

A SPECIAL ILLINOIS CORN PUBLICATION

HIGH
OCTANE
LOW
CARBON
CORN-BASED
FUEL



ENGINE
OF HOPE



ILCORN.ORG



HOLC:

Fueling growth & improving profitability

America's corn farmers are the best in the world.

Unsurpassed for quality, reliability, and availability, our corn farmers are literally outstanding in their field.

In fact, Illinois hit another record level of production in 2018, with the average yield per acre coming in at 210 bushels.

So you've got the supply side down. With your Illinois corn checkoff dollars, the Illinois Corn Marketing Board is taking on the demand side of the profitability equation with innovative approaches, supporting research to design the new, High Octane Low Carbon (HOLC) future fuel to power future vehicles that will be lighter weight with high compression engines to improve efficiencies and reduce harmful greenhouse gas (GHG) tailpipe emissions that contribute to climate change.

While internal combustion engines are more efficient and cleaner than ever, the transportation sector is still responsible for 27% of

The U.S. Department of Energy's national labs have confirmed that these new engines operating on mid-level blend ethanol fuels could achieve, depending on the octane level, 5-10% improvement in vehicle efficiency with even larger reductions in greenhouse gas emissions.

The introduction of HOLC liquid transportation fuels into North America will expand ethanol markets for Illinois corn farmers.

Analyses have shown that with a 50% adoption rate of E25 in new vehicles with high compression engines, ethanol usage in 2030 and beyond could increase as much as 5 billion gallons.

Let's state that again.

Ethanol usage could increase by 5 billion gallons or more.

Five billion gallons of ethanol takes about 1.8 billion bushels of corn, roughly equivalent to the corn carryout figures for the 2018 crop.

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GHG emissions, with half of all transportation emissions coming from light-duty passenger vehicles, like the ones we all drive every day.

The Energy Information Administration predicts the internal combustion engine will be the dominant engine for the next several decades, making both fuel and engine efficiency critical pieces in reducing the GHG intensity of the transportation sector.

Enter corn-ethanol as octane.

Your fields are growing the very octane on which these fuel and vehicle innovations depend.

By increasing the compression ratios of engines and optimizing them to run on HOLC fuels, automobile manufacturers can increase vehicle efficiency and reduce emissions.

Do we have your attention now?

Researchers from Argonne National Laboratory, the National Renewable Energy Laboratory, and Oak Ridge National Lab have been conducting coordinated studies to address the opportunities and challenges of deploying high octane fuels with mid-level ethanol blends to the passenger vehicle fleet.

They are finding that fuels that blend between 20 and 40 percent ethanol (E20 to E40) with conventional gasoline, instead of the current 10 percent ethanol blend (E10), can lead to greater fuel efficiencies and lower overall GHG emissions in the existing passenger fleet.

Additionally, the introduction of this high-octane mid-level ethanol fuel could provide an optimized fuel source for the much more efficient internal combustion engines carmakers are developing.

Your corn checkoff: Innovating relationships

IL Corn knows even the best ideas won't gain much traction without consensus, and we certainly don't have the most leverage in conversations about motor vehicles and motor fuels. That's why we diligently grow relationships with other stakeholders in the discussion of High-Octane Low Carbon (HOLC) fuels.

As an early innovator in these discussions, IL Corn led develop-

WHAT IS OCTANE?

Octane is the number you see at a gas pump, most frequently indicated by a yellow label with the numbers 87, 89, or 91.

The higher the octane number, the more likely the fuel will resist ignition when compressed in the cylinder. The higher the octane rating, the less likely an engine's propensity to knock.

Knocking causes severe engine damage at worst, and at best, is an audible indicator of poor engine tuning, or performance with the fuel. As a result, engine management systems today incorporate knock sensors to adjust ignition timing when necessary to accommodate for the inconsistencies in gasoline quality.

How does corn-based ethanol fit into the octane discussion?

Corn-based ethanol is the lowest cost, highest quality, non-toxic source of octane available in the world.

Illinois Corn Marketing Board, by investing your checkoff dollars, is doing the legwork to prove that IL Corn fields aren't just growing record levels of corn, they're growing octane for the fuels and vehicles of the not-too-distant future.

ment of what's now known as the Ag Auto Ethanol working group. The conversations aren't always easy, but they're always necessary. And they are yielding results.

For example, the country's largest automakers see a consensus-building approach as crucial to a move to high-octane future fuels for future vehicles:

Ford: Tony Ockelford, director of product and business strategy for Ford's powertrain operations, outlined two ways to elevate the octane debate: the auto industry needs to educate drivers on the benefits of higher octane and how it enables cleaner and more powerful and efficient engines, and continue collaborating. "100 RON has been on the table for a long time...The only way we will ever get there is to continue to push and work in a collaborative way."

GM: Dan Nicholson, vice president of General Motors Propulsion Systems, regularly lobbies governments and the petroleum industry to raise octane. "Higher octane is necessary for better engine efficiency...It is a proven low-cost enabler to lower CO2. 100 RON fuel is the right fuel for the 2020-25 timeframe...If we are going to get to an optimal, societal CO2 solution, we will need to work together."

Who are the members of the Ag Auto Ethanol working group?

- **Auto manufacturers:** Chrysler, Ford, General Motors, Mercedes, Toyota, VW

- **Agriculture:** IL Corn, John Deere, Monsanto, the National Corn Growers Association, many state corn organizations

- **Ethanol:** American Coalition for Ethanol, Growth Energy, Renewable Fuels Association, ICM, Poet Energy, ADM

And why does such a diverse coalition pin its hopes on HOLC? Let's examine its roles.

Mazon, IL, grower Paul Jeschke testifies on advanced fuel/ethanol benefits before the U.S. House Energy and Commerce Environment and Climate Change Subcommittee last spring.



Renewable regulator.

In 2017, the U.S. imported about 19% of the petroleum it consumed, according to the U.S. Department of Energy (DOE).

That number would have been significantly higher if ethanol had not been domestically produced and consumed.

Because transportation accounts for nearly three-fourths of total U.S. petroleum consumption, using ethanol fuel blends produced from renewable agricultural sources, has a significant impact.

This also supports the U.S. economy, helps diversify U.S. trans-

and reduce tailpipe carbon emissions from non-renewable sources by 7%.

In its 2010 fuel “life cycle” analysis, EPA recognized that carbon emitted from the combustion of ethanol is the same carbon that the corn plant absorbed from the atmosphere as it grew. Because unlike gasoline tailpipe emissions, ethanol tailpipe emissions do not alter the carbon cycle and thus do not endanger public health or welfare, treating these emissions differently makes sense under clean air rules.

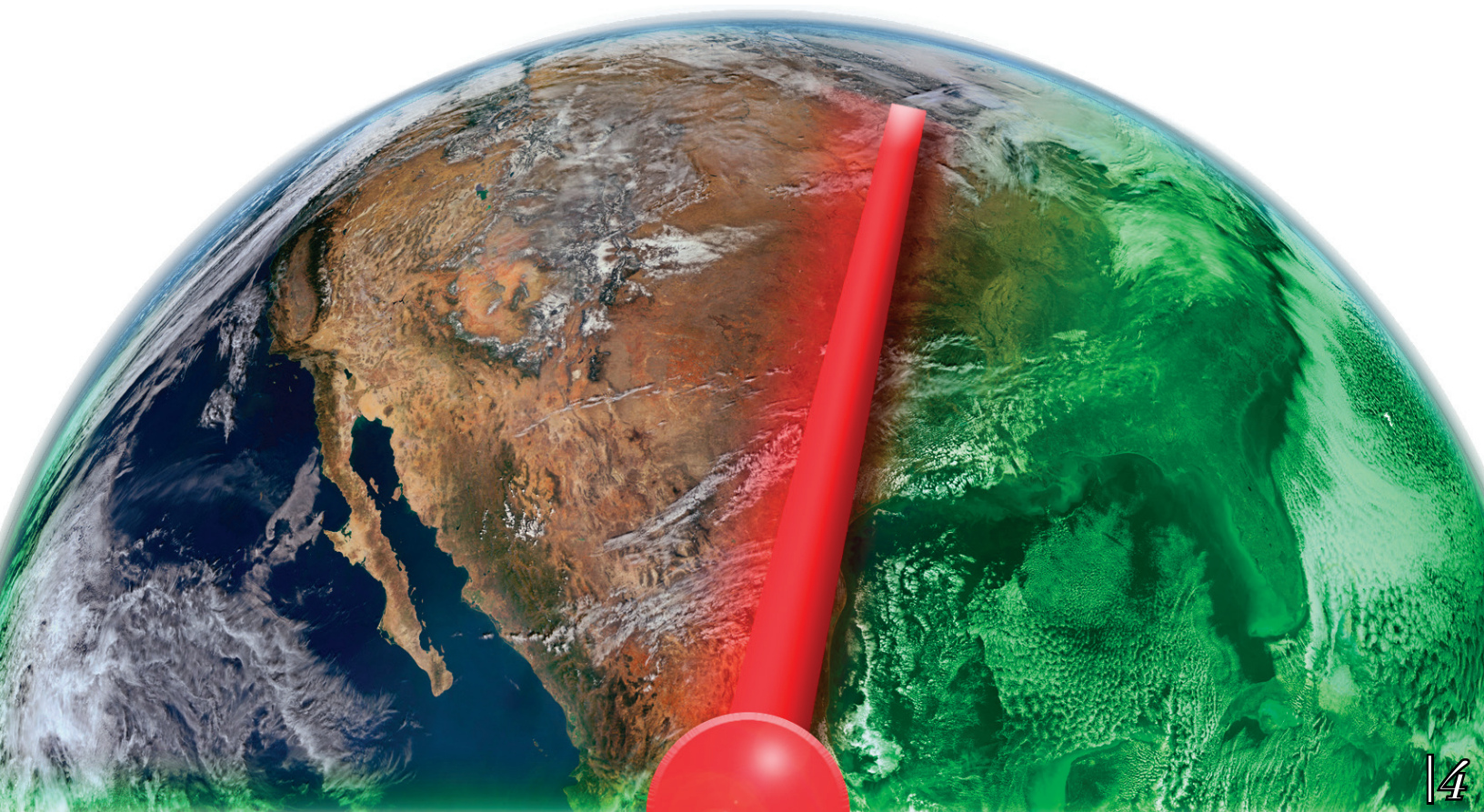
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portation fuels, and reduces the impact of international supply disruptions.

“All of this adds to our nation’s energy security,” DOE stated.

Studies by key automakers suggest high octane 30 percent ethanol fuel (E30) would allow them to boost both fuel efficiency

In addition, USDA studies confirm that high-yield corn acres sequester or trap far more atmospheric carbon than previously was believed. New data suggests that corn ethanol’s carbon “footprint” is 50–80% smaller than gasoline and shrinking, while gasoline’s carbon footprint purportedly is growing.



Performance powerhouse.

"We believe increasing the minimum octane level in U.S. gasoline for new vehicles will be a win for all industries and, most importantly, consumers," said Dan Nicholson, vice president, Global Propulsion Systems, General Motors, testifying on behalf of the United States Council for Automotive Research, at an April 2018 Congressional Hearing titled, "High Octane Fuels and High Efficiency Vehicles: Challenges and Opportunities."

HOLC is a disrupter in the fuel and automotive industries, swooping in to boost power and performance for motorists



across the country. As GM's Chairman and CEO Mary Barra, likes to say, "The auto industry will change more in the next five years than it has in the last 50 years."

Nicholson agrees, adding in his testimony before Congress, "We believe this gives us opportunity to make cars cleaner, safer, smarter, more efficient, and more fun to drive than ever before."

"As part of this significant shift, the automotive industry has taken unprecedented steps to improve engine efficiency through downsized turbocharged engines, improved multi-speed transmissions and a host of eco-friendly improvements; all with the goal of meeting customer requirements while delivering improved efficiency...We believe a higher efficiency gasoline solution with a higher Research Octane Number

(RON) is very important to achieving this."

And what's the most economical, renewable, reliable source of high-octane power? Your corn-based HOLC, that's what.

The high-octane fuel that automakers need is not being supplied by the market. Since the beginning of the lead phase-out in the 1970s, octane levels in the U.S. gasoline pool have stagnated and even declined. Premium gasoline's share of the market has also declined. High-octane gasoline hydrocarbons are simply too expensive. Today's premium fuel can be 40 to 80 cents more expensive than regular unleaded, and its octane rating varies.

Clearly, consumers deserve more affordable high-octane choices at the pump. That is where corn farmers and corn ethanol come in.

MAJOR AUTOMAKERS GEAR UP MIDLEVEL BLEND APPROVALS

More than 93% of 2019 model year (MY) vehicles are explicitly approved by the manufacturer to use 15% ethanol blends (E15), according to an recent analysis of warranty statements and owner's manuals by the Renewable Fuels Association (RFA). That's up from last year, when nearly 89 percent of MY 2018 vehicles were formally approved to use E15.

For the first time, Subaru is approving the use of E15 in several popular models for MY 2019, including the Ascent, Crosstrek, and Impreza.

General Motors, the first automaker to approve use of E15, is listing E15 as an approved fuel for its vehicles for the eighth straight model year. MY 2019 will be the seventh straight year that Ford has listed E15 as an approved fuel.

After approving use of E15 in some models in MY 2018, Nissan is approving E15 for all MY 2019 models. The Infiniti QX80 is the only non-flex fuel model in the Nissan/Infiniti family still lacking E15 approval. Hyundai has approved E15 for its MY 2019 Sonata -- the one model not listed in MY 2018.

The BMW-owned Mini Cooper line has approved use of up to 25% ethanol (E25) in all MY 2019 models.

Lower cost/better mileage.

Midlevel ethanol blends, like E15 or E30, will save consumers money.

Ethanol and gasoline are commodities, traded publicly on international exchanges like the CME Group.

In the last year, ethanol has been trading \$0.40-\$0.80 cheaper per gallon than the gasoline with which it is blended. That's a cost-saving super power!

Overall, ethanol fuels offered a 31.7% savings over unblended gasoline, while intermediate and higher blend levels were on average 2.7% cheaper than E10. Once vehicles and higher-octane fuels with midlevel

Once vehicles and higher-octane fuels with midlevel blends of ethanol, such as E25, are designed as a system and are in the marketplace, consumers will realize a savings over the life of the vehicle when measured against the fuel costs and vehicles they are driving today.

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HOLC is ready to reduce your costs per mile! And improved vehicle powertrain technologies should both improve the automotive efficiency of intermediate blends, increasing the value of ethanol HOLC fuels and, subsequently, reduce consumer fuel costs.

For fueling locations that offer mid-level and other ethanol blends, visit **www.e85prices.com** to lock in your own cost savings.



Healthy horsepower.

It's not an exaggeration to say that corn-based ethanol really can clear the air.

Gasoline contains aromatic hydrocarbons, many of which are highly toxic compounds, that are added to the fuel gasoline because they have relatively high octane values and therefore serve as anti-knock agents in vehicle engines.

Ethanol also has a high-octane value and contains no aromatic compounds. It is a substitute for the toxic aromatics and for those

and an additional tens of millions of dollars of direct healthcare costs for cancer treatment.

The U.S. Department of Health and Human Services classifies benzene as a human carcinogen that is known to increase the risk of cancer and other illnesses including bone marrow failure. It targets the liver, kidneys, lungs, heart and brain—and can even cause chromosome damage.

While you're filling up at the pump, you're breathing in those

chemicals. Worse yet, aromatics do not combust completely in the engine and escape through the exhaust into the air we breathe in the form of tiny particulate matter.

These microscopic particles can get into your bloodstream via your lungs; and once in the bloodstream, they can wreak havoc as they travel through your body—from the heart to the lungs, from the brain to the kidneys. That can lead to a variety of health risks for all people, but especially infants, children, the elderly and people suffering from respiratory

or heart problems.

that fuel companies choose not to replace with ethanol in total, the ethanol serves to dilute the remaining aromatics.

It therefore substitutes and dilutes aromatics in gasoline. When the distillation properties of ethanol are considered, it further reduces the formation of toxic emissions in a vehicle. It is known that these toxic aromatics cause cancer.

In short, what's in your fuel tank could be killing you.

The University of Illinois, in a ground-breaking study recently commissioned using IL Corn checkoff dollars, it was proven that in the five cities studied, ethanol fuel blends were estimated to yield a net reduction of approximately 200-300 cancers per city, associated with several of the key pollutants varying among cities and between ethanol fuel blends.

This means a savings of a cumulative several thousand years of

ry or heart problems.

In fact, 7 of the top 10 causes of annual deaths in the United States are related to the health effects of air pollution. So sitting at a stoplight, stuck in a traffic jam or waiting in line to pick up your kids at school are, in fact, posing significant health risks to you and your family.

In the U.S., there are 45 million people living, working or attending school within 300 feet of a major road, airport or railroad. Hundreds of studies have linked air pollution to a wide range of human health threats from low birth weights to brain cancer, from asthma to leukemia.

The increased oxygen in ethanol helps fuel burn more completely, which reduces harmful tailpipe emissions. The more ethanol in gasoline, the lower the levels of these toxic additives in the fuel — and in the exhaust. By choosing higher ethanol blends, consumers can help improve air quality simply by making the “clean air



choice” at the pump. Virtually all fuel sold in the U.S. contains 10 percent ethanol. An increasing number of pumps are selling E15. But it is the high-octane low carbon future fuels that can really knock-out the threats of these toxic aromatics.

Over the last 13 years with the American Lung Association of Illinois (ALA), in cooperation with IL Corn, Angela Tin has become determined to make the public aware of the way that switching to

Tin, a passionate advocate for the use of ethanol blended fuels, was aware of the benefits of ethanol when she was working at the Illinois Environmental Protection Agency. “At the IEPA, I was involved in regulatory and compliance programs. The U.S. EPA developed regulations to ‘clean up the new cars’, and they’ve done a great job. Cars today are a lot cleaner than they were before, but there are a lot more cars than there used to be,” Tin said.

“If we can remove the toxic components of gasoline and replace them with ethanol... the better it is for our lung health.”

biofuels such as ethanol benefits our health, but also helps cities comply with federal clean air standards.

“One of the worst things found in gasoline is benzene, a known human carcinogen,” said Tin, ALA vice president of environmental health. “When we breathe it deep into our lungs, it can cause cell mutation and lung cancer. If we can remove the toxic components of gasoline and replace them with ethanol...the better it is for our lung health.”

“Today, people own more cars, drive extra miles, and keep older cars longer. So, while pollution from individual new vehicles is decreasing, the number of vehicle miles travelled has gone up, it’s quadrupled.”

In other words, the more ethanol in the fuel, the healthier our air becomes for all of us. Now that’s a hopeful outlook for all of us, and your IL Corn checkoff investment will be part of making HOLC fuels the future to benefit your farm’s profitability and everyone’s health.

**Choose healthier air for your family.
Choose American Ethanol.**

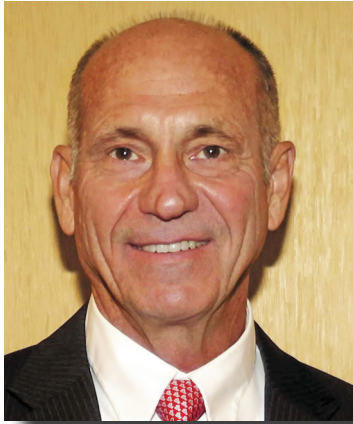
AMERICAN ETHANOL

AMERICAN LUNG ASSOCIATION | CLEAN AIR CHOICE

A Message from the Chairman

For nearly a century, the oil industry has supplied nearly all the transportation fuel – mostly gasoline – consumed in the United States. But Big Oil's undisputed reign is coming to an end. In the last dozen years, ethanol has gone from almost nothing to 10% of all U.S. motor fuel. That's due in no small part to the efforts of corn farmers to prove the benefits of ethanol to not only farmers' bottom lines, but also the benefits to the environment and human health.

Today, automakers need higher octane fuel to enable higher efficiency engines for the vehicles of the future. It is not easy or cheap to increase the octane rating of gasoline. High octane premium grade gasoline typically costs 40 – 80 cents per gallon more than lower octane regular grade gasoline.



Adding more ethanol to today's regular grade gasoline, however, not only increases its octane but lowers its price.

A recent study done by the Defour Group has shown that if all U.S. oil refineries were converted to produce a 91 octane premium gasoline (using no additional ethanol), the owner of the same 2023 vehicle would end up spending nearly \$1,000 more for fuel over the lifetime of the vehicle. No one likes the idea of spending more on fuel.

In addition, as this higher-octane fuel replaced regular grade gasoline, the price of that legacy fuel would increase as well. This would result in owners of older vehicles paying more for fuel so that new vehicle owners would have the fuel they needed for their vehicles. For instance, the owner who purchased a 2022 model year vehicle – the year before high efficiency engines went into production -- would end up paying \$498 more for fuel as the higher-octane fuel drives regular out of the market.

Enter corn-based ethanol to this discussion, with its high power, high octane, engine safe, and earth smart benefits.

The Defour Group study also illustrates how effectively ethanol can boost the octane of motor fuel. Moving today's 87 octane regular gasoline to a higher blend of E25 would increase its octane rating to that of the highest available unleaded gasoline – 94 octane racing gasoline. If that fuel were available in the year 2023 and vehicles that year were equipped with high efficiency engines, the average car owner would save nearly \$500 on fuel over the lifetime of the vehicle.

In addition, since this high-octane fuel is made by adding more ethanol to today's regular grade gasoline, the price of regular gasoline would not increase, keeping driving affordable for owners of older vehicles.

Adding 10% ethanol to gasoline has already saved consumers billions of dollars. Adding more ethanol to gasoline to make a higher-octane motor fuel would save consumers much, much more, while at the same time, increasing demand for corn, thereby supporting corn prices.

IL Corn, through investing Illinois corn checkoff dollars administered by the Illinois Corn Marketing Board, is committed to improving corn farmer profitability. Doing the hard work to bring high-octane fuels, low-carbon (HOLC) fuels to the marketplace is a challenge we gladly accept as we are certain it is a win-win for consumers and for corn farmers.

Don Duvall
ICMB Chairman
February 2019

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