

Will the current biofuels boom go bust?

US investors, companies and governments continue to breathlessly plug the biofuels industry, pouring dollars into new initiatives despite the rising cost of materials. On March 1 the US Department of Energy (DOE) announced it would give \$385 million to six companies to produce biofuels that are alternatives to corn-based ethanol (*Nat. Biotechnol.* **25**, 373, 2007). That followed a half-billion dollar dole by oil giant BP, in London, to a group of researchers in California in February to study alternative biofuels technologies. The momentum behind biofuels is reminiscent of the fervor over ethanol in the early 1980s, when oil prices soared and ethanol refineries popped up all over the Midwest—a boom that later devolved into dead companies and lost investments. There are some concerns that interest will again wane, but many experts also acknowledge that the industry now is much different from then. With a growing infrastructure and an evolving political outlook on the dangers posed by climate change, biofuels just might have staying power.

But times are different from 20 years ago. Private sector investment is unlike anything ethanol producers could have experienced in the 1980s. A slew of state incentives are now on the books, for the first time. Technology has ripened enough to make manufacturing more efficient and offer in the coming years some alternatives to traditional corn-based ethanol. Even oil-enamored President George W. Bush has cozied up to biofuels. In his State of the Union speech in January, Bush alluded to a plan to raise US biofuels production to five times current levels over the next ten years to help reduce reliance on Middle East oil. The Bush proposal assumes a continued switchover from corn to cellulosic sources, which include prairie grasses and cheap leftovers in fields such as straw and corn stalks. The US Senate, for its part, is calling for three billion gallons of cellulosic-sourced ethanol in 2016, rising to 21 billion gallons in 2022.

Ethanol, the most common US biofuel, is often sold as a blend called E10, which is 90% gasoline and 10% ethanol. In 2006, nearly five billion gallons of ethanol were produced in the US, made mostly from corn, in contrast to just 610 million gallons in 1985. A gasoline blend with 85% ethanol, called E85, is also available, but compatible fuel stations and vehicles are limited.

History shows that when corn prices are low and oil prices are high, ethanol can be profitable. Last summer, the industry saw that pitch-perfect scenario and investors jumped



Even high-performance race cars can run on ethanol. Biofuels get an advertising boost every year at the Indianapolis 500, to be held this year on May 27.

in (*Nat. Biotechnol.* **24**, 726, 2006). Fifteen new biorefineries opened in 2006 and construction began on 50 more. But by the end of the year the price for corn had crept up and oil prices steadied, causing some companies to delay new construction projects amid concerns over profitability. Even so, ethanol production is projected to increase ~25% by the end of 2007 over 2006, according to the Renewable Fuels Association, a Washington, DC-based trade group.

Such is the up-and-down cycle of corn-based ethanol. For the industry to succeed, producers must decrease their dependency on corn and switch to presumptively cheaper cellulosic sources. But the trouble with cellulosic ethanol is that no one has been able to produce it on a large scale, which is why the DOE is backing programs of companies including Ottawa, Ontario-based Iogen and BlueFire Ethanol in Irvine, California.

In the meantime, ethanol and biodiesel infrastructure is building—an encouraging sign for investors. In 2006, venture capital investment into biofuels topped \$740 million, according to Cleantech Venture Network in Ann Arbor, Michigan. That's seven times the investment made in 2005. Strong backing from the private sector gives biofuels more stability, because it frees them from vulnerability to political whim. "There's more staying power, because the private sector is not likely to invest one year and drop it the next," says Daniel Kammen, an energy researcher at the

University of California, Berkeley, and a recipient of BP's recent funding. The biggest biofuels investment in 2006 was \$200 million to Cilion of Goshen, California. Renewable Energy Group, in Ralston, Iowa, got a \$100 million boost for its biodiesel business (**Table 1**).

Menlo Park, California-based Khosla Ventures, one of the investors in Cilion, takes a diversified approach to backing biofuels. "We're not one to throw all our money into corn-based ethanol, but it is an important part," says Doug Cameron at Khosla. The company is investing in cellulosic companies as well as startups with alternative technologies such as LS9 in San Carlos, California, which is applying principles of synthetic biology to biofuels.

Of course, government support, when you can get it, helps. At least 21 states now offer tax incentives to ethanol retailers or producers. Iowa has some of the most aggressive incentives (**Table 2**). Among other things, it is offering to pay gas station owners up to 50% of the cost of installing the infrastructure to accommodate E85 fuel. Montana is trying to lure ethanol and biodiesel refineries to its state by offering a tax incentive to producers. Minnesota has more than 300 commercial E85 stations up and running. The state requires that every gallon of fuel contain at least 10% ethanol.

Unlike in the 1980s, some state policies are based on climate imperatives, rather than farm and economic policies, which can change with fluctuations of other commodities. In

Table 1 Top ten biofuels investments in 2006

Company (location)	Fuel	\$ (millions)
Cilion	Ethanol	200
Altra (Los Angeles)	Ethanol and biodiesel	120
Renewable Energy Group	Biodiesel	100
Altra	Ethanol and biodiesel	50
Biox (Oakville, Ontario, Canada)	Biodiesel	48
Imperium Renewables (Seattle)	Biodiesel	43
Iogen	Cellulosic ethanol	30
Mascoma (Cambridge, Massachusetts)	Cellulosic ethanol	30
Nova Biosource Fuels (Houston)	Biodiesel	18.8
Nova Energy Holdings (Houston)	Biodiesel	18.8

Source: Cleantech Venture Network, Ann Arbor, Michigan.

California, Governor Arnold Schwarzenegger signed an executive order for low-carbon fuel standards in January, driven by the desire to lower greenhouse gas emissions. "California's policy is not going to change when oil prices go down," Kammen declares.

Emissions-based policies could also put pressure on companies to roll out cellulosic ethanol, which is more sustainable and releases fewer greenhouse gasses than corn-based ethanol. The California mandate requires that by 2020, fuel carbon emissions must decrease by

10%. Corn-based ethanol alone won't meet that requirement, says Kammen.

The biofuels industry is also seeing some support from automakers. GM, Chrysler and Ford have said that half of all the cars they produce in 2010 will be 'flex-fuel', or E85-compatible. GM's Rich Gunther says the company has seen particular interest from states who want flex-fuel police cars.

On a federal level, the US government offers a \$0.51 tax incentive on every gallon of ethanol, and has mandated 7.5 billion gallons of

renewable fuel by 2012. The Environmental Protection Agency has been charged with implementing the plan on an ethanol credit system. The US also places a hefty \$0.54 tariff on every gallon of imported ethanol, which blocks out competition from big ethanol producers such as Brazil.

Nonetheless, worries that biofuels progress is being propped up on whimsical government subsidies, that public interest is fickle and that technologies for better biofuels are still a long way off haven't subsided. Some experts were saying five years ago that cellulosic ethanol was five years away. And there are practical matters with ethanol that make infrastructure difficult. It can corrode pipes, so it has to be sent by train or truck to stations, which can add considerable cost in states that are far from corn-growing areas.

Despite these concerns, biofuels experts who were around in the 1980s think it's a whole new game now. Technologies such as the power to sequence genomes, better enzymes, improved molecular biology and even synthetic biology were just a dream then, says Cameron at Khosla. "My feeling is we're going to do much better this time."

Emily Waltz, New York

Table 2 State mandates and incentives for biofuels

State	E85 stations	Mandates	Subsidies
Minnesota	>300	10% ethanol blend in gasoline; will consider 20% blend in 2010. MTBE banned.	\$0.20/gal up to 15 million gallons/year for first ten years of company's life; companies must have built refineries before 2002.
Iowa	>60 retail, 7 state fleet	All nonemergency state fleet vehicles must use E85 or biodiesel by 2010. MTBE banned. 25% of fuel sold in the state must be renewable by 2019.	Tax credits for fuel retailers whose ethanol sales are >60% of their total. Ethanol blends taxed at lower rate than gas. State pays up to 50% or \$30,000 of costs of installing E85 tanks and fuel lines. State pays up to 50% or \$50,000 for biodiesel infrastructure. Tax credits to E85 retailers.
California	~4	Fuel carbon emissions must decrease 10% by 2020. 20% of fuels must be renewable by 2020. MTBE banned.	
Montana	~10	All gasoline must be 10% ethanol blend when ethanol production surpasses 40 million gallons in Montana. MTBE banned.	\$0.20/gallon tax break on every gallon of ethanol up to \$2 million. \$0.10/gallon tax breaks for biodiesel, limited annually.
Hawaii	0	Beginning April 2, 2006, 85% of all fuel must be E10. MTBE banned.	Tax credits on investment in high technology, including biofuels.

MTBE, methyl tert-butyl ether, a fuel oxygenate that reduces auto emissions but may also find its way into groundwater. It is classified as a possible carcinogen by the Environmental Protection Agency.

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