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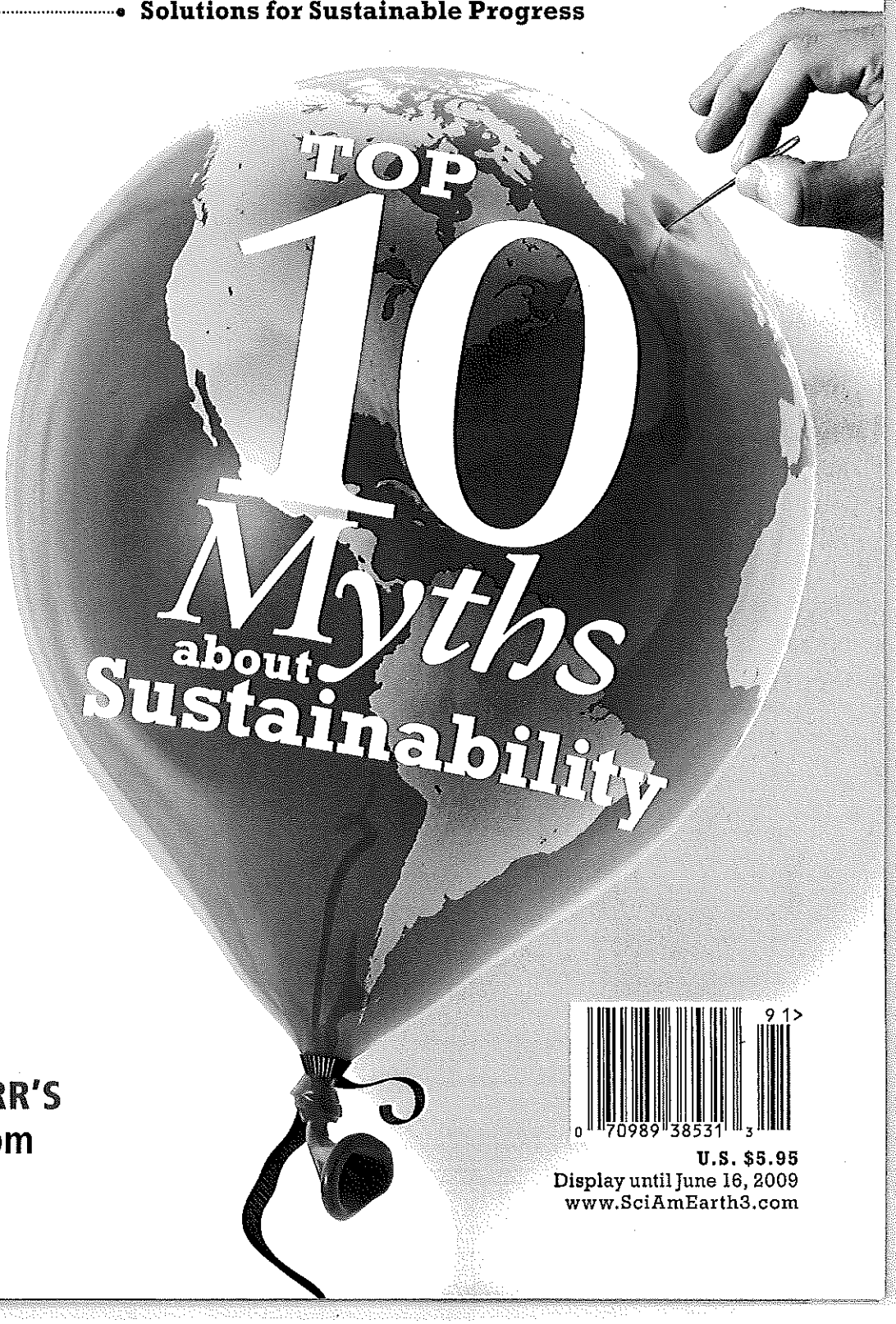

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Green Fuels for Jets

Commercial airlines are testing plant-derived jet fuels that do less damage to the environment

By David Biello

More and more frequent fliers are wringing their hands over the fact that airplanes emit greenhouse gases where they can do the most damage—high in the atmosphere. Airline companies, meanwhile, are increasingly wary of their dependence on overseas oil for fuel. Those concerns, plus the possibility that jet-fuel prices could again spike as they did in 2008, have prompted a spate of test flights powered by biofuels: planes flying on the energy-rich extracts of flowering plants, weeds and pond scum. The environmental appeal is that the growing plants absorb as much carbon dioxide as is released when their oils are burned.

Planting to Fly

On January 30 Japan Airlines flew a Boeing 747 for 90 minutes using a fuel made primarily from camelina—a flowering stalk that grows several feet tall—and small amounts of other plant oils. The blend came from Sustainable Oils in Bozeman, Mont., a joint venture of biotech firm Targeted Growth and Green Earth Fuels. Camelina can be grown without harming the soil on wheat fields when they would otherwise be left fallow.

"You give farmers an opportunity to make money in a year when they weren't going to," says Tom Todaro, CEO of Targeted Growth. "If you're expecting to have hundreds of millions of gallons of jet fuel in the next five years produced from a plant feedstock, it's almost certainly going to be camelina." His company is recruiting farmers to grow the crop as part of plans to produce one million gallons of the oil this year. "By 2010," he calculates, "we could make north of 50 million gallons."

That's a start, but every day the global commercial aviation industry burns nearly 270 million gallons of the standard Jet A kerosene. And if oil prices were to reach anything close to the $140 per barrel seen last year, demand for camelina oil could prompt farmers to grow less wheat. The aviation industry wants to steer clear of that controversy. "We don't want it to be priced above what the price is for food," says chemist Jennifer Holmgren, general manager of the renewable energy and chemicals business at UOP, a refinery division of Honeywell.

Continental Airlines

Test date: January 7, 2009
Site: Houston
Airplane: Boeing 737
Duration: Two hours
Engines: CFM International
Fuel: 50 percent biofuel from jatropha and algae

The industry is therefore experimenting with a variety of feedstocks, such as algae and jatropha—a poisonous shrub that can grow up to nine feet tall on land that is not fertile enough for food crops. "We're feedstock agnostic," Holmgren says. "They're all the same as far as we're concerned."

Test flights using various bio-jet fuels are showing consistently high-quality results. On January 7 Continental Airlines conducted the first U.S. commercial jet flight. A Boeing 737 completed a two-hour test flight from Houston with one of its two engines running on a 50–50 blend of regular Jet A and a synthetic made from jatropha and algae.

The synthetic seems to have triumphed over two historical concerns about bio-jet fuels: that their energy density was too low and that they tended to thicken at the low temperatures found at high altitudes. "The properties of the fuel are fabulous. In fact, the bio part of the blend has a lower freeze point than Jet A," says Billy Glover, managing director of environmental strategy at Boeing. "The fuels we're testing now have equal or better energy content than the Jet A requirements." UOP's alternative—known as synthetic paraffinic kerosene—also weighs less than Jet A.

For Continental's flight, Terasol Energy produced oil from jatropha seeds. But 2.5 percent of the blend also derived from algae oil procured by Sapphire Energy from Cyanotech, an al-

COURTESY OF SUSAN GROSS *UOP*

Air New Zealand
Test date: December 30, 2008
Site: Auckland
Airplane: Boeing 747
Duration: Two hours
Engines: Rolls Royce
Fuel: 50 percent biofuel from jatropha

gae grower in Hawaii. "Crude oil is nothing but algae from 10 million years ago," says Tim Zenk, vice president of corporate affairs at Sapphire. "We take that process and speed it up to produce green crude."

Of course, making algae oil in quantity remains a huge challenge, from perfecting the algae's growth to extracting the oil cost-effectively. According to Zenk, the company hopes to produce 300 barrels of oil from algae grown in brackish ponds at its test facility in New Mexico by 2011. In five years the output should reach 10,000 barrels a day, costing "between 60 and 80 dollars per barrel," he says. "That's with very conservative numbers in terms of oil produced per acre." Other players are also at work in this area: Science Applications International Corporation in San Diego has a contract with the U.S. Department of Defense to develop fuels from algae, and the San Francisco–based start-up Solazyme has made jet fuel from algae that meets commercial standards.

Where to Grow

In the meantime, efforts to grow jatropha—already planted in quantity in Africa and India—may be scaled up while camelina is improved as a rotation crop with wheat. Jet fuel from camelina and jatropha should be at the correct price point—$80 per barrel or less—within three to five years and fuel from algae in eight to 10 years, according to Holmgren. Boeing's Glover adds that "different parts of the world will source differently." To that end, chemical engineers at the University of North Dakota's Energy & Environmental Research Center have successfully turned oil from canola, coconuts and soybeans into jet fuel that rivals the conventional liquid, U.S. government tests show.

Sourcing would indeed be a big question. Critics question whether enough land would be available to meet demand. An article in the industry journal *Petroleum Review* claimed that supplying 240 million gallons of jatropha fuel—roughly the equivalent to the demand for Jet A—would require planting an area twice the size of France. Others warn that jatropha yields are unreliable and that harvesting seeds from the inedible fruit is labor-intensive. Genetic advances in biofuel plants could make them more productive [see "The Next Generation of Biofuels," on page 46]. Nevertheless, if petroleum oil stays below $80 a barrel, none of the alternative fuels may pay.

Even if hurdles are overcome, bio-jet fuel in the near term is likely to be blended with Jet A because the biofuels lack aromatics—hydrocarbon rings that interact with the seals in current engines, helping to swell them shut. "We fully expect that the first fuels will be 50–50 blends or less," Glover says. The recent flights—as well as earlier ones by Air New Zealand and Virgin Atlantic—prove that such blends can be effective. By 2017 the International Air Transport Association, an industry group that represents 93 percent of the world's carriers, hopes to source 10 percent of all aviation fuel from sustainable plant sources, both to ease the volatility of fuel prices and to cut emissions of greenhouse gases. Boeing is optimistic, too. "Three years ago we started out saying this doesn't look like it's possible," Glover says. "But every day we become more and more convinced it's not only possible, it has huge benefits for industry and the public."

David Biello is an associate editor for ScientificAmerican.com

U.S. Air Force
Test date: December 18, 2007
Site: New York City
Airplane: C-17 transport
Fuel: Synthetic derived from natural gas
Note: This alternative to oil-based fuel is not a true biofuel but can be made from coal, plant oil and wood waste