ISSUE BRIEF

Let's Give the Next Generation a Better Fuel

High Octane Low Carbon Fuels with Renewable Ethanol

2023 Edition

A Publication of the Clean Fuels Development Coalition

With growing pressure to reduce carbon emissions, and the constant whipsaw of gasoline prices, it really makes one wonder.... What if we had a fuel that could cut carbon emissions, get significantly better mileage, reduce our dependence on foreign oil saving the US billions of dollars, reduce particulate and other pollutants, cost less, create jobs here at home in the agriculture, refining, and biotechnology industries, require no subsidies or taxpayer burdens, be implemented immediately, all while maintaining consumer choice in the cars and trucks we buy. Wow, wouldn't that be great.... imagine if we had such a fuel? Well, there is good news---We do!

Despite the seemingly relentless drumbeat of stories, speeches and promises that we are going to convert the entire US vehicle fleet to electric vehicles and all will be well, that is simply not going to happen. At least not in the time frame envisioned by the Biden Administration. The pace of play for EVs cannot match the rhetoric, we covered this extensively in a previous issue brief (EVs—No Silver Bullet. https://cleanfuelsdc.org/2023/06/23/new-issue-brief-challenges-the-ev-vision/). As stressed in that piece, we are not anti-EV and wish them well, but the truth of the matter is that we are ignoring an opportunity to achieve all the goals of the imagined fuel noted above now, with high octane low carbon ethanol blend fuels that can be used in every car on the road today. The question is how do we do that....and the answer is federal legislation proposed in Congress titled **the Next Generation Fuels Act**.

> ***"Gasoline will continue to play a vital role in transportation for years to come and there are important improvements that can be made to reduce carbon, increase vehicle fuel efficiency and lower emissions supported directly by high octane low carbon fuels."***
>
> —The Alliance for Auto Innovation, June 2021

With this legislation now before both the House and Senate receiving broad bi-partisan support, the time is now to act. The bill makes the case for feasible, yet truly transformational change in our fuels and automobiles. According to the sponsors of the legislation, Congress finds that:

- *Continued increases in automobile efficiency are needed to improve consumer welfare and reduce carbon emissions;*
- *The widespread availability of high octane low carbon fuel will allow continued cost effective improvements in automobile efficiency by increasing engine compression ratios;*
- *High octane automobiles and low carbon fuels are readily available to consumers;*
- *Ethanol is a cost effective and low carbon octane enhancer;*
- *The widespread adoption of climate smart practices and precision technologies by U.S. corn producers have further reduced the carbon intensity of corn ethanol;*
- *On average, ethanol has been estimated to have lifecycle greenhouse gas emissions that are 46% lower than average gasoline, with some corn ethanol achieving a 61% reduction;*
- *Ethanol has one of the highest blending octane values available in the marketplace.*

Continued on page 2

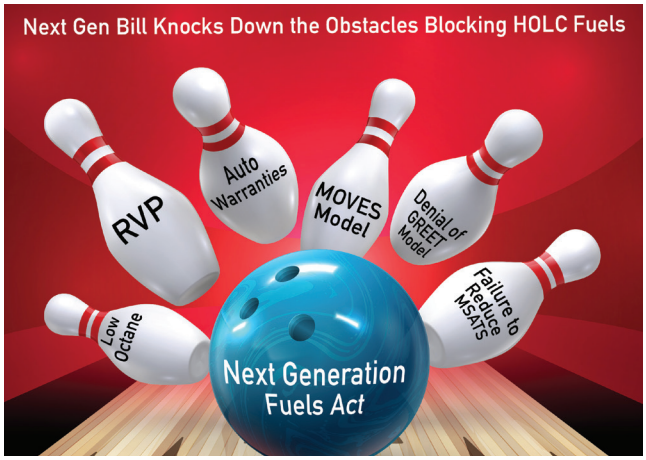
With this impressive set of facts as the basis to take action, the legislation addresses a number of market and regulatory obstacles that if corrected would open the market to the high octane low carbon (HOLC) fuels the global auto industry has said will be needed for decades to come. With 275 million light duty vehicles on US roadways, gasoline and the internal combustion engine will remain the primary transportation fuel. And, as the challenges of full adoption of EVs becomes more apparent, automakers are taking another long look at hybrid electric technologies that will still require liquid fuels.

So Let's Take a Look Under the Hood—What Does the Bill Do?

The Next Generation Fuels Act addresses the whack-a-mole problem ethanol has had throughout its history. Critics have a seemingly unlimited set of reasons why not to use ethanol and once an argument is exposed as bogus there is another waiting to pop up like in the carnival game to stop progress. This legislation, for the first time, reflects a thoughtful analysis of what has kept the United States from freeing itself from being captive to what is essentially a mandate that we depend on petroleum for 90% of our transportation fuel.

The bill boils down the solution into what we see as the key provisions. It would:

- Increase octane in gasoline
- Ensure a role for ethanol in that increase
- Require auto warrantees for higher blends
- Ensure accuracy in emissions/testing/certification of fuels
- Revise studies on fuel effects
- Ensure equipment compatibility
- Require vapor pressure parity
- Ensure GHG reductions
- Revise Efficiency Calculation of Dual Fuel Vehicles



Looking at these provisions in sequence is like snapping the pieces of a puzzle together, and when done, presents a clear picture.

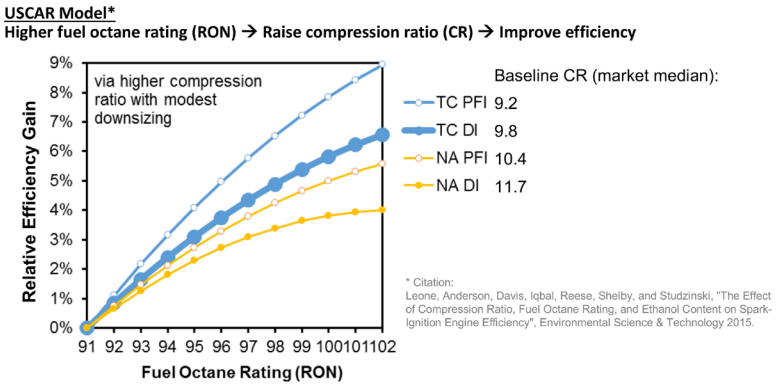
Increasing Minimum Octane Requirement for Gasoline

What It Does: Octane is calculated in several ways. There is a Research Octane Number (RON) and what consumers would be familiar with called AKI (anti-knock index) which is the posted number at the pump. The bill would require an increase from current levels of 91 RON to a 95 RON by 2028. It would require further increases by 2033 to a 98 RON.

Why It Matters: Mercedes Benz has stated "octane is the single most important consideration in engine design". Raising octane would allow automakers to increase compression of conventional engines resulting in significantly greater efficiency—up to a 7–10% increase according to Ford, General Motors, and others.

Ensuring a Role for Ethanol in Octane

What It Does: As noted in the Congressional findings for this bill, ethanol has the highest octane blending value available. The bill requires that for an automobile to be certified, ethanol is not required but the cars must be able to certify using fuels containing 20% ethanol for the 95 RON, and 25–30% ethanol for the 98 RON.



HOF enables efficiency increases for all vehicles with SI engines including hybrid electric vehicles

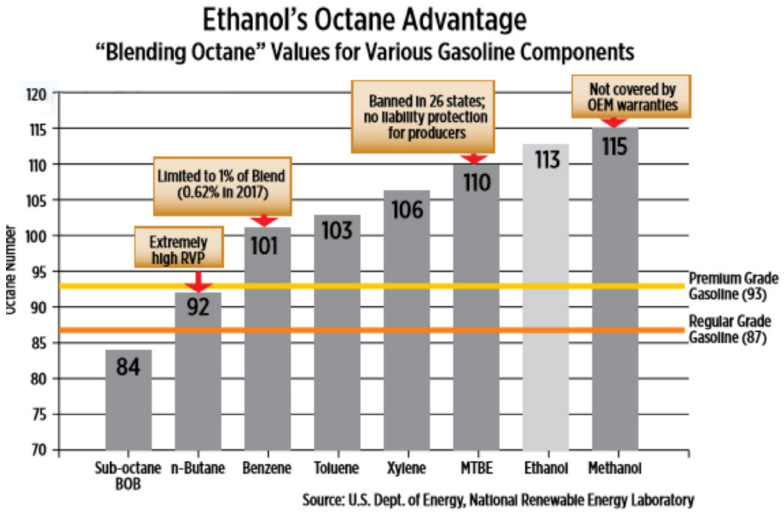
Why It Matters: Ethanol is not only the lowest carbon, highest octane additive refiners can use but also the lowest cost. Ensuring a role for ethanol by having it approved in the certification process will help keep costs low and keep higher priced, carbon intensive compounds from being used.

Auto Warrantees

What It Does: All manufacturers of automobiles would be required to honor warranties for the new octane levels and the inclusion of the ethanol blends at the 20–30% volumes.

Why It Matters: The American love affair with their automobiles is woven into the fabric of our country. The unfounded fear that those opposing ethanol have created suggesting ethanol will damage your car has been successful in masking the truth. Demonizing our renewable, clean, domestic, lower cost, job creating fuel has been part of keeping us from unleashing basic automotive technology to utilize higher blends of ethanol.

In the 1990s CFDC worked with member company General Motors to have GM honor warrantees for 10% blends, ushering in a new era of ethanol use and which is now extended to 15%. This would be the evolution of that process.



Ensuring Accuracy in Emissions/Certification/ Testing of Fuels

What It Does: For any automobile to be entered into commerce it must be certified as to its emissions and performance. The bill requires not only that the certification process is conducted with these new fuels but that the emissions be calculated by "actual measured emissions".

Why It Matters: Lack of such certification has been a core of the fear mongering of anti-ethanol forces for decades. Real world, actual emissions reveal the substantial benefits high ethanol blends provide and effectively requires EPA to address their admittedly deficient computer models.

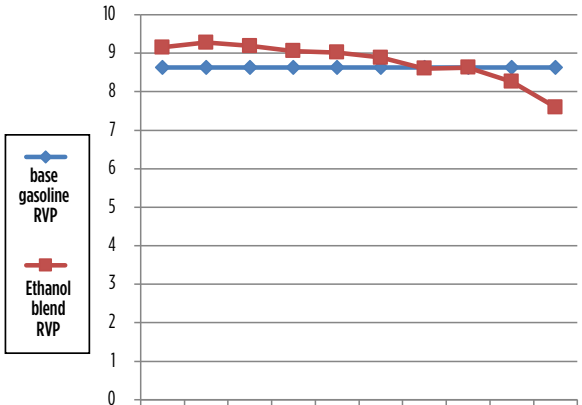
An extension of this provision is the requirement for EPA to conduct a much-needed Fuel Effects Study, taking into consideration specific pollutants such as fine particulates which would show ethanol significantly reduces pm and would provide measurable public health benefits.

Establishing Vapor Pressure Parity for All Ethanol Fuels

What It Does: Clearly requires that fuel containing 10% or more ethanol by volume is afforded a one pound waiver from vapor pressure limits.

Why It Matters: Fuel volatility, or its tendency to evaporate, is measured in part by its reid vapor pressure, or RVP. Ethanol increases RVP when added to gasoline at certain levels. Because of its chemical composition as an oxygenate, and its clean burning properties that reduce certain pollutants, ethanol has been granted a waiver from limits placed on gasoline. That waiver was defined as applicable to blends of 10%. As the benefits of higher ethanol blends have become more understood, this provision amends the restrictive language of the 10% definition and applies the waiver to all blends. In a quirk of chemistry, vapor pressure actually peaks at 10% and begins to decrease, zeroing out at blends of 30% or more so there is no negative environmental impact.

This provision then opens the door for the higher octane blends called for in the legislation.



	10%	12%	14%	17%	20%	25%	30%	35%	40%	50%
base gasoline RVP	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63	8.63
Ethanol blend RVP	9.15	9.28	9.19	9.06	9.02	8.89	8.6	8.63	8.26	7.6

Source: US DOE, National Renewable Energy Lab

Ensuring that Any Octane Additive be Low in Carbon

What It Does: This provision requires any additive used to increase octane meet a requirement of a 40% reduction in greenhouse gas emissions (ghg) as compared to gasoline. Importantly, it requires the calculus for that reduction is the gold standard of carbon intensity modeling, the Department of Energy's GREET Model (Greenhouse gases, regulated emissions, and energy use in technologies).

Why It Matters: Reducing carbon emissions has become a global movement. Whether it is electric, liquid, or any other technology, future fuels simply must provide a meaningful reduction in ghg emissions and overall carbon. Given the fact that the US will continue to rely on liquid fuels, with a 46-60% reduction in ghg emissions ethanol will play a vital role in meeting the needs of the US motor fuel pool for decades to come. According to modeling by the University of Illinois, the Next Generation Fuels Act will reduce GHG emissions by two billion metric tons.

Ensuring "Clean" Octane

What It Does: Requires a reduction in Aromatic compounds—classified as Mobile Source Air Toxics, or MSATS.

Why It Matters: As far back as the 1990 Clean Air Act Amendments Congress called for Clean Octane and directed EPA to reduce MSATS with ethanol. General Motors has stated 98% of fine particulate pollution comes from these aromatic compounds. With gasoline direct injection engines (GDI) being the predominant propulsion technology, these particulates will increase dramatically in the coming years. Replacing these toxic octane enhancers with ethanol will provide significant public health benefits.

Ensuring Equipment Compatibility

What It Does: Requires that dispensing equipment be certified and comparable with 98 octane fuels and fuels containing up to 40% ethanol. Similarly, underground storage tanks will be required to be compatible with such fuels so as to prevent any leakage and harm to the environment.

Why It Matters: For a variety of reasons ranging from safety to environmental concerns, it is imperative that the equipment dispensing these fuels be certified to do so. Existing Federal regulations requiring that underground storage tanks are capable of up to E100 simply needs certification and documentation.

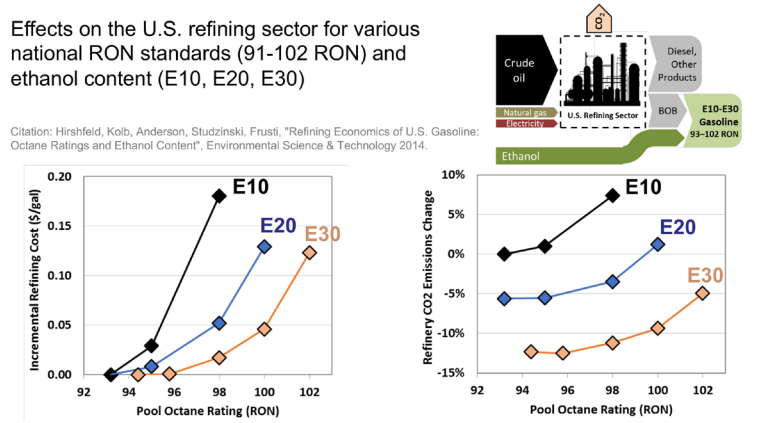
Correcting Calculations of Dual Fuel Vehicles:

What It Does: Corrects faulty efficiency and emission calculations of dual fuel, or flex fuel vehicles.

Why It Matters: While the overarching target of this legislation is new and existing vehicles, a growing demand for low carbon fuels has renewed interest in Flex Fuel vehicles that can operate on any combination of ethanol and gasoline up to 85%. EPA has penalized ethanol under the assumption that the lower energy content results in reduced efficiency and that these vehicles use less ethanol and thus increase ghg and other emissions. An accurate assessment of these vehicles will entice automakers to make more of these cars available.

Effects on the U.S. refining sector for various national RON standards (91-102 RON) and ethanol content (E10, E20, E30)

Citation: Hirshfeld, Kolb, Anderson, Studzinski, Frusti, "Refining Economics of U.S. Gasoline: Octane Ratings and Ethanol Content", Environmental Science & Technology 2014.



- 95 RON HOF minimizes production costs & CO_2 emissions at refineries
- Ethanol is a strong enabler for high RON level HOF

Winners & Losers? Just Winners

Everybody wins with the legislation just explained. Corn farmers, ethanol producers, environmentalists, consumers, taxpayers, and...the petroleum industry. Surprised? Don't be. While not a mandate or a requirement, the elimination of barriers to using ethanol at its highest value provides refiners with the lowest cost source of octane. US refinery capacity has declined considerably, and that which remains has been operating at unsustainably high capacity. In plain terms, rather than making octane in-house by processing these toxic, carbon intensive aromatic compounds, refiners can essentially outsource their octane needs using lower cost ethanol. They can actually make more gasoline by processing oil into a low octane blendstock that can then be turned into the HOLC Fuel blend. It should also increase their output of distillate/diesel, jet fuels, and other petroleum products to increase exports that will benefit their bottom line.

As the pendulum swings back to internal combustion engines the quest for low carbon isn't going to disappear. Higher ethanol blends makes their product lower in carbon—essential if they are to avoid becoming obsolete. It then supports the argument to regulators that rather than force feeding electric vehicles on to the public in the name of climate change and carbon reduction, we can achieve the same benefits with High Octane Low Carbon Fuels in the existing fleet and the conventional cars that will be produced for the foreseeable future. Peer reviewed studies also show that refinery emissions would be reduced, further improving their carbon footprint.

If the environmental community would be intellectually honest they should look at contemporary data and recognize the carbon reductions they seek not only can be achieved with new liquid fuels but also see that with less EVs than modeled in projected benefits, where are the gains in mileage and reductions in carbon going to come from? With the Department of Energy confirming ghg reductions nearing 50% as compared to gasoline and that number going up all the time, the answer is clear.

> ***"In terms of climate, improving efficiency of gasoline cars is as critical as electrification"***
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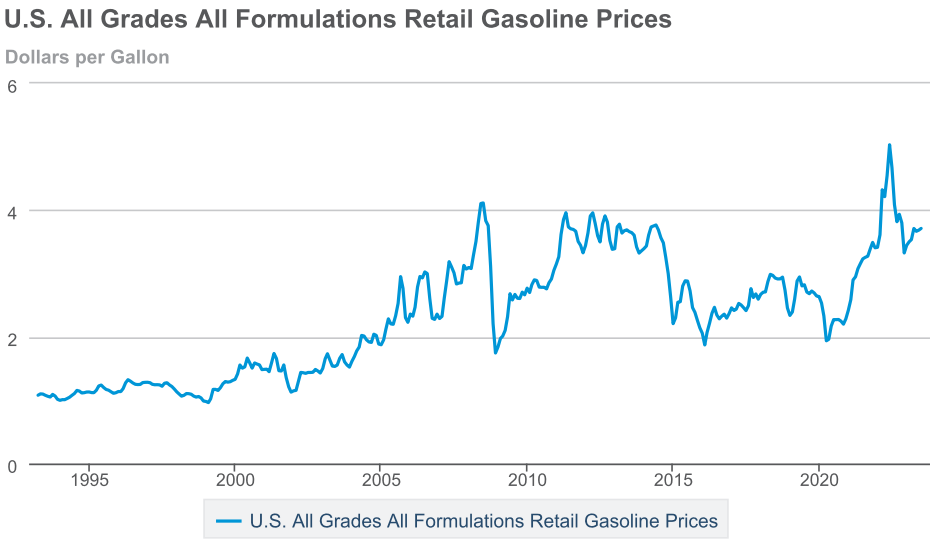
> —Massachusetts Institute of Technology, 2019



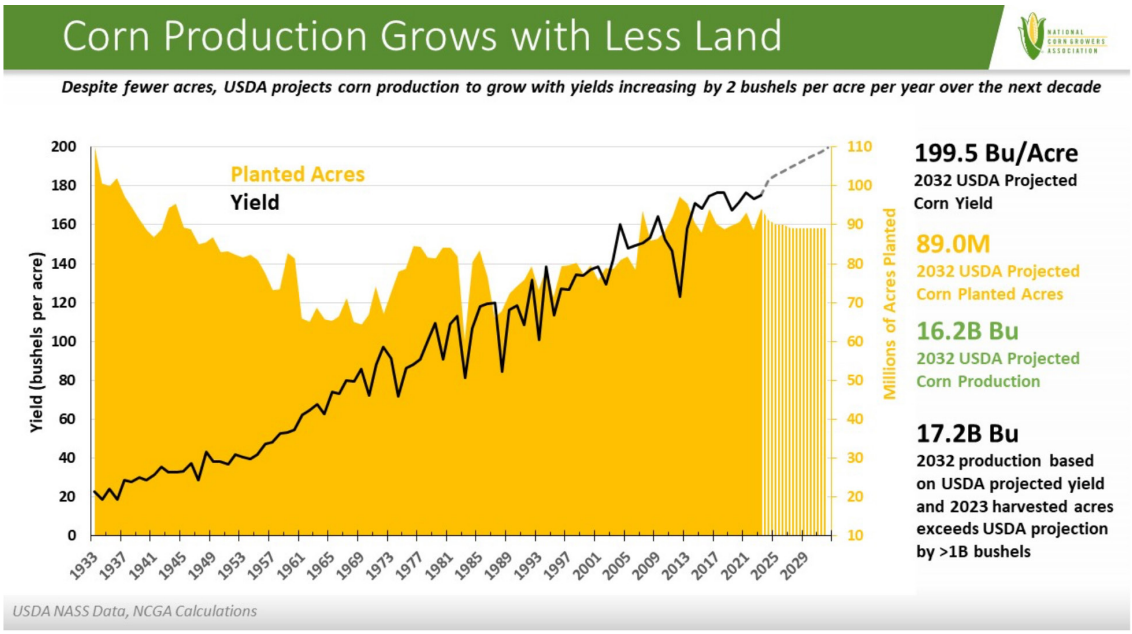
Federal and state governments cannot dictate what we drive by setting unrealistic and unattainable standards. Mandating EVs and outlawing conventional vehicles that rely on market forces the government cannot control is a recipe for failure.

Dollars and Sense

At what point does the American Public say enough is enough in terms of enriching the Organization of Petroleum Exporting Countries (OPEC). The up and down see-saw of the price of gasoline is a cruel game being played by the oil industry at the expense of the American public.

At what point do we demand more of our elected officials to do everything in their power to provide low cost fuels that are not subject to the whims of foreign countries who control supply and can raise oil prices any time they wish. When gasoline goes up 1 just one penny it reaches into the pocket of American Motorists for more than 120 million dollars in just one year. When it goes up one dollar, it is a staggering $120 billion. Moreover, it fuels inflation by raising the cost of goods and services.

For the American consumer, the benefits of the Next Generation Fuels Act could not be clearer. The price of gasoline ranks up there with death and taxes as an inevitable, unavoidable fact of life, at least for the foreseeable future. As the chart above illustrates, over the past several decades the price of gasoline has steadily increased, requiring more and more of after-tax wages to go to powering our automobiles. This is household income that is diverted from housing, food, and leisure activities. Rather than using American technology and ingenuity to lower transportation costs we have allowed them to increase. American homegrown, renewable ethanol is less expensive than gasoline, and always has been, with the exception of a few blips and brief inversions. Taking out a gallon of a $3 product and replacing it with a $2 cleaner, higher octane, renewable product is basic math. Among the myths chasing ethanol for the past 40 years is that the economic advantage is lost due to ethanol's lower energy content. While the efficiency loss has been greatly overstated, it would be irrelevant if the Next Gen bill were enacted. Automakers would be able to easily adjust compression and make other minor modifications—including to existing vehicles—to take advantage of the high octane and achieve substantial gains as illustrated in the graphic on page 2.



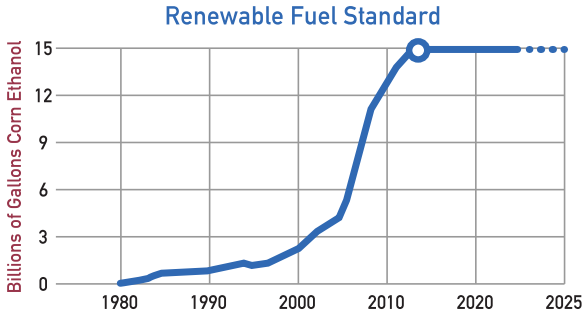
For American agriculture, the stimulus to the rural economy that ethanol has provided has revitalized communities throughout the Midwest. There have been points in time where the price of corn was less than the cost of production. Without this value added product, there would be less farmers and less supply, resulting in higher food prices. Farm support payments from the federal government would increase, hitting taxpayers and motorists yet again.

As a side note, it is critical for the public to understand these are not food products being converted to ethanol but rather it is non food grade corn used for animal feed. The production of ethanol actually creates more food and feed value from a single bushel than simply feeding that same bushel. And, farmers are becoming more efficient all the time, growing more corn with less fertilizer inputs without any increase in land, as illustrated below.

New and expanded markets will always drive efficiency, it is in the self interest of agriculture to do so. And, it is in the context of an increasingly competitive global market. Allowing corn ethanol to compete in the motor fuel market through higher blends can usher in an era of even greater efficiency and productivity. The Renewable Fuel Standard was the catalyst to use feed corn for food, feed and fuel but as the chart below clearly illustrates, the artificial caps on corn ethanol through legislative and regulatory barriers has resulted in a flatline of RFS demand.

In the meantime, Brazil, long the world leader in sugar cane ethanol, is aggressively adding corn ethanol to its portfolio. Currently the 6 billion liters of corn ethanol (1.5 billion gallons) is projected to increase to 13.5 billion liters (3.5 billion gallons) in a few short years, according to Brazilian Consulting firm Datagro.

As a Demand Driver, the RFS Got Corn Ethanol to 15 BGPY But No Further

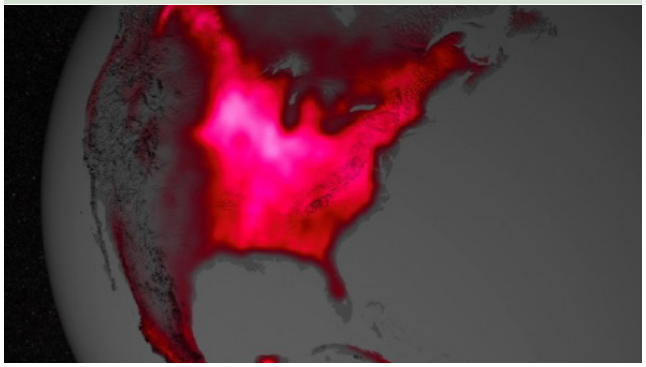


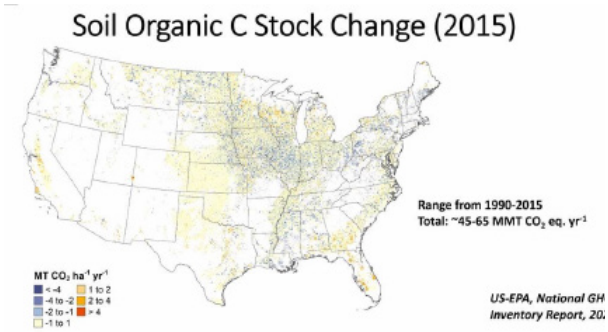
While they will use some of that internally, they will be competing in export markets for both corn and ethanol, and potentially displacing US exports. The obvious response in the US should be to use more of our own product at home, and the high value for that is in the high octane market the Next Generation Fuels Act would open up. The Renewable Fuel Standard, while being effective in getting ethanol and corn demand to its current levels, effectively caps corn ethanol making this legislation critical in order to move beyond that cap.

So there you have it.

Legislation that would simply give automakers the tools they need to provide cars that meet the objectives of efficiency and carbon reductions. It ensures those tools can be provided by domestic, renewable, clean, job creating industries. It allows the market to decide how to meet standards, maintaining a pathway to EVs but recognizing American agriculture and petroleum working together are the answer, not the problem. Nonsensical arguments that taking away volume of refined products simply transfers wealth from one part of the country to another, i.e. the Midwest, ignores the alternative which is a future where neither region remains prosperous and vibrant and U.S. dollars continue to flow to OPEC, China, and other countries.

Would increased corn production worsen climate change? Just the opposite. Corn is uncommonly efficient in its use of carbon dioxide in the air—converting it to four-carbon compounds instead of the usual three. Only about 3% of flowering plant species (including sugar cane) do the same, but this relative handful accounts for 23% of all terrestrial carbon fixation. NASA satellite images and the EPA chart illustrate the astonishing carbon uptake by the Corn Belt in the summer.





CFDC CLEAN FUELS DEVELOPMENT COALITION

For Further Information, Contact:
Douglas A. Durante, Executive Director
Clean Fuels Development Coalition
10421 Motor City Drive, Box 341876, Bethesda, MD 20817
cfdcinc@aol.com | www.cleanfuelsdc.org