MSU Researchers

Turn Wood, Waste Products into Fuel

Jim Lytle

By M. Scott Morris

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Sanjeev Gajjella, standing, and Philip Steele feed sawdust into a bio-oil processor.

Simply put, supplying the country's energy needs for the 21st century and beyond is a problem in need of a solution.

"That's what we do. That's what engineers do," said Mark Bricka, associate professor of environmental and chemical engineering at Mississippi State University. "We solve problems."

About 80 faculty members, 50 graduate students and 10 post-doctoral research associates at MSU are applying their collective brainpower to the task of finding alternatives to crude oil.

"We want to develop large quantities of liquid that can go into a refinery and be converted into gasoline, diesel, jet fuel, whatever the refinery makes," said Bill Batchelor, director of the MSU Sustainable Energy Research Center (SERC) and head of the university's Department of Agricultural and Biological Engineering.

The goal is to create fuel from wood, crop residue, cotton gin trash, nuisance plants, animal waste, human waste and other organic, nonfood products that are easily found in Mississippi. Recent results in the lab have been encouraging.

"We want to compete head to head, price to price with crude oil," Batchelor said. "Biogas is looking like it's going to be competitive between $2 and $3 gasoline prices, so we're competitive today."

Researchers have discovered a cost-effective process that turns wood chips into a substance that looks a little like gasoline and a little like diesel.

"It's time to start buying timberland," said Philip Steele, professor in MSU's Department of Forest Products.

MSU has a number of successes to report, but America's energy problems are far from solved. Developments in the lab need to be tested on larger scales, where other engineering issues are bound to crop up.

"It's very exciting. We just need to turn it into companies and jobs," Batchelor said. "There are many companies interested.

"The question is, 'How do you create an industry that doesn't exist today? What are the regulations that govern it? What kind of incentives need to be put in place? Who's going to actually make these products, and who's going to buy them?'

"We're trying to get the different players together and try to figure this out," Batchelor continued. "How do we make bio-oil in Mississippi and run our cars on it?"

Areas of Study

The SERC is not focused on creating power from food crops. Both ethanol from corn and biodiesel from soybeans are available for commercial use now.

"There's a big political debate going on about how many acres of food crops can the U.S. afford to divert into making energy to drive

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Forest Products assistant research professor Fei Yu, left, watches as Will Todd, center, and Adam Telle examine a sample of MSU-produced bio-oil. Todd and Telle were among members of Sen. Thad Cochran's staff who toured MSU energy research facilities during November.

SUVs," Batchelor said. "That's becoming a big debate, and that will only increase over time."

The corn cob and husk, which can't be easily converted into alcohol, are different stories, as are wood products, switchgrass and other "energy crops" under study at MSU. The popular term for these products is biomass, but the full engineering term is lignocellulosic biomass.

"Lingocellulose contains carbon, nitrogen, hydrogen and oxygen," said Mark White, director of the Dave C. Swalm School of Chemical Engineering at MSU. "Fuel contains carbon and hydrogen. How do you take something that contains two extra things, nitrogen and oxygen, and get rid of them?"

Batchelor said MSU has three areas of study that are showing promise:

- "If you take biomass and heat it up to 500 degrees Celsius in the absence of oxygen, then that biomass vaporizes. If you liquefy it, in about 2 seconds you convert that solid material into a liquid that looks a lot like Quaker State motor oil. That motor-oil-type product can then be upgraded or refined."
- "The second technology is called synthesis gas or syngas. If you take biomass and you burn it under limited oxygen, instead of vaporizing, it turns into a gas. You can take this gas and do several things with it."
- "The idea is to grow microbes on waste that shows up at the local waste treatment plant. They take nutrients from human waste and convert it into an oil that looks a lot like vegetable oil."

continued

SYNGAS

At other MSU labs, researchers are putting wood chips, alfalfa and other products through a gasification process, creating a gas that can fuel a generator. Bricka sees definite, real-world applications for the technology.

"If you have a hurricane that knocks down a bunch of trees and knocks the power out," he said, "you can take a gasifier, put it on a trailer, and you have power anywhere. You can do it on site, and you've got an infinite amount of wood at that time."

After Hurricane Katrina, downed trees were burned. Bricka said the Federal Emergency Management Agency should invest in portable gasifiers to put that energy to good use.

"A small generator would probably power 15 trailers," Bricka said. "Imagine that."

The process is proven, but somebody will have to invest in ways to make the technology available for commercial use.

Gasification has other potential benefits, too. White runs the gas through another process, and the result looks a lot like gasoline. It's a small-scale lab test, but it's bubbling over with possibilities.

"If we could make a crude oil equivalent that the refineries would accept," White said, "then we would love that."

Another team is working on turning human waste into oil. Researchers are testing microbes that consume nutrients and carbon, and then convert that to oil.

"We're taking the food we don't digest and converting it into oil, which is a win-win for mankind," Batchelor said. "This product does not compete with the food supply, and the infrastructure already exists to collect waste and move it to one location in every community in the country."

Someday, maybe the resulting oil could be turned into biodiesel, or sent to a refinery and converted into other types of fuels.

"This year, we'll scale it up from a test-tube scale to about a 14-liter scale," Batchelor said. "There are all sorts of engineering issues with scale-ups."

Steele and his team can turn biomass into bio-oil, a black liquid with fragments floating around in a watery soup.

"You have to upgrade it," Steele said. "You cannot use bio-oil that hasn't been upgraded as a fuel."

Sanjeev Gajjella, a doctoral student, has been working with different compounds to find one that can accomplish the upgrade. The compounds are known as catalysts, and about 6 weeks ago, Gajjella hit on a good one.

"He has developed the catalyst and a method," Steele said.

The result is a product that can easily mix with gasoline and diesel.

"We burn it now. We burn it in a diesel generator," Steele said. "We burn it in a lawn mower. We burn a 5 percent mixture with conventional fuel, not to push things. Typical bio-oil is smoky when you burn it. This stuff, when you put it in a gas tank, there is no smoke coming out of that engine at all. That's at 5 percent."

Steele said that ideally, the product could be on the market in 2 years, but more tests are needed between now and then.

"It's not so bad that it breaks the lawn mower, so I'm encouraged," he said, "but we have to do some pretty detailed work."

Engineers need to study how engines respond to the stuff, and they need to produce enough of the upgraded bio-oil so it can be sent through a refinery for further inspection.

"It is pretty new. We are having to change from wood and bio-oil chemists to petroleum chemists because of this breakthrough," he said. "We're having to buy new equipment because all of a sudden we're dealing with petroleum products. It's a bit of a change, but a pleasant change."

NO MAGIC BULLET

In 2005, the U.S. consumed 20.8 million barrels of oil a day. Can biomass replace all that?

"That's a lot of wood when you think about how many billions of barrels of oil we use," Steele said.

On the plus side, an Oak Ridge National Laboratory report says wood, agricultural waste, switchgrass and other types of biomass could someday account for 30 percent of the nation's supply of transportation fuel.

"They didn't find enough to do 100 percent," Steele said. "That's a lot of biomass. You have to increase our growth of biomass a lot.

"The story is — and everybody knows it now — you're going to need wind energy, solar energy, nuclear energy, hydrogen production, bio-oil, clean coal and conservation, and we're going to hold onto oil for as long as we can."

Mississippi is historically invested in agriculture and forestry, and the state could play a pivotal role in the production of green power for years to come.

"Everything we do has to be sustainable. That's the key to the whole thing, sustainability," Bricka said. "It has to work over the long term."

Drivers are ready for relief at the pump now, but researches still have work to do.

"If Chevron today said, 'OK, we'll take 100,000 barrels a day of that bio-oil,' we don't have an industry developed to supply that," Batchelor said. "We've got to get the end-user or the customer for the product together with potential suppliers, and, as a state, figure out how to develop this industry, especially in rural areas where the biomass is.

"We're talking about good-paying jobs and especially jobs where there are no jobs right now," he continued. "It can be a really big deal for rural economic development."

How do we get from here to there? The journey will take money, time, science, industry, politics and luck.

"Forty years ago, we went to the moon," Batchelor said. "This is not beyond us. This is certainly not beyond us. We've done more complex things as a society. We're heading that way."

A BIOMASS PRIMER

Biomass is all the organic matter we see around us: paper, wood, grass, husk, etc. It basically results from the photosynthesis process in plants that use carbon dioxide, water and solar energy to produce complex organic compounds (biomass). Biomass could be imagined as a huge reservoir of "locked" carbon and solar energy. Source: www.gaebler.com/Primer-on-Biomass-Energy.htm

About SERC

The Sustainable Energy Research Center was established in January 2006 at Mississippi State University through funding from the U.S. Department of Energy. Learn more at www.serc.msstate.edu.

WHY NOT KUDZU?

It's everywhere. It's a nuisance. It's kudzu. Wouldn't it be nice if we could run our cars on it? Not going to happen, according to Mark Bricka, associate professor of environmental and chemical engineering at Mississippi State University. "Once you get it started, kudzu grows fast," he said. "But it's got a ton of water in it. Water is hard to heat. You can test it for yourself. If you've got a pot of water on your stove and you've got to boil it, it takes a long time to evaporate, right? So kudzu's out as a fuel because of the water content."