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Biofuels: Pros and Cons for the Energy Transition

How new biofuels could ease the energy crisis.

By **Robert Turner**

Is biodiesel renewable? Feedstock crops inform biofuels' pros and cons in their role in energy transition as the world rapidly moves to adopt electric vehicles.

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Audio Article: Food Versus Fuel

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The sticker shock you've likely experienced at the gas pump in the months since February 2022, when Russia invaded Ukraine, might be a potent reminder of our economy's fragile dependence on fossil fuels. Aggression in one part of the world can catalyze an economic chain reaction that pinches oil supplies and raises prices for a wide range of petroleum-based products, including gasoline, heating oil, and synthetic fertilizers. The impact ultimately pushes up the cost of food — dependent on these inputs for its production, transport, and storage — for all of us.

Events of the past year gave me a wakeup call for considering where my energy comes from, and brought renewables, particularly agricultural biofuels, to front of mind.

What may not be as clear in this supply-chain upheaval is the link between Russian oil and gas and tropical rainforests on the other side of the planet. As Europe scrambled to secure alternative fuel sources that could supplant some of its demand for Russia-supplied energy, the continent's rush for biofuels contributed to the deforestation of rainforests in Indonesia, Malaysia, and Brazil. Farmers in these and other forest-rich countries quickly cleared trees, often illegally and on protected lands, to plant more soy and palm oil used as biofuel feedstocks. Among the first to feel the consequences were displaced Indigenous groups and threatened species, including the **Bornean orangutan**.

Despite this bleak scenario, the recent energy crisis could one day be remembered as a historic turning point, when the world adopted a cleaner and more secure energy industry and a more sustainable and regenerative agriculture system.

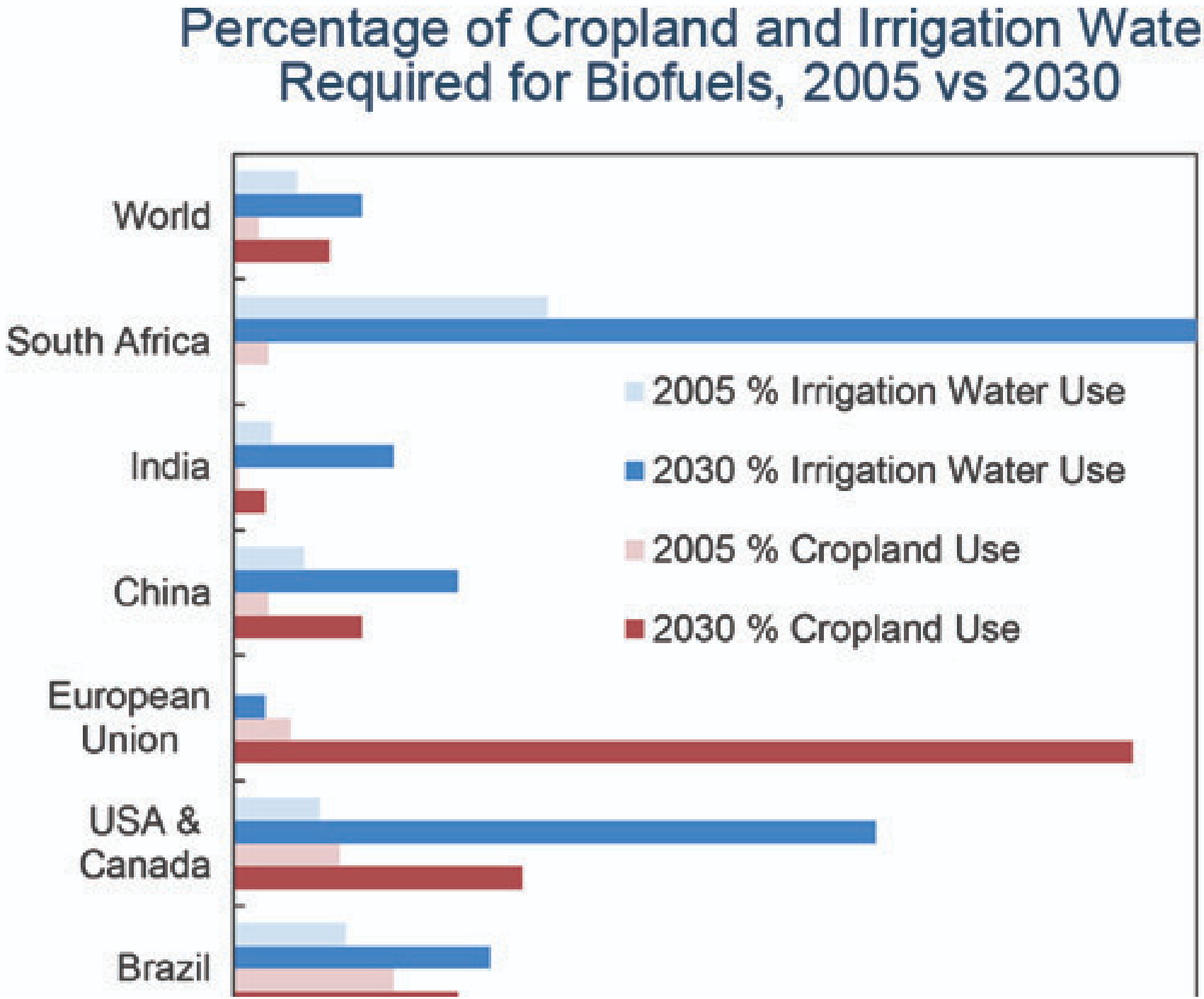
As a science writer focused on food and agriculture, I've come to view biofuels as a technological solution central to achieving this societal pivot. And I believe the rising demand for biofuels is fodder for a food-versus-fuel debate that has already been raging for years.

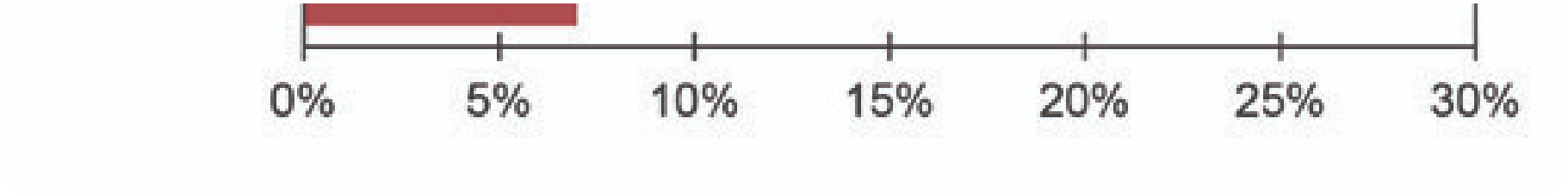
Biofuels Pros and Cons: The Critiques

To technology skeptics, I assure you that I, too, am wary of the "unintended consequences" that can spring from technological advances. Good examples are found in two of the greatest scientific achievements in the history of agriculture: the Haber-Bosch process for producing synthetic fertilizers invented in 1913, and Norman Borlaug's development of new wheat varieties in the 1960s, both winners of a Nobel Prize. Each solution is thought to have saved billions of people from starvation while fueling unprecedented energy consumption, biodiversity loss, eutrophication, and social inequality.

People are lined up on both sides of the food-versus-fuel debate. The main problem for biofuels has always centered on their competition for a finite amount of arable land, with some folks strongly opposed to any land use that diverts from food production in a world with a growing population. Today, about 2.5% or 3% of farmland around the world is used to grow biofuel feedstocks, the vast majority concentrated in only two countries: the United States (using corn) and Brazil (using sugarcane). What worries some is that the land dedicated to biofuels is expected to more than double over the next two decades — and in the U.S., this could mean a lot more corn.

As I wrote previously, **electric vehicles (EVs) could wreak havoc on the Midwestern farm economy**. Why? Because 45% of the U.S. corn crop goes into our gas tanks in the form of ethanol — and EVs don't have gas tanks. By federal mandate, gasoline must contain 10% ethanol, made from corn. Car manufacturers are pledging to sell only electric vehicles within 10 or so years, and the resulting drop in the demand for ethanol could hamper the Midwestern corn belt, a massive region of the United States that employs 300,000 farmers producing 350 million tons of corn every year.


Percentage of Cropland and Irrigation Water Required for Biofuels, 2005 vs 2030
World
South Africa
India
China
European Union
USA & Canada
Brazil
2005 % Irrigation Water Use
2030 % Irrigation Water Use
2005 % Cropland Use
2030 % Cropland Use



My question then was, should we continue to prop up the corn industry with taxpayer subsidies as it begins to fail? And my hope was that farmers in the Midwest could begin to grow more diverse food crops (not only corn and soybeans) to feed Chicago, Minneapolis, St. Louis, and beyond, improving food sovereignty and food security throughout the region.

Biofuel's detractors are also skeptical of labeling it as clean energy, arguing that biofuel production generates plenty of carbon emissions. Let's take a moment to clarify confusing terms: "Biofuel" is something of a catch-all term for any fuel produced from biomass. "Biodiesel" is a blend of plant-based fuel with regular fossil diesel, and "renewable diesel" is not blended with any fossil fuels (see "**Bioenergy Lexicon**," below). Whatever the mix, current feedstocks — corn for ethanol and soybeans for biodiesel — are grown using chemically intensive farming practices that include large amounts of synthetic fertilizers made from fossil fuels (the Haber-Bosch process). Those fertilizers — which farmers are over-applying, sometimes using twice as much as is needed — break down in the soil to release nitrogen oxide, another greenhouse gas that is 300 times more potent than carbon dioxide. We're essentially burning fossil fuels to get away from burning fossil fuels.

Given all this, I can understand fears that biofuels take the focus away from solar and wind as the perceived ultimate renewable resources.

Is Biodiesel Renewable? It Depends on Production.

Supporters, on the other hand, see biofuels as a core climate solution, further reducing our dependence on fossil fuels while keeping U.S. farmers in business.

Transportation as a sector is a huge energy user. More than one-quarter of total U.S. energy consumption in 2021 went to transporting people and goods from one place to another, accounting for 27% of greenhouse gas emissions, making transportation the largest emitter, ahead of electricity and industry. Electric cars will certainly reduce our dependence on fossil fuels, as will increasing solar power capacity, which is on track to roughly triple globally over the next five years. Battery technology, crucial for storing renewable energy, is also advancing quickly. Even a futuristic vision of nuclear fusion leaped forward in 2022. But while these technological advances are significant, biofuel advocates point out, they're not likely to power hard-to-electrify jet airplanes, cargo ships, or trains in enough time to alleviate current gas prices or entirely avert climate disaster. (A nod to the Tesla Semi truck, with a range of 500 miles carrying 80,000 pounds, but long-distance diesel trucks will likely remain on the road for the foreseeable future.)

Meanwhile, several biofuel types can be used to power all these things right *now*.

By simply **swapping out a gallon of fossil fuel for a gallon of biodiesel** (or, better yet, renewable diesel) at the gas tank for nearly any mode of transportation, we could achieve a significantly lower carbon burden. According to a 2006 study published in *Proceedings of the National Academy of Sciences*, when compared with gasoline, choosing biodiesel over fossil options reduced greenhouse gas emissions by 41% (ethanol yielded only a 12% reduction). Biodiesel also provides 93% more net energy per gallon than is required for its production; ethanol generates just 25% more net energy than it took to produce it (not a very good return on the energy invested). Even in instances where it's not practical for biofuels to cover all our heavy transportation needs, simply switching to B20 biodiesel (a blend of biofuel and regular diesel) results in a 20% savings in fossil fuels.


98
E5
95
E10
Diesel
98
95

Importantly, supporters say new biofuel feedstocks being trialed won't take away from current food production or contribute to the demise of the rainforest, because these crops can (and should) be grown on land that was previously used for producing ethanol.

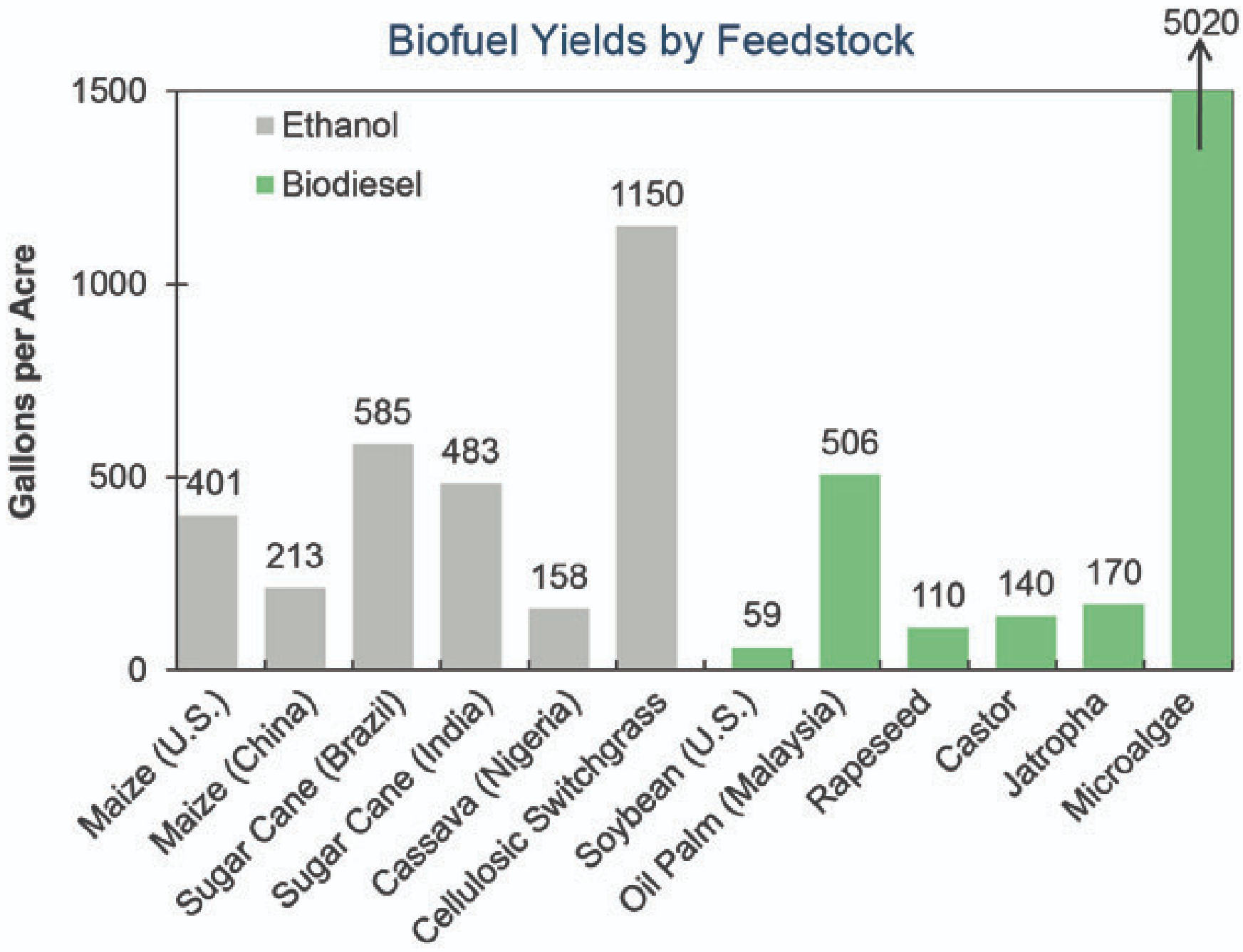
Whichever your position, billions of dollars are already pouring into new biofuel refineries, pipelines, and feedstock technologies. I tend toward cautious optimism: that these better biofuel feedstocks are on the horizon, and, if managed carefully, they can be profitable for farmers and produce fuel at competitive prices without creating a market that drives deforestation.

A Better Biofuel

New feedstock crops being developed by scientists and agronomists are showing promise for providing a range of benefits beyond producing transport-ready fuels. They add valuable nutrients to the soil, increase water and carbon-storage capacity, and improve overall soil health. In turn, they allow the farmers growing them to lower their fertilizer needs and cost.

Hybrids, such as carinata (*Brassica carinata*), are among the most promising. A **flowering plant in the mustard family** and commonly referred to as "Ethiopian mustard," carinata can produce two and a half times more biodiesel than soybeans can, and carinata can easily be planted in a three- or four-year rotation with corn and soybeans. That rotation, spread out over the vast cornfields of the Midwest, could greatly increase biodiesel production and reduce the excess corn supply just as demand for corn drops due to more people driving EVs. Carinata can be refined at existing refineries into a renewable diesel that can run any truck on the road today, and the truck won't know the difference.

Growing carinata as a winter cover crop in the U.S. South between fall harvest and spring planting would add to the harvest without affecting food or fiber production there. And as a bonus, the byproduct of carinata oil production, the low-fiber leftover solids known as "meal" that contain about 45% crude protein (a similar content as in soybean meal), can be used as an input for animal feed.


Biofuel Yields by Feedstock
Gallons per Acre
1500
1000
500
0
Ethanol
Biodiesel
401
213
585
483
158
1150
59
506
110
140
170
5020
Maize (U.S.)
Maize (China)
Sugar Cane (Brazil)
Sugar Cane (India)
Cassava (Nigeria)
Cellulosic Switchgrass
Soybean (U.S.)
Oil Palm (Malaysia)
Rapeseed
Castor
Jatropha
Microalgae

Carinata was available in the Southeast beginning in spring of this year by a company called Nuseed, but it's not the only option for biofuel feedstocks. Several more plant species are on the biofuel table, including rapeseed, switchgrass, jatropha, mustard, camelina, and others, as well as waste oils and animal fats.

In parts of the Midwest, it may be possible to grow a short-season or "90-day" corn variety each summer, leaving enough time to plant a biofuel feedstock as a winter cover crop. In this scenario, corn production wouldn't drop at all and might actually increase because of cover crops enhancing the soil. By promoting this option for cover cropping, farmers would gain an additional income source while introducing a practice proven to reduce soil erosion in a region where less than 8% of farmers use cover crops in winter.

The path to better soils, a stable climate, and diversified farm income might be as straightforward as swapping one biofuel — ethanol from corn — with another from carinata or other feedstocks. But as part of the switch, the entire biofuel system must be overhauled to make it more sustainable while avoiding technological pitfalls. Already, to reduce the climate impact of biorefining, pipelines are being planned across Iowa and Illinois to carry carbon dioxide recovered from refining to facilities deep underground as part "carbon capture-and-storage" systems that come with quite a few of their own trade-offs.

Introducing better feedstocks opens opportunities to build more economic sustainability too; particularly, by fixing the government incentives that led to runaway corn production. For instance, any taxpayer assistance or subsidies the government gives to renewable fuels could be tied to sustainable and regenerative farming practices that protect soils from erosion, such as no-till and cover cropping. Incentives could also require reduced chemical pesticides that are contributing to what scientists are calling a "bug apocalypse" in our planet's "sixth extinction" era.

Fueling the Transition

Price matters. If we want to talk seriously about leveraging biofuels in the energy transition, we need to recognize that industry will only adopt new fuels and technologies if their costs are comparable or less expensive than what they're currently using. Biodiesel and renewable diesel were cheaper at the pump in 2022 than fossil diesel. We need to ensure they remain so even while we blend in more carinata, switchgrass, or other feedstocks with greater benefit than corn.

And it's important that biofuels don't become dependent on one or two patented plant species sold by one or two Big Ag companies, as with corn and soybeans. Big Ag already has too much power and control over farmers and rural communities.

The most pressing question might be: Can we produce enough food and biofuel feedstock on *existing* farmland and at *competitive enough prices* that there's no need (or profit motive) to expand farming into rainforests or other open, natural spaces?

I believe we can by choosing a **wide range of biofuel feedstocks** that can be rotated with a diversity of food products in fields around the world. Let's orient incentives to safeguard healthy land and build an economic structure that avoids externalizing deforestation to other parts of the world. The carbon-sequestration benefit that's lost when trees are cut down in Indonesia, Malaysia, or Brazil far exceeds any climate benefit from the biofuel those trees would produce. The "carbon debt" will never be repaid.

Finally, let's keep control over biofuel production in the hands of farmers. As solar, wind, and battery technologies improve and expand, we may eventually wean ourselves off biofuels entirely. Until then, demand for renewable energy will only increase globally. The United States can take the lead in biodiesel production — supporting rural communities and farm families, who will be listening to the wind rustle a field of mustard and grasses while the sounds of chainsaws in the Amazon go silent.

Bioenergy Lexicon

- **B5 and B20.** Biodiesel blends denoting the percentage of biomass-derived fuel in the mix; B5 includes up to 5% biodiesel, and B20 includes between 6% and 20% biodiesel.

- **Bioenergy.** Any energy derived from biomass, which includes wood, agricultural residues, algae, and any other organic matter, often burned to produce heat.
- **Biodiesel.** A biofuel specifically formulated for use in transportation, either as a replacement to diesel or for use in a blend.
- **Biofuel.** Biomass that's been converted into a fuel (either liquid or gas), including methane, ethanol, methanol, and more.
- **Ethanol.** A liquid fuel often produced by fermenting corn sugars.
- **Renewable diesel.** A diesel substitute made entirely from biomass and not blended with fossil fuels.

Robert Turner is a farmer and science writer in western North Carolina. He serves on the board of Organic Growers School and is the author of Lewis Mumford and the Food Fighters: A Food Revolution in America.

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