

# The World Is Able To Eat Because It Has Energy

Dean Foreman, Ph.D.\*



---

\* Chief Economist, Texas Oil and Gas Association | 304 W 13<sup>th</sup> Street, Austin, TX 78701 | [dforeman@txoga.org](mailto:dforeman@txoga.org)  
[Economics - Texas Oil & Gas Association](#)

## **Table of Contents**

### Executive summary

1. Introduction
2. Tractors, combines, and heavy machinery
3. Chemicals in agriculture: Pesticides, herbicides, fungicides and fertilizers
4. Farm-to-Market transportation
5. Irrigation and advancements in agricultural plastics
6. Livestock operations: Calf and cow rearing
7. Propane heating and the power of NGLs
8. Contemplating a world without petroleum products
9. Water in agriculture: Supply, demand, and new solutions
10. Conclusions

## Executive summary

Agriculture and energy are inseparably linked, and modern food production depends on oil and natural gas at every stage of the value chain. Petroleum products and natural gas are not only fuels for tractors, combines, trucks, and irrigation pumps, but also essential feedstocks for fertilizers, pesticides, plastics, and livestock health products. Their contributions underpin productivity, efficiency, and affordability across global food systems.

This article illustrates these interdependencies through the example of Valley Gains Farm, highlighting how petroleum-based fuels, chemicals, and materials enable higher yields, lower labor requirements, and more resilient operations. Key areas include:

- **Heavy Machinery:** Diesel tractors and combines increase efficiency, reduce labor needs, and improve global competitiveness. Their manufacturing also relies on petroleum-based plastics, rubber, and lubricants.
- **Agricultural Chemicals:** Pesticides, herbicides, fungicides, and fertilizers—derived from oil and gas—have transformed productivity, raising U.S. corn yields from 20–30 bushels per acre in the early 20th century to 150–170 bushels today.
- **Transportation:** Diesel-powered trucks and logistics systems move crops and livestock to distant markets reliably and cost-effectively. Electric alternatives remain far more expensive and less practical, particularly in emerging economies.
- **Irrigation & Plastics:** Petroleum-based materials like PVC pipes, polytunnels, and silage wrap extend growing seasons, conserve water, and improve livestock feed storage.
- **Livestock Operations:** Fuels, feeds, veterinary products, and refrigeration—all petroleum-enabled—support U.S. beef production and exports.
- **Propane and NGLs:** Natural gas liquids such as propane provide essential heating for livestock, crop drying, and weed control.
- **Water Solutions:** Produced water from oil and gas operations, when treated, offers a promising supplement to scarce freshwater resources in Texas and beyond.

Contemplating a world without petroleum products underscores the scale of their role: mechanization would revert to manual labor, yields would fall, costs would rise, and food systems would become less reliable and more localized.

As global population growth increases demand, pragmatic policies must recognize oil and natural gas as essential enablers of food security. The future requires innovation and sustainability, but also realism: the world eats because it has energy, and oil and natural gas remain uniquely advantaged in providing the energy density, cost-effectiveness, and scale that modern agriculture requires.



## 1. Introduction

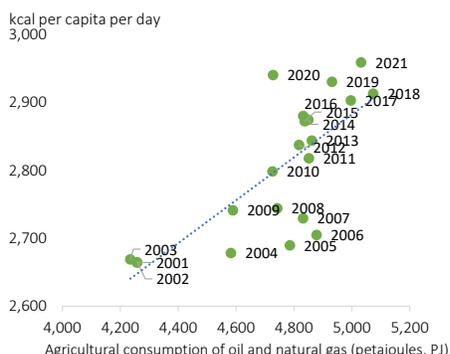
Food sustains life, nutrition and culture, and there is no food without energy. This fundamental truth has linked oil, natural gas, and refined petroleum products to agricultural production and productivity gains in the United States and globally for over a century. From feed, chemicals, and fertilizers to plastics, and fuels for heating and transportation, oil and natural gas are essential to global food supplies, powering the agricultural supply chain as well as manufactured goods and services to support it.<sup>2</sup>

Although legislation and government policies aim to accelerate a transition to alternative energy sources, particularly among advanced economies, agricultural oil and natural gas consumption has continued to grow. This article provides an overview of the critical linkages between energy and global food security. It emphasizes the role of inputs and marketing to the importance of maintaining an efficient food system in order to provide an affordable, sustainable food supply.

<sup>2</sup> See Smil (2022) and Epstein (2022) for broad discussions about the history of fossil fuels in context with expanding human and economic development.

**Figure 1. Oil and natural gas in global food supplies**

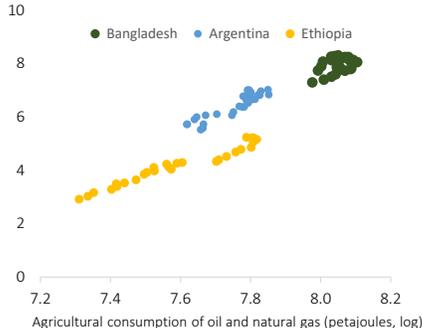
**Global food supply vs. agricultural energy consumption**



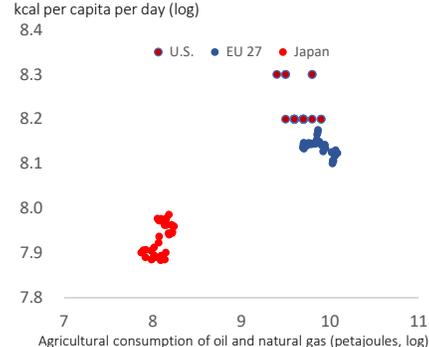
sources: United Nations Food and Agriculture Organization; International Energy Agency; TXOGA analysis

**Food supply vs. agricultural energy consumption for selected economies, 1990-2021**

**Emerging Economies**



**Advanced Economies**



In Figure 1, the left panel shows that, with rising global food supplies, agricultural industry consumption of oil and natural gas (excluding the energy content of feed and fertilizers used as inputs) has increased by an average of 0.8% per year over the past two decades. The same relationship also generally holds by individual country. Reinforcing this direct overall relationship and strong time dependence of individual country observations, the middle panel highlights one country each from Africa (Ethiopia), Asia Pacific (Bangladesh), and Latin America (Argentina), showing the consistency of relationships among fundamentally different emerging economies. The right panel shows the same relationship for Japan, the European Union, and United States, where the vertical scale for advanced economies is consistently higher than it is for emerging economies, but the fundamental fact that greater oil and natural gas consumption in agriculture has historically corresponded with an increased food supply.

The direct relationship over time across diverse geographies suggests that the world eats because of the capabilities provided by oil and natural gas. Understanding the sheer magnitude and interdependencies is essential to project the path of future agricultural energy use as well as the potential cost-effectiveness of policies intended to spur a transition.

Each stage of the agricultural supply chain depends on energy-dense, reliable, and cost-effective oil and natural gas, and the myriad ways in which agricultural production and productivity rely on petroleum products and natural gas through the multitude of intertwined supply chain touchpoints are generally underappreciated.

While granularity is important to understand the potential pace of changes, the crux is that growing demands of global supply chains delivering perishable foodstuffs just-in-time have required ever more energy to feed a world of eight billion people. To enable food supply growth that is cost-effective, reliable, and abundant, food systems are likely to require more oil and natural gas for the foreseeable future.

The contributions that oil and natural gas make within agriculture are fundamental enablers, in many cases with no practical substitutes. To the extent some dimensions primarily boil down to cost differences versus alternatives, global agriculture also remains a quintessential commodity business with narrow financial margins and relatively large numbers of small farms.

In the U.S., a small family farm is defined as one that generates less than \$350,000 in annual gross cash farm income (GFCI), a threshold that would be generous for comparisons with many emerging markets. Even in the U.S., however, 88 percent of farms were small family farms in 2022, according to the U.S. Department of Agriculture ([USDA](#)). Large-scale family farms (\$1 million or more in GFCI) accounted for only about 3 percent of farms but generated over half of the value of production.

Consequently, shifts that alter productivity or costs may appear to be small but can be consequential—and exploring the breadth and depth of these linkages is our main focus here. Cogent, economically responsible, and sustainable energy policies are essential to ensure the integrity of global food supply and environmental progress at the same time as changes occur. The following case example helps illustrate some of the key points related to energy’s role in supporting the global food system. This is done using the hypothetical case of Valley Gains Farm, which is owned by the Johnson family.

## 2. Tractors, combines, and heavy machinery



*Welcome to the Johnson family farm, Valley Gains Farm. Old Blue, a durable diesel tractor, is the workhorse of daily operations. Consistently plowing fields, sowing seeds, and hauling bountiful harvests for over 12 years, Old Blue has been the farm’s lifeblood—steady but slow, and this was the irony in the choice of yellow racing stripes for its hood. Each morning at dawn, the familiar rumble of Old Blue echoes across the Valley, signaling the start of another productive day. Three generations of the Johnson family now depend on Old Blue’s strength and endurance to maintain the farm. However, last spring, Old Blue’s engine sputtered and failed just as the planting season began. Parts weren’t readily available and needed to be shipped in. With each inactive day, the Johnsons did their best but couldn’t stick with the planting schedule. Crops laid unsown, and the growing season appeared to be in jeopardy, underscoring how critical Old Blue was to the farm’s production and productivity.*

Our discussion begins with heavy machinery that is synonymous with farming. Tractors, modern harvesters (“combines”), and other essential equipment for planting, harvesting, and processing mainly rely on diesel fuel. Heavy-duty diesel-powered machinery in U.S. agriculture has been a major source of

productivity both in the field and for transportation, reducing labor requirements while increasing efficiency, crop yields, and overall economic growth across the agricultural sector.

Diesel tractors are a mainstay because of their ability to operate for extended periods on a single tank of fuel, typically lasting an entire workday or more, depending on the fuel tank capacity and the intensity of use. Refueling a diesel tractor requires only minimal downtime and can be done in minutes with existing infrastructure. This in turn enables more efficient and timely cultivation, planting, and harvesting that raise crop yields—as well as faster transportation that extends the range of accessible consumer markets. These improvements are productivity catalysts that save time and reduce farmers’ physical requirements, allowing them to cover more ground with fewer workers. Tractors have also made U.S. agriculture more competitive in the global market.

Tractors and combines have increasingly integrated Global Positioning Systems (GPS), artificial intelligence (AI), and advanced sensors to minimize labor requirements. Electrification is also often discussed as a step to reduce tailpipe emissions. As of the time of writing, however, recharging infrastructure cost and availability, given the high energy intensity of tasks and relatively long recharging times have remained impediments to mass adoption. An electric tractor also costs approximately 70% more than a diesel-powered tractor from the same manufacturers.<sup>3</sup> For a farm producing corn or other commodities, these costs can hold far-reaching implications, affecting everything from capital expenditures and profit margins to market competitiveness and long-term sustainability.

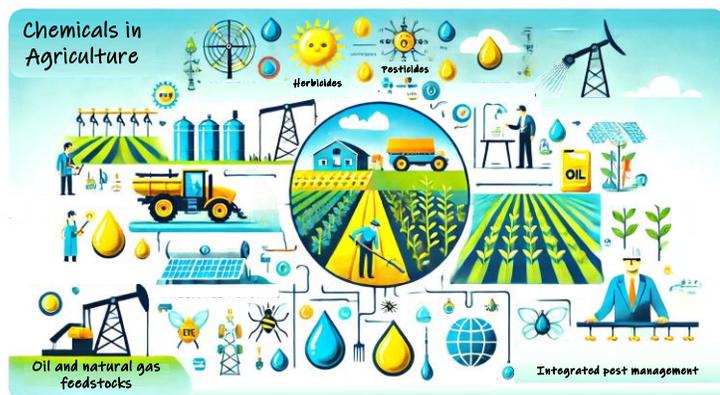
Focusing further upstream, the manufacturing of tractors, combines, and other heavy equipment like sprayers and spreaders also depends on abundant and cost-effective oil and natural gas. For a typical tractor or combine, a significant portion of the content by value comprises plastics and other materials that require oil and natural gas as feedstocks, including plastic components, rubber, synthetic fabrics, and various chemicals used in manufacturing. Exact percentages would vary based on the specific model and manufacturer but could represent 15% to 20% of a typical tractor’s value, a significant but unheralded role of petroleum-based materials in enabling modern agricultural machinery.<sup>4</sup>

---

<sup>3</sup> See [2018 New Holland Powerstar T4.75 Review | Tractor News](#) and [TractorData.com New Holland T4.75 tractor information](#).

<sup>4</sup> We estimate that 15% to 20% of a tractor's content by value comes from oil and natural gas based on products integral to manufacturing process and materials in modern tractors, including: 1) Plastics and synthetics: A significant portion of a tractor's parts, such as the dashboard, seats, and various components, are made from plastics and synthetic materials, which are derived from petroleum; 2) Rubber products: Tires, belts, and hoses are made from synthetic rubber, which is a petroleum product; 3) Lubricants and fluids: oils, greases, and hydraulic fluids used in tractors are petroleum-based; 4) fuel: The fuel system and the fuel itself are direct products of crude oil; and , 5) Manufacturing Processes: The energy-intensive processes in manufacturing tractors generally depend on petroleum products for power and heat.

### 3. Chemicals in agriculture: Pesticides, herbicides, fungicides, and fertilizers



*As spring gave way to summer, Valley Gains Farm faced a perennial threat from one of the most destructive pests in North America: the rootworm and its larvae, which feed on roots and prevent plants from getting water and essential nutrients. To reduce insect damage at the time of planting, the Johnsons applied a broad-spectrum organophosphate insecticide. This chemical, derived from oil and natural gas, combated pests and weeds effectively. The secret to their successful harvests, however, depended partly on the precise application of pesticides and herbicides, but also rotating with other insecticides, reliance on beneficial insects and integrating cultural practices, such as crop rotation, for sustainable management.*

*These solutions allowed the family to maintain clean, healthy fields without the backbreaking labor of manual weeding. With each pass of the sprayer, they watched unwanted plants wither, leaving room for crops to flourish. Pesticides were targeted to their needs ensured that harmful insects were kept at bay.*

*The Johnsons had seen firsthand the devastation that pests could cause and understood their crops would be vulnerable without oil-based chemicals. Integrated pest management techniques, which combined traditional methods with advanced chemical solutions, provided a balanced approach to maintain the farm's ecological health. Beneficial insects thrived, while harmful pests were effectively controlled. This enabled the Johnsons to produce more food with fewer resources, ensuring the farm's sustainability.*

The advent of synthetic chemicals, many of which are derived from petroleum, revolutionized agriculture in the 20th century.<sup>5</sup> Petroleum-based chemicals, including pesticides, herbicides, fungicides, and fertilizers, have significantly increased crop yields and reduced labor requirements.

In the 1930s and 1940s, largely before the mass adoption of synthetic chemicals in agriculture, U.S. corn yields averaged around 20-30 bushels per acre. In the past two decades, corn yields rose to an average of 150-170 bushels per acre.<sup>6</sup> This productivity increase also reflects increased mechanization but had profound implications for agricultural practices and economic viability—and consequently the global

<sup>5</sup> See Hough (2014) and Fischer Scientific (2016).

<sup>6</sup> See United States Department of Agriculture (2015).

food supply. Additionally, modern chemistry has helped to transform agriculture from a predominantly manual and organic process to a highly efficient and productive industry, enabling more predictable and enhanced crop protection and growth.

**Pesticides derived from petrochemicals**—including aldrin, carbaryl, DDT, dicrotophos, parathion, malathion, methyl parathion, and monocrotophos—have contributed to higher yields and improved product quality by controlling weeds, insects, nematodes, and plant pathogens among over twenty crops studied by USDA (2014). The evolution of pesticides since the 1960s was detailed by Aktar et al. (2009), including direct positive effects—productivity gains, crop loss protection, disease control, and improved quality—as well as hazards for human health and the environment, notably potential water and soil contamination as well as collateral impacts on other non-targeted species. More recently, Pathak et al. (2022) broadly surveys the effects of pesticides on the environment and human health, encouraging alternatives, such as bacterial degradation, myco-remediation, phytoremediation, and microalgae-based bioremediation, but notes that these processes are not always as efficient or straightforward for farmers to apply.

**Herbicides derived from petroleum** have improved agricultural production and productivity, including: triazines (atrazine, simazine, and propazine), 2,4-D (2,4-dichlorophenoxyacetic Acid), glyphosate (broad-spectrum herbicide), and alachlor. Moore (2020) and Mitchell (2020) estimated that, without triazine herbicides to control annual grasses and broadleaf weeds, U.S. farmers would lose 14 to 37 bushels per acre of yield for corn and sorghum, depending on the region, amounting to a nationwide loss of more than 1.2 billion bushels per year. In some cases, organically derived substitutes, such as mesotrione, could be used if replaced by a mix of herbicides, but is estimated by EPA (2019) to decrease a regional farm's net operating revenues by 32% (\$13 per acre). If alternatives cannot provide adequate weed control, growers may need to follow-up with other herbicide applications, which adds additional costs.

Several **fungicides** are derived from petroleum-based processes or contain active ingredients synthesized from petrochemical feedstocks, including: chlorothalonil, captan, mancozeb, propiconazole, and azoxystrobin. Numerous studies evidence positive impacts of petroleum-based fungicides on agricultural production and productivity by effectively controlling various fungal diseases, thereby enhancing crop yields and quality.<sup>7</sup>

**Petroleum-based fertilizers** are foundational to global agricultural production and productivity. Fertilizers made from natural gas are mainly produced via the Haber-Bosch process, where natural gas (methane) is used as a hydrogen source to synthesize ammonia. Ammonia serves as a building block for a plethora of nitrogenous fertilizers<sup>8</sup> that provide essential nutrients to crops, enhance growth, and thereby increase crop yields. Their production from natural gas ensures a steady and efficient supply of nitrogen for agricultural use. Some phosphate and sulfur-based fertilizers also require either energy or

---

<sup>7</sup> For examples, see Johnson and Cummings (2015) concerning chlorothalonil, MacHardy and Gadoury (1989) concerning captan, Gessler and Pertot (2004) concerning mancozeb, Jørgensen and Olsen (2007) concerning propiconazole, and Bartlett et al. (2002) concerning azoxystrobin.

<sup>8</sup> Natural-gas based nitrogenous fertilizers include ammonia (NH<sub>3</sub>), urea (CH<sub>4</sub>N<sub>2</sub>O), ammonium nitrate (NH<sub>4</sub>NO<sub>3</sub>), ammonium sulfate ((NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>), urea-ammonium nitrate (UAN), calcium ammonium nitrate (CAN), and ammonium phosphates (DAP and MAP).

components derived from crude oil or refining processes, such as ammonium phosphates, sulfur-containing fertilizers, urea-formaldehyde and other slow-release fertilizers.<sup>9</sup>

While scientific research and advancements continually assess the costs and benefits of pesticides, herbicides, fungicides, and fertilizers, the overarching point is that petroleum-based products have remained essential to supporting agricultural production and its productivity gains over time. For this reason, global demand for oil and natural gas-based inputs has grown along with the need for increased agricultural activities and food supplies. The world strives for continued improvements in both economical production and sustainability, but realistic and pragmatic energy policies must also recognize the pivotal role that oil and natural gas play in modern agricultural chemistry.

#### 4. Farm-to-Market transportation



*The journey of Valley Gains Farm’s produce from farm to market begins with its harvest, which is enabled by diesel tractors, combines, and trucks. The Johnsons have five tractor-trailers that run from the farm to regional processing and distribution centers, each moving up to 1,000 bushels of corn at a time.*

*During the 2020 COVID-19 pandemic, demand for food at home—including sweet corn—rose. The truck fleet operated seamlessly with logistics coordinated by the Johnsons. They packed the trucks to maximize load while maintaining safety, and timely delivery kept customers satisfied.*

*As the trucks returned to the farm in the evenings, coated in a fine layer of dust, the Johnsons felt a sense of accomplishment. Much like Old Blue the tractor, the trucks were like familiar friends—vital to the farm's operations and a testament to the benefits of technology.*

---

<sup>9</sup> For example, diammonium phosphate (DAP) and monoammonium phosphate (MAP) are made by reacting ammonia with phosphoric acid, which involves energy-intensive processes often powered by oil derivatives, and ammonium sulfate is produced by reacting ammonia with sulfuric acid, which can be derived from sulfur obtained during oil refining.

Farms use diesel and gasoline-powered engines in myriad ways, including field operations, transportation, pumping water, farm maintenance (bulldozers, backhoes, and loaders), as well as for generators and backup power. These functions require high reliability plus a capacity to handle heavy loads. For this reason, medium and heavy-duty trucks are extensively used in U.S. agriculture, and the vehicle miles traveled (VMT) by heavy-duty trucks in the U.S. more than doubled between 1990 and 2020.<sup>10</sup> For reliable and cost-effective long-range delivery, there is no practical substitute. Class 8 diesel trucks enable complex yet efficient supply chains, which in turn help farmers reach distant markets. Moreover, timely delivery reduces the need to carry inventories, so transportation efficiency and efficacy contribute to productivity and a farm's bottom line.

The Inflation Reduction Act of 2022 provides a \$40,000 tax credit for the purchase of new electric trucks. Even with this incentive, however, electric trucks impose a large premium over ones with internal combustion engines. For example, as of the time of writing, a class 8 electric truck, such as the Freightliner eCascadia or Tesla Semi, costs over \$300,000.<sup>11</sup> By comparison, a U.S. class 8 diesel truck weighing 33,000 pounds or more, as most used in agriculture, costs about \$130,000, depending on equipment—about 40% as much as a roughly comparable electric truck. Re-charging infrastructure adds additional cost. If a farm requires DC fast chargers for five class 8 electric trucks, each 150 kW DC fast charger is \$50,000 to \$75,000, plus installation. Additionally, electrical service upgrades to support multiple high-capacity chargers could exceed \$100,000. Above and beyond the premium for electric trucks, a farm therefore might need to expend over \$500,000 on charging infrastructure and electrical upgrades, without any additional incentives.<sup>12</sup>

Consequently, the cost to electrify heavy-duty transportation does not currently make economic sense for most U.S. farms. Although energy policies could motivate a shift to zero tailpipe emissions and reduce costs in the future, this shift is a relatively expensive one that farmers in most emerging economies could not afford. This helps to explain why oil and natural gas demand has continued to grow in global agriculture.

## **5. Irrigation and advancements in agricultural plastics**

---

<sup>10</sup> EPA (2020) reported medium- and heavy-duty trucks traveled 317,245 million vehicle miles, compared with 150,004 million miles in 1990 per EPA (1993), an increase of 111.5% over the period.

<sup>11</sup> See [Comparing the Total Cost of Ownership of Electric Vs. Diesel Trucks - Envase Technologies](#) and [Inflation Reduction Act Offers Incentives to Increase Electric Truck Adoptions | Transport Topics \(ttnews.com\)](#)

<sup>12</sup> Five DC fast chargers at an average cost of \$62,500 totals \$312,500, plus electrical upgrades to support five chargers, each at of \$100,000 to \$200,000, and installation costs that could run \$25,000 per charger.



*Valley Gains Farm has historically used an expansive irrigation system enabled by a network of plastic pipes and durable pumps. Sprinklers crafted from petroleum-derived materials distribute water evenly across the fields, ensuring plants receive needed moisture. Control valves and gauges made from petrochemical products enable the Johnsons to monitor and adjust the flows, delivering water efficiently and supporting strong crop yields.*

Modern plastics have improved irrigation systems over time. For example, PVC (polyvinyl chloride) and rubber components increase the durability, flexibility, and corrosion resistance of pipes, pumps, and sprinklers, while plastic tubing and emitters enable efficient drip irrigation systems that deliver water directly to a plant's roots.

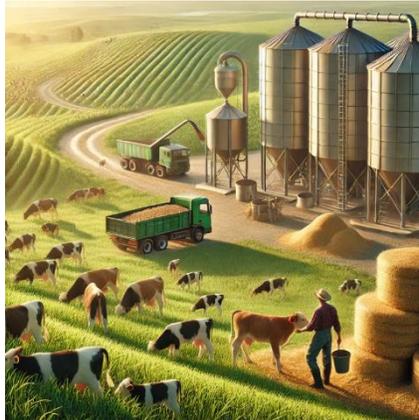
In remote U.S. regions as well as many emerging economies—including India, Bangladesh, Ethiopia, and Nigeria—electricity access is limited and solar power sometimes uneconomic. In these areas, diesel-powered pumps are often used to draw and distribute water. Compared with manual alternatives, these irrigation systems produce higher crop yields, plus an ability to cultivate varied crops that in turn improve their productivity and food security.



Petroleum-based products have also enhanced agricultural practices, particularly through the use of polytunnels and silage wrap. Polytunnels protect plants from harsh weather, extending the growing season and improving crop yields and quality. Similarly, silage wrap preserves forage for livestock, maintaining its nutritional value and ensuring a reliable feed supply year-round. Both products are made

from polyethylene, a material derived from ethane extracted from natural gas. Their relatively low cost makes them accessible to a wide range of farmers, including those in emerging economies. By enabling crop diversification and improved livestock management, these petroleum-based plastics enhance food security, support rural development, and foster more resilient agricultural systems.

## 6. Livestock operations: Calf and cow rearing



*The Johnson family has cattle that graze on the pastures of Valley Gains Farm. However, feeding and caring for them requires more than homegrown grass and harvested feed. They must purchase feed, veterinary care, medicines, fuels, and lubricants—each enabled by petroleum-based tools and systems. Automated watering is also powered by diesel pumps. These innovations are integral to modern cattle farming and help sustain the Johnson family’s livelihood.*

Livestock, especially cow-calf operations, are fundamental to U.S. agriculture. Beef is the third most consumed protein in the U.S., after chicken and pork, generating nearly 27 billion pounds annually for the food supply.<sup>13</sup> The U.S. exports more beef than any other country in the world, particularly to markets in North America and Asia (Japan, South Korea, and China). And Texas is the leading beef-producing state, with a population of about 4.3 million cows or about 15% of the U.S. total.<sup>14</sup> The Lone Star state also exported nearly 60 million pounds of beef through the first three quarters of 2024, per the U.S. International Trade Commission.<sup>15</sup> Such large-scale operations are made possible by integrated supply chains that connect livestock producers with feed suppliers, meat processors, logistics providers, and distribution channels.

Petroleum-based products key the productivity and economic feasibility of beef production. According to U.S. Department of Agriculture (2023), the Prairie Gateway region, which includes Texas, had operating costs in 2023 that averaged \$724.13 per cow, with approximately 85% of the expenditures relating to inputs that depend on petroleum, including feed production and preservation (\$530.09), fuels and transportation (\$51.15), and veterinary care and medicines (\$33.24).<sup>16</sup> We’ve already discussed the first

---

<sup>13</sup> U.S. Department of Agriculture (2024).

<sup>14</sup> [Beef Production by State 2024](#).

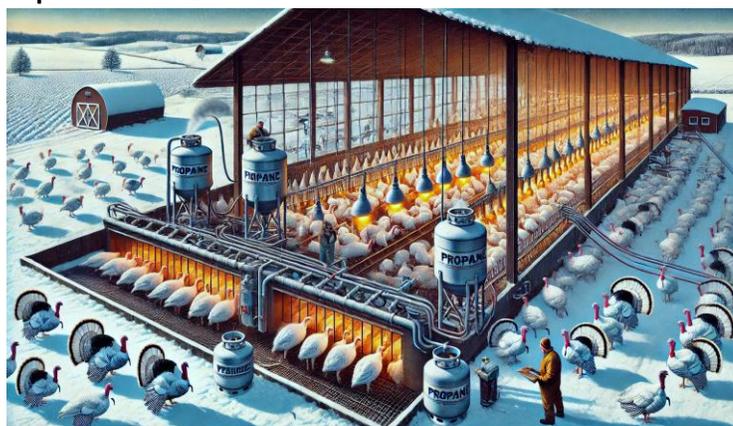
<sup>15</sup> U.S. International Trade Commission (2024).

<sup>16</sup> [USDA Calf Cost Return analysis](#).

two categories, but petroleum byproducts enable the production of vaccines, medications, and syringes—as well as refrigerated transportation for their safe storage and delivery.

Calf-cow operations costs in California are even higher than those in Texas. The all-in cost 2024 estimate for a heifer in California ranges from \$900 to \$2,400 per head, and a case study by Jasinski (2024) suggests a 10% increase in the production cost per yearling steer corresponds with a 40% reduction in profitability.<sup>17</sup> Consequently, relatively small cost changes can have an outside impact on profitability, and petroleum-based products and systems support the scale and cost effectiveness of modern operations.

## 7. Propane heating and the power of NGLs



*From Minnesota to Texas, keeping poultry alive through the winter requires heat. Turkeys at Valley Gains Farm stay warm thanks to propane heaters and heat lamps— providing a safe haven that secures the flock’s well-being.*

Like ethane, propane is another natural gas liquid (NGL) that is extracted from natural gas. In agriculture, propane provides heating, crop drying, and weed control. However, it is also commonly used in residential heating and cooking; industrial heating, machinery power, and as a feedstock in making some of the plastics (propylene, polypropylene, and derivatives) we’ve discussed. Additionally, it’s useful in recreational grilling, RVs, and camping.

The decision whether to extract ethane, propane, and other NGLs is an economic one that generally depends on the relative prices of natural gas versus (that is, the value of keeping the energy content in the natural gas stream) versus the total value of using the NGLs in petrochemical applications. When NGLs are extracted, a typical “NGL barrel” comprises about 40% to 60% ethane, and 25% to 35% propane, 10% to 15% butane, with the remainder being pentanes-plus (natural gasoline).<sup>18</sup> The precise mix varies by region.

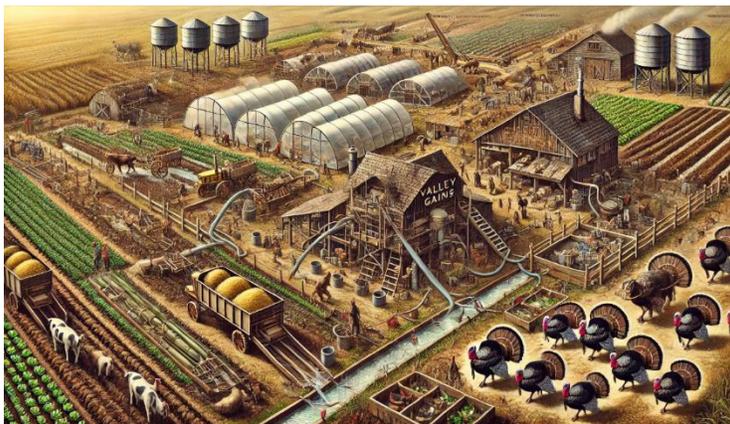
---

<sup>17</sup> See Jasinski (2024) for a complete case study.

<sup>18</sup> Keller (2012).

NGLs have quietly become a major U.S. supply source. U.S. NGL production reached a record-high of 7.0 million barrels per day (mb/d) in April 2024 per the Energy Information Administration (EIA).<sup>19</sup> More than half of the production, 3.7 mb/d—also a record high—came from Texas, where Mont Belvieu is the premier domestic NGL storage and trading hub. By contrast, U.S. crude oil production in total was 7.5 mb/d in 2013, so the NGL stream essentially doubles what the U.S. produced a little over one decade ago. Consequently, NGLs have supplemented U.S. oil supplies, but also enabled manufacturing and agriculture to be more productive and globally competitive.

## 8. Contemplating a world without petroleum products



*In a world without petroleum products, manual labor and animal-drawn plows would replace Valley Gains Farm's diesel tractor, Old Blue. Irrigation would shift to labor-intensive methods instead of diesel pumps with PVC pipes. The absence of plastic greenhouses, polytunnels, and silage wrap, would also limit the growing season and cause feed to spoil more quickly. Last but not least, winter operations would be limited without propane-based heat. In short, slower fieldwork, lower yields, reduced productivity, and higher overall consumer costs would result.*

Although it's hard to envision a modern society without petroleum-based fuels and materials, it would invariably be characterized by reduced mechanization, less effective alternative chemicals and materials, and greater transportation challenges. Although a transition to alternative sources and farming practices could mitigate some of these effects, they cannot fully compensate for the scale and efficiencies enabled by petroleum-based machinery—and currently would likewise imply higher costs.

Similarly, in a scenario that requires alternative chemicals and organic or bio-based fertilizers, higher production and processing costs, generally due to more labor-intensive production, would lower scale economies and raise raw material costs, which ultimately increase farms' operations costs.

As we've discussed concerning the potential electrification of heavy-duty transportation, insufficient petroleum product supplies would raise transportation costs and challenges. This is also a proverbial "in for a penny, in for a pound" model, where vehicles represent an initial cost, but additional expenses are

---

<sup>19</sup> Energy Information Administration (2024).

required to build-out necessary (and sometimes redundant) infrastructure. Moreover, vehicle availability and supporting infrastructure may be limited in some regions, particularly rural areas and emerging markets where agriculture is prominent.

These hurdles imply a return to localized food systems and lower utilization of large-scale distribution networks that would in turn reduce efficiencies and raise unit costs. As farmers have smaller markets in which to sell and production constraints for crops unsuited to the local climate or consumer preferences, the product variety would diminish, adding additional upward pressure to consumer prices.

The shift to alternative fuels would affect both transportation and machinery used in operations, affecting costs and productivity. For regions that currently rely on imported inputs—fertilizers, seeds, or feed—transportation challenges could spur shortages. Finally, for countries or regions that specialize in agricultural exports, a forced energy transition imposes significant challenges.

In short, in today's economic environment where farmers and consumers are sensitive to relatively minor increases in operations costs, a government-driven shift to a world without petroleum products presents myriad challenges.

## 9. Water in agriculture: Supply, demand, and new solutions



*Valley Gains Farm is irrigated in part by systems that take treated produced water from nearby oil and natural gas operations. Cattle graze in adjacent pastures, while a reservoir with advanced filtration and treatment technology supports its use. This blend of traditional agriculture with an innovative new water source reflects the need for sustainable water management.*

Sustainable water management is important for agriculture. Agriculture accounts for about 70% of global freshwater use—and up to 90% in low-income countries.<sup>20</sup> In Texas, more than 50% of water withdrawals are for agriculture.<sup>21</sup> Cotton, Texas' leading cash crop, accounted for \$969 million in production value in 2023, representing 40% of U.S. production.<sup>22</sup> However, yields depend on rainfall and were below average in 2024, due to adverse weather (Stalcup 2024). As previously discussed, drip irrigation helps conserve

---

<sup>20</sup> Fujs and Kashiwase (2023).

<sup>21</sup> Texas Comptroller (2019).

<sup>22</sup> [Leading U.S. states based on cotton production value 2023 | Statista](#)

water, but Texas' growing population and increasing urbanization, industrial activities, and livestock operations have intensified water scarcity challenges.

Produced water from oil and natural gas operations presents a potential solution (Bechera et al., 2024). Texas generates billions of gallons of produced water annually, most of which is re-injected underground. Redirecting some of this water for agricultural use could alleviate pressure on freshwater supplies, and recent advancements have made it for irrigation and other agricultural applications. The most efficient current methods include reverse osmosis/ultra high pressure reverse osmosis (RO/UHP-RO) and mechanical vapor compression/recompression (MVR). Thermal desalination also can be suitable to treat highly saline water, with total dissolved solids (TDS) levels often exceeding 120,000 mg/L. The piloting of produced water treatment in the Permian Basin has yielded treated water quality ranging from 36 mg/L to 900 mg/L TDS, which is within acceptable limits for agricultural use.<sup>23</sup>

By encouraging collaboration between farmers and the oil and natural gas industry, Texas can lead the way in integrating innovative water solutions that sustain agriculture and bolster the broader economy.

## **10. Conclusions**

Oil and natural gas power heavy machinery through the entire agricultural value chain—and provide raw materials for fertilizers, pesticides, and herbicides. Supply chains and transportation networks that move produce and other goods between farms and markets—as well as the irrigation systems that enable crop growth—rely on petroleum products that are integral to the economics and security of global food supplies.

For these reasons, oil and natural gas demand has continued to grow in global agriculture despite government policy-driven impetus for changes. In both advanced and emerging economies, small and large farms leverage the abundance and affordability of petroleum-based products. For today and the foreseeable future, the intertwining of global agriculture with oil and natural gas is a matter of necessity because of the energy density, cost-effectiveness, ubiquity, and productivity that oil and natural gas provide.

Ultimately, the world continues to eat because it has energy, which to date is uniquely advantaged by oil and natural gas. The future requires technological advancements, but also pragmatism as the world grapples with challenges to feed a large and growing population. Policymakers must strike a balance between pursuing sustainable energy goals and acknowledging the needs of the agricultural sector. Innovative solutions that enhance efficiency, reduce environmental impacts, and increase the reliability of energy supplies will be essential in navigating change.

---

<sup>23</sup> Texas Produced Water Consortium (2024) and Texas Produced Water Consortium (2022).

## References

- Aktar, M., Sengupta D., and Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip Toxicol.* 2009 Mar;2(1):1-12. doi: 10.2478/v10102-009-0001-7. PMID: 21217838; PMCID: PMC2984095.
- Bartlett, D. W., et al. (2002). Efficacy of Azoxystrobin in Controlling Powdery Mildew and Increasing Wheat Yields. *Crop Science*, 42(2), 539-547.
- Bechara, E, Watson M., and A. Nachiket. Unlocking Sustainability: Transforming Tight-Oil Produced Water into a Lifeline for West Texas. *Environmental Processes* 11:26, <https://doi.org/10.1007/s40710-024-00704-8>
- Energy Information Administration (2024). Petroleum & Other Liquids: Natural gas plant field production. Data retrieved on July 19, 2024. [https://www.eia.gov/dnav/pet/pet\\_pnp\\_gp\\_dc\\_nus\\_mbbldpd\\_m.htm](https://www.eia.gov/dnav/pet/pet_pnp_gp_dc_nus_mbbldpd_m.htm)
- Environmental Protection Agency (2019). Atrazine and Simazine Use on Sweet Corn: Response to Comments, Usage, Benefits, and Impacts of Potential Mitigation; PC Codes (080803 and 080807). Memorandum dated November 25, 2019. <https://downloads.regulations.gov/EPA-HQ-OPP-2013-0251-0142/content.pdf>
- Environmental Protection Agency (1993). A Comparison of Historical Vehicle Miles Traveled Projections, pg. 9, table 1. U.S. [EPA](#).
- Environmental Protection Agency (2020). Fast Facts: U.S. Transportation Sector Greenhouse Gas Emissions: 1990-2020, pg. 5, U.S. [EPA](#).
- Environmental Protection Agency (2024). Ingredients Used in Pesticide Products: Atrazine. <https://www.epa.gov/ingredients-used-pesticide-products/atrazine>
- Epstein, A. (2022). Fossil future: why global human flourishing requires more oil, coal, and natural gas-- not less. [New York, New York], Portfolio/Penguin.
- Fisher Scientific (2016). The Evolution of Chemical Pesticides. *Lab Reporter*. 2016(4). <https://www.fishersci.com/us/en/scientific-products/publications/lab-reporter/2016/issue-4/the-evolution-chemical-pesticides.html>
- Fujs, T. & Kashiwase H. (2023). Strains on freshwater resources: The impact of food production on water consumption. *World Bank Blogs*. August 23, 2023. <https://blogs.worldbank.org/en/opendata/strains-freshwater-resources-impact-food-production-water-consumption#:~:text=Today%2C%20around%2070%20percent%20of,goes%20to%20the%20industrial%20sector.>
- Gessler, C., & Pertot, I. (2004). Effectiveness of Mancozeb in Managing Downy Mildew in Grapevines. *Crop Protection*, 23(12), 1171-1177.

Hough, P. (2014). The Trading and Use of Agrochemicals. In: Campbell, W., López-Ortíz, S. (eds) Sustainable Food Production Includes Human and Environmental Health. Issues in Agroecology – Present Status and Future Prospectus, vol 3. Springer, Dordrecht. [https://doi.org/10.1007/978-94-007-7454-4\\_1](https://doi.org/10.1007/978-94-007-7454-4_1)

Jasinski, E. (2024) Case Study: California Cow-Calf. Ambrook. August 31, 2024. <https://ambrook.com/education/analysis/cost-of-production-for-cow-calf>

Johnson, D., Cummings T. (2015). Efficacy of Chlorothalonil for Control of Late Blight in Potatoes. Plant Disease, 99(8), 1052-1058.

Jørgensen, L., Olsen, C. (2007). Impact of Propiconazole on Yield and Disease Control in Wheat. European Journal of Plant Pathology, 117(2), 153-162.

Keller, A. (2012). NGL 101-The Basics. Midstream Energy Group. June 6, 2012. [https://www.eia.gov/conference/ngl\\_virtual/eia-ngl\\_workshop-anne-keller.pdf](https://www.eia.gov/conference/ngl_virtual/eia-ngl_workshop-anne-keller.pdf)

MacHardy, W., Gadoury D. (1989). Impact of Captan Fungicide on Apple Scab Control and Yield. HortScience, 24(5), 742-745.

Mitchell, P. (2020). Comments Submitted by Dr. Paul Mitchell, Professor, Univ. of Wisconsin-Madison, to the U.S. Environmental Protection Agency. March 2, 2020. [EPA-HQ-OPP-2013-0266-1564 attachment 4.pdf](https://www.epa.gov/epahq/epa-hq-opp-2013-0266-1564-attachment-4.pdf)

Moore, C. (2020). Comments Submitted by Cherilyn Moore, Syngenta Crop Protection, LLC to the U.S. Environmental Protection Agency. March 18, 2020. <https://www.regulations.gov/document/EPA-HQ-OPP-2013-0266-1564>

Pathak, V., Verma V., Rawat B., Kaur B., Babu N., Sharma A., Dewali S., Yadav M., Kumari R., Singh S., Mohapatra A., Pandey V., Rana N., Cunill J. Current status of pesticide effects on environment, human health and it's eco-friendly management as bioremediation: A comprehensive review. Front Microbiol. 2022 Aug 17; 13:962619. doi: 10.3389/fmicb.2022.962619. PMID: 36060785; PMCID: PMC9428564.

Smil, V. (2022). How the World Really Works: The Science Behind How We Got Here and Where We're Going. Penguin Publishing Group. ISBN 9780593297063

Stalcup. L. (2024). Once Again, Weather Cuts Cotton Yields Short in the Southwest. AgWeb Farm Journal. December 6, 2024. <https://www.agweb.com/news/crops/cotton/once-again-weather-cuts-cotton-yields-short-southwest>

Texas Comptroller (2019). Texas Water: Planning for More. Economy: Fiscal Notes. April 2019. <https://comptroller.texas.gov/economy/fiscal-notes/archive/2019/apr/tx-water-planning.php#:~:text=In%202016%2C%20Texas%20came%20close,18%20percent%20of%20total%20use.>

Texas Produced Water Consortium (2024). Beneficial Use of Produced Water in Texas: Texas Produced Water Consortium Report to the Texas Legislature 2024. October 2024. <https://www.depts.ttu.edu/research/tx-water-consortium/XPWCFINALDRAFT.pdf>

Texas Produced Water Consortium (2022). Beneficial Use of Produced Water in Texas: Challenges, Opportunities and the Path Forward: Texas Produced Water Consortium Report to the Texas Legislature 2022. September 2022.

U.S. Department of Agriculture (2024). Livestock, Dairy, and Poultry Outlook: November 15, 2024. <https://www.ers.usda.gov/webdocs/outlooks/110424/ldp-m-365.pdf?v=7448.4>

U.S. Department of Agriculture (2015). Historical Track Records. National Agricultural Statistics Service. [https://www.nass.usda.gov/Publications/Track\\_Records/2015/Track%20Record%202015.pdf](https://www.nass.usda.gov/Publications/Track_Records/2015/Track%20Record%202015.pdf)

U.S. Department of Agriculture (2014). Pesticide Use in U.S. Agriculture: 21 Selected Crops, 1960-2008. May 2014. [https://www.ers.usda.gov/webdocs/publications/43854/46734\\_eib124.pdf](https://www.ers.usda.gov/webdocs/publications/43854/46734_eib124.pdf)

U.S. International Trade Commission. USITC DataWeb: Texas Beef Export Data. Accessed December 9, 2024. <https://dataweb.usitc.gov/>.

Vaiknoras, K., and Hubbs, T. (2023). Characteristics and Trends of U.S. Soybean Production Practices, Costs, and Returns Since 2002. USDA Economic Research Service. Report No. ERR-316. <https://www.ers.usda.gov/publications/pub-details/?pubid=106620>