

INTERNATIONAL  
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## Turning to chemistry for alternative fuel

By **Matthew L. Wald**

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**DENVER:** Mitch Mandich proudly showed off his contraption made of tanks, valves, hoppers, augers and fans. It hissed. It gurgled. An incongruous smell wafted through the air, the scent of turpentine.

Mandich's 150-foot, or 45.72 meter, machine devours pine chips from Georgia and turns them into an energy-rich gas, a step toward making liquid fuels. His company, Range Fuels, is near the front of the pack in a technology race that could, over time, have an impact on the way America powers its automotive fleet - and could even help to ameliorate global warming.

"Somebody's going to hit a home run here," Mandich said. "We want to be first."

For years, scientists have known that the building blocks in plant matter - not just corn kernels, but also corn stalks, wood chips and even some household garbage - constituted an immense potential resource that could, in theory, fill the U.S. gasoline tanks.

Mostly, they have focused on biology as a way to do it, tinkering with bacteria or fungi that could digest the plant material, known as biomass, and extract sugar that could be fermented into ethanol. But now, nipping at the heels of various companies using biological methods, is a new group of entrepreneurs, including Mandich, who favor chemistry.

They believe that techniques borrowed from oil refining and other chemical industries will allow them to crack open big biological molecules, transforming them into ethanol or, even more interestingly, into diesel fuel and gasoline. The latter could be transported in existing pipelines and burned in existing engines without fuss. Advocates say the chemical methods may be flexible enough to go beyond traditional biomass, converting old tires or even human waste into clean transport fuel.

In Madison, Wisconsin, a company called Virent is turning sugar into gasoline, diesel, kerosene and jet fuel, with the long-run plan of getting the sugars from biomass. In Chicago, a Honeywell subsidiary called OUP is cooking various forms of biomass, what a scientist there calls "the recalcitrant stuff," into a synthetic oil that can be refined, much like oil from the ground. In Irvine, California, BlueFire ethanol is using acid to break down organic material to convert to fuel.

Possibilities like these are coming to the fore at a time when rising oil prices have spurred development of substitute fuels. Making them from biomass would be environmentally friendly in that, unlike standard ethanol, gasoline or diesel fuel, they do not entail dumping much carbon dioxide into the air. That gas, emitted in large volume when people burn fossil fuels, is the primary culprit in global warming.

Lately, these factors have resulted in a flood of investment capital into both biological and chemical techniques for using biomass. Experts consider both approaches promising and say it is too early to tell which will win.

"It's not obvious, and I don't think it will be obvious for a very long time," said Andrew Karsner, the assistant secretary of energy for energy efficiency and renewable energy, in Washington. His department is awarding grants to support both approaches.

Experts say it is possible that more than one type of plant will reach commercial success, with the ideal technique for a given locale depending on what material is available.

Range Fuels favors pine chips and other waste from softwood logging operations, largely because there is so much material available - logging in Georgia, for instance, leaves behind about a quarter of the tree.

"Bark, needles, cones - we use all of it," said Mandich, chief executive of Range. Range is a privately held company whose chief scientist, Bud Klepper, has been working on the two problems, getting gas from biomass and then converting it to liquid fuels, since the 1980s, testing over 30 feedstocks. The company is heavily backed by Vinod Khosla, a famed Silicon Valley venture capitalist who has turned his focus to energy investments.

Range plans to break ground on the first full-scale biomass-to-fuel plant in this country next month, in Soperton, Georgia. That plant, its cost not publicly disclosed, is supposed to produce 20 million gallons of ethanol a year, with additional capacity to be added later.

In Georgia alone, enough waste wood is available to make two billion gallons of ethanol a year, Mandich said. If all of that material could be captured and converted to fuel, it could displace about 1 percent of U.S. gasoline consumption.

Biomass of various types is abundant in every state, some of it gathered daily by garbage trucks. The Bush administration is counting on fuels of this sort to help limit the growth of petroleum demand, and environmentalists routinely include such fuels in their forecasts as a way to cut carbon dioxide emissions. But to date, no one has shown that the fuels can be made profitably, even when competing with gasoline at \$3 a gallon, or 79 cents a liter.

Daniel Kammen, director of the renewable and appropriate energy laboratory at the University of California at Berkeley, said that "I suspect we will have a trickle" of fuels from biomass in the next few years. But it will be only a trickle unless the government adopts quotas or offers other support, he said.

Companies like Range that are trying to convert biomass by chemical methods follow one of two broad approaches. The first is to run the material through a high-temperature, low-oxygen furnace that turns it into a type of gas known as synthesis gas. With additional processing, that gas can be converted to liquid fuels. This is the technique the Germans used during World War II to make fuel from coal, although Range said it had improved on their technology.

The second process does not break down the material as far, creating a product that resembles oil that can then be refined into liquid fuel.

Research papers and patents are flying these days as scientists struggle to refine these techniques for maximum efficiency and lowest cost. As with oil refineries, the final stages typically produce a variety of chemicals, of varying value. "Everybody is dealing with a byproduct they don't want," said Arnold Klann, chief executive of BlueFire.

Range Fuels is one of the companies that turns biomass into a gas before converting it to liquid fuel. The company wants to make ethanol, a form of alcohol, but its technique produces less valuable varieties of alcohol as well. Range Fuels scientists are tweaking their approach to maximize the ethanol yield.

The other day, laboratory technicians grabbed samples of a yellow liquid emerging from the machinery and swirled it like a suspect Chenin Blanc. An expensive chemical analyzer stood in the corner, allowing engineers to calculate what changes in temperature, pressure and flow rates would work best to produce ethanol.

Overseeing the operation, Mandich radiated confidence. "You can't have so many people at bat without hitting something," he said.

As the country seeks to develop new types of fuel, the U.S. Congress has leaned heavily toward ethanol made from corn kernels, and it is the only alternative fuel available today in large volume. Ethanol benefits from a tax break and a mandate that a significant volume of it be blended into gasoline.

Turning biomass into gasoline would be simpler, requiring no changes in the country's cars or pipelines, but government policy is tilting many research programs toward ethanol.

Range, for instance, could make any of several types of fuel from its pine chips. Asked if the company had chosen ethanol for the 51-cent-a-gallon tax break, Klepper declared: "It's the American way."

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