of crop management that includes ridge-till, low-till, minimum-till, and no-till practices. Common to all is the concept of leaving some level of crop residue on the ground as protective cover and to improve soil fertility by maintaining nutrient-rich organic matter in the field.

Soil acts as a carbon sink. Plants are the primary vehicle for maintaining organic carbon in soils. Photosynthesis is the most effective natural method of absorbing atmospheric carbon dioxide. When a plant dies, decomposing residue leaves a portion of the stored carbon in the soil, while emitting the remainder back into the atmosphere. Organic carbon in the soil can be enhanced by returning more crop residue to the soil through conservation tillage practices.

Soil is essentially a buffer between production inputs and the environment. Conservation tillage practices reduce pesticide and fertilizer runoff by reducing rainfall runoff by more than 60% and soil loss/erosion by more than 90%. Between 1982 and 2003, soil erosion on U.S. cropland decreased 43%. *(National Resource Conservation Service)*

Historical Comparison of U.S. Corn Production

U.S. Corn	1931	2008	% change
Acres Planted	109,364,000	85,982,000	-21.4
Acres Harvested	91,131,000	78,640,000	-13.7
Yield (Bu/Acre)	24.5	153.9	+528.5
Corn Production (Bu)	2,229,903,000	12,101,000,000	+442.7

Source: USDA

Competition for water is also driving farming practices. Leaving crop residue on the ground helps shade the soil, reduce evaporation, and reduce soil erosion from wind and water. Reduced tillage improves soil structure, increasing water movement through the soil and retaining moisture from rainfall or irrigation. Conservation tillage, combined with the reduced need for pesticide applications due to biotechnology, reduces trips across the field by up to half or more. According to USDA, a corn farmer can save at least 3.5 gallons of fuel per acre by going from conservation tillage to full no-till *(USDA/NRCS)*. No-till corn production can reduce the use of diesel fuel per acre by nearly 74% compared to conventional tillage—conserving 160 to 280 million gallons of fuel a year.

Farmers also use buffer zones, terrace, and contour farming, underground drainage, subsurface irrigation, and other innovative practices to control soil erosion, reduce runoff, improve wildlife habitat, and enhance environmental stewardship.

> *"There's a misconception that it would be better to go back to more primitive methods of agriculture because chemicals are bad or genetics is bad. This is not true. We need to use the science and technology we have developed in order to feed the world's population, a growing population. And the more yield we get per acre of land the less nature has to be destroyed to do that…It's simple arithmetic. The more people there are, the more forest has to be cleared to feed them, and the only way to offset that is to have more yield per acre."*
>
> PATRICK MOORE
> Co-founder of environmental group Greenpeace

Historically, biofuels advocates have been strong supporters of a low carbon fuel standard (LCFS), because the biofuels industry has been working to perfect and produce low carbon fuels for decades. According to a recent study published in Yale's *Journal of Industrial Ecology*, ethanol produced from corn in modern facilities reduces greenhouse gas emissions by more than 50% when compared to gasoline!

Study after study shows that ethanol has a superior carbon footprint to fossil fuels. But now, it appears, that being "better" is simply not enough. Thanks to the concept of indirect land use change (ILUC), biofuels are being tasked with being "better than better". Worse yet, biofuels are the only energy source expected to meet this challenge.

ILUC has become part of the LCFS equation by which the carbon value of fuels is assessed. Essentially, ILUC attempts to extrapolate global changes in land use and the subsequent carbon emissions that may occur when the United States produces biofuels. In simple terms, ILUC poses this question: If an acre of American corn is used to make ethanol, what impact does that have on the conversion of pristine lands to agricultural use in South America or Africa—and what effect does that change have on greenhouse gas emissions?

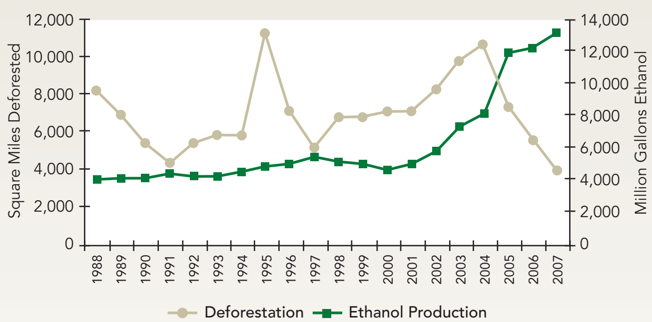
The theory of ILUC gained notoriety when a study by Tim Searchinger was published in *Science* in February 2008. Even though Searchinger is a lawyer with no scientific training or credentials, his "findings" received wide media coverage. Academics across the board quickly criticized his methodology and called his findings "highly speculative" and "seriously flawed"—and many academics in the life cycle analysis community have patently dismissed the study due to its many ethical and intellectual weaknesses.

But here we are—with ILUC a significant part of serious policy discussions related to biofuels, even though it isn't taken seriously by hundreds of scientific and academic experts.

This unfounded logic is having a dramatic impact on policy development and threatens the very future of first- and second-generation biofuels. The problem is that the criteria, modeling and "science" being used to measure ILUC are shaky at best. Moreover, ILUC modeling fails to take into account market-mediated effects and other "ripples" that occur as the result of changes in the energy marketplace. "The marginal impact of land use changes here in the United States on land use in the rest of the world is extremely hard to predict with economic equilibriums and agricultural and trade policies all interacting in complex ways," according to Nathaneal Greene of the Natural Resources Defense Council.

But perhaps most disturbing is the fact that only biofuels are being singled out in the accounting of so-called "indirect effects". Energy sources such as petroleum are not subject to this scrutiny, even though they represent the largest segment of the transportation fuel sector.

Brazilian Deforestation and Global Ethanol Production



Deforestation Sources: IEA; Butler, Mongabay.com (FAO, NISR)
Ethanol Production Sources: American Coalition for Ethanol; Renewable Fuels Association

The proposed low carbon fuel standard in California and the EPA's criteria for the life cycle analysis of biofuels have become the battlegrounds for this issue—and the scientific, academic, and biofuels community have weighed in with a number of serious concerns and challenges. In March 2009, 111 of the nation's top scientists signed a letter to California Governor Schwarzenegger, warning that: "Enforcing different compliance metrics against different fuels is the equivalent of picking winners and losers, which is in direct conflict with the ambition of the LCFS."

is silly game, let's make everyone play by the same rules.

In March 2009, twelve U.S. Senators, including ***Ethanol Across America*** co-chairman Ben Nelson (D-NE) and advisory board member Tim Johnson (D-SD), wrote EPA Administrator Lisa Jackson, expressing a range of concerns with the approach being adopted by EPA in assessing the impact of biofuels on land use changes. "Given the complexity of this issue as well as what we believe are basic analytical limitations, we urge EPA to refrain from including any calculations of the ILUC components in determining lifecycle GHG emissions for biofuels at this time. The premature publication or use of inaccurate or incomplete data could compromise the ability to formulate a sound approach to implementing this lifecycle GHG emissions requirement in the future," the letter said.

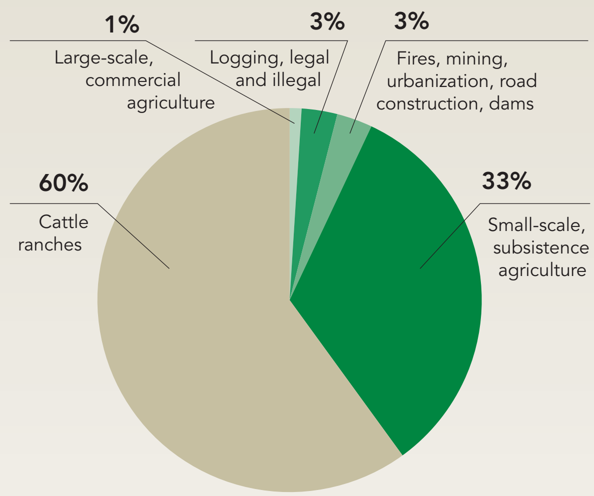
In an April 14, 2009, letter to Mary Nichols, chair of the California Air Resources Board (CARB), Mike Edgerton, biofuels technology lead for Monsanto Company, wrote: "The models [to estimate indirect land use change] are very dependent on assumptions used, poorly reflect the world today and do not adequately address the complex issues underlying land use change...inclusion of the indirect land use change based on current methods would penalize both first–and second–generation biofuels based on one set of opinions rather than a sound science-based measure."

In May 21, 2009, testimony to the House Agriculture Committee, Brian Jennings of the American Coalition for Ethanol, urged the policy makers to "get the science right, then move forward on...low carbon fuels policy. If comparing indirect effects, compare indirect effects for all fuels. Undertake a complete lifecycle assessment of the indirect emissions associated with petroleum."

During that same hearing, Growth Energy CEO Tom Buis, said: "The LCFS is a worthy cause...if done correctly. First, it should apply equally to all transportation fuels. Second, it should be based on universally accepted science and economic modeling...Oddly, science and parity have not been part of the equation, which makes us seriously question the motivation."

In an April 30, 2009, letter to key Obama administration officials including the EPA Administrator and Secretaries of Energy and Agriculture, five professors from universities in Nebraska, Iowa, Maryland, and South Dakota noted the distinct and unique advantages and advancements in using corn as a first-generation biofuel feedstock—citing its highly efficient photosynthesis system, water use efficiency and steady yield increases on fewer acres. The group also noted the fact that "for every two bushels of corn processed in an ethanol

Causes of Deforestation in the Amazon 2000 – 2005



Source: Mongabay.com

facility, approximately one bushel of corn equivalent is preserved and used to displace bulk corn as livestock feed." They state that ethanol's land use effects should recognize the importance of this feed product's value and role in the feed and food chain. The letter closed with the following statement: "...recent unfavorable press reports on corn ethanol's negative environmental footprint, and its alleged food vs. fuel tradeoffs, have been unfairly exaggerated, and are in some instances outright distortions of the facts."

Dr. Michael Wang of DOE's Argonne National Laboratory, a highly regarded expert on lifecycle analysis, agrees: "There seems to be no indication that U.S. corn ethanol production so far has caused indirect land use changes in other countries."

(continued)

A 2009 report commissioned by the International Energy Agency (IEA) examined greenhouse gas emissions from grain ethanol since 1995 and projected GHG reductions from ethanol out to 2015. According to the report, "the GHG emissions savings from ethanol production and use will have more than doubled between 1995 and the projected level in 2015. This indicates the danger of making policy decisions based on historical data without taking into account learning experience and the potential gains that can be expected as industries develop. The GHG emissions reductions in 2015 from corn ethanol would qualify as advanced biofuels under proposed U.S. regulations."

The United States must overcome its expensive and dangerous dependence on imported oil—and develop a portfolio of low carbon, domestic, renewable fuels. Placing unfounded, unrealistic, and unfair standards on biofuels—and then not expecting petroleum to play by the same rules—is counterproductive to America's energy strategy and only serves to strengthen the economic and environmental stranglehold of fossil fuels. Biofuels producers support low carbon fuels, because they measure up admirably in this regard. But clearing the bar of indirect land use change—and being the only energy player expected to do so—threatens the future of the U.S. biofuels industry, and the benefits it can bring for decades to come.

So why is this important and what's at stake? Everything, actually. The U.S. EPA modeling will determine the eligibility of various types of biofuels to meet the RFS compliance requirements of refiners at the federal level. Applying this unaccepted "science" of ILUC could deny biofuels entry into the market because a refiner must use fuels with a higher rating, including imported biofuels such as often-overrated Brazilian ethanol. New grain ethanol plants and expansions of existing plants would be virtually stopped dead in their tracks, with no market to serve. And that will lead to no new jobs, more imported oil, and more dollars going overseas.

Even if the federal models become more reasonable in their rating of first-generation ethanol, independent actions at the state level using this voodoo science could literally preclude the use of most ethanol. Among other things, this sets up a potential train wreck of a national biofuel requirement such as the RFS being in force, but a state like California having such stringent standards that the fuel cannot be used there. With other states adopting California standards, it is not out of the question to have a situation where 2/3 of the nation's gasoline cannot use ethanol because it is being penalized for land use changes in Sri Lanka or some other corner of the globe.

The final inconsistency in this entire process is the question: How much is enough? Initial EPA modeling indicated U.S. grain based ethanol achieved more than a 20% reduction in greenhouse gases as compared to the baseline fuels of 2005 petroleum. When the ILUC was factored in, that reduction dropped to 16%, even with this questionable methodology. A 16% improvement—less than gasoline!

When many major cities in the U.S. were not meeting ozone and smog standards in the 1990's, the Clean Air Act required them to make reductions of 15%—a level that was universally hailed as a significant improvement. Recent action by the House Energy and Commerce Committee to report out landmark Climate Change legislation called for sweeping GHG reductions of 17% from stationary sources. Many members of Congress were quite pleased with themselves for this accomplishment, deeming it to be indeed significant. So why is 17% from stationary sources cause for celebration—but the same amount from corn ethanol brings a storm of criticism? Isn't better good enough?

In the end, energy and climate change policy should reward any reduction in greenhouse gas emissions. Biofuels are proven to perform better in this arena.

And better is better. Period.

ENERGY CONSUMPTION

One of the greatest costs in an ethanol plant is the energy it takes to generate the heat needed for the process. As a result, ethanol producers are continually motivated to reduce energy costs and improve efficiency, productivity, and environmental stewardship.

A recent study by Christianson & Associates, PLLP, found that, between 2004 and 2007, ethanol plants reduced the energy required to produce ethanol and feed co-products by 13.5%. Stated another way, it took an average of 31,588 BTUs to produce a gallon of ethanol in 2004. In 2007, that had dropped to 27,298 BTUs. It's important to note that a gallon of ethanol contains about 77,000 BTUs—so we're getting about 50,000 more BTUs than we're putting into the process.

The Christianson study also noted that the most efficient ethanol plants have reduced energy requirements by a dramatic 19%—using fewer than 21,000 BTUs per gallon. Moreover, electricity usage dropped by 13% in these plants.

The U.S. Department of Energy's Argonne National Laboratory compared ethanol production in 2001 versus 2006 and found:

- Water consumption down 26.6%
- Grid electricity use down 15.7%
- Total energy use down 21.8%

Innovation continues. New "no cook" processes reduce natural gas usage by up to 15 percent. Some ethanol producers are using alternatives to natural gas, such as biomass gasifiers which use wood chips or corn stover as a source of fuel for processing. One Nebraska plant displaces almost one-third of their natural gas demand by harvesting methane produced by decomposing garbage at a nearby landfill—essentially using a renewable source of energy to create another renewable source of energy.

Two recent studies by economic policy analysts conclude that modern ethanol plants have a superior carbon footprint and net energy benefit when compared to gasoline refineries:

Steffan Mueller, the author of *Global Warming Impact of Corn Ethanol*, indicates that the global warming impact of modern ethanol plants is 40% lower than gasoline. "This is a sizeable reduction from numbers currently being used by public agencies and in the public debate," he said. "The study also documents the significant net energy benefits of ethanol when compared to gasoline."

In *Ethanol's Potential Role in Meeting U.S. Energy Needs 2016-2030*, Ross Korves suggests that sufficient corn will be available to increase ethanol production to 33 billion gallons per year by 2030 using current technology. The study also factors in increased demand for corn from both export and food sectors. Korves notes that the study provides compelling data that ethanol production can grow substantially at no risk to food supplies.

EMERGING ETHANOL PROCESS TECHNOLOGIES

Higher energy costs, market dynamics and environmental regulations are driving innovation and efficiency in the ethanol industry. Here are just a few highlights:

Dry Fractionation Today, most ethanol plants use corn as their primary feedstock—and most take whole corn into the plant in its raw form for processing. Fractionation is a new technology that precisely separates the corn into different component parts before it enters the ethanol stream in order to improve process efficiencies and expand the range of products that can be produced. Reduced emissions and energy costs are also benefits of fractionation.

> *"Advanced renewable transportation fuels will be one of the nation's most important industries in the 21st Century. Combined with improved energy efficiency, biofuels are the primary near-term option for insulating consumers against future oil price shocks and for lowering the transportation sector's carbon footprint. The direct consumer benefit has been well documented and producing and using more biofuels today means an immediate reduction in oil imports in addition to an immediate increase in domestic employment."*
>
> PRESIDENT BARRACK OBAMA
> Letter to Governors' Biofuels Coalition
> May 27, 2009

Most fractionation systems separate the corn kernel into three main components—starch (endosperm), germ, and bran. By removing non-fermentable material from the fermentable starch in the kernel before the corn enters the ethanol process, the plant can improve throughput while reducing the use of organics in fermentation, thus generating less VOC emissions—about 10% less.

Fractionation increases the concentration of ethanol in the fermentation system, while reducing overall energy demand by a minimum of 6,000 BTUs per gallon of ethanol. This translates directly into lower natural gas usage, which in turn leads to less overall NOx emissions from the plant.

Moreover, fractionation provides an ethanol plant with more options in terms of the products it can make from corn. The ability to add value in more ways will provide ethanol plants with greater market and profit potential—and will amortize energy usage across more products, further improving the environmental impact of the biorefinery.

Combined Heat and Power (CHP) After several years of study, the Environmental Protection Agency (EPA) has concluded that combined heat and power (CHP) systems can reduce energy consumption in dry mill ethanol plants by some 15%. A CHP system combines electricity and steam in a plant, recovering waste heat for heating, cooling, and dehumidifying.

According to Felicia Ruiz, program manager for EPA's Combined Heat and Power Partnership, "CHP can help meet corporate environmental goals and enhance a company's image." EPA offers CHP partnership participation to ethanol plants, a program that began in 2002.

CHP provides a number of benefits including:

- Energy savings of 10% to 25%
- A hedge against energy cost volatility
- Ensuring continual plant operation in the event of electrical supply cutoff
- Opportunities to partner with municipal utilities or rural cooperatives to leverage resources
- Ensuring optimal use of available energy resources by increasing fuel options
- Reduced carbon dioxide emissions

Biomass Gasification In this process, biomass—any sort of organic material such as switchgrass or agricultural waste such as corn cobs or stover—is superheated, producing "syngas." Syngas can then be used as a fuel source for the boiler in an ethanol plant—or its components can be reconstituted into ethanol. Char, the biomass leftovers from gasification, can be used as a soil amendment to increase fertility.

Syngas reduces GHG emissions by displacing fossil fuel demand—and any GHG emissions from syngas combustion are counterbalanced by photosynthesis during the cultivation of biomass itself. If left in the field, decomposing biomass produces methane, which has a far greater greenhouse effect than the CO_2 resulting from gasification. If renewable energy inputs are used for gasification, the process has the potential to be carbon-negative.

Evaluating Environmental Performance

Accurately quantifying the environmental impact of individual biofuel systems is increasingly important for environmental, public policy, and economic reasons. Determining how well plants measure up will be critical to the industry's long term success and sustainability. In the future, it is likely that biofuels plants will be required to certify their energy efficiency and greenhouse gas emissions to meet renewable or low-carbon fuel standards being developed in several states and nations.

Agricultural researchers at the University of Nebraska–Lincoln have developed a tool to assess greenhouse gas mitigation and energy efficiency of corn-based ethanol plants. Nicknamed BESS, this "seed-to-fuel" tool quantifies lifecycle carbon savings and environmental impact of individual biofuel production systems. It factors in energy use and greenhouse gases from crop production, ethanol conversion, co-product use, waste disposal, and transportation.

The BESS model estimates net energy efficiency and net greenhouse gas emission for each component in biofuel production throughout the entire system. "In the future, the marketplace is likely to reward the most environmentally efficient biofuel plants," says UNL agronomist Ken Cassman, director of the Nebraska Center for Energy Sciences Research, who leads the BESS project.

The BESS model is designed for easy use by ethanol plant operators, crop producers, researchers, regulators, policy makers, and others concerned with optimizing the economic and environmental performance of biofuel systems. The model is backed by detailed software development and extensive, well-documented scientific data.

For more information on BESS, visit: http://www.bess.unl.edu

SUMMARY

Every process that requires carbon-based energy produces emissions. Before you can put gasoline in your car, oil must be drilled from an oil well, shipped to a refinery, refined into gasoline and other products, and transported to the gas station. Every step requires energy inputs and consequently emits greenhouse gases.

Clearly, this road to energy production leads to a dead end, since we're relying on a finite resource. As the world's oil reserves are tapped, oil becomes not only harder to find, but its extraction and processing come with a higher environmental and economic cost.

> *"America can be the innovation engine that changes the course of history by creating crucial new clean-energy technologies, 21st century jobs, and a democratizing force that provides the solutions to our greatest needs."*
>
> RICHARD E. SMALLEY
> Late scientist, technology visionary, and
> Nobel Prize winner

Tar sands and oil shale will require more capital, more energy and more water to process into oil. Just one pound of oil shale has less energy than a recycled phone book—and produces up to twice the GHG emissions of conventional oil.

When fossil fuels are burned in a combustion engine, greenhouse gases (GHG) such as carbon dioxide are emitted. This is the fundamental flaw of petroleum-based energy: carbon sequestered underground for millennia as oil is ultimately burned in an engine and released into the atmosphere.

In the meantime, oil companies and OPEC privatize the profits of an oil-based energy economy, while the rest of the world is left with a hefty social, political, and environmental bill.

Biofuels such as ethanol have a number of innate advantages that fossil fuels cannot duplicate.
The cycle of biofuels helps reverse the negative effects of fuel combustion. Plants grown for biofuels use photosynthesis to convert CO_2 in the atmosphere into oxygen, thus reducing the lifecycle GHG emissions of biofuels significantly.

The science is clear: When compared to gasoline, corn ethanol pollutes less, uses less energy, and produces fewer climate-changing GHG emissions.

Meanwhile, a hazy cloud of pollution is darkening the sky over portions of Asia, Africa, the Middle East, and in the Amazon—changing weather patterns and threatening world food supplies. Experts report these "atmospheric brown clouds" are caused primarily by burning fossil fuels.

Need we say more?

BIBLIOGRAPHY

Brown, Dr. Robert C., Cassman, Dr. Ken, Kephart, Dr. Kevin D., Klopfenstein, Dr. Terry, and Kratochvil, Dr. Robert. Letter to EPA Administrator Jackson, Agriculture Secretary Vilsack, Energy Secretary Chu and Assistant to the President for Energy and Climate Change Browner; April 30, 2009

Buis, Tom. Testimony at the Hearing of the Agriculture Committee, United States House of Representatives, Low Carbon Fuels Standard Policies, May 21, 2009

Christianson, John O.,*"U.S. Ethanol Industry Efficiency Improvements: 2004 through 2007"*, Christianson & Associates, PLLP, 2007

Ebert, Jessica. "Solar-Powered Biomass Gasification." *Biomass Magazine*, June 2008. http://www.biomassmagazine.com/article.jsp?article_id=1674

Farrell, Alexander and AR Brandt. "Risks of the Oil Transitions." October 2006. http://www.iop.org/EJ/article/1748-9326/1/1/014004/erl6_1_014004.html

Farrell, Alexander, *et al.* "Ethanol Can Contribute to Energy and Environmental Goals." *Science Magazine,* January 2006. http://www.sciencemag.org/cgi/content/full/311/5760/506

Jennings, Brian. Testimony at the Hearing of the Agriculture Committee, United States House of Representatives, Low Carbon Fuels Standard Policies, May 21, 2009

Korves, Ross. "The Potential Role for Corn Ethanol in Meeting the Energy Needs of the United States in 2016-2030." October 2008. http://www.ethanolrfa.org/objects/documents/1965/potentialforcornethanol.pdf

Moore, Patrick. Quoted in "Sustainability" white paper published by National Corn Growers Association, 2007

Mueller, Steffen, *et al.* "The Global Warming and Land Use Impact of Corn Ethanol Produced at the Illinois River Energy Center." July 29, 2008

Obama, President Barrack. Letter to Governors' Biofuels Coalition; May 27, 2009

Read, Peter. "Carbon Cycle Management with Increased Photo-Synthesis and Long Term Sinks." http://www.royalsociety.org.nz/Site/news/science_topics/energy/ccmgmt.aspx

Rice, Charles W. "Storing Carbon in Soil: Why and How?" *Geotimes*, January 2002. http://www.geotimes.org/jan02/feature_carbon.html

Ruiz, Felicia. Attributed remarks in *BioFuels Journal*, p. 17, July/August 2008

(S&T)2 Consultants Inc. *An examination of the potential for improving carbon/energy balance of Bioethanol.* IEA Task 39 Report T39-TR1, 72 pp., 2009

Simmons, Dr. Blake A., Keasling, Dr. Jay D., Blanch, Dr. Harvey W. *et al.* Letter to California Governor Arnold Schwarzenegger re: Opposed to Selective Enforcement of Indirect Effects in California Low Carbon Fuel Standard; March 2, 2009

Smalley, Dr. Richard. "Our Energy Challenge" address delivered at Houston Museum of Natural Science, April 22, 2003

Tran, Tini and John Heilprin. "UN: Clouds of pollution threaten glaciers, health." Associated Press, November 14, 2008. http://www.journalstar.com/articles/2008/11/14/news/doc491cc4b00346d888237313.prt

U.S. Senators Harkin, Grassley, Bond, Brownback, Corker, Conrad, Johnson, McCaskill, Nelson, Roberts, Tester and Thune. Letter to EPA Administrator Jackson; March 13, 2009

Wang, Dr. Michael. Letter to *Science Magazine*, March 14, 2008

CFDC CLEAN FUELS DEVELOPMENT COALITION

www.cleanfuelsdc.org

american coalition for ethanol

www.ethanol.org

Nebraska Ethanol Board

www.ne-ethanol.org

Maryland Grain Producers
Utilization Board

www.marylandgrain.com

Nebraska Public Power District
Always there when you need us

www.nppd.com

The *"Environmental Impacts of Ethanol Production"* Issue Brief was produced and distributed as part of the **Ethanol Across America** education campaign.

The Issue Brief series is sponsored by the Clean Fuels Development Coalition, the American Coalition for Ethanol, the Maryland Grain Producers Utilization Board, Nebraska Public Power District and the Nebraska Ethanol Board.

Special thanks are extended to the U.S. Department of Agriculture's Office of Rural Development and the Office of Energy Policy and New Uses. Additional thanks to the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy.

Technical writers: Douglas Durante, Todd Sneller and Dave Buchholz
Editing, Design & Production Coordination: David & Associates, Hastings, NE (www.teamdavid.com)

Produced in cooperation with the USDA United States Department of Agriculture and the United States Department of Energy

Ethanol Across America

Ethanol Across America is a non-profit, non-partisan education campaign of the Clean Fuels Foundation and is sponsored by industry, government, and private interests. U.S. Senators Ben Nelson (D-NE) and Richard Lugar (R-IN) , Co-Chairmen. For more information, log on to www.ethanolacrossamerica.net.

09CFDC-003_0609_2.5M