NEWS

Is There a Road Ahead For Cellulosic Ethanol?

After early optimism, alcohol brewed from farm and forest waste struggles to fulfill its promise as the next great biofuel

JUST A FEW YEARS AGO, THE IDEA OF turning farm and forest wastes into "cellulosic" ethanol, a biofuel to power cars and trucks, seemed a sure winner. Some researchers were predicting that they would soon perfect the new technologies needed to crack the cellulose and lignin molecules that had made grasses, cornstalks, and wood chips so much tougher to brew into ethanol than corn kernels. Both government agencies and private investors were pouring money into the field. In the United States, for instance, the Department of Energy (DOE) in 2007 unveiled plans to spend $385 million to back six commercial-scale reactors, while Congress approved hefty tax credits for biofuel makers. Venture capitalists invested billions in new cellulosic ethanol companies.

That was then. Now, much of the optimism surrounding cellulosic ethanol has faded thanks to the ongoing economic slump, a plentiful supply of ethanol made from corn, and uncertainty among policymakers. Numerous companies have either shelved plans to build commercial-scale cellulosic ethanol plants or walked away altogether. Even the promise of DOE's millions hasn't enticed them back. "In the current financial climate, existing federal policies are simply not enough to encourage the investments that will make these fuels a reality," says Jeremy Martin, a chemist with the Clean Vehicles Program of the Union of Concerned Scientists (UCS) in Washington, D.C.

The upshot: The U.S. government's flagship plan to reduce the nation's dependence on oil by scaling up cellulosic ethanol is in deep trouble, highlighting the complex technical, economic, and political forces buffeting global efforts to create viable alternatives to fossil fuels. And observers say decisions that Congress and federal agencies make this year could shape the nascent U.S. biofuels industry for decades to come. "It's an absolutely critical year for biofuels," says Wally Tyner, an agricultural economist at Purdue University in West Lafayette, Indiana.

A promising start

The plan to build an American biofuels industry on cellulose had been starting to pay off. In 2005, Congress approved new rules mandating a steady ramp-up in biofuels use. By 2022, lawmakers envisioned cars burning up to 36 billion gallons (136 billion liters) of biofuel a year, an amount equivalent to about one-quarter of today's U.S. gasoline use. Much of the early increase was to come from "first-generation" biofuels, primarily ethanol made from corn kernels. That industry has grown steadily, from turning out some 3 billion gallons of corn ethanol in 2005 to 12.1 billion gallons today. Most is blended with gasoline (typically 10% ethanol to 90% gasoline) to help reduce urban smog.

Congress, however, has capped the amount of corn ethanol it wants in gas tanks at 15 billion gallons by 2015. In part, that's because making corn ethanol is energy intensive, so the fuel doesn't do much to offset fossil fuel use or lower greenhouse gas emissions. Beyond that first 15 billion gallons, policymakers envisioned biofuels coming from "advanced" sources, such as ethanol and gasoline-like hydrocarbons made from plant materials high in cellulose.

The ramp-up in cellulosic ethanol production, however, is already well off track. Demonstration facilities are expected to turn out up to 25.5 million gallons this year—far below the 250 million gallons that the U.S. Environmental Protection Agency (EPA) once wanted fuelmakers to produce. In a telling sign of cellulosic ethanol's struggles, over the last year the agency twice scaled back its expectations after it became clear that the industry wouldn't be building commercial-scale plants as quickly as once thought.

What happened to the promise?

Part of the problem in scaling up cellulosic biofuels continues to be technical. To brew ethanol, manufacturers use yeast to ferment simple sugars such as glucose. That task is relatively cheap and easy when starting with a raw material—or "feedstock"—rich in those simple sugars, such as sugar cane in Brazil. In the U.S., brewers using corn as a feedstock face a slightly more complex pro-

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Fueling doubts. Making ethanol from switchgrass (*far left*) can't yet compete with corn.

cess, because they first must use enzymes to break apart the starch in corn kernels into their component glucose molecules. The task becomes even more difficult when using cellulosic feedstocks such as switchgrass, corn stalks, or wood chips. The sugars in these feedstocks are locked in cellulose, hemicellulose, and lignin, biopolymers more complex than starch. Breaking those biopolymers into intermediate compounds that can be converted to ethanol remains a difficult problem. Researchers call it "recalcitrance," and it currently limits brewers to converting just 40% of the energy content available in cellulosic feedstocks to ethanol. Fermentation, by contrast, converts about 90% of the energy in simple sugars to ethanol. That means cellulosic ethanol plants currently need far more raw material than first-generation plants do to make the same amount of ethanol.

Researchers say they are making steady, if slow, progress in increasing the conversion rate. They've engineered novel microbes, for instance, that can break down cellulose into fermentable sugars. "The recalcitrance barrier will fall," predicts Lee Lynd, a metabolic engineer at Dartmouth College.

Hitting the blend wall

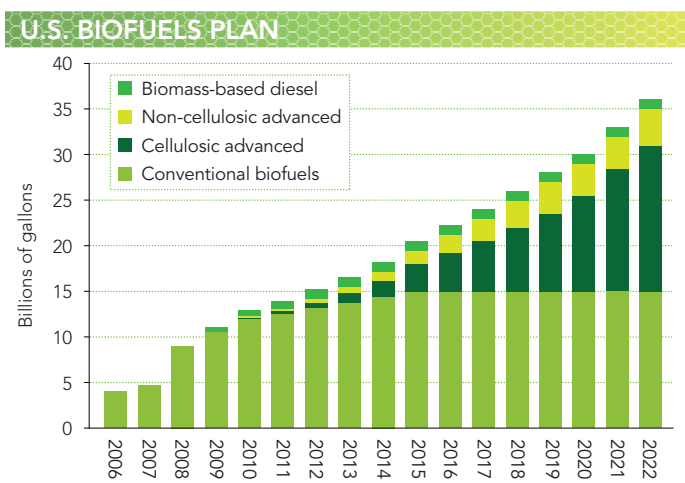
Even if it does, however, that breakthrough may not rejuvenate the field. That's because there is already an oversupply of first-generation ethanol on the market, Tyner says. At the moment, he notes, most ethanol is used to provide the 10% share in blended gasoline. But with the U.S. using a total of about 140 billion gallons of gasoline a year, the demand for ethanol is currently capped at about 14 billion gallons. Biorefineries already make 12.1 billion gallons of corn ethanol annually, he notes, and idled plants are capable of boosting the total to 15 billion gallons. The result is that the industry has reached a "blend wall," he says. "There is no room for cellulosic ethanol."

That could change if the government and carmakers start pushing cars that run on "E85"—a blend of 85% ethanol and 15% petroleum—or if cellulosic ethanol brewers figure out how to make their product cheaper than corn ethanol. (Cellulosic ethanol currently costs about double.) But neither development is likely anytime soon, and that partly explains why investors now shy away from backing cellulosic ethanol. The recent recession didn't help. "You can't get a loan to fund an ethanol plant of any kind right now because of the blend wall," says Bruce Dale, a chemical engineer and ethanol processing expert at Michigan State University, East Lansing.

Policy worries

Investors are also skittish because they aren't sure that government requirements mandating biofuels, and tax credits supporting them, are ironclad. Most of the existing $6 billion a year in ethanol subsidies and tax credits are currently up for renewal by Congress. Lawmakers have already allowed one tax credit for biodiesel to lapse, adding to investors' worries that ethanol subsidies could be next on the chopping block. "Until the government makes it absolutely clear that this is a long-term policy, investors will be reluctant to support the industry," says Sean O'Hanlon, the executive director of the American Biofuels Council in Miami, Florida.

A final challenge facing companies is ensuring long-term supplies of feedstock. Commercial-scale cellulosic ethanol plants, which can cost tens to hundreds of millions of dollars to build, are expected to operate for 3 decades or more. That means making deals with farmers to ensure steady access to agricultural wastes and other feedstocks. But "we don't have the supply chain in place to provide that much cellulosic material," Dale says.



Growing gap. Energy legislation from 2007 mandates an increasing share of cellulosic ethanol (dark green). But the industry is already falling behind.

SOURCE: W. TYNER/PURDUE UNIVERSITY

Driving forward

Despite all these challenges, analysts say Congress, EPA, and others can still make cellulosic ethanol viable. One option is for the government to alter tax incentives for biofuels. The current ethanol tax credit simply pays fuel blenders a flat $0.45 for each gallon of ethanol they use. A smarter option, UCS's Martin says, would be to offer larger credits to fuels—such as cellulosic ethanol—that are cleaner than corn ethanol or that could displace more gasoline.

Purdue's Tyner suggests taking this approach one step further by linking ethanol subsidies to oil prices. Current technology produces cellulosic ethanol at prices equivalent to $120 a barrel, he says, well above oil's recent price of about $77 a barrel. Taxpayers would make up the difference under Tyner's plan. If oil sold for $80 a barrel, cellulosic ethanol makers would get a $40-per-barrel subsidy; if oil rose to $120 a barrel, they'd get nothing. The sliding system would give cellulosic technologies time to become competitive and established, he argues. Another idea, say Dale and others, is simply to require that more—or all—new cars be able to use E85. The change could cost just $100 per car.

Both ideas have at least some support in Congress, but the industry won't know how much until work on a new agriculture bill moves into high gear later this year. Meanwhile, EPA is considering another option: increasing the required amount of ethanol in blended fuels to 12% or even 15%. That would boost demand from the current 12.1 billion gallons to as much as 14.6 billion gallons. Not everyone is in favor. Carmakers say they've optimized their engines to run on current blends, and they ask who would compensate unhappy car owners if the new blends damage engines. EPA is expected to make its decision by November; Tyner believes an increase to 12% would be "the politically and probably technically safe move."

Even such a boost, however, won't do much to attract new investors to build cellulosic ethanol plants, Tyner notes, because companies could meet the extra demand simply by bringing idle corn ethanol plants online. "It's a temporary fix at best," he says. Longer-term solutions to scaling up cellulosic biofuels, it appears, will need to come from the lab—and creative policymakers. **–ROBERT F. SERVICE**