

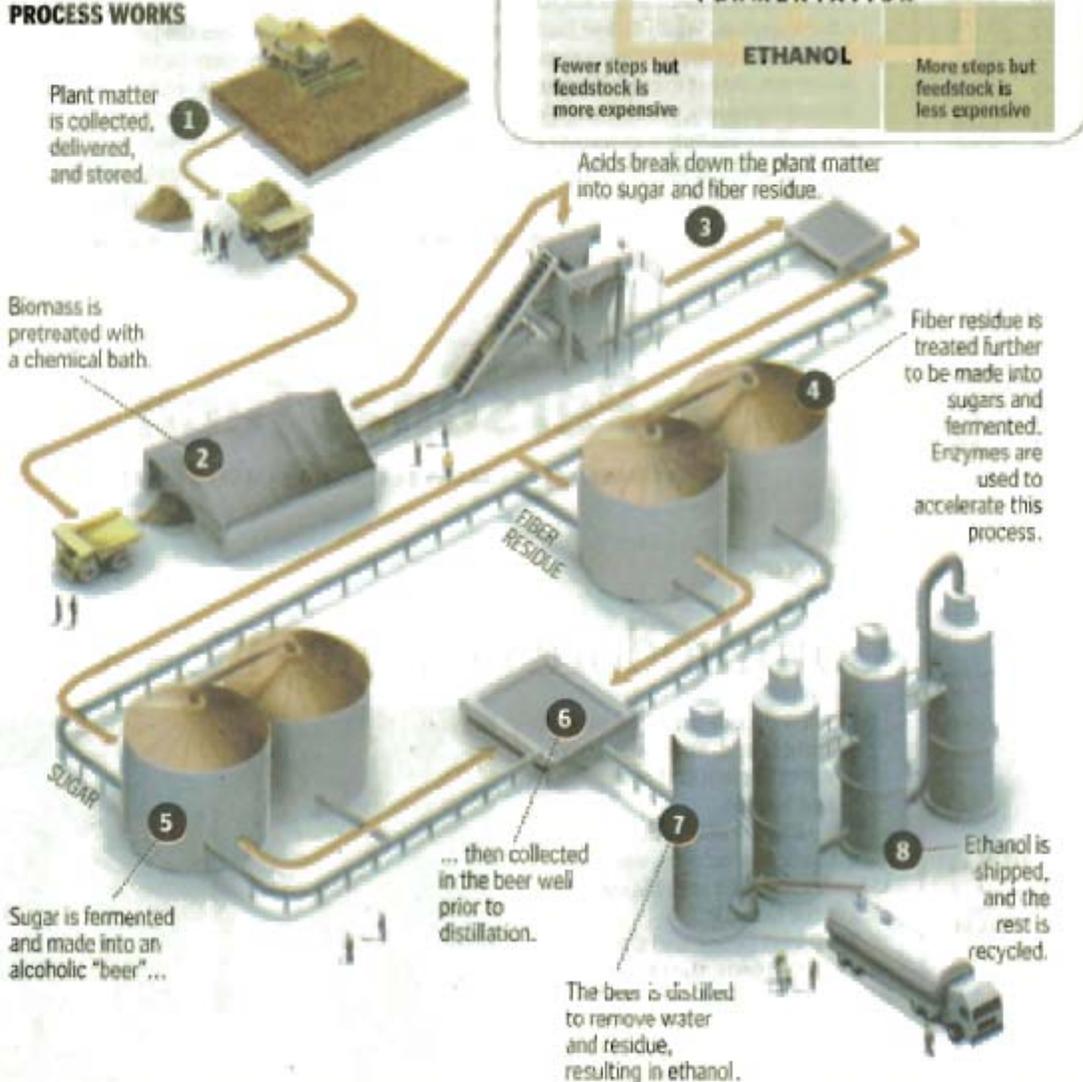
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Biotech firms sprint to cut ethanol's cost

Creating fuel from plant waste

Ethanol, the leading alternative to gasoline, is now made from the edible parts of corn or sugar cane. A more efficient method would be to use the rest of the plant, but the leaves and stalks need to be broken down and fermented — currently an expensive process. Two Cambridge companies are trying to invent new ways to produce so-called "cellulosic ethanol" more cheaply. This graphic depicts the process used by Celunol Corp.

HOW THE PROCESS WORKS



Two in Cambridge among many seeking practical ways to make the clean-burning alternative fuel

By Stephen Heuser
GLOBE STAFF

If the car of the future runs on old cornstalks and scraps of sugarcane, you might be able to thank a group of executives sitting eight stories above the Charles River.

That's where energy-industry veteran Carlos Riva presides over Celunol Corp., one of a host of new companies racing to turn farm waste into potent, clean-burning ethanol.

It might seem unlikely that the fuel industry and big agriculture, two goliaths of the red-state American economy, would intersect at a conference table overlooking CambridgeSide Galleria. But increasingly, energy analysts say, the next major shift in American energy is likely to come from high-tech science being developed in places like Cambridge.

"Historically, energy companies were located near the energy supply. You had oil companies in Houston, coal companies where they get the coal. I think what we're going to see now is almost a new type of company emerge — an energy innovation company," says Jeff Andrews, a venture capitalist with Atlas Venture of Waltham, which invests in several "cleantech" firms.

Recently, privately held Celunol said it would merge with Diversa Corp., a public California firm, creating a 240-person national company. Diversa will buy Celunol for \$115 million in stock, but the resulting company will be run by Celunol's executives in Cambridge.

Several competitors, including East Cambridge neighbor Mascoma Corp., are jostling with Celunol to be the first to prove

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SOURCE: Celunol Corp., American Coalition for Ethanol, Diversa Corp.

JAVIER ZARRACINA, DAIGO FUJIMURA/GLOBE STAFF



John Bardsley (left), a researcher at Mascoma Labs in Cambridge, takes a sample from a bioreactor. Above, farmers in a field of switchgrass, among the materials being explored for a cheaper way to produce ethanol as an alternative to gasoline.

Biotech firms aim to curb cost of ethanol

► ETHANOL

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a new idea: that by using biotechnology, they can make affordable ethanol from something besides ears of corn.

They're all trying to solve a stubborn problem that vexes advocates for so-called biofuels, or fuel made by growing plants rather than drilling for oil. American ethanol, the most important domestic biofuel, comes from corn, and there's a limit to how much corn American farmland can produce. Currently just a tiny percentage of US automobile fuel comes from ethanol, and it can't get much higher without interfering with the food supply.

"If you want to get to energy independence, you're not going to get there from corn," says Samir Kaul of Khosla Ventures, a firm that has invested in both Mascoma and Celunol.

Better than using corn, say Kaul and others, would be to make ethanol from more profuse plant matter — cornstalks, extra woodchips, even grasses such as switchgrass.

The phrase for that plant matter, cellulosic biomass, doesn't exactly roll off the tongue. But if fuel can eventually be made from the junk parts of plants, "it really shifts the equation dramatically," says John Preston, a technology investor and MIT lecturer.

In February, Celunol broke ground on a pioneering new fuel plant in Louisiana to make ethanol out of bagasse, the residue left after sugarcane is pressed. Mascoma is building a \$30 million plant in upstate New York to make ethanol from wood chips. A plant in Iowa is being built to make it from corn cobs and stalks. All of them are trying to set the course for the next wave of biofuel.

And further down the line, they hope to apply genetic engineering more broadly to the process. Celunol, for instance, has developed a new form of sugarcane called energy cane, an inedible plant with ultra-high quantities of cellulose.

"There's no crusty old man of biofuels saying, 'This is how it's done,'" says Celunol chief Riva. "We're making it up as we go along."

The key to the process at both Celunol and Mascoma process is in breaking down the tough plant matter into a substance that can be fermented into alcohol. Enter the science of biotechnology, which can design enzymes to digest the plants and custom-make living microbes to ferment the mash. Both companies have developed their own methods, and hope to use



MASCOMA LABS

Anne Warner is one of the Mascoma Labs researchers working to engineer new bacteria capable of producing ethanol from cellulosic materials.

their new plants to demonstrate it can work at a larger scale.

Still, cellulosic ethanol has proved persistently hard to get right, never mind cheap enough to replace gasoline. Enzymes are expensive. And the microbes that turn the mash into alcohol must be hardy enough so they don't die as the alcohol content goes up. In the 1990s, Celunol — then known as BC International — tried and failed to get a commercial-scale cellulosic ethanol plant off the ground.

"The proof of the pudding is going to be in having one of these operational 365 days a year," says David Morris of the Institute for Local Self-Reliance in Minne-

apolis, who served as an energy adviser to the administrations of both Bill Clinton and George W. Bush.

Despite the uncertainties, the field has also sparked enthusiasm of investors. Venture capitalists invested \$774 million in biofuels companies in 2006, according to a trade group called the Cleantech Venture Network. That's a huge leap from the \$111 million in 2005.

Down the line, even if the companies get the process right, other obstacles loom. Fewer than 5 percent of American cars sold today can burn ethanol as fuel, according to the National Ethanol Vehicle Coalition, although the substance is

mixed in small quantities into current gasoline. And even people with "flex-fuel" cars, which can take both gasoline and ethanol, are limited by the paucity of stations that pump it.

"The oil companies control a lot of the distribution, and there's not much incentive for them to play ball," says Kaul of Khosla Ventures.

For now, cellulosic ethanol remains a research-driven business, which is why two of the leading firms are in Cambridge. Although neither is based on science invented in the Boston area — Celunol's labs are in Florida, and Mascoma's are in New Hampshire — they cite the local pool of

engineers, biotech experts, and enthusiastic venture firms.

"Almost half of our employees are PhDs, and this is where the talent is," says Mascoma chief executive Bruce Jamerson, who joined the company last month from a South Dakota ethanol maker, and still commutes on weekends back to his home near Sioux Falls.

Riva, an MIT engineering graduate, concurs. "You have to be somewhere," he says, "and from that perspective it's better to be here than close to the biomass."

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