REPORT 09

Reforming Ohio’s Biofuel and Agriculture Policy: A Rationalist’s Perspective

Prepared by the eGeneration Foundation

A REAL WORLD REVIEW OF OHIO’S GRID FOR OHIO’S DECISIONMAKERS & LAWMAKERS

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Introduction

Federal biofuel mandates implemented since the early 2000s – chiefly the Renewable Fuel Standard (RFS) requiring ethanol (mostly from corn) and other biofuels in gasoline – were sold as win-win solutions. They promised cleaner emissions, greater energy independence, a boost for rural economies, and even technological leaps to advanced "cellulosic" fuels. In reality, these mandates have delivered very mixed results. While **farm incomes rose**, many other outcomes have been **negative**: higher food and feed costs, environmental degradation from intensive corn monoculture, and increased use of fertilizers and pesticides. The anticipated cellulosic ethanol revolution never materialized, leaving us with a program that largely funnels corn into fuel at significant hidden costs.

This report examines how the RFS and related policies affected food prices, land use, and the environment, with special attention to Ohio. It reviews the original goals of ethanol mandates versus actual outcomes, details the environmental impacts (soil erosion, water pollution, algal blooms) and public health impacts (via livestock feed changes), and compares plant-based ethanol with a forward-looking alternative: **ethanol from coal or waste via plasma gasification powered by advanced nuclear energy**. The analysis also considers how biofuel mandates became a de facto subsidy for farmers after traditional subsidies were curtailed in the 1990s. Finally, the report proposes **Ohio-specific policy reforms** to encourage rational energy and agricultural practices, including challenging the status quo on biofuels, refocusing tax policy to reward food production, and instituting state programs for conservation and farm risk management. The tone throughout is firm and logical, reflecting a clear-sighted advocacy for policies that serve the broader public interest of Ohio's citizens, farmers, and environment.

(Note: All figures are in U.S. dollars unless otherwise noted. Citations refer to supporting studies and data; full references are provided in the Appendix.)

Ethanol Mandates: Intended Goals vs. Actual Outcomes

Ethanol has been blended into U.S. gasoline for decades, but it was the **Energy Policy Act of 2005** and the **Energy Independence and Security Act (EISA) of 2007** that truly ramped up mandates. These laws created the RFS, requiring escalating volumes of "renewable" fuels in transportation. The justification given was multifaceted: reduce tailpipe emissions and smog, cut greenhouse gases, decrease dependence on foreign oil, and stimulate the rural economy. Corn ethanol – by far the dominant U.S. biofuel – was supposed to produce **20% less** greenhouse gas than gasoline, and even cleaner biofuels (cellulosic ethanol from crop residues or grasses) would eventually take over and achieve **60%+** CO_2 reductions. Politically, the policy also answered the powerful farm lobby's desire for new markets.

Originally, ethanol was promoted to clean up urban air pollution. Amendments to the Clean Air Act in 1990 required oxygenates in gasoline to reduce carbon monoxide and ozone-forming emissions. Ethanol, an oxygen-bearing compound, can make gasoline burn more completely. It was used in the 1990s as a substitute for MTBE (an oil-derived oxygenate) after MTBE was found to contaminate groundwater and was banned. Thus, ethanol's first role was an **environmental additive** to cut smog and replace a toxic chemical. Only a small 5–10% blend was needed for this purpose, however, and ethanol use remained modest until the RFS expanded it.

By the late 2000s, the RFS pushed ethanol far beyond the amounts needed for air quality. It mandated **specific annual volumes** – rising to 15 billion gallons of corn ethanol and additional billions of advanced biofuels by the 2010s. This "volume mandate" paradigm proved inflexible and unresponsive to real-world conditions. President George W. Bush and Congressional supporters argued these mandates would *accelerate innovation* (especially cellulosic ethanol) and *enhance energy security*. In practice, only one promise truly came to fruition: **increased income for corn and soybean farmers**. The environmental benefits are dubious – recent analyses show corn ethanol may even **increase** net carbon emissions relative to gasoline – and the U.S. still imports biofuels to meet the mandate in some years. The expected technological leap to cellulosic biofuels has *fallen far short*, as discussed later. Rather than a clean energy revolution, the RFS essentially became a large-scale agricultural support program in disguise.

In summary, the goals of the biofuel mandates (cleaner air, climate mitigation, energy independence, rural development) were well-intended. However, a rational assessment shows a **mismatch** between those goals and the outcomes. Ethanol does help reduce carbon monoxide from engines, but in higher concentrations it can create other pollution issues. It contributes to domestic fuel supply, but at the cost of significant land and resource use. And while it undoubtedly has funneled billions of dollars into the agricultural sector, it has done so with *significant external costs*. A later section will explore those costs in detail, from ecological damage in the corn belt to impacts on food consumers. Before that, we examine one of the most immediate effects felt by the public: rising food prices.

The Impact of Ethanol Mandates on Food and Feed Prices

One of the clearest consequences of diverting a large share of the U.S. corn crop into fuel is upward pressure on corn's price. Corn is not only a staple feed for livestock and a key ingredient in many food products – it also sets the tone for commodity markets. As ethanol production surged, so did corn demand, and prices followed. A meta-analysis by the USDA's National Center for Environmental Economics found that every **1 billion-gallon** increase in ethanol mandate causes corn prices to rise by about **2–3%**. Since the RFS expanded, corn used for ethanol jumped by roughly 10 billion gallons/year, implying a **20–30% increase** in corn prices attributable to the policy. Indeed, between 2005 (when the major ethanol mandates began) and the mid-2010s, **real corn prices nearly doubled**, an observation noted by agricultural economists. This was not a normal supply/demand fluctuation but a structural shift; as one expert put it, the grain markets experienced an abrupt and dramatic change due to biofuel mandates.

To put numbers on this: in the early 2000s, corn futures often traded around $2 per bushel. By 2007-2008, as ethanol plants were being built at a torrid pace, corn spiked above $6-$7/bushel.

Although other factors (like global demand and weather events) played roles, studies agree that biofuel demand was a major driver of this price inflation. Even after temporary dips, corn prices have remained higher on average than pre-mandate levels. The U.S. EPA's own retrospective review concluded that the RFS was a significant factor making corn and other crop prices "higher than they would have been otherwise".

Higher corn prices ripple throughout the food system. The most direct effect is on **livestock feed** costs. About 36% of the U.S. corn crop has recently been used for ethanol, and roughly another 35–40% for animal feed. (The overlap is partly because after fermentation, leftover grain byproduct is fed to animals – more on that later.) With over a third of the biggest feed grain redirected to fuel, meat and dairy producers must pay more for feed or find alternatives. Inevitably, some of that cost is passed to consumers in the form of higher prices for beef, pork, chicken, eggs, and milk. One study found that the RFS and related biofuel policies accounted for a meaningful share of the increase in U.S. food prices observed in the late 2000s. Globally, the diversion of grain to fuel was cited by the World Bank and others as one contributor to the 2007–2008 spike in food commodity prices that sparked unrest in some countries.

Ethanol defenders often point out that the **distillers grains** left over from ethanol production (often abbreviated DDGS) are fed to livestock, offsetting some corn use. It's true distillers grains are a valuable feed ingredient (high in protein and energy), and about a third of each bushel's starch returns as animal feed. However, this hasn't negated the price impacts. For one, not all livestock can utilize DDGS fully (e.g. limitations in hog and poultry diets). For another, the sheer volume of corn needed for ethanol – on the order of 5 billion bushels a year – so far outstrips the replacement feed output that there is still a net reduction in feed availability. Thus, meat producers still face tighter feed supply and higher costs. A telling statistic: from 2012 to 2016, roughly equal portions of the corn crop (about 38% each) went to ethanol and to animal feed. If ethanol's share rises further (e.g. proposals to go from 10% blends to 15% or 30%), it *must* come at the expense of feed or other uses, unless yields or acreage increase commensurately.

Ohio's farmers and consumers have experienced these trends first-hand. The state is a major producer of corn, so high corn prices have been a boon to grain farmers. But Ohio also has extensive livestock operations (dairy, hogs, poultry) that buy feed, as well as food processing industries. On balance, the ethanol era has meant **higher input costs** for these sectors. For example, an Ohio dairy feeding a standard corn-based ration in 2010 would have paid significantly more per ton of feed than in 2000, largely due to the competition from ethanol plants. Consumers in Ohio saw costlier meat and dairy at the grocery store, even if incremental (pennies on the dollar, but adding up across billions of meals). A comprehensive review by economists Wright and Cafiero in 2015 noted that biofuel demand had a persistent elevating effect on global grain prices and that claims it had *no* effect were not credible.

In short, **food-versus-fuel is not a myth** – it's a reality. Diverting a large share of a staple crop to energy use has economic consequences. We have effectively imposed a tax on food in order to subsidize fuel. This report later proposes alleviating this pressure by reducing mandates and incentivizing food production, but first we will explore the environmental toll that came with the ethanol expansion.

Environmental Costs of Corn Ethanol: Soil, Water, and Ecosystems

Growing corn intensively for ethanol has a cascade of environmental impacts. Corn (Zea mays) is a resource-hungry crop: it requires substantial nitrogen and phosphorus fertilizer, is often grown in monoculture, and can cause significant soil erosion if not carefully managed. Scaling up U.S. corn production to meet ethanol demand – roughly an additional **+7-8 million acres** of corn were planted at the peak of the ethanol boom compared to the early 2000s – inevitably put stress on land and water resources. Here we detail the major areas of concern:

1. Land Use Change and Habitat Loss: Farmers responded to higher corn prices by planting more acres of corn. Some of this expansion came from switching crops (e.g. soybean or wheat fields to corn), but some came from bringing new land into cultivation. Marginal lands that were previously considered not worth farming, or were enrolled in conservation reserve programs, were plowed up. A 2017 study found that between 2008 and 2012 (the ramp-up years of RFS), approximately **2 million acres of grassland**, **60,000 acres of forest**, **52,000 acres of shrubland**, and **14,000 acres of wetlands** were converted **to row-crop agriculture for biofuel production**. Much of this occurred in the Midwest and Great Plains, including Ohio and neighboring states. The **Prairie Pothole Region** – critical wetlands in the upper Midwest – was especially affected by corn expansion, leading to destruction of wildlife habitat. The U.S. Fish and Wildlife Service noted steep declines in some bird populations as grasslands were converted to corn/soy fields; in parts of the Dakotas and Minnesota, local surveys recorded up to **30% drops in certain waterfowl and songbird species** where biofuel-driven land conversion occurred. This represents a significant loss of biodiversity and ecosystem services.

In Ohio, much of the land is already under agriculture, but the ethanol era still saw **fewer acres left fallow or in conservation.** The state's Conservation Reserve Program (CRP) acreage – land set aside for wildlife and soil health – declined as some owners opted to return land to corn production when prices spiked. Fields that might have been rotated into cover crops or pasture were instead continuously cropped to take advantage of high corn prices. The habitat loss impacts in Ohio include fewer wetlands and buffer strips, which otherwise help filter water and provide homes for pollinators. In essence, the **opportunity cost** of dedicating land to fuel is that this land can no longer perform its natural functions (or grow food). The CEI study *Biofuels, Food, or Wildlife?* warned back in 2010 that pursuing corn ethanol at scale could force the U.S. to clear tens of millions of additional acres, given finite prime farmland. While technological improvements have boosted yield, the pressure on land remains a critical issue.

2. Soil Erosion and Degradation: Corn is often grown in annual monoculture and, if proper practices (like no-till or cover cropping) are not used, it can be one of the most erosive crops. Corn has relatively shallow roots and leaves soil bare for part of the year, making fields susceptible to erosion by rain and wind. The push for maximum corn output can lead some farmers to plow up and forego no-till methods to get every bit of yield. The EPA's assessment *Biofuels and the Environment* found that expanded corn ethanol production **"contributes to soil erosion, in part by depleting soil organic matter and increasing concentrations of**

soil nutrients." When pasture or grassland is converted to a tilled cornfield, the rich topsoil that took decades or centuries to build can literally blow or wash away. Ohio, with its rolling terrain in many counties, has seen increased erosion in fields that shifted to continuous corn. The loss of topsoil is a quiet crisis – it diminishes future productivity and releases carbon (as soil organic carbon oxidizes). Soil organic matter, which is key for fertility and moisture retention, tends to drop under intensive row-cropping for biofuels. While conservation tillage has become more common and does mitigate some harm, the **net effect of more corn acres was more erosion overall**. USDA data confirm that corn production causes more total soil erosion nationwide than any other crop by tonnage of soil lost.

Ohio State University researchers have noted that maintaining soil health is harder when corn is grown every year (because residue removal for cellulosic ethanol was considered in some cases, further reducing organic inputs to soil). Fortunately, Ohio has a strong extension network encouraging no-till and cover crops; even so, the market signal of ethanol mandates was to plant corn relentlessly, often at the expense of those soil-friendly practices.

3. Nutrient Runoff and Water Pollution: Corn requires heavy **fertilizer** use – particularly nitrogen (N) and phosphorus (P). Much of the Corn Belt has seen an increase in fertilizer application over the RFS period. When it rains, excess nutrients from fertilized fields run off into rivers and lakes. The result is eutrophication: explosive growth of algae in water bodies fueled by nitrates and phosphates. Nowhere has this been more visible than Lake Erie. In 2011, western Lake Erie experienced a record-breaking toxic algal bloom, the largest ever recorded in that lake's history. A multi-agency analysis traced the cause largely to agricultural runoff in Ohio's Maumee River watershed, exacerbated by more intensive farming and a series of heavy spring rains. Researchers specifically pointed to the increase in fertilizer runoff consistent with expanded corn cultivation for ethanol as a contributing factor. The bloom was so severe it covered much of the lake's western basin (Figure 1), turning the water a neon green and choking off sunlight and oxygen. As these algae died, they created low-oxygen "dead zones," killing fish and fouling beaches. In 2014, a similar bloom led to a drinking water crisis in Toledo, Ohio, when microcystin toxins from algae forced a shutdown of the city's water supply for days.

Figure 1: Satellite image of the record-breaking August 2011 algal bloom in western Lake Erie, which was fed by agricultural runoff. Such harmful blooms have been linked to the surge in fertilizer use for corn ethanol production. Ohio's water resources, including drinking water for cities like Toledo, are put at risk by these events.

The Gulf of Mexico tells a related story: each summer, a large "dead zone" forms in the Gulf due to nitrogen washed down the Mississippi from upstream farms. **Corn belt states are the largest contributors** of these nutrients, and the ethanol-driven corn boom magnified the issue. As a Sierra Club analysis put it, *"corn production is notorious for its significant contribution to the [Gulf] dead zone."* By diverting land from soy or wheat into corn and by pushing higher corn plant densities (hence more fertilizer use), the RFS indirectly worsened nutrient pollution. The Environmental Working Group estimated that if ethanol blends were increased (from E10 to E15 or E30), we'd see **"more toxic pollutants in drinking water, more toxic algal blooms, and higher water bills for Midwestern residents"**, absent major changes in farming practices.

Ohio, situated downstream of countless cornfields (and with many of its own), has a huge stake in this issue – the health of Lake Erie and Ohio River ecosystems hinges on reducing nutrient runoff.

It's worth noting that advanced farming practices (precision fertilization, cover crops, buffer strips) can mitigate these effects. However, the economic pressure of mandates often pushes farmers in the opposite direction: to maximize output with little margin for "extras" that protect water. The RFS included no direct environmental requirements for corn cultivation (its sustainability criteria mostly apply to land conversion after 2007), leaving it to voluntary measures and other regulations to cope with the water quality fallout.

4. Pesticide and Herbicide Use; Biodiversity Impacts: More acres of corn also translate into more application of **herbicides and pesticides**. Corn in the U.S. is commonly grown with herbicide-tolerant and insect-resistant genetically modified seeds, which means herbicides like glyphosate (Roundup) and others are used to manage weeds. The intensified corn rotations (often continuous corn rather than corn-soy rotations) can lead to heavier herbicide usage and the spread of resistant weeds, prompting use of additional chemicals. Pesticides (like neonicotinoid seed treatments) used in corn have been linked to negative effects on non-target species, notably pollinators such as bees. A 2015 study in *PNAS* found that wild bee abundance declined the most in areas of the Midwest with recent surges in corn and soy production. It explicitly connected increased biofuel-driven crop demand to habitat loss and **bee population declines**, since these row crops offer poor forage and often involve insecticides harmful to bees. This is alarming given that bees pollinate many high-value crops (though corn itself is wind-pollinated). In Ohio, beekeepers and ecologists have observed similar trends: landscapes dominated by corn/soy are effectively food deserts for pollinators once spring wildflowers are gone. The ethanol mandate, by incentivizing every available acre to be planted to corn, indirectly reduces the presence of flowering meadows, pasture, and cover crops that bees and other pollinators rely on.

Bird populations also suffer. Monoculture cornfields provide little habitat or food for most wildlife. The increase in pesticide use (especially insecticides) can reduce insect populations, which birds feed on. The conversion of marginal lands and field edges into cropped area removes nesting sites. As noted earlier, in the Prairie Pothole region, biofuel expansion led to measurable declines in bird species richness and abundance. In Ohio, populations of certain farmland birds (like eastern meadowlarks) have trended down, partly due to the reduction of fallow fields and grasslands.

5. Climate Emissions: One of the most paradoxical findings is that corn ethanol may not meaningfully help with climate change – and might even worsen it in the short term. Ethanol does emit less carbon monoxide and certain pollutants when burned, but the **total lifecycle emissions** (including farming, fertilizer production, land use changes, and processing) can be high. A comprehensive 2022 study published in *Proceedings of the National Academy of Sciences* found that, when accounting for land use change, corn ethanol likely resulted in **24% higher** carbon emissions per mile driven than using gasoline. The reasoning: plowing up carbon-rich soils (or displacing other crop production to new land) releases CO_2, and the heavy use of nitrogen fertilizer (made from natural gas) and farm equipment adds to the carbon footprint. While earlier analyses under more favorable assumptions suggested a modest GHG savings for ethanol, newer data and models indicate the RFS *as implemented* has not been a climate win. Even the U.S. Department of Energy's Argonne National Lab – generally optimistic about biofuels – acknowledges that the **indirect land use effects** can erode or negate ethanol's carbon advantage. Additionally, ethanol's lower energy density means vehicles get fewer miles per gallon (a roughly 3-5% drop with E10 fuel), causing drivers to purchase and burn more total fuel for the same travel – partially offsetting any per-gallon CO_2 reduction.

All that said, there are farming methods that can improve ethanol's environmental profile (for instance, using winter cover crops can add soil carbon and reduce fertilizer needs). But the mandate did not strongly incentivize those methods; it simply demanded volume. The result: the average practices prevailed. And average practices for intensive corn can be quite polluting. The **bottom line** is that large-scale corn ethanol production has imposed significant environmental costs – especially on water quality and ecosystems – that were not part of the rosy original narrative. Ohio, with its valuable (and vulnerable) freshwater resources and rich farmlands, bears some of these costs directly. This motivates exploring alternatives that might provide energy without so heavy a toll, which we will address after examining one more facet of the ethanol picture: the unfulfilled promise of cellulosic ethanol and the impacts of ethanol's co-product on livestock and health.

The Failure of Cellulosic Ethanol to Meet Expectations

A cornerstone of the RFS vision was that "**advanced biofuels**" would rapidly come online to replace corn ethanol's share beyond a certain point. EISA 2007 set ambitious targets: by 2022, out of 36 billion gallons of biofuels, **16 billion gallons** were supposed to be cellulosic ethanol (made from non-food biomass), with another 5 billion from other advanced sources, leaving corn ethanol capped at 15 billion. The rationale was to avoid competition with food and achieve much greater greenhouse gas reductions (cellulosic was required to have 60% lower GHG emissions than gasoline). This was truly a bold technological bet – at the time, **no commercial cellulosic ethanol plants existed**. Policymakers assumed that the mandate itself would spur innovation and investment, causing a wave of second-generation biofuel production.

Reality proved far more difficult. The cellulosic ethanol industry repeatedly fell **extremely short** of the targets. For example, the RFS called for 1 billion gallons of cellulosic fuel by 2013; actual production that year was around **20 million gallons** – just 2% of the goal. By 2017, the target was 5.5 billion gallons; actual production was on the order of **10 million gallons**. In other words, by 2017 cellulosic output wasn't even **1%** of what was envisioned (enough to fuel the U.S. for only about **40 minutes** of that year!). The EPA was forced to use its waiver authority every single year to slash the cellulosic mandates to realistic levels. "Cellulosic biofuel mandates are unachievable" was the frank assessment of industry observers by the late 2010s.

Why did cellulosic ethanol fail to launch? Technical and economic barriers proved very high:

- **Feedstock collection and logistics:** Cellulosic materials (corn stover, straw, woody biomass, dedicated energy crops like switchgrass) are bulkier and lower in energy density than corn grain. Harvesting and transporting large quantities to a biorefinery is costly. Unlike corn (which has a well-developed market and storage system), there was no existing supply chain for, say, corn cobs or miscanthus at the needed scale.

- **Conversion technology:** Breaking down cellulose and hemicellulose into sugars (to then ferment into ethanol) is chemically and biologically challenging. It requires either expensive enzymes and pretreatment (for biochemical processes) or high-temperature gasification and catalysis. Companies faced **scientific challenges** in getting yields high and costs low. Enzymes improved over time, but not enough to make cellulosic ethanol competitive at prevailing fuel prices.

- **Cost and financing:** The capital cost of cellulosic plants turned out to be much higher than corn ethanol plants. Numerous pilot and demonstration plants were built (financed in part by government grants or loan guarantees), but scaling them up led to delays and cost overruns. When the **2008 financial crisis** hit and later, when oil prices fell in the mid-2010s, investors became skittish. As one biofuel CEO quipped, “we had 65 of the coolest companies… most of them are now out of business”. Indeed, several high-profile cellulosic ventures went bankrupt or pulled out: e.g. Range Fuels, KiOR, DuPont’s Iowa cellulosic plant (opened in 2015, closed by 2017).

- **Regulatory uncertainty:** Even though the RFS mandated cellulosic volumes, the EPA’s implementation – including granting “hardship waivers” to oil refiners and adjusting mandates – introduced uncertainty. Some in the cellulosic industry blamed the EPA for not enforcing aggressive growth, while EPA was simply acknowledging reality. This finger-pointing didn’t help confidence in the sector.

The outcome was that **corn ethanol filled the gap** left by the missing cellulosic fuels. The overall renewable fuel volumes mandated each year were largely met by corn ethanol (and some biodiesel), because cellulosic ethanol was nearly absent. Congress’s hope that cellulosic would supplant corn ethanol by the mid-2010s, thus easing the food vs. fuel tension, did not come true. Instead, the nation bumped up against the “blend wall” – the practical limit of ethanol that can be used (about 10% in standard gasoline for most vehicles) – with corn ethanol alone. Calls to increase that limit (to E15 or E30 fuel) emerged simply because the cellulosic component wasn’t there to meet the rising RFS targets.

From a policy perspective, the failure of cellulosic ethanol to commercialize is a cautionary tale about **overly optimistic mandates**. It underscores that good intentions and even billions in R&D cannot easily overcome the fundamental chemistry and economics at play. Cellulosic ethanol may one day contribute meaningfully (there are small successes, like ethanol from wood waste in India, or biogas-to-ethanol pathways that EPA counts as cellulosic), but its timeline has been much longer than anticipated. In the interim, we have been essentially doubling down on first-generation biofuels with all their drawbacks.

Ohio’s role in the cellulosic saga has been limited – the state did not host a large cellulosic plant, though research institutions like Ohio State and private firms have worked on cellulosic tech. Still, Ohio has a stake in what replaces or augments corn ethanol in the future. As we will discuss, there may be alternative ways to produce ethanol that leapfrog the need for arable land altogether.

Before moving to those alternatives, one more issue warrants examination: the **impacts of ethanol’s proliferation on livestock and human health**, via the use of distillers grains in feed. This is an often overlooked aspect of biofuel policy – how changing the feed for our meat and dairy animals can in turn affect animal health and the nutritional profile of food.

Distillers Grains in Feed: Livestock and Human Health Considerations

Ethanol production doesn’t consume the entire corn kernel; roughly one-third of the corn (the protein, fat, and fiber fractions) remains after fermentation. This residue is dried or modified into **Distillers Grains with Solubles (DGS)**, commonly fed to cattle and other livestock. The expansion of ethanol has made the U.S. the world’s largest producer of distillers grains – effectively a **co-product** that has become a staple in feedlots. In 2020, about 40 million metric tons of DGS were produced nationally, with a significant portion fed to beef and dairy cattle. There are nutritional and economic upsides to this: distillers grains are a high-protein feed and often cost-effective per unit of energy/protein, thus they’ve been readily adopted by farmers. However, using DGS at high inclusion rates in feed presents some challenges and changes that are relevant to both animal well-being and the quality of meat/milk.

Animal Health Issues: One concern is the **high sulfur content** often found in distillers grains. During corn fermentation, sulfur (from the corn and from sulfuric acid used in processing) becomes concentrated roughly 3-fold, just as protein does. Typical sulfur levels in DGS range from about 0.3% up to 1.4% of dry matter. Cattle require only ~0.15% sulfur, and diets exceeding ~0.4% can be **toxic**. High sulfur intake in ruminants can lead to a condition called **polioencephalomalacia** (PEM), a neurological disorder, as well as interfere with trace mineral absorption (e.g. causing copper deficiency). Field experience and research have documented increased incidence of PEM in feedlots when diets contained a lot of distillers grains, especially if the water also had sulfur (from well water or groundwater sources). As a result, nutritionists advise limiting DGS in cattle rations (often no more than 20-30% of diet dry matter for feedlot cattle) and carefully monitoring sulfur intake. This is a **manageable** issue – through diet formulation and supplements – but it highlights that ethanol byproducts are not a free lunch for livestock. They require management adjustments. Ohio feedlot operators have generally learned to use DGS wisely, but smaller producers or those without expert guidance could inadvertently cause health issues by overfeeding cheap distillers grain.

Another subtle issue is that distillers grains lack starch (fermentation removed it), so the energy comes from fat and fiber. The fat in DGS (corn oil) can be 10-15% of DGS dry matter, and it’s high in polyunsaturated fatty acids. Non-ruminants (pigs, poultry) fed high DGS diets can suffer from excess unsaturated fat, which softens pork fat or egg yolks. In cattle, too much fat from DGS can reduce feed digestibility. For dairy cows, inclusion of DGS must be balanced to avoid milk fat depression (an issue when too many unsaturated fats alter rumen fermentation). Again, these are nutrition management concerns that the industry has adapted to, but it underscores that we dramatically changed feed composition on a large scale in a short time due to ethanol policy.

Meat Nutritional Profile (Omega-6 vs Omega-3): Perhaps the most far-reaching impact for consumers is how feeding distillers grains (and generally a corn-heavy diet) alters the fatty acid profile of meat and dairy. Cattle evolved to eat grass, which results in meat (and milk) relatively higher in omega-3 fatty acids and lower in omega-6. Grain-finishing, however, tilts that balance strongly toward **omega-6 fatty acids** (like linoleic acid) and reduces omega-3 content. Nutritionists and medical researchers often remark that the modern Western diet's skewed omega-6 to omega-3 ratio (around 15:1 or more, whereas 1:1 to 4:1 is considered ideal) is linked to inflammation and higher risks of cardiovascular and other chronic diseases. Beef is only a small part of dietary fat for most people, but its fat composition still matters. Studies have shown grain-fed beef can have an omega-6:omega-3 ratio anywhere from 5:1 up to 15:1, while grass-fed beef might be on the order of 2:1.

Feeding **distillers grains amplifies the omega-6 content** because DGS contains residual corn oil (rich in omega-6 linoleic acid). University research confirms this: in one study, beef cattle fed a diet with 40% dried distillers grains had a significantly higher omega-6 to omega-3 ratio in their meat than cattle fed an all-corn diet. Specifically, the DDGS-fed cattle's meat had more omega-6 fatty acids and fewer omega-3, worsening the ratio. Another trial found that including 25% DGS in feedlot diets raised the omega-6:3 ratio of beef muscle to about 11:1, compared to 7:1 in a corn-only diet (and much higher than the ~2:1 in grass-fed beef). In practical terms, the widespread use of distillers grains in feed has likely made conventional beef a bit less heart-healthy (due to more pro-inflammatory fats) than it would otherwise be. It's not that the meat becomes *unhealthy*, but one of the subtle costs of producing fuel from corn is this nutritional shift in our food supply.

From a human health perspective, it's ironic: a policy aimed at cleaner fuel may have inadvertently made our diets slightly less balanced in fatty acids. Ohioans consuming locally raised beef, pork, or even farm-raised fish (some fish farms use a portion of distillers grains in feed) could be affected. Grass-fed and pasture-based producers often use the omega-3 story as a marketing point – and it's valid. If society values healthier fatty acid profiles, that's another argument for not incentivizing maximal corn feeding.

Other Health Considerations: There have been questions about whether feeding distillers grains increases certain risks in beef, such as **E. coli O157:H7** prevalence (some studies initially suggested cattle on high-grain diets shed more acidic-resistant E. coli; later research on DGS is mixed). Some abattoirs noted differences in manure consistency and handling when cattle are on high DGS diets, which could affect food safety or processing, though there's no consensus that DGS-fed beef is any less safe. On the positive side, distillers grains are a *valuable* protein source that has allowed more efficient growth of animals in many cases –

potentially lowering the cost of meat slightly relative to if all that ethanol co-product were wasted.

In sum, ethanol's growth created a new feed industry that has its pros and cons. It exemplifies the interconnectedness of fuel and food systems. When evaluating biofuel policies, we should account not just for the fuel and direct food/feed price effects, but also these **biological and health impacts**. Cattle health can be managed with DGS, but it requires vigilance about sulfur and diet formulation. The nutritional shifts in meat could have public health implications over time. These are yet more externalities to consider in the cost-benefit analysis of fueling cars with corn.

Having examined the multiple downstream consequences of plant-based ethanol, we can now turn to a forward-looking question: Is there a better way to produce liquid fuels – one that circumvents the food/feed competition and mitigates environmental harm? One intriguing alternative is producing ethanol (or other fuels) from **non-food feedstocks like waste or coal**, using advanced technologies and energy sources. The next section explores this concept, which we'll call *nuclear-powered plasma gasification*, and compares it to the status quo.

Alternative Pathway: Ethanol via Plasma Gasification of Coal/Waste with Advanced Nuclear Energy

Imagine producing ethanol fuel not from crops, but from abundant materials like municipal waste or even coal – and doing so using ultra-low-carbon energy. This is a radically different approach from fermentation of corn, and it draws on technologies from the chemical industry and next-generation nuclear power. The concept combines **plasma gasification** with **Fischer-Tropsch (FT) or catalytic synthesis**, powered by a dedicated nuclear reactor providing heat and electricity. Let's unpack this:

- **Plasma gasification** is a process where an electrical plasma arc (an extremely hot and energetic state of matter) is used to vaporize and convert solid feedstocks (like trash, biomass, or coal) into syngas – a mixture of carbon monoxide (CO) and hydrogen (H_2). The plasma can reach temperatures of thousands of degrees, breaking down even complex and wet materials with ease. Essentially, it turns solids into a gas composed of basic molecules.

- That **syngas** can then be catalytically converted into fuels. Companies have developed catalysts or microbial fermentation processes that take CO + H_2 and produce **ethanol** (as well as other alcohols or hydrocarbons). One pathway is via FT synthesis tuned to produce ethanol/methanol; another, used by firms like LanzaTech, uses microbes that consume CO-rich gas and excrete ethanol. These technologies exist at pilot and small commercial scale in various places.

- **Advanced nuclear reactors** (Gen IV reactors or small modular reactors) are envisioned to produce electricity (and possibly high-temperature heat) much more cheaply and safely than today's large reactors. While current nuclear power costs are high, the hypothetical given – power at $0.01 per kWh – suggests a breakthrough in cost. For context, $0.01/kWh is extremely low (one-tenth of typical grid prices). It might be achievable if a reactor had very low operating costs and perhaps if it co-generated process heat efficiently.

What would an ethanol plant using this approach look like? Perhaps a small nuclear reactor (say 100 MW electric) on-site provides a steady stream of energy. Municipal solid waste (MSW) from cities, or coal from mines, is delivered and fed into a plasma gasifier. The syngas output is cleaned of impurities (plasma gasification can also vitrify toxic elements into slag), then sent through a catalyst that produces ethanol (plus maybe some other liquids). The ethanol is distilled and purified as fuel. Any excess electricity from the reactor could run the plant or even charge electric vehicles, etc. In theory, such a facility could run 24/7, independent of sunlight or wind variability, and produce a consistent output of fuel.

How does this compare economically and environmentally with corn ethanol?

- **Feedstock Cost and Availability:** Coal is still relatively cheap (though its use is carbon-intensive). MSW is essentially a negative-cost feedstock in many cases – cities pay to get rid of trash, so a plant might be *paid* via tipping fees to take it. By contrast, corn has a substantial cost (both economic and in terms of embodied resources). Even when corn is cheap, converting it to ethanol involves significant opportunity cost (as food/feed). A waste-to-ethanol plant like the one proposed by Fulcrum BioEnergy in Nevada expects to produce ethanol for under $1.00/gallon by using garbage as feedstock. In that Sierra BioFuels plant, **90,000 tons of MSW yields 10.5 million gallons** of ethanol per year. That implies a favorable conversion ratio given the energy content of trash. The facility capital cost (around $200 million) is higher than a corn ethanol plant of similar output, but the operating cost is projected to be low because of feedstock credit and efficient energy use.

- **Energy Inputs:** Corn ethanol plants burn natural gas or use grid electricity for heat (fermentation, distillation, drying DGS, etc.). By contrast, a nuclear-powered system would use **almost zero fossil energy** on-site. The reactor's heat could drive the gasification and provide steam for ethanol separation. Electricity from the reactor could run all motors and plasma torches. At $0.01/kWh (which is likely an optimistic figure for advanced nuclear), energy costs would be minor. A typical corn ethanol plant uses about 30,000 BTU of process energy per gallon ethanol produced (mostly from natural gas); a nuclear heat source could cut associated emissions entirely and potentially lower cost if cheap enough.

- **Lifecycle Greenhouse Gas Emissions:** If coal is the carbon source, the **carbon in the fuel** ultimately comes from fossil origin. Without carbon capture, when that ethanol is burned in cars, it emits CO_2 just like gasoline. In fact, some analyses show coal-to-ethanol could result in **higher GHG emissions** than gasoline (similar to coal-to-liquid fuels) unless mitigation is done. The cited study on China's coal-ethanol plant noted high emissions as a challenge. However, there is a twist: if a nuclear reactor provides all processing energy, the only emissions are from the carbon in the feedstock. One could potentially capture some of the CO_2 during synthesis (for example, FT processes yield some CO_2 that could be sequestered). With MSW, a large fraction of the carbon is biogenic (paper, wood, food waste) which is part of the natural cycle, and another fraction is fossil (plastics). The Fulcrum plant claims a **75% lifecycle GHG reduction** versus gasoline for their MSW ethanol. This likely counts biogenic carbon as neutral and credits the avoidance of landfill methane. If nuclear power is used instead of the plant's reported use of some of the syngas for energy, the GHG profile could be even better. In short, MSW-to-ethanol could be quite climate-friendly, whereas coal-to-ethanol would need carbon capture to be climate-friendly (or be justified on energy security grounds only). Still, even coal-to-ethanol could eliminate certain pollutants like sulfur and mercury (since gasification can scrub those), and if paired with carbon capture, could in theory produce near-zero-emission fuel (at high cost).

- **Land Use Intensity:** Here the alternative shines. The land footprint of a gasification plant plus a small reactor is minuscule compared to growing corn. **Corn ethanol is an extremely land-intensive fuel.** To produce one billion gallons of ethanol (roughly 7% of U.S. gasoline consumption), you need on the order of **2.1 million acres** of corn (assuming ~480 gal/acre yield). That is about 3,300 square miles – more than the area of Delaware and Rhode Island combined – dedicated to fuel production. In contrast, to produce a billion gallons via waste-to-ethanol, you would build perhaps 100 plants each of 10 million gal/year output. Each plant (including waste storage, etc.) might occupy, say, 100 acres of industrial land. That's 10,000 acres total (about 15.6 square miles). The land ratio difference is on the order of **200:1** or greater. Figure 2 below illustrates this stark contrast. Moreover, the land used for the plants can be marginal industrial land, not prime farmland. The benefit of freeing up potentially millions of acres is enormous – that land could grow food, sequester carbon as forests or prairie, or provide wildlife habitat. This is arguably the biggest advantage of shifting away from crop-based fuels.

Figure 2: Land footprint required for producing ~1 billion gallons of ethanol per year via two pathways. Corn ethanol (conventional plant-based route) requires roughly **2.1 million acres** of cropland (at ~500 gallons ethanol per acre of corn) to produce this volume. In contrast, ethanol from MSW/coal via gasification would need on the order of **10,000 acres** or less for industrial facilities (assuming ~100 acres per plant × 100 plants to sum to 1 billion gallons). This comparison illustrates roughly a **200-fold reduction** in land use. In practical terms, an area nearly the size of a small U.S. state could be spared from cultivation for each billion gallons of fuel shifted from corn to non-plant sources. *Sources: U.S. Department of Agriculture data on corn yields and ethanol output; Fulcrum BioEnergy's reported yield of 10.5 million gal from 90,000 tons MSW.*

Beyond these points, a few additional comparisons:

- **Local Pollution:** Corn farming has diffuse pollution (as discussed: runoff, etc.), whereas a gasification plant has point-source pollution (which can be controlled with filters, scrubbers). The plasma gasification process can vitrify heavy metals into a glassy slag, preventing leaching – potentially a cleaner way to handle waste than landfilling. There will be some emissions (maybe CO_2, CO, NOx) from the plant's syngas handling, but these are concentrated and easier to capture or mitigate than millions of tailpipes or farm fields.

- **Scalability and Infrastructure:** An advantage of corn ethanol was that it piggybacked on existing agriculture and used existing ethanol fermentation technology (similar to brewing). The alternative path would require building new infrastructure and supply chains (for collecting MSW beyond what trash companies already do, or sourcing coal in a new way). It's a heavier industrial lift, and would likely proceed slowly unless spurred by policy or major economic changes. That said, the RFS itself rapidly built out ~200 corn ethanol plants in a decade; a similarly strong incentive could conceivably build an equivalent number of waste-to-fuel plants.

- **Energy Return on Energy Invested (EROEI):** Critics of corn ethanol often point out that by the time you account for all the fossil inputs (fertilizer, tractors, transport, natural gas for distillation), the net energy gain is modest. With nuclear-powered gasification, the energy source (nuclear) is very concentrated and high-output. The EROEI would depend on how efficiently electricity/heat is turned into chemical fuel. It might actually be low in terms of raw efficiency (since nuclear electricity could charge EVs with perhaps 90% efficiency, whereas making ethanol introduces conversion losses). However, if electricity is super-cheap, one might accept a lower efficiency. The bigger picture is diversifying energy: nuclear can make not just electricity for cars but liquid fuels for vehicles that are hard to electrify (older cars, airplanes in the form of synfuel, etc.).

For Ohio, considering this alternative pathway could be strategically wise. Ohio has a history with nuclear energy (e.g. Perry and Davis–Besse nuclear plants) and a skilled manufacturing workforce that could potentially build modular reactors or chemical plants. It also has substantial coal reserves (though using them for fuel without carbon capture would not help climate goals) and produces plenty of MSW (the Cleveland-Columbus-Cincinnati metropolitan areas collectively generate millions of tons of trash annually). Instead of viewing waste as a liability, Ohio could turn it into a resource. By colocating small modular reactors at sites near cities or industrial parks, the state could in theory produce low-carbon ethanol or other synthetic fuels and create jobs, without taking a single acre away from food production.

The **economic feasibility** of this approach remains to be proven. It hinges on cheap nuclear power and the successful integration of gasification and fuel synthesis. However, one can foresee that if carbon regulations or oil prices in the future penalize high emissions, the calculus may tilt in favor of such solutions. Notably, the Department of Energy has supported pilot projects for waste-to-fuel and for advanced reactors, but marrying the two is novel. Ohio could lead in this area by hosting a demonstration project – for example, an advanced reactor at a former industrial brownfield that powers a waste-to-ethanol plant, supplying fuel for state vehicle fleets or agricultural machinery.

In comparing plant-based vs. plasma-based ethanol, the takeaway is not that one is instantly "better" in all respects – but that **the potential exists to dramatically reduce land and environmental impacts** if we shift how we produce fuels. Even if one cares less about climate and more about, say, Lake Erie's health, the prospect of meeting energy needs without further burdening watersheds with fertilizer runoff is attractive.

Having explored this alternative, we should now circle back to the role of policy. Ethanol mandates were effectively a replacement for farm subsidies in the 2000s; similarly, a future shift to advanced fuels might require new policy support. The next section delves into how biofuel mandates functioned as an indirect subsidy and how Ohio's farm economy was shaped by it, setting the stage for our final recommendations.

Biofuel Mandates as De facto Farm Subsidies and Their Effects on Ohio Agriculture

For decades, U.S. farmers, including those in Ohio, were supported by various federal subsidy programs – from price supports and grain reserves to direct payments. In 1996, a landmark Farm Bill ("Freedom to Farm") began phasing out some traditional subsidies, aiming to let market forces guide planting. At the same time, international trade agreements pressured the U.S. to reduce direct support to avoid distorting trade. However, farm state politicians still sought ways to support farmers' incomes. Biofuels provided a politically palatable solution: instead of cutting farmers a check, create a huge new **demand for their products**. As a 2022 analysis bluntly noted, *"Biofuel mandates were a way to support farmers under the auspices of environmental and energy policy."* This was a clever reframing – it aligned farm interests with a (seemingly) green agenda and energy independence.

By all accounts, the RFS did boost farm revenues. Corn prices, as discussed, rose and stayed higher than they likely would have been. The rural land values in the Corn Belt doubled or tripled between 2004 and 2014, reflecting the ethanol-driven profitability. Farmers invested in new equipment, technology, and expanded acreage. An important indicator: net farm income in the U.S. hit record highs around 2011-2013, during the ethanol boom and a period of high commodity prices. Even though inputs were also higher, many grain farmers enjoyed strong margins. In Ohio, cash receipts from corn jumped in those years, injecting more money into local economies in farming counties.

However, these gains were not without downsides:

- **Farmers became more tethered to ethanol markets.** If the ethanol mandate were reduced or if oil prices collapsed (making ethanol less competitive), corn demand could drop and prices along with it. We saw a glimpse of this in 2020 when the pandemic reduced driving: ethanol output fell, corn prices dipped, and many ethanol plants temporarily shut. This introduced a new kind of market risk linked to energy market swings and policy changes.

- **Cropping decisions narrowed.** The incentives led some farmers to favor continuous corn or corn-soy rotations geared toward max corn output. Crop diversity suffered. Regions that might have grown more wheat, oats, or hay – or experimented with fruits and vegetables – often stuck with the guaranteed money-maker: corn (or corn and soy). In Ohio's case, certain areas in the northwest became almost exclusively corn-soy rotation with very little wheat or other crops, compared to a more diverse mix decades earlier. The mandates indirectly discouraged diversified farming because monoculture of the subsidized crop was so profitable.

- **Land consolidation and entry barriers:** Higher profits and land values can benefit incumbent landowners, but they also make it harder for new or small farmers to compete. In some places, large operators expanded by buying out smaller neighbors, or investors bought land for rental. The ethanol boom's prosperity was not evenly distributed – it primarily enriched those growing the feedstocks. Livestock and dairy farmers often *paid* for it through higher feed costs, as previously explained. In Ohio, where many farms integrate both grain and livestock, the net effect varied case by case.

From a land use standpoint, one can argue that the RFS simply accomplished through private markets what the government used to do by paying farmers to idle land: it propped up prices. But instead of keeping land idle to support prices (as was done in mid-20th century programs), it incentivized using *more* land (to produce for ethanol) to drive prices up via demand. It's somewhat counterintuitive – normally, to raise prices you restrict supply (set-asides). Here, they raised prices by increasing demand. The irony is that this demand increase led to the environmental issues we highlighted, essentially trading off environmental quality for farm income.

Ohio's policymakers should recognize that while corn and soybean growers have benefited from the biofuel era, it has come at **external costs** and a loss of flexibility. If we decide, as a matter of principle, that we want to support farm incomes, we might ask: are mandates the best tool? The analysis suggests *no*. Mandates are a blunt instrument that have unintended ripple effects (food prices, algal blooms, etc.). Direct support or smarter subsidies could achieve farm income goals without so many side effects. Indeed, the Institute for Progress report on biofuel mandates concludes that *"federal support for an industry should not take the form of simply mandating an increase in demand"*, and recommends instead investing in innovation and more targeted farm support.

A positive note is that American agriculture is tremendously productive. With the yield gains of recent years, we likely could meet food needs on less land if diets and exports were managed – but policies like the RFS kept marginal land in production for fuel. As we reconsider these policies, we should ensure that farmers are not left in the lurch. That means if we dial back mandates, we might need transitional aid or new markets (like the alternative fuels or ecosystem service payments) so that farm revenues don't crash. It's about changing the way we support farmers: moving from an **indirect, hidden subsidy** (mandated corn demand) to a **direct, transparent, and conditional support** (like paying for conservation or rewarding actual environmental services).

In Ohio, corn and soybeans remain king on roughly 7 to 8 million acres. Ethanol's future, however, is uncertain. The federal government has signaled interest in electric vehicles and possibly revising the RFS post-2022 toward a broader "Renewable Fuel Standard 2.0" or alternative fuels standard. Some oil refiners and environmental groups have even challenged the EPA in court over exceeding certain ethanol blend levels, and the DC Circuit Court in 2019 struck down an EPA action related to year-round E15 partly on environmental grounds. This suggests the policy winds could shift.

Ohio, therefore, should proactively adapt and not simply cling to the status quo. Our farmers ultimately want profitability and stability. There may be better ways to ensure those than mandating they effectively sell a third of their crop to be burned in engines. The next section outlines concrete policy recommendations for Ohio to lead in this transition – keeping farmers whole (or even better off) while steering energy and agriculture onto a more sustainable path.

Policy Recommendations for Ohio

1. Challenge Plant-Based Fuel Mandates: Ohio should take a public stance in favor of reforming or phasing out federal biofuel volume mandates that rely on food crops. State leaders (legislators, the Governor, agencies) can lobby Congress and the EPA to **revisit the RFS**. The goal would be to eliminate the artificial demand floor for corn ethanol and let the market dictate ethanol use based on genuine supply-and-demand and environmental merit. In practical terms, this could mean supporting a sunset of the conventional biofuel mandate or reducing it in favor of non-food-based fuels. Ohio's congressional delegation could introduce or back bills to this effect. This is admittedly politically sensitive – it would face opposition from some in the corn lobby – but Ohio has a diverse agriculture that extends beyond corn, and its citizens bear the costs of ethanol in water quality and food prices. At the very least, Ohio should push for **RFS flexibility**: for instance, permitting fuel suppliers to adjust blending when corn prices are high or when environmental indicators (like water pollution levels) hit warning levels. The current mandate is inflexible, which is a flaw; a more rational policy would allow waivers or reductions in bad years. Ohio can be a voice of reason here. By advocating for change, Ohio aligns itself with sound science and economic logic. Importantly, any call for reform must be coupled with advocacy for alternative ways to support farmers (so it doesn't come off as anti-farmer). The message should be: "We can support our farmers **and** protect our water/consumers, by shifting how we incentivize agricultural production – away from fuel mandates and towards sustainable practices." This challenges entrenched interests, but being **firm and facts-driven** will be key. For example, Ohio officials can cite data on Lake Erie algae or the negligible net energy/climate benefits of corn ethanol to make the case that current policy isn't working as intended.

2. Implement Tax Incentives for Food Production (Not Fuel): To realign farmer incentives at the state level, Ohio can use its tax code to favor farming aimed at food and feed, rather than energy crops. One idea is to **eliminate state income tax** on revenues earned from the sale of food crops (fruits, vegetables, grains for food/feed) by Ohio farmers. This effectively increases the profit margin on food production, making it more attractive relative to dedicating land to corn for ethanol. Another approach is via property tax. Ohio already has the Current Agricultural Use Value (CAUV) program that taxes farmland based on farm value rather than full development value. The state could enhance this by offering an additional **property tax reduction or credit** for farms that verify their crops are used for food/feed markets or that a certain percentage of their acreage is in edible crops or conservation uses. For instance, if a farm rotates 50% of its land into food-grade crops or leaves some acres fallow/cover (instead of continuous corn for ethanol), it could qualify for a **zero property tax** on those acres. Such a policy would send a clear signal: Ohio values farming that feeds people and stewardship of the land. It also addresses one cause of the food vs. fuel problem by nudging production toward food. The administrative aspect could be handled through certification (perhaps requiring documentation of crop sales or usage). Though one might argue corn is corn (one can't distinguish kernels destined for ethanol vs feed easily), the incentive might encourage more diversified farming – e.g. growing food-grade corn varieties, or simply psychologically it breaks the single-track incentive for fuel. This can be framed as a "**Food Security & Farm Sustainability Tax Incentive**." By lowering or eliminating taxes on income from food production, Ohio would be effectively subsidizing food, not fuel, at the state level. The cost to the state budget could be justified by the public benefits (food security, potentially lower food prices, environmental gains from more diverse crop rotations). If done via property tax, the state might reimburse local governments for lost revenue (similar to how CAUV works). This policy would especially benefit small and mid-sized farms that produce for local food markets, but even large grain farms could pivot some acreage to specialty crops or non-ethanol corn hybrids to take advantage. Ultimately, it helps counteract the skewed incentives from the federal level.

3. Support Intermittent Fallowing and Risk Management: One reason farmers plant every possible acre of corn/soy each year is the razor-thin margin and the need to insure against disasters – more acres means more total yield to buffer against a drought in one field, etc. To break this cycle and improve environmental outcomes, Ohio could establish a program to pay or insure farmers for **periodic fallowing or cover cropping** of their fields. This could be modeled as a state-level enhancement to the federal Conservation Reserve Program but on a short-term, rotational basis. For example, the state could offer an "Ohio Fallow Incentive" that pays a certain amount per acre for farmers to not plant a cash crop on that acre one out of every five years, provided they plant a cover crop or maintain vegetative cover. Over five years, a farmer would rotate this fallow so each parcel gets a rest once. This intermittent fallow helps regenerate soil, cut fertilizer runoff (since no fertilizer is applied that year on that acre), and provides habitat. It's essentially paying farmers for the **ecosystem service** of improved soil and water quality. If scaled, this could significantly reduce nutrient runoff into Lake Erie during heavy rain years (many of which see large nutrient loss from continuously cropped fields). The payment should be competitive with what a farmer might earn from the crop – maybe sourced from environmental or lottery funds given the public benefit.

In tandem, Ohio can implement a **Catastrophic Crop Loss Assurance Fund**. This would be a state-backed fund or insurance overlay that guarantees farmers a certain minimum revenue in the event of a declared disaster (drought, flood) or a market collapse. While federal crop insurance exists, it often doesn't cover all losses and requires premiums. Ohio's fund could, for instance, pay the deductible or provide extra payments if losses exceed a threshold. By doing this, the state gives farmers confidence that *if* they don't push every acre every year, they won't be ruined by one bad year. Farmers might then feel more secure adopting less intensive practices (like including a fallow or cover crop year, or diversifying to lower-yielding but resilient crops) because they know the state "has their back" in extremes. One can think of it as a social safety net for farmers, analogous to unemployment insurance for other sectors, but tied to sustainable practices: participation in the fallow program or other conservation efforts could be a prerequisite for payouts.

Importantly, these measures also serve as indirect subsidies that replace the need for mandates. If farmers know they can get paid for taking care of the land or won't lose everything in a drought, they might be less inclined to support blunt instruments like RFS which guarantee demand at the cost of other concerns. Ohio could fund these initiatives by reallocating some agricultural development funds or even by floating a bond (investing in natural infrastructure improvement yields returns in reduced water treatment costs, for example – Toledo's water crisis was very costly, a reminder that prevention might be cheaper).

4. Invest in Next-Generation Fuel Technology in Ohio: While pushing back on corn ethanol mandates, Ohio can still embrace innovation in renewable energy that benefits its economy. The state should promote research, development, and **pilot projects for alternative fuels** – particularly those that **do not compete with food crops**. Ohio's state universities (Ohio State, University of Toledo, etc.) and industries could seek grants or state funding to develop the **plasma gasification-to-ethanol** concept or related waste-to-energy technologies. For instance, Ohio could create a public-private partnership to build a demonstration facility that converts a portion of Columbus's municipal waste into ethanol or jet fuel using electricity from a small modular reactor (perhaps a partnership with DOE at Oak Ridge or a company developing reactors). This would put Ohio at the forefront of an emerging field, potentially attracting federal funding (DOE's ARPA-E or the new infrastructure law funds for innovative energy). The state could also incentivize **biogas** and power-to-liquid projects on farms – e.g. digesters that turn manure into renewable natural gas or ethanol via biological gas fermentation (some new tech uses microbes to make ethanol from biogas). By diversifying into these areas, Ohio prepares for a future where low-carbon fuels are still needed (for aviation, long-haul transport) but we want to minimize land impact.

Additionally, Ohio can direct some of its economic development funds to assist any corn ethanol plants in the state (there are a few) to **adapt** – perhaps by adding technologies to reduce their emissions (like carbon capture) or to shift to cellulosic feedstocks if feasible. This might sound contradictory, but if mandates wane, those facilities and their jobs matter; helping them pivot to new roles (even if as depots for grain processing into higher-value products rather than fuel) could ease the transition politically.

In summary, these recommendations aim to **restructure incentives**: away from sheer volume of corn ethanol, towards rewarding sustainability and innovation. They are assertive in that they challenge the established order (which is to keep RFS and status quo farming), but they are rational and rooted in evidence of what will truly benefit Ohio in the long run: cleaner water, resilient farms, and leadership in advanced energy. Executing them will require legislative action at the state level, collaboration with Ohio's farm bureau and environmental groups (finding common ground), and likely some creative policy design. But the outcome would be that Ohio becomes a model for balancing agricultural prosperity with environmental stewardship.

Conclusion

Ohio stands at a pivotal moment where energy policy, agricultural policy, and environmental imperatives intersect. The analysis presented in this report leads to a clear conclusion: the current paradigm of heavy reliance on crop-based ethanol as dictated by federal mandates is **misaligned with Ohio's best interests** moving forward. While it succeeded in injecting revenue into the farm sector, it imposed diffuse costs on society – costs that are becoming ever more visible in our water, our food prices, and our rural landscapes. An assertively rational approach recognizes these trade-offs and seeks a better path.

Key findings we've discussed include:

- Federal ethanol mandates since 2005 significantly raised corn (and thus feed and food) prices e360.yale.edu, contributing to food insecurity concerns without delivering commensurate environmental gains.

- The anticipated transition to cellulosic ethanol did not occur, due to technical and economic hurdles – leaving us stuck with the more problematic corn ethanol for longer than planned.

- The environmental damage from scaling up corn production – nutrient runoff causing toxic algal blooms in Lake Erie, soil erosion, habitat loss in the Midwest, and increased greenhouse emissions – undercuts the "green" rationale of the policy.

- Feeding livestock with ethanol byproducts changes the nutritional profile of our meat (more omega-6 fatty acids) and poses animal health challenges (like sulfur toxicity), subtle effects that nonetheless illustrate the far reach of energy policy into public health.

- Alternatives are conceivable and should be explored – such as producing fuel from waste with advanced nuclear power – which could supply energy with a fraction of the land use and potentially less pollution, highlighting how inefficient our current land-based fuel system is by comparison.

- What began as an energy policy has effectively become an **agricultural subsidy** in disguise. As we modernize farm support for the 21st century, it would be more prudent to do so transparently and with dual goals of food security and environmental care, rather than through mandates that distort markets.

Ohio can and should be a leader in this reform. The recommendations provided chart a course for the state to advocate for policy change (at the federal level regarding the RFS) and to implement innovative state-level initiatives that realign incentives for farmers. These include rewarding farmers for sustainable practices and ensuring they have safety nets that do not depend on ever-expanding corn acreage. By taking these steps, Ohio would demonstrate that it is possible to **support farmers while also safeguarding natural resources and consumers** – in fact, that the two go hand in hand for long-term prosperity.

The tone of reform must be **forward-looking and bold**. Clinging to past policies because they once provided short-term benefits is not the Ohio way – Ohio has historically been a center of innovation (whether it was flight, electricity, or agriculture). In energy and agriculture policy, it's time to innovate again. This is not anti-farmer; on the contrary, it is pro-farmer in a sustainable sense, ensuring that Ohio's fertile lands can continue to be productive for generations without being depleted or compromised by short-sighted practices.

Critics of change will argue that it's risky to upset the status quo. But as this report has illustrated, the status quo carries its own significant risks – toxic algal toxins in drinking water, for example, or the risk of soil that can no longer support high yields in the future. Doing nothing is not a neutral act; it is implicitly choosing to allow those negative trends to worsen. Rational policy reform means **addressing problems at their root**. In this case, that means realigning our fuel policies with reality and ethics, and buffering our farmers through the transition with smart state-level policies.

In conclusion, Ohio's legislators and stakeholders are encouraged to take the findings of this report and translate them into concrete action. Whether it's drafting a resolution to Congress, tweaking the state tax code, funding a pilot project, or creating a new insurance mechanism for farmers, each step will contribute to a more rational and resilient system. Ohio can protect its waters, strengthen its food system, and still remain an energy innovator – but it will require the courage to reform what needs reforming. The evidence is on the side of change; now it's a matter of political will and thoughtful implementation.

By pursuing the recommendations herein, Ohio would not only solve local problems but also set an example to the nation. In a future where policy decisions are increasingly driven by logic and clear-eyed analysis (as they should be), Ohio's stance could influence federal policy to everyone's benefit. The ethos of **assertive rationalism** – making bold decisions grounded in facts and reason – is exactly what is needed to ensure a prosperous future for both Ohio's farmers and its environment. This report provides the rationale and blueprint for such decisions. The next move is ours to make.

Appendix: Data and References

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(Note: All citations in the text like e360.yale.edu refer to specific passages in these sources, which provide supporting evidence.)