CLIMATE ETHANOL ALLIANCE

Ethanol revisited

While the climate challenge is not new and much work remains to be done to decarbonize the transportation sector across the planet, perspectives on available solutions today are different from those of a decade ago. Although electrification has made significant progress, liquid fuels remain dominant and are likely to continue to do so in the coming decade and beyond, and no silver bullet has emerged to end the reliance on oil.

The most impactful solution for decarbonizing transport, aside from efficiency gains, has been the most abundant renewable fuel: crop-based bioethanol. Ethanol continues to replace fossil fuels with renewables today, just as it did a decade ago, but the context has evolved. Whereas some of the credentials and benefits of ethanol were once questioned, with policymakers previosuly relying on models and assumptions, today we have two decades of real-world experience to inform our decisions.

Thanks to continued investments in industrial efficiency, ethanol is not only a better solution today, but early questions about ethanol's efficiency and natural resource impacts have also been answered through observation and experience. While the initial fears and often legitimate concerns about ethanol have not materialized, the positive outcomes are here to stay and have even improved.

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In the following, the most important aspects of ethanol today will be reviewed

GHG balance keeps improving

Most vehicles on the road until 2030 and well beyond will run on liquid fuels worldwide, necessitating solutions for reducing their fossil fuel consumption.

The ethanol industry has undergone substantial innovations in efficiency. As constant technological innovations are implemented and crop yields continue to increase, the average Greenhouse Gas (GHG) emissions performance of ethanol improves every year.

Due to differences in lifecycle analysis methodologies (such as the treatment of co-products and the inclusion of indirect impacts) and in the feedstocks used by major ethanol-producing countries, presenting a single GHG savings figure for the global industry is challenging. Almost all ethanol produced today in the United States, Brazil, the EU, Canada and India achieves 50% GHG savings or more (compared to gasoline) under globally accepted lifecycle analysis methodologies.

All other things being equal, jurisdictions that have higher energy costs (spurring investments into energy efficiency), that allow bioengineered processing aids (like GMO yeasts), or that create markets with price premiums for better GHG savings each result in higher than average GHG savings. EU ethanol currently has 79% GHG savings under the EU RED methodology, and an increasing amount of global production has 100% or better GHG savings. Going forward, Carbon Capture and Storage (CCS) presents the largest opportunity for ethanol to exceed 100% GHG savings. Irrespective of the lifecycle methodology used, ethanol is always much better for the climate than oil.

Thanks to its high octane level, ethanol blending increases engine efficiency, and thus contributes to total fuel consumption savings. High Octane Fuels (E20 or E30) allow vehicles to travel further per unit of energy, delivering additional GHG savings.

Cost-effective transport decarbonisation

Transport is the single largest sectoral source of carbon emissions in major economies, with road transport being the key problem.

There are limited cost-effective solutions to decarbonize transport. Ethanol has proven to be inexpensive; in fact, it is often less expensive or only marginally more expensive than fossil fuels. In the US, filling up the tank with ethanol blends (such as the standard E10 and the increasingly available E15) saves consumers money.

Modelling finds that crop-based ethanol has negative carbon abatement costs, making it perhaps the lowest cost solution for decarbonising the existing vehicle fleet. Among fuels, ethanol has contributed the most to decarbonizing vehicles on the road, which is unsurprising given that it is both scalable and cost-effective. Expensive climate change mitigation options are increasingly being rejected by voters.

From "Food v fuel" to Food and fuel

On the surface, the concern that certain biomass energy applications could adversely impact food security by raising food prices is logical. However, two decades of real-world experience show that "food v fuel" is a false dichotomy.

Global ethanol production is past its rapid growth phase, and if major global food security issues were to arise, they should have become apparent by now—but they haven't. Sufficient time has passed to allow for a review of potential impacts on food security of ethanol production. Whereas previously one could rely only on models, today we have real world data available, and that data suggest overwhelmingly that the models and assumptions of a decade ago were structurally unsound. The risks from crop based biofuels were exaggerated in those models.

The FAO cereal price index in real terms is the same in 2024 as it was ten years ago, despite the growth in ethanol production, indicating that any price impact has likely been minimal. Indeed, compared in general to other commodities, biofuel feedstocks have increased less in price, a fact that invalidates continuing reference to the old models. Moreover, energy prices—particularly the price of oil—has been shown to be a primary driver of food prices, since energy is required in all stages of the production, processing, and transportation of agricultural commodities and food products.

It remains a seemingly logical argument to believe that 'the more land is devoted to ethanol production, the less land is available for food production'. However, while simplistically appealing, this argument is based on flawed assumptions. First, key biofuel feestocks (such as corn) are not designed for human consumption. Second, this argument assumes that agriculture is static, with each hectare producing the same harvest year after year. However, yield increases over the last two decades have been significant, even in the parts of the world that were already highly productive. Third, the appropriate way to approach biomass used for fermentation purposes (as opposed to combustion) is to consider the specific components being utilized. Each component of a crop (starch / sugar, fiber, fats and proteins) has different uses.

For food security in general, fats and proteins are important. A crop processing technology that converts fats or proteins into energy poses more of a threat to food security than one that turns carbohydrates or fiber into energy.

Biorefineries do not remove nutrients in the grains from the food chain, but channel them back in the form of animal feed. Ethanol production removes only the starch components of corn – a component with low nutritional value – while the protein content remains in the food chain and is actually concentrated. Notably, a modern biorefinery produces equal quantities of ethanol and animal feed.

By producing more than just ethanol, biorefineries also produce food, feed and other bio-based materials. Given historical market trends, which have resulted in continued abundant global food supplies and volatile but not unusual prices, the "food vs. fuel" debate has faded, giving way to a "food and fuel" approach.

iLUC is found to be low and manageable

Some stakeholders hypothesized that there would be large scale indirect impacts of biofuels, and the so called indirect land use change (iLUC) debate was hot for the best part of the 2010s. Early fears of runaway land use change impacts however did not materialise.

iLUC cannot be measured or observed directly; it can only be modeled. While some early studies suggested that indirect land use impacts could be substantial—especially if all fossil fuel consumption in transport were to be replaced with biofuels—empirical evidence indicates that the assumptions in these models were flawed. More recent scientific papers find that the iLUC impacts of ethanol are low and manageable.

Furthermore, an ever-increasing share of global ethanol production is becoming iLUC-free. According to global methodology practice, the iLUC impact is amortized over 20 years (and sometimes over 30 years). Since the bulk of the growth in ethanol production worldwide occurred in the mid-2000s, ethanol's predicted iLUC impacts are near the end of the amortization period and rapidly approaching zero.. As a result, a quarter of global ethanol production today is already iLUC-free by definition (28 million m3 in 2004 v about 113 million m3 in 2024). By 2030, three-quarters of current global ethanol production should become iLUC-free.

Energy independence

After decades of relative peace, energy independence is becoming a priority as many parts of the world prepare for a multipolar world.

Ethanol is a form of renewable energy that replaces fossil fuels, thereby reducing oil dependence. Its production and use offset the need for crude oil, which is often imported.

Improving agriculture

Agriculture is a dynamic industry; it responds to economic signals just like any other sector. While concerns about competition for resources and food prices remain valid, science and real world data suggest that effective biofuel policies drive agricultural innovation and investment in productivity. Biofuel policies, particularly those promoting ethanol production, can have a positive impact on agricultural productivity by reducing price volatility and stimulating investments in farming technologies. This can lead to higher crop yields and potentially enhance food security by increasing overall biomass production, with protein becoming more available in food markets. Effective biofuel policies could close the yield gap and increase biomass production for various uses.

With the right policies, more biomass can be produced sustainably on the same amount of land, simultaneously contributing to increased food security and unlocking the potential in bioenergy to contribute to mitigating climate change. Moreover, government policies can be structured to recognize and provide incentives for the adoption of practices and technologies that directly reduce the carbon footprint of feedstock production.

Biorefinery

Industry evolves. Today, plants are increasingly based on the concept of biorefineries, rather than focusing on the production of a single output.

Biorefineries are modern crop processing plants that produce a range of products, including fuel (ethanol, biomethane and Sustainable Aviation Fuel), feed, food, biochemicals, and other bio-based materials, using biomass as feedstock. Biorefinery complexes may be designed to process a wide range of feedstocks, including crops, agricultural residues, forest waste, and energy crops. Non-energy products are gaining importance, and the asset class is shifting away from a focus solely on energy to a complex system of interlinked processes rooted in the principles of the circular economy and industrial efficiency.

Jobs and rural development

Ethanol production, along with its co-products, provide a valuable market for crops grown across the planet. A typical biorefinery greatly enhances the value of the crops produced in the local area.

It is relatively easy to create jobs in urban environments, but achieving it further away from business centers is more challenging. Biorefineries directly and indirectly create jobs requiring skilled labour in the rural space. By stimulating the buildout of a service industry, they also create permanent and predictable demand for a wide range of suppliers, which boosts competitiveness of the local economy, diversifies activities and stimulates employment.

Air quality

The negative human health impacts of poor urban air quality are well known, with road transport being a key contributor.

Replacing petroleum-based aromatic compounds with ethanol in petrol reduces the associated health risks. As a clean-burning fuel, ethanol lowers particulate matter (PM), carbon monoxide (CO), and total hydrocarbon (THC) emissions compared to petrol. Additionally, ethanol is used as an octane enhancer, and replacing toxic aromatics with ethanol further reduces the health impacts associated with petrol. In general, petroleum based octane enhancers and oxygenates are the most hazardous and most expensive molecules in gasoline, so ethanol doesn’t just replace gasoline, it replaces the worst parts of gasoline.

Carbon removal

Science, including IPCC reports, finds that the deployment of CO2 removal, mostly to counterbalance hard-to-abate residual emissions, is unavoidable if a net-zero climate target is to be achieved.

Carbon Capture and Storage (CCS) can be applied not only in industrial applications (power plants) but also in fermentation processes, leading to what can be called Fermentation CCS. Fermentation plants produce a clean source of biogenic CO2, meaning an almost zero cost of carbon capture. Given the cost advantage of the fermentation process, the ethanol industry is poised to champion carbon removal. Biogenic CO2 from fermentation can be stored geologically at a cost well below $100 per ton.

The US is the most advanced in this area, with three biorefineries already sequestering their carbon and the build out of CO2 pipelines across states to link biorefineries underway, with the potential to store tens of millions of tons of CO2 annually in the next few years. In Europe, about 10 million tons of biogenic CO2 could be sequestered cost-effectively by 2030.