Oklahoma is Leading the Way in Alternative Energy Development and Production
By Debra Levy Martinelli

In the 1985 classic comedy/science fiction movie Back to the Future, Marty McFly and "Doc" Brown travel through the history of their hometown in a garbage-fueled DeLorean time machine.

The idea of using a waste-based energy source may have seemed futuristic at the time, but the concept of biomass-to-fuels, i.e. biofuels, has been around for at least a century.

Rudolf Diesel demonstrated his engine at the 1900 World Exhibition in Paris by running it on peanut oil. Henry Ford expected his Model T, first manufactured in 1908, to run on corn-based ethanol. In the 1930s and 40s, vegetable oil was sometimes used for diesel fuel.

Petroleum, however, was the most logical fuel source because of supply, efficiency and price. Today, of course, that's changing and biomass is once again at the forefront of energy development.

Four Generations of Biofuels

At the Center for Biomass Refining based at the University of Oklahoma, chemical engineers Daniel Resasco, Lance Lobban and Richard Mallinson lead a team that is developing the third generation of biofuels.

To put that into perspective, a few words about the first two generations:

Generation one is corn-based ethanol, like what Ford envisioned for his Model T. The most common type of ethanol in the United States, corn ethanol is considered inefficient because only a portion of the crop is used in fuel production. It's also controversial, since using corn crops for fuel reduces the amount available as a food source for humans and animals. Besides, corn ethanol cannot replace currently used fossil fuels because the two are not fungible, or interchangeable.

The second generation is cellulosic ethanol, made from grasses like switchgrass, alfalfa and sorghum, which are both plentiful and sustainable. Like corn ethanol, the cellulosic form isn't fungible. "Ethanol made from any substance is still ethanol," notes Resasco.

Which brings us to generation three, being developed by the CBR team: Biofuels made from ligno-cellulosic materials, a complex mixture of lignin, an integral part of plant cell walls, with cellulose and hemicelluloses, both carbohydrate polymer fibers. The team's unique method integrates two distinct chemical processes -- pyrolysis, the chemical decomposition of a condensed substance by heating, and catalysis, the process in which the rate of a chemical reaction is either increased or decreased by means of a catalyst.

This approach produces two usable products, gasoline and diesel fuel, from grasses. And, unlike its predecessors, the biofuels made with it are both sustainable and fungible.

Another family of biofuels being investigated by CBR researchers comprises diesel fuels made from vegetable oils, including recycled restaurant fats. While easily produced, biodiesel made from vegetable oil using current technologies is known as transterification; the converting of natural vegetable oils into methyl alcohol esters, which aren't interchangeable with petroleum-based fuels. By contrast, the process developed by CBR utilizes triglycerides from vegetable oils and fats to produce diesel components compatible with standard diesel fuels.

For several years, the CBR group and other researchers have used the molecular engineering approach in the upgrading of fossil fuels. In the case of biofuels, a comparable approach has been used more sporadically. "The increasing severity of environmental regulations on fuels has made refiners during the last decade embrace the concepts of molecular management engineering. A number of the properties that determine the quality of a given fuel -- among them octane and cetane numbers; water solubility and viscosity; freezing, flash and cloud points; thermal and chemical stability, and storability; can be modified by catalytic upgrading," explains Resasco.

"The goal is not to replace gasoline or diesel, but make them from biomass rather than fossil fuels like oil and gas. By understanding the nature of the molecular structures present in biomass, we can design the optimal thermal and..."
catalytic conversions to efficiently convert it into finished products that meet current and future requirements.

The center's biofuel conversion work has captured the attention of the international scientific community and the energy industry and is supported with funding from the National Science Foundation, U.S. Department of Energy, Proctor & Gamble, Oklahoma Bioenergy Center, and Oklahoma Secretary of Energy.

Triglycerides and Grasses

While triglycerides, a type of saturated or bad fat, are typically associated with high cholesterol and cardiovascular disease in the human body, they can be converted into an efficient engine fuel. We have invented a novel method for changing triglycerides into fuel molecules to make what we call green diesel. Lobban says. Green diesel dramatically lowers the emissions and odor of diesel-powered trucks and buses.

Where do the triglycerides come from? One of the most abundant sources is algae, which need only light, water and carbon dioxide to flourish. Among the fastest growing plants on the planet, algae are able to double in size in a matter of hours. A typical algae pond is more productive per acre than most crops and can continue to grow and be harvested year round. In addition to the oils produced, the algae plant also makes proteins and starches that can be used for food for feedstock, thus there is little waste.

Because algae thrive on carbon dioxide, they are excellent carbon sequesters. The best place for algae ponds is near power stations, where carbon dioxide is an operational byproduct. The algae can absorb an enormous quantity of the gas. By using algae grown in that environment, we add one more path for the carbon dioxide, Mallinson explains.

Switchgrass, on the other hand, is a ligno-cellulosic material. Native to the American Great Plains, switchgrass is tough and hardy, growing up to 10 feet high and measuring as much as 20 inches in diameter at ground level. Its permanent root system penetrates more than 10 feet into the soil. Like algae, switchgrass grows rapidly.

Last year, the Oklahoma Bioenergy Center planted more than 1,000 acres of switchgrass near Guymon for biomass production. These fields provide a unique environment that will help us understand the production and long-term impact of bioenergy crops, says Oklahoma Secretary of Energy Bobby Wegener. Additional acreage, including switchgrass and sorghum, has also been planted in the central part of the state.

Oklahoma Commerce Secretary Natalie Shirley says the advance of renewable energy sources in Oklahoma, including biofuels, means creating green collar jobs for Oklahoma citizens and capitalizing on the state's most abundant natural resources.

Continued growth in biofuels and the renewable energy arena is a top priority of Oklahoma's overall economic development strategy, Shirley explains. With the state-of-the-art research being done in our state, we are paving the way for a bright future in alternative energy development. With bold initiatives that are energizing local economic development, promoting strong public/private partnerships, and creating an attractive business environment for research and development, renewable energy sources like biofuels are making the state's energy portfolio stronger and more diverse.

With an unlimited supply of source material and viable production technology, a start-up company is the next logical step for Resasco and his colleagues. He has some solid experience in that arena.

In 2001, Resasco founded SouthWest NanoTechnologies Inc., created to commercialize the single-wall carbon nanotube technology he developed at OU. Since then, SWeNT has grown into a privately held independent company that in 2008 moved into an 18,000-square-foot manufacturing facility on an eight-acre site in Norman. A global leader in single-walled carbon nanotube production, the company has helped Oklahoma establish itself as a center for nanotechnology innovation and commercialization.

Resasco hopes this new venture will do the same for Oklahoma's biofuels industry.

Oklahoma is emerging as a leader in biofuel development and production, he says. We expect that the work we're doing at CBR and the company we plan to create will support and enhance that position.

Marty McFly and Doc Brown surely would be impressed.
Oklahoma's Role in Biofuel Research

Switchgrass as a biofuel alternative was a hot topic at the recent 2009 BIO International Convention, the largest global event for the biotechnology industry. And Oklahoma was at the epicenter of the discussion. That's because some groundbreaking switchgrass research and development is being conducted throughout the state, from Ardmore to Norman and Stillwater. From increasing crop yields to developing novel methods to convert switchgrass into biofuel, Oklahoma is taking on the challenge from beginning to end.

Switchgrass is a perennial, drought-resistant grass that grows on marginal cropland. The native prairie grass indigenous to the American Great Plains can be grown in abundance. It has a higher energy output than corn as an ethanol feedstock and does not compete with human or animal food sources. The U.S. Department of Energy and U.S. Department of Agriculture have identified switchgrass as a prime feedstock for producing next-generation biofuels and bioproducts.

Through the Oklahoma Bioenergy Center, a world-class research center focused on biofuel research, development and education, some of Oklahoma's leading research organizations are collaborating to advance the development of cellulosic ethanol from switchgrass.

Researchers at the Samuel Roberts Noble Foundation are studying conventional and molecular breeding of switchgrass and other perennial grasses for use in renewable transportation fuel production.

At Oklahoma State University, research is under way to produce greater bioenergy yields from switchgrass and develop unique fermentation technology that ensures a high rate of energy output from the crop.

And scientists at the University of Oklahoma are exploring a wide array of biofuel options, ranging from production and processing techniques to engine design and consumer applications.

When it comes to developing switchgrass as an alternative biofuel, Oklahoma is doing it all.