Brewing Energy from Natural Resources

Reprinted from the Summer 2006 edition of NC State's Results *magazine*

In a recent visit to North Carolina, President George W. Bush touted the benefits of ethanol and other alternative fuels that could help break America's "addiction to oil." He might have accomplished much the same thing just by telling everyone to take a look at the research being done at NC State.

"The university has always been strong in engineering and agriculture and forestry," Vice Chancellor of Research and Graduate Studies John Gilligan says, "and these are the areas where the next breakthroughs in energy research will happen."

From turning forest products and crop wastes into ethanol to harnessing clean and renewable energy sources like solar, wind, and nuclear power to developing technological innovations like smaller batteries and more reliable electrical transmission systems, North Carolina State University has been a force in energy-related research for years.

For example, how about fuel from sweet potatoes?

Drs. Craig Yencho and Bryon Sosinski want to cultivate sweet potatoes that are white inside and out, bulbous, overly starchy, and contain genes from deep-sea bacteria. These certainly aren't your grandmother's candied yams, but they just might be a future fuel source for North Carolina. The so-called industrial sweet potato is just one way that NC State researchers are trying to boost production of biofuels and reduce the need for imported petroleum. Scientists in the colleges of Engineering, Natural Resources, and Agriculture & Life Sciences are testing ways to transform crops, wood chips, and agricultural wastes into feedstocks for biofuel refineries and to fine-tune the production process.

Yencho, who ranks among the leading sweet potato researchers nationwide, has been working quietly for years to turn the tuberous root into an energy crop. "Sweet potatoes are capable of producing tremendous amounts of biomass, mostly starch-based," he says. There is also a tremendous amount of them around the state—North Carolina grows about 40 percent of the U.S. crop. Using plants from China, Africa, and South America, Yencho has created hybrids with starch contents over 50 percent higher than the sweet potatoes most Americans eat. More starch means more sugars that can be fermented into ethanol.

But producing an acre of sweet potatoes costs about ten times what it does to produce an acre of corn, the dominant source nationally for ethanol. "Sweet potatoes produce much more starch than corn, so the yield advantage is in our corner," Yencho says. "Cost is still the major impediment to the economic viability of using them as fuel." So he is studying ways to cut production costs. He also has teamed with Sosinski, an associate professor of horticulture and the director of the Genome Research Lab, on an innovative way to increase ethanol yields.

Sosinski is trying to insert genes from bacteria that live in the hot waters around thermal vents on the ocean floor into sweet potato plants. The genes are active only at high temperatures, producing enzymes that break starch chains apart into much smaller sugars. The goal is to

produce what Yencho calls a "self-processing" sweet potato that doesn't need additives to be prepared for fermentation. The harvested roots could be thrown into a vat, and when the heat is turned up, the internal enzymes would digest the starch to a point where the resulting sugars could be fermented into fuel. Sosinski is now growing genetically modified sweet potato seedlings in the lab, and he hopes to move into greenhouse trials next year and into field plantings within three years. "Sweet potatoes are just one answer to our energy needs. The key to all this is diversification," he says. "We need to get every possible energy source into the equation for the future."

Other university researchers are studying materials like switchgrass, cotton stalks, and wood chips as possible biofuel sources. And NC State has partnered with North Carolina A&T and the University of Tennessee to develop a curriculum for teaching people how to grow crops specifically for biofuel production.

"We have to figure out how to get ethanol out of more sources than just corn," says Dr. Steve Kelley, the head of NC State's Department of Wood and Paper Science, noting that biofuels now account for less than two percent of U.S. energy consumption. "There's a gathering momentum both nationally and here at NC State to get this done."

Kelley has been working on streamlining biofuel production for more than a decade, first as a researcher at the U.S. Department of Energy's National Renewable Energy Lab before arriving in Raleigh a year ago. "Mundane things like how well materials flow through pipes get very important when you're talking about commercial production," he says. To improve the processing of wood chips for fuel, for example, he is experimenting with pretreating the wood to extract sugars from the cellulose before the wood is made into paper. At the same time, he has to determine when that pretreatment begins to degrade the quality of the paper.

Ethanol and biodiesel production are beginning to take hold across the state, with entrepreneurs working to open more than a half-dozen refineries using plant starches, wood chips, and waste oils as feedstocks. Drs. Steve Peretti and Henry Lamb hope to accelerate the trend by making biofuel refining more commercially attractive. Using a three-year, $1.6 million grant from the U.S. Department of Agriculture, the chemical engineering professors have teamed with the North Carolina Solar Center to find inexpensive ways to transform glycerin, a byproduct in biodiesel production, into high-value chemicals like glycerol carbonate, which can be used to make polyesters.

Converting what is now seen as waste into a secondary revenue source could induce more people to refine biodiesel, Peretti says. "North Carolina is beholden to everybody else for its energy," he says. "Biofuel production is a way to use the agricultural resources we have to make our own energy."