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Motor Vehicle Fuels: Concepts for a Rational and Sustainable National Energy Policy

Econergy International Corporation

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Econergy International Corporation is a leading worldwide carbon consulting company that performed seminal work for the World Bank which led directly to the establishment of the Prototype Carbon Fund; has traded verified and certified carbon emissions reductions in the U.S. and globally; has vast experience within the Brazilian sugarcane ethanol industry; has authored several original methodologies for the Kyoto Clean Development Mechanism carbon market; has built, owned, and operated carbon mitigation projects producing verified carbon offsets; and has vast carbon accounting and modeling experience throughout the world. Econergy's headquarters are in Boulder, Colorado with offices in Washington, DC; Monterrey, Mexico; Sao Paulo, Brazil; San Jose, Costa Rica; and London, UK.

Econergy Consulting was retained by ICM, Inc. to develop the "ICM/Econergy Model", a full life-cycle analysis (LCA) model focusing on the life-cycle energy balance and associated carbon emissions of corn ethanol production, in comparison to Brazilian sugarcane ethanol and gasoline. This paper is an outgrowth of analyses conducted with this model, and an outgrowth of years of providing advisory services to governments worldwide aimed at mitigating GHG emissions from the transportation sector. It presents Econergy Consulting's policy recommendations with respect to the US domestic liquid transportation fuels industry and related infrastructure.

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Executive Summary

Corn ethanol today displaces more than $8 billion/year of imported petroleum. Because of corn ethanol, these billions of dollars are not being exported from our economy to purchase foreign oil. Rather, these billions of dollars remain in our economy generating economic activity, creating jobs, and generating tax revenue. And these economic benefits will become much more significant over time as more ethanol enters the marketplace to satisfy the requirements of the Energy Independence and Security Act (EISA) of 2007 and as the price of a barrel of petroleum inexorably rises, overwhelming the occasional and temporary oil price declines such as we are currently enjoying.

Corn ethanol is a necessary bridge to the future. The United States must use its domestic corn ethanol industry to take aggressive action today to reduce petroleum imports and to expand the use of low-carbon motor fuels so that when tomorrow's truly sustainable biofuels technologies are commercialized, the necessary infrastructure and market demand are in place to take full advantage of next-generation renewable fuels such as cellulosic ethanol.

A market-based approach to producing low-carbon corn ethanol is needed in order to make significant reductions in carbon emissions associated with combustion of vehicle fuels. The new administration and Congress must create incentives to encourage the "greening" of today's corn ethanol so that the existing ethanol production plants manufacture progressively lower-carbon corn ethanol during the transition to truly sustainable, ultra-low-carbon fuels produced by next-generation technologies.

The EISA only encourages new ethanol production facilities to mitigate the carbon intensity of their product. Market-based incentives must be created to incentivize the large fleet of existing corn ethanol production facilities to do likewise. Specific actions toward this end include:

- Create a production tax credit aimed specifically at industrial process heat (IPH) to encourage existing ethanol plants to switch from fossil fuels to carbon-neutral thermal energy sources for their IPH needs.
- Establish a motor fuel carbon-content standard (grams CO_2/MJ) so that the marketplace will reward ethanol producers, distributors, and blenders for supplying lower-carbon vehicle fuel.
- Encourage the use of low-cost and low-carbon Brazilian sugarcane ethanol within a market-based framework that drives down the carbon intensity of motor fuels.

To facilitate the harnessing of market forces to drive the nation's transportation sector toward lower-carbon fuel usage, a national fuel-rating system should be developed. Based on the output of a plant-specific life-cycle analysis, the ethanol produced by a specific individual ethanol plant would be rated on its GHG performance relative to gasoline. The fuel rating would provide the basis for fuel blenders to choose the ethanol product that best enables them to meet a national clean-fuel standard. The fuel rating would eventually also be displayed on the fuel pump to empower motorists to make a fuel choice based on its relative "green-ness" if they so desire, thereby enabling them to directly participate in a clean-energy economy. Thus, we will increase our energy independence, keep US dollars in our own economy, and continue to create the "green collar" jobs that are the foundation of our future economic prosperity.

There is a gaping incentive "dead zone" between the 20% threshold and the 50% threshold established by the EISA to encourage alternative-fuel carbon emissions reductions compared to gasoline. This is better viewed as an "opportunity zone" in which strategically important carbon emissions reductions can be cost-effectively captured, if appropriate incentives are provided. This paper shows that there is more than one pathway to greener corn ethanol, using technology available today, that would fall within this opportunity zone. However, as EISA currently stands, an ethanol producer has zero incentive to implement a pathway that is any greener than the least-cost pathway that just barely meets the 20% threshold. Thus, tremendous potential to green-up the nation's fleet of corn ethanol plants will remain untapped under the current EISA incentive structure. We believe it is imperative to create a sliding-scale incentive structure to reward ethanol producers who are willing to go beyond the 20% threshold and venture into the opportunity zone. The farther they go beyond the 20% threshold, the greater the incentive they would earn under a sliding-scale system. A more rapid transition from conventional corn ethanol to lower-carbon ethanol would thus be encouraged.

It is absolutely necessary to embrace policies that promote a rapid and dramatic reduction in the gasoline consumed by the nation's vast and thirsty fleet of existing vehicles. The obvious strategy for newly manufactured vehicles is to incentivize automakers to make high-efficiency vehicles. An obvious strategy for the existing vehicle fleet – one that has the potential to make each and every US motorist an active partner in realizing our nation's energy independence – is to make mid-level blends of ethanol fuel widely available.

We recognize it is fundamentally important to understand the carbon-balance impacts associated with changes in land use that are caused by biofuels production. However, we believe that the present state of land-use-change science is not well-enough developed to yet know how best to assess the indirect land-use change (ILUC) impacts associated with biofuels. Thus, we believe that the use of an ILUC adder in determining EISA compliance by corn ethanol (or any other motor fuel) is not presently justified by the immature scientific discipline of ILUC carbon analysis.

Fossil fuel consumption in the US transportation sector poses a triple threat to our national security, our economic security, and our climate security. In an effort to contribute to the debate on national policy, this paper focuses on several specific means by which we can rapidly move our nation toward resolution of these serious challenges by using a market-based approach. Perhaps the most important of these is the recommendation to create a national standard that establishes maximum values for the carbon content of motor vehicle fuels. This standard should be aggressive yet achievable, and should become more aggressive over time.

Recommendations for a National Standard for Carbon Content of Motor Vehicle Fuel

Econergy recommends a two-phase national standard to reduce the carbon intensity of motor vehicle fuel as follows:

Phase I: Require by 2015, a 2.3% reduction in motor vehicle fuel carbon intensity relative to the 91.6 $gC0_2e/MJ$ GREET baseline for gasoline.

Phase II: Require by 2022, a 4.9% reduction in motor vehicle fuel carbon intensity relative to the $91.6gC0_2e/MJ$ GREET baseline

Contents

Glossary of Terms

CAFE	Corporate Average Fuel Economy (vehicle fuel-efficiency standard)
CARB	California Air Resources Board
CHP	Combined Heat and Power (a.k.a. cogeneration)
EISA	Energy Independence and Security Act of 2007
EPA	Environmental Protection Agency
EV	Electric Vehicle
FTT	Field-to-Tank (full life-cycle of bio-fuel production)
FFV	Flex Fuel Vehicle (designed to run on E85 or gasoline)
FTW	Field-to-Wheels (full life-cycle of bio-fuel production and use)
GHG	Greenhouse Gases
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GWI	Global Warming Intensity (in reference to a product or process)
ILUC	Indirect Land Use Change
IPCC	Intergovernmental Panel on Climate Change
IPH	Industrial process heat
ITC	Investment Tax Credit (federal)
LCA	Life-Cycle Assessment
LCI	Life-Cycle Intensity (usually in reference to an LCA component)
NRER	Net Renewable Energy Ratio
NREV	Net Renewable Energy Value
OPEC	Organization of Petroleum Exporting Countries
PHEV	Plug-in Hybrid Electric Vehicle
PTC	Production Tax Credit (federal)
REC	Renewable Energy Certificate
RFS	Renewable Fuels Standard
WTT	Well-to-Tank (full life-cycle of fossil fuel production)
WTW	Well-to-Wheels (full life-cycle of fossil fuel production and use)

Introduction

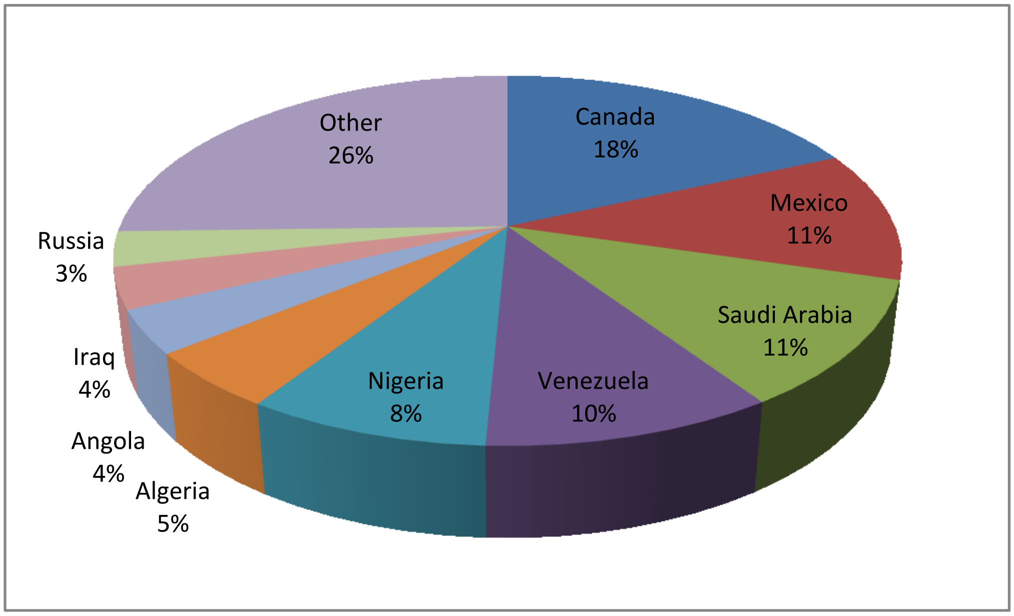
This paper aims to articulate a policy perspective that strikes an appropriate balance among seemingly conflicting positions with respect to several of the greatest national challenges of our time. Rising energy costs, heightened concerns about national security, and the realization that climate change is real and is happening today represent the confluence of three crises that are each rooted in fossil fuel consumption. This "perfect storm" demands that we rethink how we use fossil energy and, more to the point of this paper, that we establish aggressive, rational, and sustainable national policies to address these crises. This paper explores the logical next steps we must take to reduce dependency on foreign oil, reduce the associated balance-of-payments deficit, and mitigate the impact on our global climate caused by combustion of fossil-based motor fuels. We believe that these challenges must be met with market-based approaches that incentivize the production and consumption of lower-carbon fuels. The necessary far-reaching policy initiatives must be based on well-developed scientific research.

Toward a Rational and Sustainable National Energy Policy

For 35 years, policymakers have recognized that it is imperative to wean the US economy off of foreign oil. During that time, it has unfortunately been the case that politics generally trump policy. Consequently, US dependence on foreign oil has increased dramatically and dangerously. In 1973, the US imported about 36% of its total oil consumption. During 2007 the United States was the world's 3rd largest producer of crude oil, behind Russia and Saudi Arabia, and yet imported 58% of the oil it consumed. Almost 70% of our 20.7 million barrels per day (bpd) addiction is consumed in the transportation sector, with more than 9 million bpd consumed as motor gasoline alone[1]. Clearly, the battle for energy independence must focus on how we consume petroleum in the nation's fleet of vehicles. Figure 1 on page 10 presents the picture of the current US dependence on foreign oil.

[1] According to The Department of Energy's Energy Information Administration www.eia.doe.gov

Figure 1: Breakdown of crude oil import to the US in 2007



The first policy imperative is to take aggressive steps to reduce our foreign oil dependence. The balance-of-payments deficit has been seriously inflated by our oil imports such that we are currently sending at least $300 billion per year out of the country to pay for oil. This has obvious deleterious impacts on our economy at exactly the same moment we have been shocked by the global financial crisis into the realization that we cannot afford to continue to export this frightening amount of hard currency outside of the domestic economy.

Another critical dimension of our dependence on foreign oil is the fact that our national security is dangerously compromised by the export of this huge amount of our national wealth in exchange for foreign oil. It is now widely recognized that some significant portion, perhaps as much as 10%, of our exported petrodollars wind up in the hands of terrorist organizations[2]. The USA must quickly and aggressively reduce our foreign oil imports. This can only happen within the framework of a rational national energy policy.

Another policy imperative our nation must embrace is to develop and aggressively pursue a rational strategy to mitigate global climate change. For the first time in human history, we face a perfect storm of threats to our economic security, national security, and climate security. Fortunately, sustainable

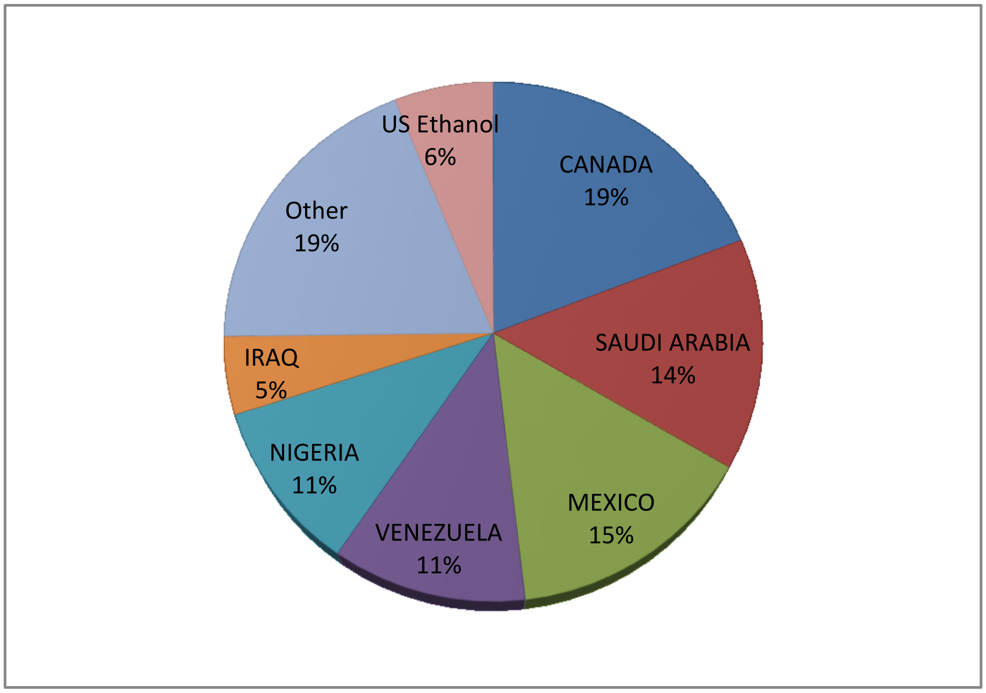
[2] According to Robert McFarlane, President Reagan's National Security Advisor and James Woolsey, President George H. W. Bush's CIA Director

pathways into our future are already emerging that will enable us to simultaneously address each of these national challenges with success. The US cannot afford to delay. A new administration presents the opportunity to elevate these policy imperatives to the status they deserve – analogous to the Manhattan Project of the 1940s and the Apollo Project of the 1960s.

Conventional corn ethanol is already making an important contribution to these policy objectives. Figure 2 shows the sources of energy used for producing gasoline for US motor vehicle fuels, excluding the gasoline which is refined from domestically produced crude. In the absence of US ethanol production, 6% more crude oil would need to be imported. Domestically produced ethanol displaces more than $8 billion/year of imported petroleum (at $69/barrel)[3]. Because of US corn ethanol, these billions of dollars are not being exported from our economy to purchase foreign oil. Rather, these billions of dollars remain in our economy generating economic activity, creating jobs, and generating tax revenue. And these economic benefits will become much more significant over time as more ethanol enters the marketplace to satisfy the requirements of the Energy Independence and Security Act (EISA) of 2007 and as the price of a barrel of petroleum rises. Corn ethanol is a necessary bridge to the future, fomenting the development of necessary infrastructure and market demand for fossil fuel alternatives while truly sustainable next-generation technologies mature.

[3] According the DOE's EIA, the US produced 155.26 million barrels of ethanol which would displace $8 billion to import the crude oil needed to refine the equivalent amount of energy into gasoline, at a global average crude price in 2007 of $69/bbl.

Figure 2: US ethanol and imported petroleum used in the non-domestic fraction of motor vehicle gasoline



The urgency of the converging crises threatening our nation demands a simultaneous two-pronged attack on both the demand side and the supply side of our motor fuel supply challenge.

Demand-Side Efficiency

Our nation's out-of-balance dependency on foreign oil cannot lead to anything other than higher energy prices, an ever-worsening balance-of-payments deficit, and continued global terrorism - unless we take decisive action to achieve stability and sustainability in our economy's liquid fuels sector. The equation for rational utilization of any resource involves balancing the supply side of the resource with the demand side. If either side of the resource equation is out of balance, the system experiences disequilibrium with undesirable consequences. It is a general truism that, for any resource, the least-cost supply option is not the development of *new* supply sources but rather the more efficient use of *existing* supply sources. We have a huge, untapped energy resource that can dramatically reduce our foreign oil imports. This untapped resource is not the expanded domestic production of oil, which cannot achieve a quick impact nor can it significantly affect the price of oil, a global commodity. Rather, our most abundant and least-cost energy resource is demand-side efficiency. In the particular case of petroleum, our most abundant and least-cost oil "resource" is a high-efficiency vehicle fleet. The very first agenda item President Obama and the 111th Congress must address is to demonstrate to the nation and the world how the US will respond to the perfect storm that is bearing down on us is to mandate substantially higher fuel-economy standards for new vehicles. Unfortunately, the US has lost decades of time we could not afford to squander. The time for dramatic action is long overdue and it is critically important to seize upon the opportunity as US automakers seek a bailout from American taxpayers. On December 10, 2008, the U.S. House passed a $14 billion bailout for the struggling Detroit automakers, but the aid package hit a snag and the bailout was scuttled in the U.S. Senate on December 11. On December 16 however, the White House stated an abrupt bankruptcy of the U.S. automakers could be further devastating to the economy. The auto bailout was ultimately approved. General Motors and Chrysler have already received government bailout funds.

When President Bush signed EISA of 2007, the Corporate Average Fuel Efficiency (CAFE) standard target was raised to 35 mpg by 2020, the first significant raise in almost 20 years. However, compared with the strides being made by the other industrialized nations, this goal is quite weak, especially considering the goal of promoting "energy independence and security". Figure 3 on page 14 reveals that the US compares very poorly to its global peers in this category; California is taking slightly more aggressive action but is still a decade behind the EU and Japan. Even China has substantially higher vehicle fuel-efficiency standards than the US.

Fortunately, President Obama has already initiated new policies that establish a clear path forward to significantly improve America's energy security and independence. On January 26, 2009, President Obama issued a memorandum regarding EISA 2007 that signals a departure from the policies established by the previous administration. This memorandum instructed the EPA to re-examine whether California and other states can have tougher auto emissions standards, and directed the U.S. Department of Transportation to complete increased automotive fuel economy standards by March 2009 in order to take effect with the 2011 model year.

Figure 3: CAFE normalized mpg targets by region[4]

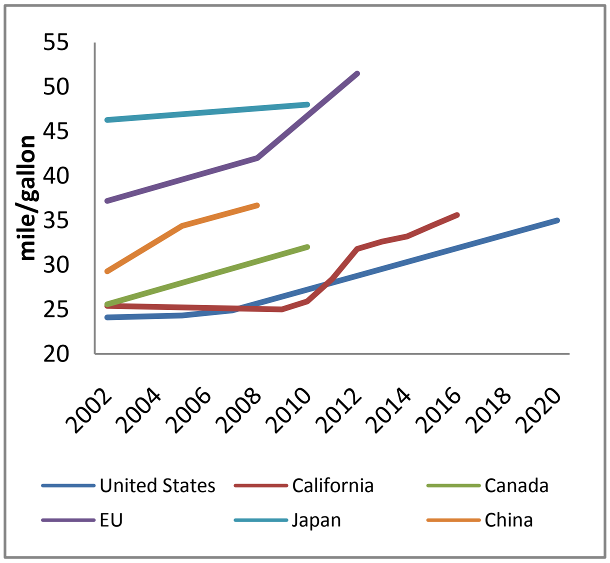


Figure 4: gCO2e/mile normalized targets by region[4]

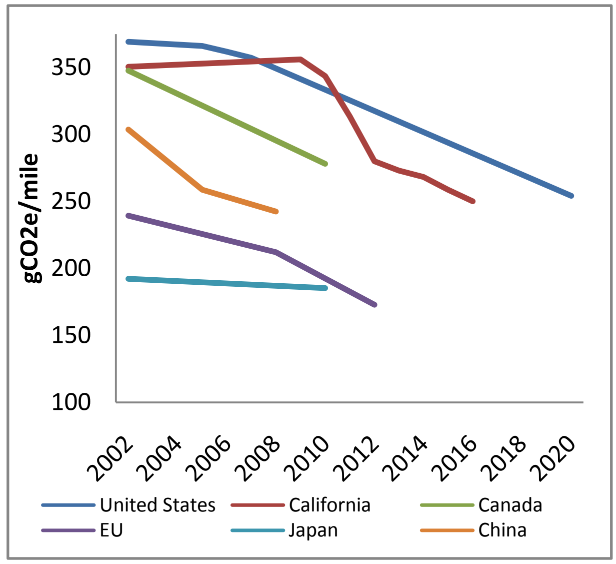


Figure 4 above shows the same data but converted to a gCO2e/mile-driven basis to illustrate the impact of fuel-economy standards on GHG emissions. The United States has the lowest mpg standards, resulting in the highest emissions of greenhouse gases per mile driven.

Well-to-Wheels Analysis and the Impact of Vehicle Fuel Efficiency

According to Argonne National Lab's analysis of well-to-wheels (WTW) GHG performance using their GREET model, four of the 20 best-performing combinations of fuels and technologies involve corn-derived alcohol fuel. The continued use of corn-derived ethanol should be encouraged because it is a fully commercialized means for displacing gasoline, derived from imported petroleum, with domestically sourced transportation fuel. Furthermore, corn ethanol achieves significant GHG emissions savings relative to gasoline (20-40% on a per-unit-of-energy basis according to GREET). In order to achieve the needed dramatic emissions reductions in the transportation sector, there needs to be a much greater focus on the efficiency at which energy is converted to motive power. Promoting the production of corn ethanol, and E85 in particular, falls woefully short of its potential to slash foreign oil imports, to keep our national wealth in our own economy, and to combat global climate change when our current policies promote ethanol use in vehicles that have extremely poor fuel efficiency. The flex-fuel vehicles (FFVs) now manufactured and sold in the US get such poor gas mileage that WTW emissions savings provided by ethanol on a per-unit-of-energy basis are squandered by the volume of fuel required by these

[4] Adapted from Pew Center on Global Climate Change, Comparison of Passenger Vehicle Fuel Economy and Greenhouse Gas Emission Standards Around the World, 2004. CO_2 per mile numbers are converted from the CAFE equivalent MPG numbers and may therefore not show accurate gCO_2e targets for countries not using the CAFE system.

typically large vehicles. Ethanol is an excellent motor fuel but its many benefits are yet to be tapped because of the low efficiency at which it is currently converted to motive power in vehicles.

One way to influence this is by establishing life-cycle WTW emissions targets which vehicle manufacturers have to meet (gCO2e/mile). In the EU, vehicle manufacturers are required to meet a 140 gCO2e/km target, which will be lowered to 120 gCO_2e/km by 2012[5]. This contrasts very starkly to the US situation where the fleet average gCO2e/mile is more than double the current EU average, and where the new vehicle standard is more than twice the current limit for new vehicles in the EU. Adopting a strategy in the US that is similar to that of the EU would both place pressure on fuel producers to lower life-cycle emissions, and force vehicle manufacturers to improve vehicle fuel economy. With implementation of sound policy and rule making, the market will reward the producers and suppliers of low-carbon motor fuels and the manufacturers of high-efficiency vehicles.

Supply–Side Action Required: Provide a Near-Term Solution for the Existing Vehicle Fleet

While setting an aggressive fuel-economy standard for new vehicles is the necessary first step in the process of transforming the nation's fleet, we must simultaneously move to make an immediate and dramatic impact on the existing fleet. The average age of cars in the US vehicle fleet is 9 years and therefore, it will take many years – years we cannot afford to lose – to make substantial reductions in imports of foreign oil imports via new vehicle fuel-economy standards by themselves. An obvious near-term solution is promoting the use of mid-level ethanol blends in existing vehicles.

It is absolutely necessary to embrace policies that promote a rapid and dramatic reduction in the gasoline consumed by the nation's vast and thirsty fleet of existing vehicles. Making mid-level blends of ethanol fuel (E20, E25 etc.) widely available has the potential to make each US motorist an active partner in realizing our nation's energy independence. Ongoing research indicates that every single vehicle on America's roads today (1985 model year and newer) can burn E25 with zero modifications to the vehicle and without sustaining any damage to the engine and fuel system[6]. Additionally, many existing vehicles actually get higher fuel economy (in terms of miles/Btu) with E30 than with regular gasoline[7]. Even considering the entire ethanol supply chain, it is possible to produce corn ethanol using today's technology that provides a significant net reduction in life-cycle greenhouse gas emissions compared to gasoline[8].

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[5] This target date may be pushed back to 2015 in light of the global financial crisis, according to the European Commission website.

[6] Report to the US Senate on E20 Ethanol Research, Rochester Institute of Technology; The State of Minnesota is studying mid-level blends, as is the University of South Dakota and other institutions.

[7] According to Oak Ridge National Laboratory, US Department of Energy

[8] ICM/Econergy carbon model LCA comparisons for corn-derived ethanol versus gasoline

A recent case study conducted by ICM using mid-level blends in non-FFVs shows improved fuel economy and improved energy efficiency. ICM used blender pumps to supply E10, E20, E30, and regular gasoline to more than 17 vehicles which logged about 157,000 miles of real-world test driving. The results indicate that, on average, vehicle fuel economy (miles/gallon) improved with E10 and E20 but decreased for E30 blends (relative to gasoline) as shown in Figure 5. However, both E20 and E30 show improved energy efficiency (mile/MMBtu) over regular gasoline. When evaluated on the basis of miles traveled per unit of energy (LHV), E20 and E30 both offer an improvement of roughly 9.2% over gasoline, as shown in Figure 6. Note that higher level blends, such as E40 or E50 have not been studied, due to lack of access to flex-fueled vehicles, and that an optimum blend may in fact be greater than E30.

Figure 5: Average fuel economy of vehicles studied with 3 or more tank fillups at each blend

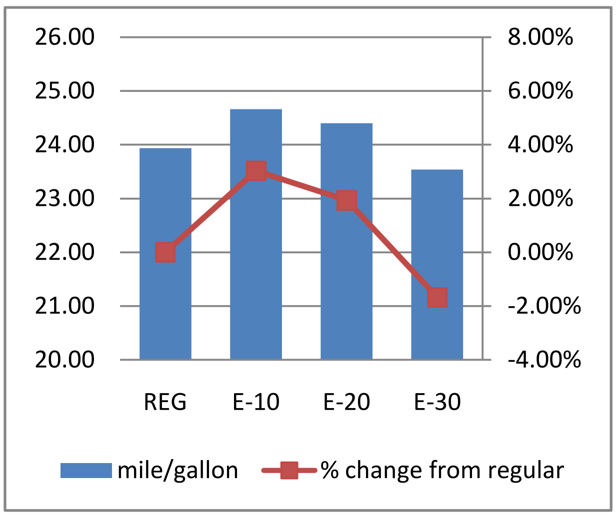
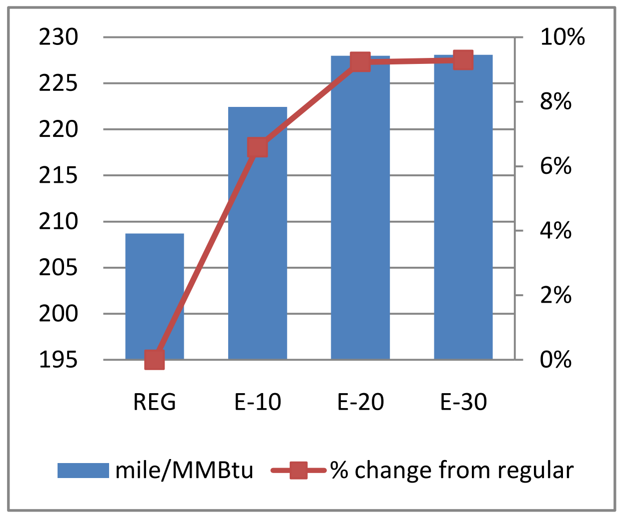


Figure 6: Average fuel energy efficiency of vehicles studied with 3 or more tank fillups at each blend



Clearly, national energy policies must promote varieties of ethanol that achieve true sustainability, starting immediately with 1) producing high volumes of low-carbon varieties of corn ethanol (discussed later in this paper) blended with gasoline to achieve E20 or E25 blends, 2) making mid-level blends of ethanol fuel widely available at the pump and authorized for use by the EPA and states, 3) achieving rapid and deep market penetration of mid-level blends in the existing vehicle fleet, and 4) transitioning swiftly to truly sustainable ethanol made with next-generation technologies that can use non-food feedstocks.

Supply-Side Action Required: Provide a Solution for Newly Manufactured Vehicles

While aggressive demand-side fuel-economy standards are the obvious imperative for new vehicles, the perfect storm requires that we also pursue aggressive supply-side policy that will promote the ability of new vehicles to use high-level blends of ethanol fuel. The way to accomplish this is to 1) start requiring automakers to produce only FFVs, 2) make E85 and other high-level blends of ethanol fuel widely available at the pump, and 3) rapidly raise the awareness of FFV owners that their vehicles are designed to burn E85.

In addition, further research and testing are needed to determine the optimum blend of ethanol and gasoline which delivers the highest fuel efficiency and lowest emissions of criteria pollutants. Studies indicate that optimum blends range from 20% to 40%. However, this can vary for different engines. More investigation by automakers is required to determine which blend is optimum for each engine type. Policy should then incentivize automakers to re-engineer their engines to optimally run on gasoline-ethanol mixtures. Any discussions aimed at using tax-payer funds to provide financial assistance to US automakers must be accompanied by aggressive programs for re-tooling to produce only low-weight, high-efficiency, flex-fuel and/or electric vehicles.

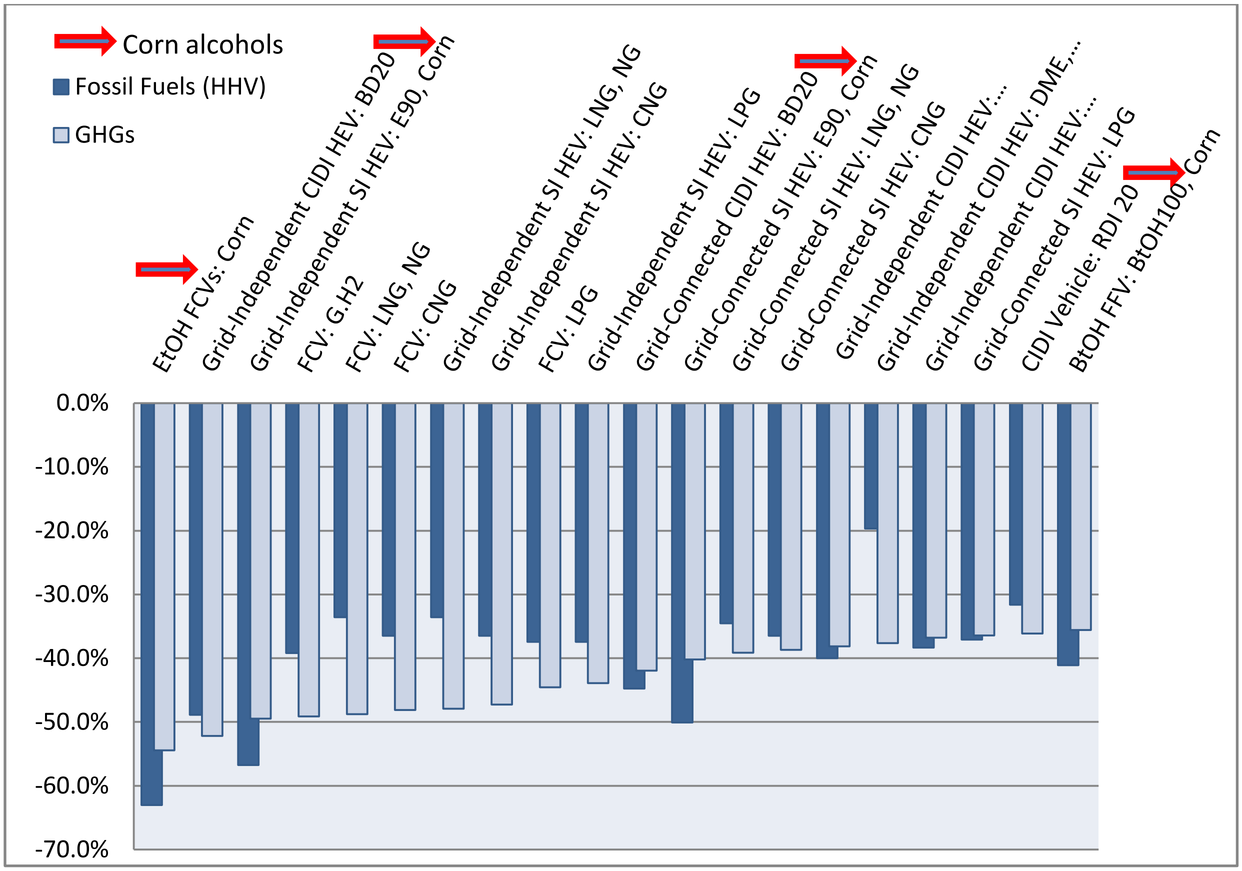
Supply-Side Action Required: Promote Electric and Plug-in Hybrid Electric Vehicles

Widespread adoption of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) must be promoted because both have a very positive impact on reducing imports of foreign oil and on reducing greenhouse gas emissions. If PHEV technologies are coupled with the use of ethanol blends, these impacts are even more dramatic. Four of the GREET model’s 20 best-performing combinations of fuels and technologies involve corn-derived alcohol fuel, as can be seen in Figure 7 on page 19. Note that the vehicle-fuel combination with the highest reduction in GHGs, relative to a standard gasoline-fueled vehicle, uses corn-derived ethanol. PHEVs running on E90 can reduce WTW greenhouse gas emissions by 40% compared to gasoline, assuming the US national average carbon intensity of grid electricity. Additionally, PHEVs can reduce consumption of fossil fuels by 50% compared with gasoline. Clearly, a comprehensive approach that uses the most fuel-efficient vehicles in combination with the lowest-carbon biofuels available will offer the US the best chance of reducing petroleum imports. We should be using our tax dollars to incentivize automakers to produce EVs and PHEVs, via tax credits and loan guarantees, and incentivize consumers to purchase them.

The fuel/technology combinations illustrated in Figure 7 are:

- Corn ethanol/fuel cell vehicle
- B20 biodiesel/hybrid electric vehicle
- E90 corn ethanol/hybrid electric vehicle
- Hydrogen/fuel cell vehicle
- Liquified natural gas, natural gas/fuel cell vehicle
- Compressed natural gas/fuel cell vehicle
- Liquified natural gas, natural gas/hybrid electric vehicle
- Compressed natural gas/hybrid electric vehicle
- Liquified petroleum gas/fuel cell vehicle
- Liquified petroleum gas/hybrid electric vehicle
- B20 biodiesel/plug-in hybrid electric vehicle
- E90 corn ethanol/plug-in hybrid electric vehicle
- Liquified natural gas, natural gas/plug-in hybrid electric vehicle
- Compressed natural gas/plug-in hybrid electric vehicle
- Ethanol-biodiesel/hybrid electric vehicle
- Dimethyl ether/hybrid electric vehicle
- Conventional and low-sulfur diesel/hybrid electric vehicle
- Liquified petroleum gas/plug-in hybrid electric vehicle
- 20% renewable diesel and 80% petrodiesel/compression ignition direct injection
- Corn butanol/flex-fuel vehicle

Figure 7: Top 20 vehicle-fuel combinations for reducing GHGs, as presented in GREET 1.8b



Promote Production of Domestic Fuels That Bridge the Gap to Sustainable Biofuels

The President and Congress must embrace aggressive policies that promote rapid expansion of domestic production of clean and sustainable vehicle fuels. To successfully address the climate change component of the perfect storm, it is imperative that coal-to-liquids, tar sands-derived fuels, and shale oil-derived fuels ***not*** be a part of the strategy. All of these unconventional fossil fuels will increase emissions of greenhouse gases relative to gasoline. They are not a sustainable solution and do not represent even a bridge to a more sustainable future. Although coal-to-liquids and shale oil do address energy independence and energy security issues, they do not address climate security and therefore do not represent a sustainable future fuel option. Furthermore, it is not physically possible to glean significant increases in domestic liquid fuels production via offshore drilling, nor will even minor associated relief be felt in the near term. Therefore, domestically produced corn ethanol is the logical policy target for the immediate term.

The current Renewable Fuels Standard (RFS) calls for expanding ethanol supply to 15 billion gallons of ethanol by 2015. During this timeframe, most of this will necessarily be derived from corn. Therefore, in order to dramatically increase ethanol production and its penetration into the liquid transportation market, both corn yield increases and accelerated production of cellulosic biofuels will need to occur. Corn ethanol is currently our most effective bridge to the future of truly sustainable liquid fuels that will be made from non-food feedstocks. Federal and state policies must incentivize the near-term commercialization and deployment of next-generation biofuels technologies. Simultaneously, policy must be devised so as to harness the power of market forces to transform the nation's corn ethanol infrastructure to produce, not the conventional ethanol currently manufactured, but rather low-carbon corn ethanol. The fact that so many of the signatories to the New Fuels Alliance letter (see Appendix C) are second-generation technology companies is testament to the fact that a vibrant corn ethanol industry is the necessary bridge for the rapid emergence of next-generation technology.

The extraordinary amounts of investment capital deployed toward corn ethanol and soy biodiesel to date have built the structural members of this bridge to the future. While these plants have been built to convert commodity grains into biofuels, using fossil fuel-derived thermal energy and grid electricity, they have created the necessary biofuels infrastructure for the sustainable next-generation technologies to build upon. Furthermore, by installing combined heat and power (CHP) in these existing plants, by fuel-switching to biomass, and by installing other front-end technologies for converting cellulosic materials into biofuels, the life-cycle carbon emissions associated with fuels produced by our existing corn ethanol production capacity can be lowered dramatically – enough to be comparable with Brazilian sugarcane ethanol (see Figure 8 on page 23). In addition, corn ethanol production yields large amounts of protein to help feed a hungry world.

Facilitate Market Segmentation and Demand for Low-Carbon Fuels

To facilitate the harnessing of market forces to drive the nation's transportation sector toward lower-carbon fuels, a national fuel-rating system should be developed. Based on the output of a plant-specific life-cycle analysis (LCA), such as that produced by the ICM/Econergy model (discussed starting on page 27), the ethanol produced by an individual ethanol plant would be rated on its GHG performance relative to gasoline. This rating would provide the basis for oil companies to blend gasoline to lower carbon intensity and for motorists to make informed choices at the pump. Motorists who place a value on lower-carbon fuels will pay a premium price for such fuels. Thus, with sufficient information available within the marketplace, consumers would make distinctions among the fuel choices, rewarding relatively lower-carbon fuels with a marginally higher price. Lower-carbon versions of corn ethanol would thus be favored over conventional corn ethanol and meaningful progress toward weathering the perfect storm would be facilitated. This approach uses market mechanisms to first incentivize the use of currently available technologies to lower the carbon intensity of corn ethanol produced in existing plants and then to incentivize the construction of next-generation facilities to convert agricultural residues and wastes into liquid transportation fuels with very low carbon intensity.

A fitting analogy is the Renewable Energy Certificates (RECs) market that has incentivized the production of clean, renewable electricity. The RECs market captures the marginally higher price that certain consumers are willing to pay for renewable energy and funnels that incremental revenue stream to renewable energy projects as an additional project-finance mechanism. Dozens of RECs retailers connect millions of individual citizens and businesses nationwide to renewable energy projects through the sale of RECs. In addition, dozens of electric utilities offer green power programs whereby their customers can support renewable energy projects via RECs. RECs representing about 36 billion kWh of renewable electricity were sold in the US in 2007.

A similar approach could facilitate market demand for low-carbon fuels and incentivize ethanol producers to supply "greener" corn ethanol that is lower-carbon than conventional corn ethanol. Although the motor fuels market is inherently different from the electricity market, it is not hard to imagine an approach similar to the RECs market that successfully drives consumer demand for, and producer supply of, low-carbon alternatives to gasoline.

Net Life-Cycle Energy Value of Corn Ethanol versus Brazilian Sugarcane Ethanol

The ICM/Econergy Model can be used to generate life-cycle fossil energy balances for ethanol produced from corn, milo, and wheat grown in a number of locations worldwide and using a number of different process-energy configurations. Additionally, the model contains a Brazilian sugarcane ethanol data set as a basis for comparison, since it is typically regarded as the most energy-efficient class of ethanol.

To more effectively understand how these compare, some definitions should be introduced which provide metrics that can be used as a basis of comparison.

Equation 1 Net Renewable Energy Ratio

$$NRER = \frac{\text{Renewable Energy Out}}{\text{Fossil Energy In}}$$

Equation 2 Net Renewable Energy Value

$$NREV = \text{Renewable Energy Out} - \text{Fossil Energy In}$$

The Net Renewable Energy Ratio (NRER), often simply expressed as the Net Energy Ratio, is the sum of the energy outputs of the process divided by the energy inputs to the process. A value larger than one (1) indicates that the process produces more renewable energy than it consumes in fossil energy. The process, in this case, is an ethanol plant value chain including the upstream and downstream energy inputs necessary for the production of ethanol product. The produced energy ("Renewable Energy Out") includes the fuel energy replaced (gasoline-equivalent) and the energy embodied in the co-products displaced (i.e. distillers grains displacing corn grain and soybean meal in the case of corn ethanol). Brazilian sugarcane ethanol produces grid electricity as a co-product of making ethanol; the energy value of that electricity is a component of the "Renewable Energy Out" in that case.

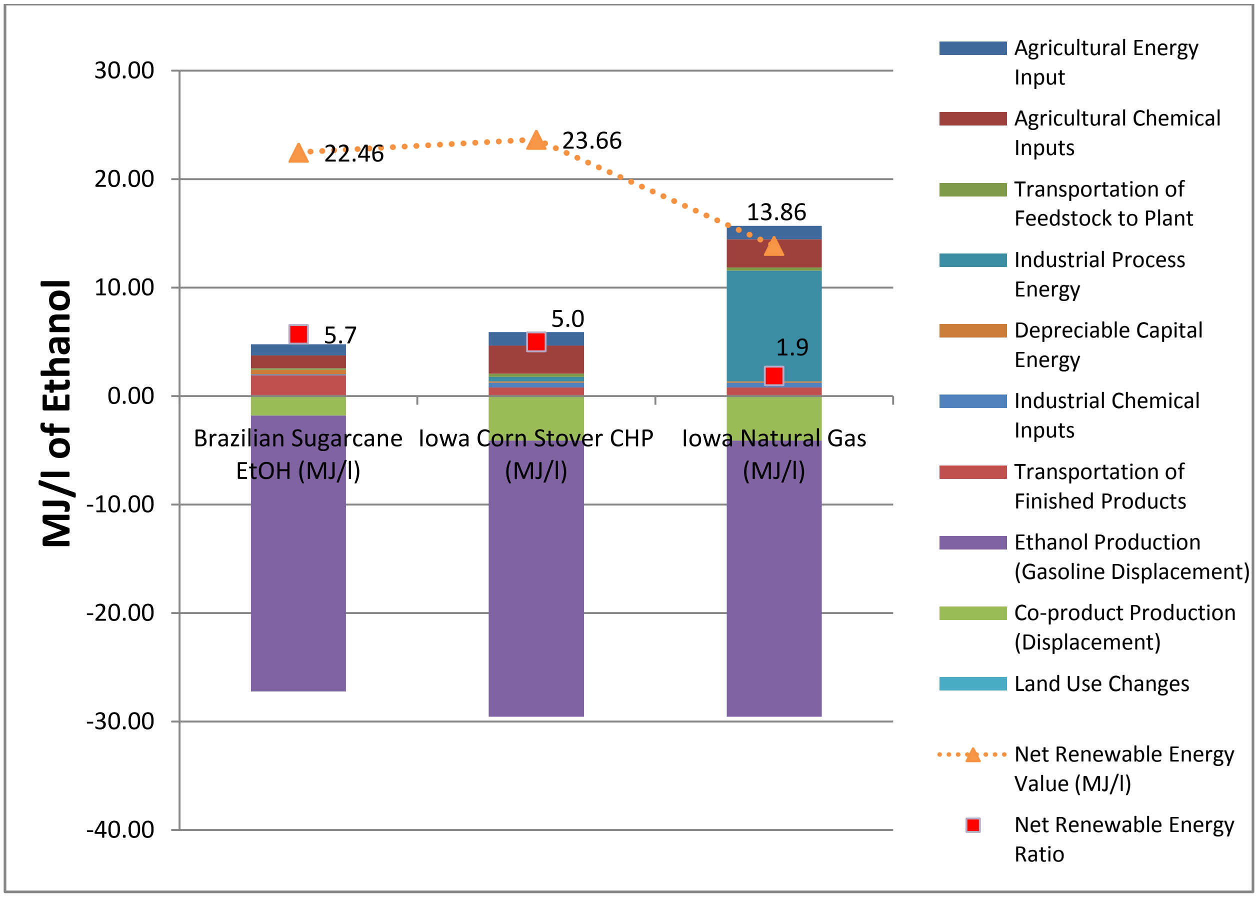
Equations 1 and 2 express renewable energy metrics, and thus input energy from renewable energy resources is ignored. For example, Brazilian sugarcane ethanol plants burn sugarcane waste biomass for heat and power production. This energy input is a renewable resource and therefore is not included in the "Fossil Energy In" terms of the NRER or the NREV. Only contributions from natural gas, diesel, coal, or other fossil fuels are included as "Fossil Energy In."

Figure 8 on page 23 shows a comparison of how ethanol produced at a modern[9] dry-grind natural gas-fired corn ethanol plant in Iowa (far-right stacked bar) compares with ethanol produced at a typical Brazilian ethanol plant (far-left bar). The chart is showing how energy inputs and outputs sum up to a Net Renewable Energy Value (NREV) and a Net Renewable Energy Ratio (NRER) as described previously. The fossil energy inputs are shown as positive values (above the x-axis) and include such inputs as industrial process energy and diesel used for transportation. The renewable energy outputs are shown as negative values (below the x-axis) and include ethanol and co-products produced by the plant. Ideally, a process would have very small positive values (fossil energy inputs) and very large negative values (renewable energy outputs). This would yield the highest NREV and the most energy efficient renewable energy conversion process.

Figure 8 shows that the NREV value for Brazilian sugarcane ethanol is 22.46 MJ per liter of ethanol produced, while this value is 13.86 MJ/liter for corn ethanol produced at a modern dry-grind plant in Iowa. Brazilian ethanol returns 62% more renewable energy than the dry-grind corn ethanol case. Additionally, the NRER values are 5.7 for Brazilian sugarcane ethanol and 1.9 for corn ethanol. In other words, for every unit of fossil energy consumed during the life-cycle production process, sugarcane and corn ethanol return 5.7 and 1.9 units of renewable energy, respectively. Clearly, Brazilian sugarcane ethanol has a large advantage over conventional corn ethanol from a net energy-balance perspective.

[9] A modern dry mill uses 29,000 Btu of natural gas/gallon of anhydrous ethanol and 0.65 kWh of electricity/ gallon. These metrics are better than the industry-wide and Iowa-wide averages.

Figure 8: Field-to-Tank Fossil Energy Use Comparison



Examining the stacked bars in Figure 8 showing the life-cycle component contributions to the totals reveals three points of note. First, industrial process energy– the thermal and electrical energy required to run the plant – is zero for a Brazilian plant because this energy is derived 100% from biomass. In contrast, industrial process energy amounts to over 10 MJ/liter for the US corn case. The second interesting point is that Brazilian sugarcane ethanol (when transported to US terminals) requires twice the energy for transportation to market as does US corn ethanol. Third, the animal feed co-products produced in US plants displace more than twice the fossil energy that exported grid electricity displaces in the case of Brazilian sugarcane ethanol.

The stacked bar in the center of Figure 8 shows the same dry mill in Iowa, but using corn stover as fuel for the production of all required heat and power rather than using natural gas and grid electricity. In this case, the NREV of corn ethanol is comparable to Brazilian sugarcane ethanol. Brazilian sugarcane ethanol still has a greater NRER, 5.7 compared to 5.0, but the NREV of this corn ethanol case is greater at 23.66 MJ/l compared to 22.46 MJ/l for sugarcane ethanol. The reason that the corn ethanol NRER is lower than that of sugarcane ethanol, but the NREV is higher, is that the Iowa dry mill exports more energy (animal feed + ethanol) than its Brazilian counterpart. If the Iowa plant also exported electricity to the grid, its metrics would be even more favorable.

Addressing Indirect Land Use Changes

The indirect land use change (ILUC) effects resulting from the conversion of pastures, idle lands, and forests into cropland, as a result of biofuels production, has come to the forefront of the discussion surrounding the sustainability of biofuels use. Indirect land use changes are phenomena that can be attributed to the conversion of land for any purpose. Ethanol and biodiesel made from any agricultural product are but two examples of activities eliciting ILUC effects. The effects attributable to each type of fuel can vary widely and with great uncertainty. It is Econergy's position that the science, models, and methodologies used to estimate ILUC impacts are not sufficiently well-developed to provide a basis for writing biofuels policy. Our stance echoes that of the New Fuels Alliance who on October 23, 2008 submitted a letter to the California Air Resources Board (CARB), discussing the limitations of the procedures used to estimate ILUC effects. The referenced letter, in Appendix C, made numerous substantive arguments, and some of the main points are highlighted below:

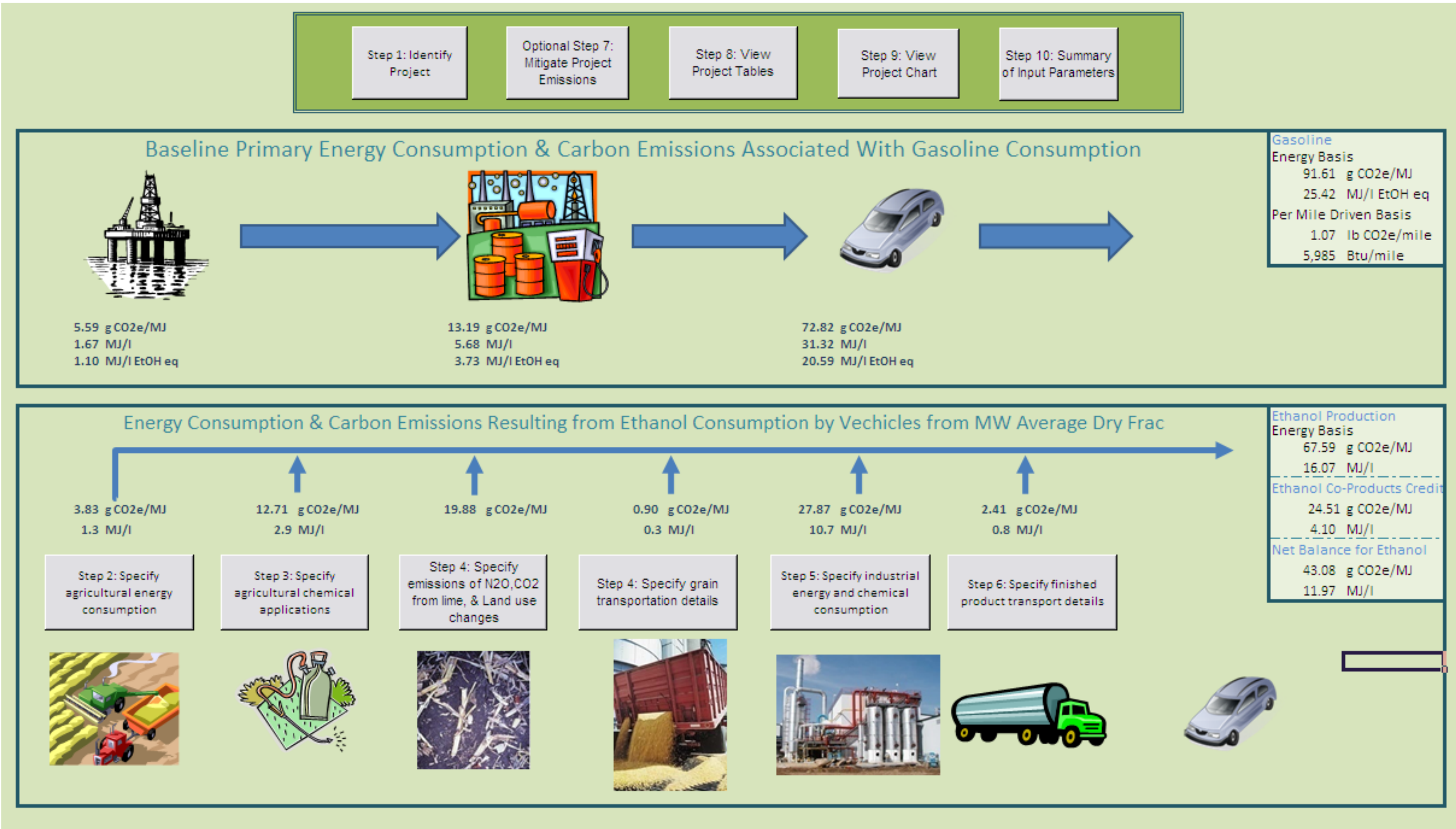
- Land use change is one of many types of indirect effects which an activity can have on a global economy and which can lead to an additional release of carbon emissions. There are many other types of ILUCs, and CARB does not seem to be considering any other indirect market-driven effects. This is particularly troublesome because no indirect effects from use of petroleum-derived fuels are considered by CARB. If indirect effects are included for proposed alternative fuels, they should also be included when evaluating the baseline fuel options.
- It is not clear that existing economic equilibrium models can accurately capture the "interplay of economic, institutional, technological, cultural and demographic variables inherent with quantifying the indirect impact of any fuel". Furthermore, assigning the effects of a given change in land use to any single cause may in fact not be possible, but rather these effects may be created by multiple causes acting synergistically throughout our agricultural economies. If the synergistic effects are much larger than the actual ILUC effect, then attempting to trace these effects back to individual causes will undoubtedly show amplified results.
- The New Fuels Alliance and the companies who have signed the Alliance letter support the further investigation of ILUC effects, but feel that policy based on a limited number of potentially inaccurate analyses would unfairly disadvantage the biofuels industry and counteract progress toward energy independence and the commercialization of truly sustainable biofuels.
- Finally, current ILUC analytical methods are not sufficiently well-developed to provide reliable, thoroughly vetted factors (gCO_2e/MJ) to be applied to a fuel's life-cycle emissions balance.

Econergy has performed an analysis to determine the maximum ILUC value that each of several ethanol-production technology pathways can support and still achieve the minimum 20% life-cycle GHG reduction, compared to gasoline, that qualifies for tax credits under the 2007 EISA. The intent of this analysis was to show that low-carbon corn ethanol can be made today with existing technologies.

Low-Carbon Corn Ethanol

There are technology pathways available today that allow for the production of low-carbon corn ethanol. The ICM/Econergy Model has been used to generate life-cycle emissions profiles, or Global Warming Intensity (GWI) values, for conventional dry-grind corn and milo (grain sorghum) ethanol plants existing today, as well as for the advanced dry-fractionation plants of the immediate future. A Brazilian sugarcane ethanol case was evaluated as a point of comparison. A screen shot of the ICM/Econergy Model is shown in Figure 9.

Figure 9: Home Screen Shot of the Econergy/ICM Model



Analysis of Conversion Systems Using ICM/Econergy Model

The ICM/Econergy Model enables the calculation of life-cycle energy and GHG emissions balances for corn, milo, and wheat-derived ethanol using a range of different process energy scenarios. Recognizing that modifications to the process energy systems will provide the largest emissions mitigation potential, a range of scenarios using CHP and biomass energy were evaluated and compared to typical corn ethanol plants that would be built today, and to today's typical Brazilian sugarcane ethanol plant . This analysis is intended to show values for newly constructed plants and, therefore, state-of-the-art plant energy consumption values have been used. The analyzed production pathway scenarios and relevant assumptions are displayed in Table 1 on page 28 and are graphically displayed in Figure 10 on page 30. All feedstocks are corn unless otherwise noted. Corn farming is assumed to occur in the Midwest and milo farming is assumed to take place in the Plains[10]. The "Maximum ILUC value" presented in Table 1 represents the maximum gCO_2e/MJ burden attributable to ILUC that a particular technology pathway can carry and still achieve the 20% CO_2 emissions reduction required by the EISA to receive the blenders' tax credit.

Technology pathways presented in Table 1 are:

1. Brazilian sugarcane ethanol – Bagasse-fired CHP provides 100% of plant thermal energy and electricity needs and supplies excess electricity to the grid
2. Midwest dry-grind NG heat – New dry-grind corn ethanol plant in Iowa using natural gas for thermal energy and grid-supplied electricity
3. Midwest dry-grind NG heat wet cake – Same as #2 but distillers grains are not dried
4. Midwest dry-grind NG CHP – Same as #2 but with a natural gas-fired CHP providing 100% of the plant's thermal energy and electricity
5. Midwest dry-grind coal heat – Same as #2 but using coal for thermal energy rather than natural gas
6. Midwest dry-grind coal CHP – Same as # 5 but using a coal-fired CHP providing 100% of the plant's thermal energy and electricity
7. Midwest dry-grind corn stover heat – Same as #2 but using corn stover rather than natural gas as the fuel providing thermal energy
8. Iowa dry-grind corn stover CHP – Same as #7 but with corn stover-fueled CHP providing 100% of the plant's thermal energy and electricity

[10] The Midwest region includes states NE, SD, OH, IA, MO, IL, MI, WS, MN, IN, ND and KS and the Plains states include TX, OK, KS, NE, SD, and ND

9. Iowa dry-fractionation corn stover + bran/syrup CHP – New dry-fractionation corn ethanol plant in Iowa receiving 100% of its thermal energy and electricity from a CHP fueled by corn stover, corn bran, and corn syrup
10. Kansas dry-grind milo natural gas heat – Same as #2 but fermenting milo rather than corn
11. Kansas dry-grind milo stover CHP – Same as #10 but 100% of process electricity and thermal energy are produced from corn or milo stover.

Table 1: GWI values and max ILUC adders for selected plant types

	Lifecycle Emissions (gCO2e/MJ)	Maximum value of ILUC factor allowed for compliance	% reduction from gasoline
1. Brazilian Sugar Cane Ethanol	26.1	47.2	72%
2. MW Dry-grind NG Heat	42.8	30.5	53%
3. MW Dry-grind NG Heat wet cake	35.3	38.0	62%
4. MW Dry-grind NG CHP	38.6	34.7	58%
5. MW Dry-grind Coal Heat	63.2	10.1	31%
6. MW Dry-grind Coal CHP	61.2	12.1	33%
7. MW Dry-grind Corn Stover Heat	29.0	44.3	68%
8. MW Dry-grind Corn Stover CHP	20.9	52.4	77%
9. MW Dry-frac Corn Stover + Bran/syrup CHP	40.7	32.6	56%
10. Plains Dry-grind Milo Natural Gas	50.9	22.4	44%
11. Plains Dry-grind Milo Stover CHP	28.5	44.8	69%

As these results indicate, there is a pathway by which corn ethanol can out-perform Brazilian sugarcane ethanol on a life-cycle carbon-emissions basis. A state-of-the-art plant in the Midwest using today's conventional dry-grind technology has lower life-cycle carbon emissions than sugarcane ethanol if it gets all of its thermal energy and electricity from a CHP fueled with corn stover (technology pathway #8). This particular corn ethanol pathway has a GWI of 20.9 gCO_2e/MJ, which is lower than Brazilian sugarcane ethanol and is 77% lower than conventional gasoline.

Figure 10 on page 30 presents the life-cycle carbon emissions for these various plant scenarios. A more detailed breakdown by individual emissions source contribution (Agricultural, Industrial, Transport etc.) is shown in Appendix B. Recognizing that consumers may one day have the choice to buy Brazilian sugarcane ethanol, it is shown for comparative purposes.

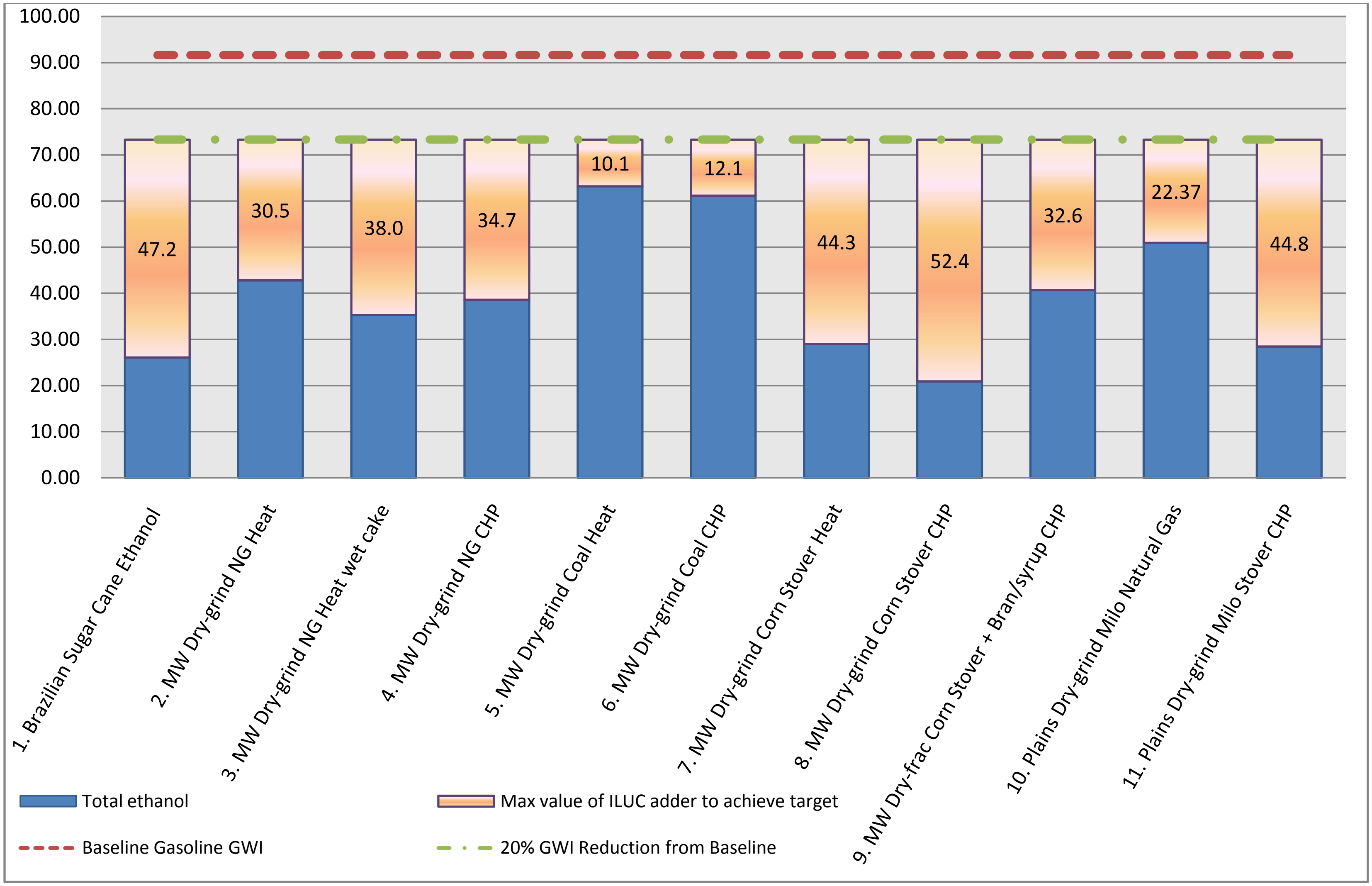
Also depicted in Figure 10 are two dotted lines, one showing the gasoline baseline GWI of 91.6 gCO_2e/MJ and the other showing a 20% reduction from this baseline, at 73.3 gCO_2e/MJ[11]. In Figure 10, the area in blue represents the fuel's GWI excluding ILUC effects. The orange area represents the maximum ILUC value that each fuel shown could support and still meet the 20% reduction target. As the results show, even Brazilian sugarcane ethanol can support an ILUC value of just 47 gCO_2e/MJ. The most common type of US corn ethanol plant currently on the drawing boards can support an ILUC value of only 30.5 gCO_2e/MJ. The highest-performance corn ethanol technology pathway available in the immediate term, dry-grind with biomass CHP, outperforms Brazilian sugarcane ethanol and can support an ILUC value of approximately 52.4 gCO_2e/MJ. These values clearly illustrate that between now and when cellulosic ethanol technology becomes commercially available, the ethanol production targets of the RFS can be met only if modest ILUC values are imposed. It is Econergy's opinion that methods used to assign ILUC values are not yet well-developed enough for use in informing national biofuels policy.

As illustrated in Figure 10, if policy were aimed at promoting biomass fuel usage in CHP installations at corn ethanol plants, their carbon emissions would drop substantially. Biomass-fueled CHP is a reasonable pathway given the ready availability and large volumes of suitable biomass in the immediate vicinity of typical plants. Biomass utilization for heat and power production at ethanol plants has the capability to dramatically reduce ethanol GWI, but if appropriate incentives promoting biomass utilization are not provided, plants making these switches are likely to sell the carbon emissions offsets into voluntary carbon offset markets to generate an additional revenue stream, thereby justifying the investment. This would have the unfortunate effect of transferring ownership of the carbon reduction benefits away from the ethanol product.

Unlike corn-derived ethanol, the EISA allows milo-derived ethanol to qualify as an "advanced biofuel" if it has a life-cycle emissions reduction greater than 50% compared to gasoline. The milo example shown in Figure 10 satisfies this requirement with the use of biomass for CHP fuel.

[11] The Energy Independence and Security Act allows EPA to select a 20%, but no lower than 10%, reduction target relative to gasoline

Figure 10: Life-Cycle GWI (gCO_2/MJ) of Various ICM Technologies for Converting Iowa Corn and Maximum Feasible ILUC Adder



Summary of Recent EU Biofuels Policy Developments

On December 5, 2008, the EU agreed that 10% of its road transport fuel needs are to come from renewable sources. This agreement applies to all trucks and automobiles, utilizing either gasoline/diesel. By 2020, the EU has required that renewable energy used in transport be applied to trains and electric vehicles.

In the December 2008 agreement, the EU also dropped any legally binding reference to Indirect Land Use Change (ILUC) in computing the carbon intensity of biofuels. The EU's decision to drop the ILUC reference valides the fact that this issue needs to be thoroughly examined. It is critically important for the environmental and other public benefits to be firmly established before a reasonable decision on policy can be formulated. It must also be noted that when these impacts are incorporated, they must be compared to indirect carbon emissions from the petroleum lifecycle.

Additionally, on December 17, 2008, the European Parliament adopted amendments to the Renewable Energy Sources Directive, which raised targets for biofuels production. The Parliament also set stringent sustainability standards to monitor and reduce GHG emissions from the use of road transport fuels. The language adopted by the Parliament clearly illustrates that it intends to calculate climate change emissions from international road transport fuels, but recognizes that the science is not currently available to perform this function. The agreed upon amendment also asserted a two-year study of ILUC that is to include methods to ensure that sustainable biofuels avoid causing land use change. By December 31, 2010, the Commission will submit a report to the Parliament reviewing the impact of ILUC on GHG emissions and addressing ways to minimize this impact. It must be noted that the EISA of 2007 called for the National Academies to study ILUC, and for this study to be completed within 18 months of the law's enactment. To date, that study has not yet been funded.

Achieving sustainable mobility is essential, and it requires continuous commitment among all stakeholders to effectively address the challenges we face. Countries worldwide cannot afford to take shortcuts along the way as we aggressively pursue this pathway. As previously indicated, we have the extraordinary opportunity to collaborate on finding solutions and shaping sound policies at the national and international levels.

The EU has long recognized the fact that renewable sources of energy are essential alternatives to fossil fuels. Renewable sources not only help reduce GHG emissions from energy generation and consumption, but also reduce the dangerous dependence on fossil fuel imports.

Included in *Appendix A* is Econergy's detailed examination of the EU's biofuels policy. The EU established a second draft proposal for its Renewable Energy Directive (RED) in early 2008. Among the various sustainability criteria that the EU has delineated, one in particular – annual emissions resulting from carbon stock changes caused by land use change –only included emissions associated with direct land use change, *not* indirect land use change. As recently as December 5, 2008, the European Parliament and EU countries remained split over the biofuels sustainability criteria – particularly on the issue of indirect land use in the formula to calculate biofuels' overall CO_2 performance. A compromise deal was achieved and the legally-binding reference to indirect land use was dropped.

The EU's December 2008 decision clearly reinforces the fact that there is no globally accepted scientific measure of ILUC impacts, nor is there any peer-reviewed methodology for efficiently calculating land use changes. In the absence of establishing sound and solid scientific measures related to ILUC, we must exercise extreme caution from a regulatory approach if we want to continue proceeding along the pathway to sustainable mobility.

Setting a Motor Vehicle Fuel GWI Standard

An analysis has been conducted to determine feasible global warming intensity (GWI) targets for blended fuels (gasoline and renewable fuel mixtures) sold in the US. A maximum GWI (gCO_2e/MJ) should be established in order to promote the production of lower-carbon fuels, reduce petroleum consumption, and encourage adoption of clean fuel-production pathways. The standard would be a weighted average of all types of gasoline and gasoline substitutes sold in the US and would include conventional and reformulated gasoline, ethanol, renewable gasoline, Fischer-Tropsch gasoline, butanol, etc. The current motor fuel baseline – conventional gasoline and reformulated gasoline (CG & RFG) – is estimated by GREET to have a GWI of 91.6 gCO_2e/MJ, while the GREET default GWI for corn ethanol is assumed to be 73.3 gCO_2e/MJ, which represents a 20% reduction in lifecycle emissions relative to gasoline. The national weighted-average GWI of all fuels sold would be determined using Equation 3 below, where GWI_j represents the Global Warming Intensity in gCO_2e/MJ of each fuel consumed, Vol_j represents the volume (gallons) of each fuel type consumed annually, and LHV_j is the lower heating value in MJ/gallon of each fuel consumed.

Equation 3 Weighted Average GWI

$$GWI_{WA} = \frac{\sum_{j=1}^{n} GWI_j * Vol_j * LHV_j}{\sum_{j=1}^{n} Vol_j * LHV_j}$$

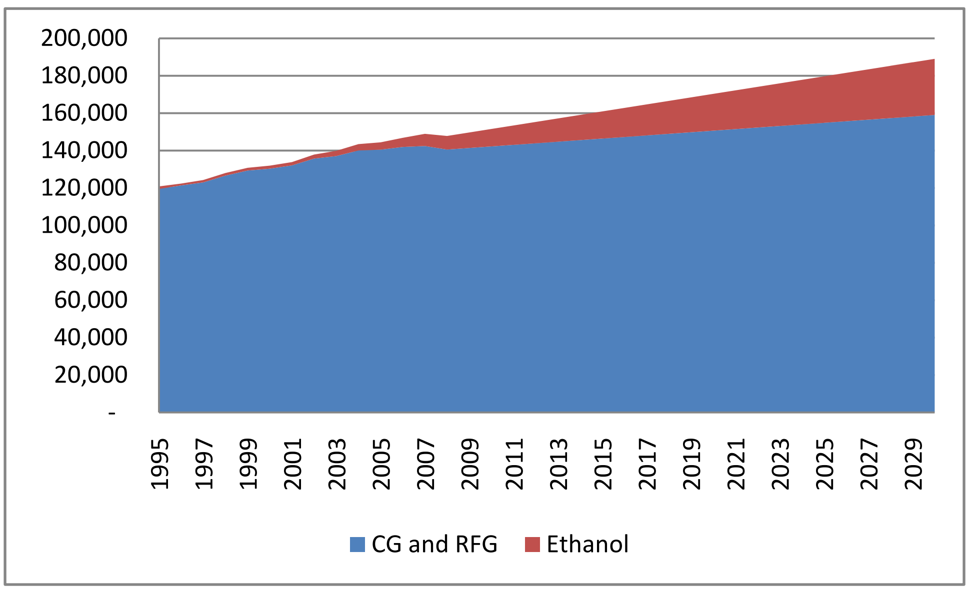
This analysis has been conducted to determine potentially feasible target values of GWI_{WA} for years 2015 and 2022. Historical data for gasoline and ethanol sales up to 2007 have been used to determine what the projected consumption of gasoline motor vehicle fuels will be in these years[12] and is shown in Figure 11 on page 33. A linear regression analysis on the historical consumption of ethanol and gasoline

[12] Gasoline and ethanol production/sales data obtained from www.eia.doe.gov

is used to forecast consumption in the future. The forecast function has been adjusted so that in 2015, 15 billion gallons of ethanol are in the market, roughly equal to the RFS goal. The projected production volumes of ethanol subsequently grow at the same rate thereafter. These values are subtracted from the total projected demand (ethanol + gasoline) to estimate the consumption volumes of gasoline in a particular year. It is anticipated that because of the current recession, the future adoption of EVs and PHEVs, and an anticipated increase in CAFE standards, historically observed growth rates will not hold.

The RFS targets could also be used to generate an estimate of the future volumes of ethanol in the marketplace, but this is only policy and does not necessarily reflect a likely reality. Additionally, it is anticipated that the GWI of ethanol will decrease over time as new plants are made to operate more efficiently and utilize biomass for heat and power production. An analysis conducted for the Energy Resources Center at the University of Illinois at Chicago projected weighted-average GWI values for corn ethanol produced in the United States through 2030. These GWI values reflect the assumption that new ethanol production capacity gets greener over time. The resulting declining GWI values are used in this analysis.

Figure 11: Historical and projected US gasoline and ethanol consumption (millions of gallons)



Econergy proposes setting blended-fuel weighted-average GWI values for 2015 and 2022. Table 2 on page 34 and Table 3 on page 35 provide a basis for selecting such values and show the resulting nationally weighted-average GWI for blended gasoline and gasoline substitutes as a function of both the volume of ethanol in the marketplace and the average GWI of ethanol produced (including cellulosic).

Table 2 shows indicative values for 2015 in terms of ethanol production volumes versus ethanol GWI. The far left column contains different values for ethanol production volumes in 2015 and the percentage change from 2007. The column headers show a range of values for the weighted average GWI of ethanol which will be blended into gasoline. The value of 73.3 gCO2e/MJ is the current GREET default average value and would represent no change. Values in the red-colored cells represent the most likely feasible values for weighted-average GWI of blended fuels.

Econergy recommends in 2015 that a target blended-average fuel (gasoline + ethanol) GWI content be 89.5 gCO_2e/MJ. This could, for example, correspond to 16.3 billion gallons of ethanol produced at an industry weighted-average GWI of 58.6 gCO_2e/MJ of ethanol. Realizing this target would result in a net reduction of 2.3% from the baseline of 91.6 gCO_2e/MJ. This data point is shown in the lower left of the red cells highlighted in Table 2.

Table 2: GWI Target Ranges for US Average Motor Fuel Blends in 2015

	Average GWI of Ethanol (gCO_2e/MJ)/% change							
Ethanol Production (MMgal/yr)/% increase From 2007	73.3 (0%)	69.6 (-5%)	66.0 (-10%)	62.3 (-15%)	58.6 (-20%)	55.0 (-25%)	51.3 (-30%)	47.6 (-35%)
6,521/(0%)	91.1	91.0	90.9	90.8	90.7	90.6	90.5	90.4
7,825/(20%)	91.0	90.9	90.8	90.7	90.5	90.4	90.3	90.2
9,782/(50%)	90.9	90.7	90.6	90.4	90.3	90.1	90.0	89.9
11,412/(75%)	90.8	90.6	90.4	90.3	90.1	89.9	89.7	89.6
13,042/(100%)	90.6	90.5	90.3	90.1	89.9	89.7	89.5	89.3
16,303/(150%)	90.4	90.2	89.9	89.7	89.5	89.2	89.0	88.8
19,563/(200%)	90.2	89.9	89.6	89.4	89.1	88.8	88.5	88.2
26,084/(300%)	89.8	89.4	89.1	88.7	88.3	88.0	87.6	87.2
32,605/(400%)	89.4	88.9	88.5	88.1	87.6	87.2	86.7	86.3
39,126/(500%)	89.0	88.5	88.0	87.4	86.9	86.4	85.9	85.4

Table 3 shows the results of the same analysis for 2022. Recognizing that climate change mitigation measures need to be aggressively pursued, we believe that values toward the lower end of each range should be adopted. The yearly production volumes of ethanol are shown in the left column, the ethanol industry weighted-average GWI is shown in the top row, and the blended fuel GWI is shown in the table as a function of these two variables. The red highlighted cells show the likely blended-fuel results given recent trends.

Econergy recommends in 2022 that a target blended-average fuel (gasoline + ethanol) GWI content be 87.2 gCO_2e/MJ. An example combination to achieve this includes 30 billion gallons of ethanol produced at an industry weighted-average GWI of 49.7 gCO_2e/MJ of ethanol. This results in a net reduction of 4.9% from the baseline of 91.6 gCO_2e/MJ.

Table 3: GWI Target Ranges for US Average Motor Fuel Blends in 2022

	Average GWI of Ethanol (gCO_2e/MJ)/% change							
Ethanol Production (MMgal/yr)/% increase from 2007	73.3 (0%)	67.8 (-8%)	62.3 (-15%)	56.8 (-23%)	51.3 (-30%)	45.8 (-38%)	40.3 (-45%)	34.8 (-53%)
6,521/(0%)	91.1	91.0	90.9	90.7	90.6	90.4	90.3	90.2
9,782/(50%)	90.9	90.7	90.5	90.3	90.1	89.9	89.7	89.5
12,390/(90%)	90.7	90.5	90.2	90.0	89.7	89.5	89.2	88.9
16,303/(150%)	90.5	90.2	89.8	89.5	89.2	88.8	88.5	88.2
22,824/(250%)	90.1	89.6	89.2	88.7	88.3	87.8	87.4	86.9
29,345/(350%)	89.7	89.1	88.6	88.0	87.4	86.8	86.3	85.7
35,866/(450%)	89.3	88.6	88.0	87.3	86.6	85.9	85.2	84.5
42,387/(550%)	89.0	88.2	87.4	86.6	85.8	85.0	84.2	83.4
52,168/(700%)	88.5	87.5	86.6	85.6	84.7	83.8	82.8	81.9
71,732/(1000%)	87.5	86.3	85.1	83.9	82.7	81.5	80.2	79.0

Calls for Action

The creation of a market-based approach to encourage the production of lower-carbon ethanol would be greatly facilitated by new targeted tax credits. For example, modifying the existing biomass production tax credit (PTC) for power generation to also qualify biomass utilization for thermal energy generation would provide an incentive for ethanol plants to lower their carbon footprint via fuel switching to biomass. With a biomass PTC for thermal energy generation and the recently introduced business investment tax credit (ITC) for CHP, the biofuels industry could begin to rapidly deploy biomass CHP with the aim of reducing the non-ILUC GWI of this product. As an example, a typical Midwest dry grind facility using natural gas for heat would lower its ethanol carbon intensity from 42.8 gCO_2e/MJ to 20.9 gCO_2e/MJ by adopting biomass CHP, making it comparable to Brazilian sugarcane ethanol. Refer to Table 1 on page 28 for this data.

Currently, the sale of carbon offsets from such a project (fuel switching) can be used as a financial mechanism to incentivize ethanol producers to take these kinds of actions. However, if the project (ethanol plant) were to sell any environmental benefit (CO_2 emissions reduction) associated with the fuel switching, it would no longer be able to take credit toward reducing the GWI of the ethanol product, but rather the carbon emissions reduction would be transferred to the buyer of the carbon offsets. Therefore, ethanol producers need a different incentive that enables them to keep ownership of the emissions reductions so they can be credited toward "greening" their product. A PTC awarded for using biomass to produce thermal energy would accomplish this.

Absolutely critical to the establishment of market mechanisms that place premium value on lower-carbon ethanol is the quantification of the GWI of each gallon of ethanol in the marketplace. Toward this end, we recommend that ISO 14040 be adapted to create a biofuels-specific standard based on existing IPCC calculation procedures and default factors from published literature. According to the International Organization for Standardization, ISO 14040 describes the principles and framework for life-cycle assessment (LCA) including: definition of the goal and scope of the LCA, the life-cycle inventory analysis (LCI) phase, the life cycle impact assessment (LCIA) phase, the life-cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, the relationship between the LCA phases, and conditions for use of value choices and optional elements.

The ISO biofuels standard would be used to quantify the GWI of ethanol produced by individual plants and companies. Various organizations could develop different tools (ICM/Econergy Model for example) for quantifying the GWI of biofuels produced by an individual production facility, but each tool should be certified as an approved tool for this purpose. Once a standard is established, the process of quantifying GWI for the industry's products must begin immediately in order to accelerate the market placing a higher value on low-carbon ethanol. Oil companies who buy ethanol for purposes of blending it with their product in order to meet the proposed national carbon-content-of-fuel standard will scrutinize the GWI of available product and they will make their choices accordingly. As infrastructure becomes more advanced and we have the capability to display real-time GWI at the pump, the freedom to choose lower-carbon ethanol will become available to the consumer. It is critically important to develop these market mechanisms now, to encourage the swift introduction into the marketplace of the lower-carbon fuels that we are able to manufacture today. The perfect storm impels us to act aggressively now, because we cannot afford to wait until cellulosic ethanol becomes widely available.

As a result of the RFS, the ethanol industry has grown so rapidly that within 1-2 years ethanol will account for over 10%, by volume, of the motor vehicle fuels consumed in the United States. The "blender's wall" is an industry term used to describe the point at which it will be impossible to get more ethanol into the market unless a significant number of cars can use E85 or mid-level ethanol blends. Since dramatically increasing the number of FFVs in the domestic fleet will take many years to accomplish, Econergy strongly believes that EPA should expedite testing and approval of E25 and other mid-level blends so Americans can begin using these domestically produced fuels in the existing vehicle fleet, thereby breaking through the blender's wall. To date, the EPA has only allowed the sale and use of E10 and E85. However, it has become abundantly clear that neither E85 nor E10 is the optimum ethanol/gasoline blend for internal combustion engines, and using E85 requires purchasing an FFV. The urgency of our situation requires that blends up to E30 must be tested and the associated emissions quantified by EPA so that these lower-carbon fuels can be certified for use and sale. In addition, the EPA must certify the use of aftermarket modifications that convert existing vehicles to FFVs.

US automakers face a very uncertain future at the moment. Detroit must be required to collaborate with the federal government on creating a renewed domestic auto industry that totally supports progressive and strategic federal energy policies that will enable the nation to weather the perfect storm that is upon us. The unequivocal mission of the renewed US auto industry must be to produce super high-efficiency vehicles, biofuel vehicles, plug-in electric vehicles, and ultimately fuel cell vehicles.

A Sliding-Scale Incentive Structure

One of the most important calls for action is for the federal government to augment the incentives provided by the EISA. There is a gaping incentive "dead zone" between the 20% threshold and the 50% threshold, in terms of alternative-fuel carbon emissions reduction compared to gasoline, as delineated in EISA. This is better viewed as an "opportunity zone" in which strategically important carbon emissions reductions can be cost-effectively captured, if appropriate incentives are provided. This paper has shown that there is more than one pathway to greener corn ethanol, using technology available today, that lands within this opportunity zone. However, as EISA currently stands, an ethanol producer has zero incentive to implement a pathway that is any greener than the least-cost pathway that just barely meets the 20% threshold. Thus, tremendous potential to green-up the nation's fleet of corn ethanol plants will remain untapped under the current EISA incentive structure. We believe it is imperative to create a sliding-scale incentive structure to reward ethanol producers who are willing to go beyond the 20% threshold and venture into the market-based opportunity zone. The farther producers go beyond the 20% threshold, the greater the incentive they would earn under a sliding-scale system. A faster transition from conventional corn ethanol to lower-carbon ethanol would thus be encouraged.

Recommendations for a National Standard for Carbon Content of Motor Vehicle Fuel

Fossil fuel consumption in the US transportation sector poses a triple threat to our national security, our economic security, and our climate security. In an effort to contribute to the debate on national policy, this paper focuses on several specific means by which we can rapidly move our nation toward resolution of these serious challenges. Perhaps the most important of these is the recommendation to create a national standard that establishes maximum values for the carbon content of motor vehicle fuels. This standard should be based on the GREET baseline for gasoline with required percentage reductions in motor vehicle fuel carbon intensity. The standard should be aggressive, progressive yet achievable, and should become more aggressive over time.

Econergy recommends a two-phase national standard to reduce the carbon intensity of motor vehicle fuel as follows:

Phase I: Require by 2015, a 2.3% reduction in motor vehicle fuel carbon intensity relative to the 91.6 $gC0_2e$/MJ GREET baseline for gasoline.

Phase II: Require by 2022, a 4.9% reduction in motor vehicle fuel carbon intensity relative to the 91.6 $gC0_2e$/MJ GREET baseline.

We believe establishing a national standard will be a powerful tool for achieving the multiple policy goals that comprise an appropriate response to the threats of the perfect storm. Each of the concepts presented in this paper can contribute significantly toward compliance with this national standard.

Appendix A - Biofuels Policy and Vehicle Fuel Economy in the European Union

Introduction. This section provides a summary of the European Union's biofuels policy, tracking its evolution from its original articulation in the 2003 Directive, to the 2006 Strategy and Roadmap, and finally to the most recent and ongoing efforts and discussions to establish an updated and coherent framework. The objective of this section is to give an account of the progress being made in the EU market for renewable fuels, and of how the Union has been advancing on the parallel but interrelated tracks of blending targets, technical standards/regulations and, especially, criteria to ensure a sustainable implementation of targets set.

Lastly, this section provides a brief account of the latest progress in the EU with regards to vehicle fuel economy and CO_2 emissions targets.

Landmark EU biofuels acts. The EU biofuels policy was progressively established and re-oriented through a sequence of binding and non-binding acts,[13] as outlined below.

- The foundations of the EU biofuels policy were set in the Directive 2003/30/EC of the EU Parliament and Council.[14] This act, known as the **Biofuels Directive (2003)**, establishes a target for biofuels to represent at least 2% (in energy content) of all fossil fuels in Member States' markets by 2005 (which was not achieved), and 5.75% by 2010. Appropriate biofuels standards and regulations were presented as a key element in support of the policy's targets. The document notes that technical standards form the basis for requirements concerning emissions and their monitoring, and that they are necessary to introduce new types of fuel while maintaining environmental performance requirements. It also notes that promotion of both the production and the use of biofuels can contribute to a reduction in emissions of greenhouse gases, and that quality standards should take into account potential contaminations in biofuels that may cause emissions to deteriorate. Finally, it states that the promotion of biofuels should be consistent not only with considerations of security of supply and cost competitiveness, but also with environmental objectives, and that the life-cycle impact of biofuels should be taken into consideration while setting biofuels targets for the Union and monitoring the performance of the EU biofuels market. The 2003 Directive indicated the competence of the European Commission and of the European Committee for Standardization (CEN)[15] to establish

[13] Binding legislation of the European Union includes (i) *Regulations*, which are immediately effective in Member States without any need of implementing measures; and (ii) *Directives*, which bind Member States to achieve some result, but leave it to them to determine and implement the means to do so (what is known as "transposition")

[14] Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport, available at http://ec.europa.eu/energy/res/legislation/doc/biofuels/en_final.pdf

[15] *Comité Européen de Normalisation* (CEN), which of course addresses all types of standardization, not only those regarding fuels

appropriate quality standards for biofuels, both as pure fuels and as blending components in conventional fuels.

- Subsequent to the Biofuels Directive, the EU Commission developed an **EU Strategy for Biofuels (2006)**.[16] The Strategy confirms the need to ensure that biofuels production and use is globally positive for the environment. It also states the Commission's commitment to support second-generation biofuels, as well as its commitment to encourage the first-generation biofuels market as a transition towards the future commercial viability of new production technologies and feedstocks. Under the title "Capturing Environmental Benefits" (3.2), the Strategy recognizes that incentives for biofuels had not, until that moment, taken into account their actual GHG benefits or their production pathways, whereas a mechanism establishing a direct linkage between GHG benefits and incentives would send a clear signal to the industry about the importance of further improving production processes. The Strategy also states the principle that only biofuels whose production in the EU and third countries complies with minimum sustainability standards may count towards targets set. Finally, the Strategy states the need to update and develop new fuel quality standards in a way that will allow (a) enhancing biofuels use in a technically and environmentally sustainable way, and (b) complying with WTO obligations, therefore developing standards that would apply to both domestic and imported products in a non-discriminatory way.
- The same year, the European Commission published the **Renewable Energy Roadmap (2006)**.[17] This programmatic document recommends an increased overall target of 20% of all energy consumption in the EU to be represented by renewable energy by 2020. Specifically for biofuels, the Roadmap recommends that these should represent 10% of total consumption of petrol and diesel in transportation by 2020. Such targets were then taken up in the following year's **Strategic Energy Review (2007)**,[18] where the Commission formally asks the Parliament and the Council to (a) endorse the targets for a new Energy Policy for Europe (including the 10% target for biofuels in 2020), and (b) invite the Commission itself to table a new Directive on renewable energy.

Current evolution of the EU biofuels policy. Biofuels activities in the EU are currently concentrated on advancing, updating and bringing together in a more comprehensive framework all efforts conducted until now on blending targets, technical standards and sustainability criteria. The objective is to establish a more coherent EU biofuels policy, and ensure its smooth implementation. Discussions on several

[16] Commission Communication of 8 February 2006 – An EU Strategy for Biofuels – COM(2006) 34, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0034:FIN:EN:HTML

[17] Communication from the Commission to the Council and the European Parliament – Renewable Energy Roadmap – COM (2006) 848, available at http://ec.europa.eu/energy/energy_policy/doc/03_renewable_energy_roadmap_en.pdf

[18] Communication from the Commission to the Council and the European Parliament – An Energy Policy for Europe – COM (2007) 1, available at http://ec.europa.eu/energy/energy_policy/doc/01_energy_policy_for_europe_en.pdf

pieces of proposed legislation are still under way, and many important aspects have still not been defined in their final form. It is anticipated, or hoped, that the entire process will come to an end before June 2009, when new elections for the EU Parliament will take place, lest significant delays occur.

The process includes, first of all, two draft Directives. These acts are not immediately effective: they set general obligations for Member States of the Union, but refer to subsequent national acts and separate regulations to determine the means to achieve compliance (what is known as "transposition").

- The Commission has developed a **Proposal for a Directive (2007) amending the original Fuels Quality Directive of 1998** (Directive 98/70/EC). The Proposal[19] includes appropriate modifications to the specifications of fossil fuels in order to accommodate an increased introduction of alternative fuels. This proposed Directive also introduces (a) the obligation, starting in 2009, for Member States to require fuel suppliers to monitor and report the lifecycle GHG emissions of the fuels they place on the market; and (b) the obligation, starting in 2011, for Member States to require fuel suppliers to reduce GHG emissions from their fuels by an additional 1% of 2010 emissions per year, up to and including 2020, in a way that lifecycle GHG emissions per unit of energy reported in 2020 be no greater than those reported in 2010. Monitoring, reporting and verification methodologies for compliance with these obligations are left to be determined separately.

  Specifications for petrol contained in the draft Directive have been determined with the view of moving the market towards an E10 standard achieved in most part with direct ethanol blending, and introducing a waiver to allow for increased fuel vapor pressure. The European automobile industry, on the other hand, is strongly against increased fuel vapor pressure (it does not wish to be forced to devise how to control it), and supports reaching an effective E10 level purely through ETBE (an oxygenate additive), which seems feasible using innovative technologies.[20]

- In early 2008, the Commission also presented a second Proposal for a Directive, which is known as the **Renewable Energy Directive (RED, 2008)**.[21] This act, proposed in its first draft, is not yet effective but, when it enters into force, it will in effect establish an overall binding target of a 20% share of renewable energy sources in energy consumption in the EU by 2020 (with various binding national targets in line with such overall targets) and, in particular, a 10% binding minimum target for biofuels in transport to be achieved by each Member State by the same year 2020.

[19] Proposal for a Directive of the European Parliament and of the Council, presented by the Commission – COM (2007) 18, available at http://ec.europa.eu/environment/air/pdf/fuel/com_2007_18_en.pdf

[20] Conversation (10.24.2008) with Paul Greening, Director of Emissions and Fuels of the European Automobile Manufacturers' Association (ACEA). RVP in the EU, as set by Standard EN 228, currently stands at 60kPa

[21] Proposal for a Directive on the promotion of the use of energy from renewable sources – COM (2008) 0016, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0019:FIN:EN:PDF

The relevance of this proposed legislation lies in the fact that it will represent the Union's fundamental act on renewables, with the establishment of national and Union-wide targets. The RED will provide specific parameters for elements that, until now, had consisted only of general principles or objectives.

More specifically for the purposes of this paper, the draft RED includes the elements and conditions defining a biofuels sustainability regime: it formally establishes a series of sustainability criteria that must be fulfilled for biofuels to be taken into account for purposes of both (a) compliance with targets and obligations, and (b) eligibility for EU financial incentives.

The criteria, as they appear in the first draft, are the following (Article 15):

- Biofuels, if they are to be taken into account for compliance and incentive purposes, must generate GHG emissions reductions of at least 35% (for biofuels produced by plants operating in January 2008, this would apply only starting in April 2013)
- Biofuels feedstocks may not consist of material obtained from land that in or after 2008 has a recognized high biodiversity value (forest undisturbed by significant human activity; areas designated for protection purposes, unless biofuels productions is demonstrated not to interfere with such purposes; and highly biodiverse grassland)
- Biofuels feedstocks may not consist of material obtained from land that in January 2008 had a high carbon stock, and no longer has it (wetlands and continuously forested areas)
- Biofuels feedstocks grown in the EU must be cultivated in accordance with applicable EU standards and regulations, and with EU minimum requirements for good agricultural and environmental conditions

Specifically regarding the calculation of biofuels' GHG impact, the draft RED (Article 17) indicates that this should be done by either (a) using default values (provided in an annex for current and future biofuels), in cases where biofuels are produced with no net carbon emissions from land use change; or (b) using actual values, calculated according to a methodology also described in an annex; or (c) using a combination of (i) disaggregated default values for the cultivation, processing and transport/distribution steps of the production process, and (ii) disaggregated actual values for the other steps, calculated according to the methodology mentioned above.

The methodology[22] to calculate actual GHG impact values covers the various steps of biofuels' production pathway: (a) emissions from extraction/cultivation, land use change, processing, transport/distribution, and fuel in use; and (b) emissions *savings* from carbon capture and sequestration, carbon capture and replacement, and excess electricity from cogeneration.

[22] Annex VII.C of the Proposal for a Directive COM (2008) 0016

Regarding, in particular, annual emissions resulting from carbon stock changes caused by land use change, these – at least, according to the first draft of the RED – only include those associated with direct land use change, but *not* those associated with indirect land use change. Total emissions from land use change are to be divided over a period of 20 years.

Emissions savings from biofuels are to be calculated as the percentage difference between (a) the total emissions from the biofuel considered, and (b) those of a fossil fuel reference, which consist of the latest available average emissions of petrol and diesel consumed in the EU or, lacking such data, 83.8 grams CO_2e/MJ. Different values are provided for bioliquids for electricity generation, heat generation and cogeneration.

An updated draft of the RED is expected for December 2008 and, according to conversations with various sources, much of what described above is subject to change:

- The 10% target for the transportation sector, which according to the letter of the current draft applies to biofuels only, could actually be more broadly intended for all renewable energy in transportation, therefore also including, in particular, hydrogen and electric vehicles.
- An intermediate target of 4% could be set for year 2015 (also including all renewable energy sources for transportation, and not only biofuels).
- The 35% GHG emissions reduction criterion is likely to be increased, as it is seen as too easily achievable by the biofuels industry, in particular using first-generation technologies. Levels of 40-45% are currently being discussed in Parliament for the first phase (up to the projected intermediate date of 2015), and 60%-65% for the second.
- In addition to the criteria included in current Article 15 and briefly described above, other environmental and social sustainability criteria are currently under discussion and still need to be defined. It has also not yet been decided whether these will become binding or not.
- The likelihood that indirect land use change effects will be included in GHG impact calculations is unclear. Some sources refer that the EU Directorate-General for Environment, and that for Transport and Energy, are keen on including them. Other sources refer that it is more likely that in the end they will not be included, given that they would be excessively onerous for the biofuels industry. The debate is ongoing and intense, and only the final draft of the RED will provide a definitive answer.

- While general parameters, targets and limits are set at the level of EU Directives, full fuel Standards are mostly[23] defined by the **European Committee for Standardization (CEN)**, and they

[23] Or, in some special cases, by national standards (e.g. France allows B30 for some fleets)

provide the level of detail that allows actors to comply with the dictates of EU law, as well as with reporting requirements. The CEN therefore carries out its activities within a general framework set at EU level. Its key ongoing efforts regarding biofuels are as follows.[24]

- After the adoption in 2007 of a **Standard for bioethanol** as a blending component at up to 5% (known as EN 15376[25]), CEN Technical Committee 19 is currently developing a slightly modified Standard for bioethanol as a blending component at up to 10% (consistent with the proposed updates to the Fuels Quality Directive). Another Technical Committee is developing a Standard for E85 fuel. Unlike it had been anticipated, it currently seems unlikely that only one ethanol specification may work for all blends.[26] These Standards focus on technical and performance features of biofuels.

- CEN Technical Committee 383 was established in May 2008 to focus specifically on **biofuels sustainability criteria**. The activities of TC 383 have only just begun (only two meetings have taken place, the last one in September 2008), and they stem from the four articles on biofuels sustainability currently included in the proposed RED outlined above. The approach taken by TC 383 is not to redefine these criteria, but to take them as a reference as they appear in the RED (and as they will evolve in the updated draft) to create a full CEN Standard and an associated certification scheme that will assist the industry in reporting the sustainability of their fuels in compliance with the EU Directive.

  With regard to sustainability issues currently under discussion, but not yet included in the RED, particularly social and economic criteria, TC 383 will also address these aiming at a Standard. If they end up not becoming legally binding in the RED's final draft, these criteria will be transformed from a Standard (EN) to a Technical Specification (TS). A TS is a CEN act with a lower rank which, unlike a Standard, does not carry an obligation of implementation, but that can be subsequently transformed into a Standard (and that actually cannot be in contrast with an existing Standard).

  With regard to indirect land use change, TC 383 has decided, based on the assumption that this will end up *not* being included in the GHG impact calculation, to create within itself a specific working group that will develop for them not a Standard, but a Technical Report (TR). A TR is a CEN act of an even lower rank than a TS, and cannot be transformed into a Standard. TC 383 anticipates that the Technical Report for indirect land use change will be used to monitor and report the entire GHG impact of biofuels on a voluntary basis by some representatives of the biofuels industry. If discussions at EU

[24] Conversation (10.2.2008) with Ortwin Costenoble of the Netherlands Standardization Committee, and member of both CEN TC 19 on ethanol standards and CEN TC 383 on biofuels sustainability criteria

[25] Available at http://www.biofuels-platform.ch/en/infos/en15376.php

[26] A standard adopted for biodiesel, known as EN14214, works for different blending percentages

level evolve towards including indirect land use change in the GHG impact calculation, it is likely that TC 383 may consider preparing for it at least a Technical Specification.

EU biofuels policy – conclusions. The EU biofuels policy is advancing towards the end of a process that, by means of a gradual approximation of general principles and objectives, will in effect establish a biofuel standard with binding targets at both the Union and at the national level. Only biofuels produced in compliance with a series of sustainability criteria – many of which are still under discussion – will count against the targets, and will enjoy the support of financial and fiscal incentives. The European Committee for Standardization is working in parallel with the evolving definition of these criteria to develop standards and certification schemes as a tool for the industry's compliance and reporting.

This framework is sending a strong double-edged signal to the biofuels industry. On the one hand, the EU is establishing a standard and incentives that will stimulate the market, stating that "the main purpose of binding targets is to provide certainty for investors".[27] On the other, it is setting the environmental sustainability of the industry's products as the condition to participate in this market.

The support for second-generation biofuels is embedded in the framework of obligations and incentives. Rewards for feedstock diversification will be granted with the specific purpose of providing additional support to second-generation technologies.[28] In particular, the binding targets which are being determined are considered by the Commission "appropriate, subject […] to second-generation biofuels becoming commercially available", but the Commission also stated that "it did not consider that the binding nature of the target should be deferred until second-generation biofuels become commercially available".[29] This means that the industry is being supported already during the first-generation biofuels period, provided that its products are environmentally sustainable, and that such support is being granted also with the expectation that it will allow the industry to transit to second-generation biofuels necessary for the policy to be fully implemented according to the anticipated schedule.

Important issues that remain to be determined relate to the inclusion of indirect land use change in the calculation of biofuels' GHG impact, the degree of GHG reductions that will be required from biofuels, and the inclusion of renewables others than biofuels to achieve the 2020 10% target for transportation.

EU vehicle fuel economy and CO_2 emissions targets. In 1998, the European Automobile Manufacturers' Association (ACEA) signed a voluntary Commitment with the EU Commission to assist in achieving the EU's Kyoto goals. The most visible part of the commitment was to reduce emissions from new passenger cars to 140gCO_2/km by 2008, mostly through vehicle technology improvements. Japanese and Korean Automobile Manufacturers' Associations (though not, expectedly, US manufacturers) adopted a similar commitment in 1999. The 1998 Commitment was largely achieved (average ACEA emissions for new vehicles stand at about 141-142gCO_2/km), a considerable result given increasing safety standards being

[27] RED – 2008/0016 (COD), *cit*. no.6 (page 13)
[28] RED – 2008/0016 (COD), *cit*. (page 7)
[29] RED – 2008/0016 (COD), *cit*. no.5 and 6 (page 13)

enacted, as well as consumer choice increasingly directed towards luxury features in vehicles, all of which translate in greater vehicle weight.

More recently, however, EU institutions have come to the conclusion that an even lower level of emissions should be achieved by new passenger cars. In 2007, the Commission presented a Proposal for a Regulation (an EU act which, unlike Directives, is immediately effective in all Member States with no need of national legislation for its transposition) that would bring such level to 120gCO_2/km by 2012.[30] This would in effect be the first binding legislation on passenger vehicle emissions in the EU. There currently is no binding legislation directly on vehicle fuel economy in the EU: however, fuel economy would be an indirect albeit major element in achieving the binding carbon emission targets being considered.

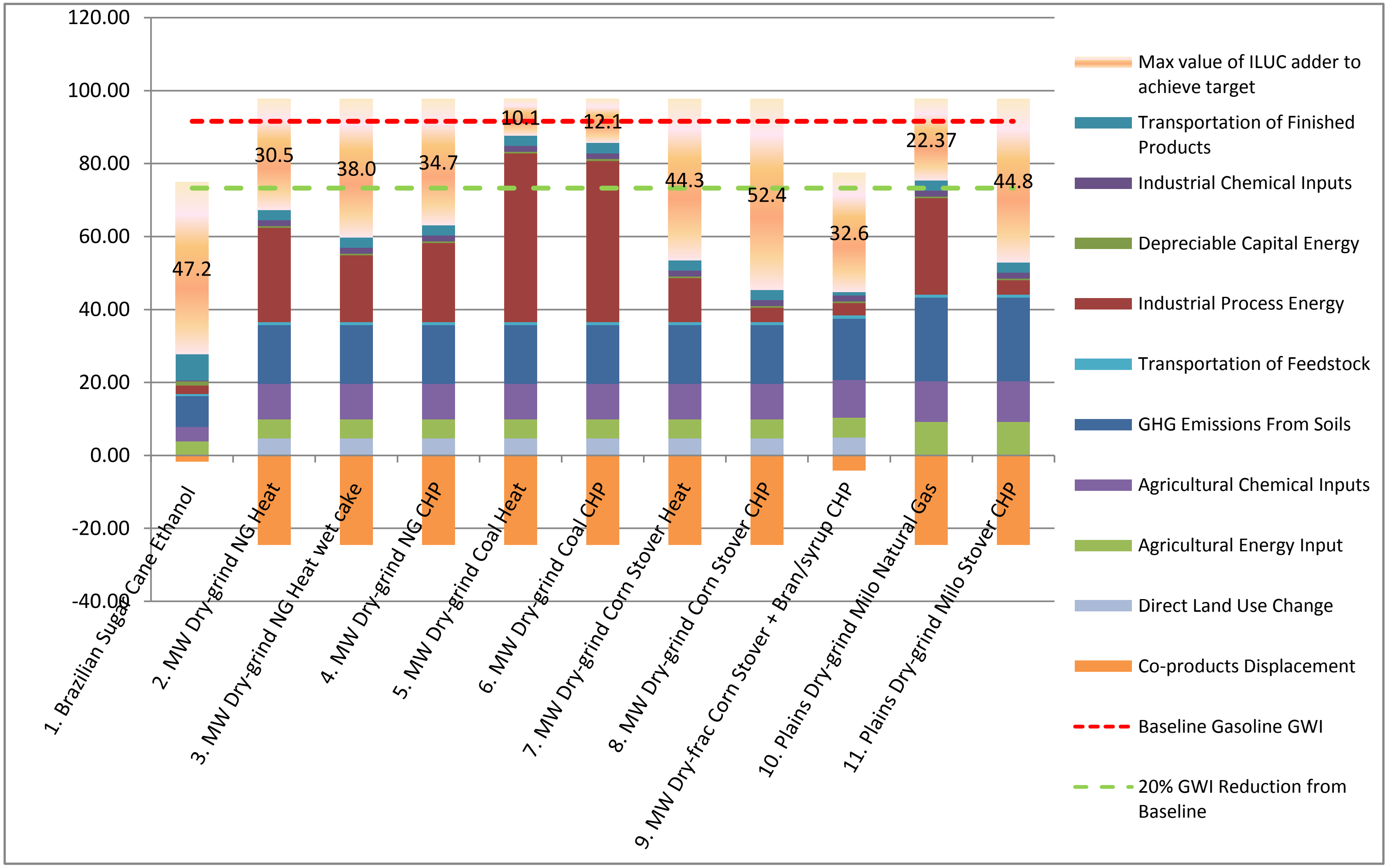
The components of the 120gCO_2/km target according to the proposed EU Regulation would be as follows: a reduction to 130gCO_2/km would need to be achieved by vehicle internal engine technology, and a further reduction of 10gCO_2/km by other technological improvements (such as tire inflation sensors) and, in particular, by an increased use of biofuels.

The proposal is currently being discussed in the EU Parliament, and several details are still evolving. The European car industry, represented by ACEA, in general agrees that a 120gCO_2/km target is feasible given anticipated safety regulations and evolving consumer preferences. However, it tends to disagree with the 2012 date, as well as with the different specific targets set for different vehicles according to their weight.[31]

[30] Proposal for a Regulation of the EU Parliament and of the Council Setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles – COM (2007) 856, available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0856:FIN:EN:PDF. Heavy duty vehicles (>3.5tons) not included.

[31] Conversation (10.24.2008)with Paul Greening, Director of Emissions and Fuels of the European Automobile Manufacturers' Association (ACEA)

Appendix B - Detailed Version of Figure 10 Showing Individual Contributions to GWI[32]



[32] Discussed in section "Analysis of Conversion Systems Using ICM/Econergy Model"

Appendix C – New Fuels Alliance Letter to CARB

October 23, 2008

Mary D. Nichols, Chairman
California Air Resources Board
Headquarters Building
1001 "I" Street
Sacramento, CA 95812

Dear Chairman Nichols,

We, the undersigned 30 companies and individuals, are writing to provide comment on the prospect of including indirect land use change (ILUC) in the California Low Carbon Fuel Standard (LCFS), and in general, to discuss the public policy implications of enforcing indirect effects of any kind in the regulation. This letter is submitted in response to comments submitted to the Air Resources Board (ARB) on the issue of ILUC over the past several months, including at the most recent public workshop held on October 16th.

First and foremost, we recognize that promoting the production and use of biofuels could help achieve domestic and global sustainable development goals, but that there are challenges associated with growing the biofuels industry in an environmentally responsible way. While the growth of crop-based biofuels should not be allowed to exacerbate sensitive land degradation here or abroad, there is nonetheless an opportunity to promote positive land use development in the context of both conventional and advanced crop-based biofuels. As such, it is important that the LCFS be careful in its regulatory approach if it is to foster sustainable fuel production.

The argument in favor of including ILUC in the LCFS is based on the belief that biofuels have significant indirect land use impacts, and ignoring them is the wrong public policy decision. The argument against including ILUC in the LCFS is based on the belief that the field of ILUC – and perhaps indirect impact modeling in general – is too uncertain to regulate at this time.

The public policy decision to extend the scope of the LCFS from direct to indirect, market-mediated effects is a monumental one. This is true for land use change, or any other indirect effect. Direct impacts are relatively certain, verifiable and attributable to specific types of fuels. This is true because these effects are directly related to and traceable to the production, transportation and combustion of those fuels, including upstream land use change attributable to fuel production, such as the conversion of pasture to corn or other biofuel feedstock.

Indirect impacts, on the other hand, are market- and policy-mediated. They are, in essence, the ripple effects of any given market decision in the global economy. Indirect impacts have not been enforced by any regulatory agency against any product in the world. Indirect impacts, whether applied to biofuels or any other fuel, occur as a consequence of a myriad of nested, policy and socio-economic variables. An article published in *BioScience* magazine captures the complexity of indirect effects, as they relate to deforestation: "[a]t the underlying level, tropical deforestation is … best explained by multiple factors and drivers acting synergistically rather than by single-factor causation, with more than one-third of the cases being driven by the full interplay of *economic, institutional, technological, cultural and demographic variables."*[33] This review of land change science goes on to conclude that it has proven difficult to achieve a theory of coupled land use changes that lead to useful, predictable outcomes for this highly complex process. Similar approaches have led to strikingly different outcomes depending on location, scale and other complex factors, making prediction uncertain.

It may be possible to model these impacts over time, so we should not abandon the idea of developing the science. But it is also true that no model today comes close to capturing the interplay of economic, institutional, technological, cultural and demographic variables inherent with quantifying the indirect impact of any fuel. In fact, the economic equilibrium models being offered as the mechanisms to quantify (and perhaps enforce) ILUC in the LCFS were not designed for regulatory use – i.e. to assign specific compliance metrics to specific fuels. They were designed to analyze the impacts of policies in more general terms. Using a model to publish a paper is very different than using a model to assign specific values that could fundamentally change the business landscape for alternative energy companies. As indicated in a 2008 GTAP paper on biofuels, referenced by the ARB LCFS website under GTAP peer review: "researchers have begun to use a CGE (computable general equilibrium) framework [to assess biofuels], however, with several caveats such as lack of incorporating policy issues, absence of linkages to other energy markets, and land use changes, etc. Our study makes an attempt to address these issues. However, the studies on CGE modeling are few, largely due to the infancy of the industry and limitations on the availability of data [emphasis added]."[34]

We are aware that proponents of including ILUC in the regulation argue that a preliminary quantification of ILUC is better than ignoring the impact all together; that "zero" is not the right number for ILUC for biofuels. While it is likely true that zero is not the right number for the indirect effects of any product in the real world, enforcing indirect effects in a piecemeal way could have very serious consequences for the LCFS. For example, zero is also not the right number for the indirect impact of producing a gallon of petroleum, using more electricity from coal and natural gas, producing advanced batteries and hybrid vehicles, or commercializing fuel cell technology. Yet, to date, ARB has not devoted any significant LCFS rulemaking resources to investigating the indirect effects of other fuels. If ARB is to enforce indirect, market-mediated effects, they must be enforced against all fuel pathways. The argument that zero is not the right number does not justify enforcing a different wrong number, or penalizing one fuel for one category of indirect effects while giving another fuel pathway a free pass.

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[33] Helmut J. Geist & Eric F. Lambin, *Proximate Causes and Underlying Driving Forces of Tropical Deforestation*, BioScience Magazine, Volume 52, No. 2 (Feb. 2002).

[34] See https://www.gtap.agecon.purdue.edu/resources/download/4034.pdf , p. 3.

Proponents of ILUC inclusion insist that they know enough about ILUC to enforce it in a fuel regulation. For example, the June 26 UC letter defending ILUC inclusion states that ILUC is more certain than claimed because the analysis conducted to date utilizes peer-reviewed models like FAPRI and GTAP. However, the fact that these models are peer-reviewed should not be inferred to mean that they have been peer-reviewed to be used for the purpose of enforcing indirect effects against specific fuels in a carbon-based fuel regulation. CGE models like GTAP provide estimates of land use change in distant locations, but at the price of severe limits in accuracy and at the expense of a realistic inclusion of complex causes of land use change. It seems that the desire for the utility of CGE models has overwhelmed the need for accuracy in estimating ILUC effects. The outcome could be poor public policy in the early stages of an unprecedented yet incredibly important transition in our liquid transportation fuel economy.

The June 26 UC letter also does not acknowledge the depth of uncertainty of predicting market-mediated effects of any kind, or the status of current research into this vast scientific space. For example:

- The current ILUC analysis for biofuels is very limited in scope. The public discussion has thus far been limited to the reductive effect of corn ethanol demand on world agricultural markets, and the possible conversion of relatively pristine lands that could occur from agricultural expansion. In addition, ARB has commented that non-corn energy crops (e.g. for cellulosic ethanol) will have a similar land use ripple effect if, in fact, land is used. But the analysis has not investigated the possible counter-balancing effect (i.e. benefits) of increased biofuel production, whether related to more sustainable agricultural land use and crop shifting, decreased urbanization, or the market-mediated effects of additional fuel supplies. Simply by increasing the profitability of agriculture, both domestically and overseas, biofuel production can have many positive effects on farmers and farming systems. In Californian, profitability helps farmers resist the pressures to transfer irreplaceable cropland to urban development, among other benefits. Given that land use change comes as a result of the interplay of so many variables, the exclusive focus on the reductive land use effect is of great concern.

- The modeling scenarios publicized to date have severe data and technical shortcomings. While it is true that the GTAP model is peer-reviewed, it is also well recognized that any model is only as good as the inputs used. For example, the UC letter states that they are using the "state-of-the-art" GTAP model to perform ILUC analysis for corn ethanol. The GTAP results were largely similar to those released by another researcher using the FAPRI model. But the UC letter fails to mention that they used the same land use conversion emissions data – a single set of data from the 1990s – for both exercises, without any apparent additional analysis or verification. So it should not be surprising that the results are largely the same. Other land use emissions studies have shown a ten-fold difference in land conversion emissions depending on what assumptions are used. In another example, the GTAP model does not include inputs for idle or CRP lands. This is a concern for two obvious reasons: (1) idle lands will be the first to be converted under any reasonable land conversion scenario; and, (2) any model that does not include idle and CRP land will produce exaggerated forest effects because the major points of domestic agricultural land use expansion are disabled. Lands in developing countries without clear rents (economic values in a marketplace) cannot be analyzed in GTAP. This includes much one-time cropland that is not accounted for or included in the GTAP estimates of effects. The preliminary ILUC numbers reviewed to date have been described as robust by several researchers involved, but an analysis that does not include the major points of domestic and international agricultural land expansion is not robust. It is important to note that the amount of U.S. agricultural land acreage dedicated to all crops, and coarse grains in particular, has generally declined during the last several decades while agricultural output has increased. It is also important to note that U.S. corn acreage has decreased in 2008. Historically in North America, advances in crop production technology correlate to the stabilization of forest use and a steady increase in forested acreage over the last century. Biofuel production, if carefully developed, could lead to a similar process in many third world settings, and the opposite effect of that feared. These considerations put into serious doubt the fundamental assumption that increased demand for crop-based products necessarily increases acreage planted.

• None of the available models being utilized for ILUC analysis are capable of taking into account the "interplay of economic, institutional, technological, cultural and demographic variables" inherent with land use change. For example, the GTAP figures presented by ARB staff on June 30 were neither sensitive to U.S. federal biofuels policy, which contains land use provisions designed to discourage certain types of land conversion, nor the energy or land use policies in those countries where the land conversion allegedly takes place in the scenarios modeled. This means that the ILUC scenarios do not (and cannot) take into account variables that would fundamentally change the outcome of the given modeling exercise, even directionally. Among the many variables driving deforestation and other forms of land use change are domestic and international policy, infrastructure development (including roads for oil and timber extraction), soil quality, topography, droughts, floods, wars, domestic cost of labor/land/fuel or timber, population and migration, urbanization and poverty. A recent paper published by the National Academy of Sciences (NAS) notes that, "… no facet of land change research has been more contested than that of cause. Empirical linkages between proposed causal variables and land change have been documented, but these commonly involve the more proximate factors to the land-outcome end of complex explanatory connections, such as immigrant, subsistence farmers and deforestation or locally configured common property resource regimes and land degradation. The distal factors that shape the proximate ones, such as urban poverty or national policies, tend to be difficult to connect empirically to land outcomes, typically owing to the number and complexity of the linkages involved. Attention to proximate causes elevates the potential to commit errors of omission "[35]

• The noticeable lack of indirect effects analysis for other fuels, particularly oil, is of serious

[35] B.L. Turner II, Eric F. Lambin, Anette Reenberg, *The emergence of land change science for global environmental change and sustainability*, PNAS vol. 104, no. 52 (Dec. 26, 2007).

concern. ARB staff has mentioned the possibility of an ILUC analysis for petroleum, but land use is only a part of the overall indirect carbon effect of oil. The indirect effects of unmitigated petroleum consumption, in a world economy largely dictated by petroleum and energy indicators, are vast. For example, noted agricultural economist (and architect of the GTAP model) Wally Tyner recently concluded that 75% of the run-up in corn prices is due to increased oil prices. Advocates for ILUC inclusion argue that higher corn prices cause crop shifting toward corn and away from soybeans, which drives up the price of soybeans and attracts Brazilian (rainforest) acres to soybean production. However, the UC researchers appear more inclined to ascribe the carbon effects of this theoretical causal chain to biofuels rather than to oil. It remains unclear, in a space characterized by many layers of interrelated effects, whether ascribing this effect solely to biofuels is correct. If the rising price of agricultural commodities is a concern – as the catalyst for additional planting – it is now clear that oil prices have a profound effect on agricultural commodity markets. There are also market- and policy-mediated effects for electrification from coal and natural gas, hydrogen production from coal and natural gas, and hybrid production.

• The June 26 UC letter posits the argument that underestimating ILUC for biofuels is probably worse than overestimating ILUC since underestimating ILUC would create incentives for the overproduction of crop-based biofuel. The obvious implication is that without ILUC penalties for biofuels, we may face a runaway, unfairly advantaged crop-based biofuels industry with potentially serious land use impacts. This position seems out of touch with the realities of the U.S. transportation fuels industry. Roughly 86% of the federal subsidies handed out to energy companies between 2005 and 2009 will go to fossil fuel companies. A recent report out of Purdue University (by an author of the GTAP model) concluded that the price of oil is primarily responsible for the increased price of grains, including corn. The increasing price of agricultural commodities has put enormous strain on the conventional biofuels industry, suspending production at dozens of plants. The initial LCFS Policy Analysis published in August 2007 recognized that the new, low-carbon transportation fuels needed in California are at a disadvantage because they “compete on a very uneven playing field: the size, organization and regulation of these industries are radically different.” It is difficult to see how enforcing even conservative indirect effects against biofuels, especially while not enforcing any indirect impacts against other fuels (as is the current LCFS trajectory), would unfairly incent crop-based biofuels. More likely, it will perpetuate the status quo, and continue California on a path toward (increasingly less sustainable) oil dependence. It is also instructive to point out, as the LCFS Policy Analysis did in August 2007, the duality of California’s climate policy: to encourage investment and improvement in current and near-term technologies, while also stimulating innovation and the development of new technologies. To this end, it is imperative that the LCFS value and devalue all fuels equitably, so as not to exacerbate an already uneven playing field for alternative fuels.

• The fundamental assumption of the current ILUC argument – that using an acre of land in the

U.S. for fuel will require almost an acre of crop development somewhere else – produces questionable results when applied to “good” public policy initiatives. For example, under the same assumption it is possible that setting aside land for the Conservation Reserve Program (CRP) creates more carbon emissions, because it takes agricultural acreage out of domestic food and feed production, which results in agricultural cultivation of grasslands and deforestation abroad. It is possible that other land protection policies, including national parks and wilderness areas, also fail the “zero sum” land use assumption because they take timber and agricultural land out of traditional production. By the “zero sum” standard, any land conservation policy in California or the United States exports pollution (or creates ILUC) elsewhere.

• Enforcing indirect impacts using the methodology envisioned by ARB may produce questionable market behaviors. ARB has discussed having a “non zero” land use change attribution (i.e. penalty) in the LCFS for certain broad categories of fuels (e.g. corn ethanol, biodiesel, cellulosic ethanol, etc.). However, it is generally accepted that different regions have different tolerances for increased agricultural production, as well as different indicators for agricultural products based on weather, supply/demand, annual plantings, etc. Yet, agricultural expansion in a region that can tolerate it pays the same ILUC price under the LCFS as expansion in regions that cannot tolerate intensification. And both farmers, irrespective of the efficiency or sustainability of their crop, pay for theoretical environmental damages abroad that they have no control over. The public policy proposal to penalize products for decisions and trends far outside of their sector and control is a major one, may not produce the desired behavioral effect, and should endure a substantial public review process.

• We are not sure that ARB is applying the principle of indirect effects enforcement in a balanced and consistent way. For example, ARB staff has made clear their inclination to debit all crop-based ethanol for ILUC, irrespective of the type or location of the land used for production. However, on the subject of tar sand petroleum use by oil companies, ARB staff has implied only that oil companies will be debited if they use tar sands in California. Put another way, the penalty for biofuels is automatic while the penalty for oil can be avoided by redistributing its product. This creates obvious compliance inequities, but also questionable climate accounting in the marketplace. Oil companies will simply use lighter crude in California to escape penalty under the LCFS. But this decision will short supply of light crude elsewhere and increase the demand for tar sands and other resource intensive crude with obvious climate impacts. Requiring oil companies to account for tar sands use abroad is the definition of a market-mediated effect. Yet ARB seems more inclined to enforce market-mediated effects against ethanol, for land use change, than indirect effects against oil companies for heavy crude and tar sands.

To be clear, the renewable fuels industry supports the ongoing effort to better understand the indirect effects of the energy choices we make. But the enforcement of indirect effects of any kind, given the complexity and relative infancy of the field, must be done carefully and in a balanced way. Some members of the UC scientific community want to include ILUC in the LCFS. But this is not a consensus position. In addition to the 27 signatories of the June 24 letter to ARB, Dr. Michael Wang of Argonne National Laboratory, one of the foremost experts in lifecycle carbon assessment (LCA) field and author of the GREET model being used as the framework for the LCFS, recently stated, "indirect land use changes are much more difficult to model than direct land use changes. To do so adequately, researchers must use general equilibrium models that take into account the supply and demand of agricultural commodities, land use patterns, and land availability (all at the global scale), among many other factors. Efforts have only recently begun to address both direct and indirect land use changes … [w]hile scientific assessment of land use change issues is urgently needed in order to design policies that prevent unintended consequences from biofuel production, conclusions regarding the GHG emissions effects of biofuels based on speculative, limited land use change modeling may misguide biofuel policy development."[36]

The UC letter signatories dismiss the rationale that ILUC be left out of the LCFS at this time based, in essence, on the assertion that ILUC exists. As stated, all fuels and products have indirect carbon impacts. Yet, zero may in fact be the right number for "indirect effects" for all fuel pathways in the first version of the LCFS from a public policy perspective if: (1) ARB and UC cannot enforce scientifically defensible numbers because of the lack of verifiable or reliable data or an incomplete understanding of the full spectrum of indirect effects across all fuel pathways; and/or, (2) there are serious unanswered public policy questions about the merits of enforcing indirect effects in a performance-based carbon regulation; and, (3) there is no accounting for the foregone public benefits of domestic and international biofuel development, or for the export of pollution to other locations on a strict LCFS policy with high penalties for domestically produced biofuels. To this latter point, it is worth noting in any discussion about market-mediated, indirect effects the potential to destabilize the advanced biofuels sector with overly aggressive or inequitable compliance metrics against conventional biofuels. It is well understood that conventional biofuels are a cornerstone for the development of advanced biofuels, which includes infrastructural, political, market acceptance and investment risk considerations. Enforcing additional compliance metrics against conventional biofuels will not accelerate the commercialization of advanced biofuels.

Notwithstanding the challenges ahead, our industry is eager to be an early actor under the regulation and looks forward to the ongoing formulation of the LCFS rule. We strongly agree with the UC researchers that the challenge that comes with ushering in new technical, economic, social and environmental areas of inquiry and action is of balancing further study with implementation. But we do not agree that throwing uncertain numbers at selected fuels under the LCFS will create a positive outcome for either the environment or the LCFS policy itself.

[36] See http://www.transportation.anl.gov/pdfs/letter_to_science_anldoe_03_14_08.pdf.

We would be happy to address questions or concerns you may have, and appreciate your leadership on this important endeavor.

Sincerely,

Brooke Coleman
Executive Director
New Fuels Alliance