Despite uncertainties, cellulosic biofuels still a win for ground transportation

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Despite the fervor around electric vehicles and their potential to reduce the transportation sector's carbon footprint, 2023 projections suggest EVs won't edge out gas-powered vehicles for decades to come. With

conventional vehicles likely to dominate the ground fleet for the foreseeable future, University of Illinois Urbana-Champaign experts say cellulosic biofuels shouldn't be discounted.

Researchers in the College of Agricultural, Consumer and Environmental Sciences (ACES) and the Institute for Sustainability, Energy, and Environment (iSEE) at U. of I. note that support for cellulosics has waned in part due to uncertainty around land availability, feedstock yields, costs, and greenhouse gas (GHG) emission savings. In a recent study, they quantified these uncertainties for multiple feedstocks and policy scenarios, concluding that cellulosic feedstocks outperform corn ethanol in nearly all cases—but will require considerable policy support to grow and sustain the industry.

"There are a lot of advantages for perennial feedstocks to decarbonize transportation," said Madhu Khanna, ACES Distinguished Professor in Environmental Economics in the Department of Agricultural and Consumer Economics, the Alvin H. Baum Family Fund Chair, and director of iSEE, and a senior author on the U.S. Department of Energy-funded study led by the Center for Advanced Bioenergy and Bioproducts Innovation (CABBI).

"We need long-term policy commitments with assured demand for cellulosic biofuels, as well as short-term policy support like tax credits, which could be based on the carbon intensity of biofuels."

The CABBI team developed a complex model integrating economics, crop growth information, land availability, refinery processes, and carbon benefits to compare multiple biofuel feedstocks—corn, soybeans, corn stover, miscanthus, switchgrass, and energy sorghum. The team projected outcomes for 2016 to 2030 under various policy scenarios.

These included a "no policy" or baseline scenario in which corn ethanol

held steady at 6 billion gallons per year, a corn ethanol mandate of 15 billion gallons, and a corn + cellulosic ethanol mandate adding 16 billion gallons of cellulosic ethanol (a total of 31 billion gallons) by 2030.

The model predicted everything from the effect of ethanol mandates on corn and feedstock prices to where each feedstock would be grown most productively, taking into account land use change, greenhouse gas emissions, and societal costs. In the end, the cellulosic mandate came out on top.

"Electrification has caught a lot of attention, and there's a lot of policy support for it, but it's going to be a slow process to change the vehicle fleet. Liquid biofuels offer an almost immediate benefit with existing infrastructure," Khanna said.

"Cellulosic biofuels are particularly promising because they are high yielding per unit land and can be grown at least partly on marginal land, which is low-productivity land that can support crops without conversion, such as fallow cropland. Hence, their production conflicts much less with food crops compared to the use of corn and soybean for biofuel."

The team was particularly interested in quantifying indirect land use change (ILUC). When biofuels are produced, Khanna explains, the price of land goes up, forcing up the price of commodities. That creates incentives for non-cropland (e.g., grassland or forest) to be converted into cropland, but conversion releases stored carbon.

"This creates a 'carbon debt' that can take many years to pay back. The more crop prices go up, the higher the ILUC effect and the lower the overall carbon benefits," Khanna said. "Even though we say cellulosic biofuels are not going to conflict with food production and have lower carbon intensity, there's still a lot of uncertainty about that."

Khanna says a major source of uncertainty is the amount of marginal land that could be used to produce cellulosic biofuel crops.

"Our analysis showed a relatively small amount of marginal land (1.5 million hectares or 3.7 million acres) will be converted to energy crops," she said. "The corresponding estimate of the amount of marginal land likely to convert to cropland under the Corn Ethanol Mandate scenario would be much larger and more uncertain at 2.2 M ha."

The model predicted greenhouse gas emissions under the baseline scenario would gradually rise a couple of percentage points over time, but the corn ethanol and the corn + cellulosics mandates reduced emissions by 3% and 10.4%, respectively, by 2030.

Correspondingly, the model estimated the corn + cellulosics policy would cost substantially less for greenhouse gas abatement than a corn ethanol-only policy, at about $150 and $233 per megagram of carbon dioxide, respectively.

These figures factor into another major focus of the analysis, a concept known as the economic welfare cost for each policy.

"When we force consumers to pay for products that are more expensive, their welfare goes down. It's a net cost for them. So if there's a mandate that we have to consume 16 billion gallons, that forces much more costly biofuel into the market, and the welfare goes down. But carbon emissions go down as well," Khanna said.

"We looked at the change in the economic welfare with the imposition of more stringent mandates and compared it to the reduction in greenhouse gas emissions. Then we can say, per ton of reduction, what is the cost that has been borne?"

The model predicted that although cellulosic ethanol far exceeds the cost of corn ethanol, overall welfare costs of reducing GHG emissions would decrease with a cellulosic mandate thanks to additional carbon savings.

The study suggests policy support for cellulosics would not only be good for the planet; it could be good for society.

"Even if we achieve current policy targets for a 50% share of electric vehicles in new sales, it will take decades for the share of electric vehicles in the total stock to dominate due to slow turnover, particularly at a global level. A large share of the cars are still going to need liquid fuel. It's better driving them on low-carbon biofuels rather than on gasoline," Khanna said.

"It doesn't have to be electric vehicles or biofuels. We have to have a balanced approach and rely on multiple paths to reducing emissions from the transportation sector."

The study is published in the journal *European Review of Agricultural Economics*.

More information: Yuanyao Lee et al, Quantifying uncertainties in greenhouse gas savings and abatement costs with cellulosic biofuels, *European Review of Agricultural Economics* (2023). DOI: 10.1093/erae/jbad036

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