The race is on for better biofuels

By UNH may lead way for better biofuels
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PORTSMOUTH — Combine the sky-rocketing price of crude oil with the environmental crisis of climate change and you have what seems like a perfect market for renewable fuels.

America's demand for energy is rising. Add the instability created by our reliance on foreign crude and all roads seem to point to increased domestic production of biofuels. But what are our choices when it comes to renewable liquid fuels, and how do the different biofuels perform in our vehicles and homes? How do they impact the environment? What do they cost and what biofuels are actually available for purchase on the Seacoast?

Barclay Jackson from Green Start, a Portsmouth-based, nonprofit advocacy group that seeks to educate about — and expand access to — biodiesel on the Seacoast sees lower prices as the key to biofuel growth.

"Biodiesel now costs the same or less than regular diesel, so people are starting to take notice," Jackson said. "But we are at square one with awareness.

"We have nearly 100 years of a crude-oil-dominated economy. Oil has been so cheap for so long, alternative fuels didn't stand a chance," said Jackson. "Now that's changing, as are consumers' priorities. People are looking closer at the full costs of the fuel they burn, and see that biodiesel is both financially and environmentally viable."

All biofuels are made from renewable plant sources. However, not all are created equal.

Each biofuel has a different energy equation, which incorporates how much fossil fuel is used to grow, produce and transport it to consumers. Ethanol and biodiesel are entirely different in energy balance, source, production and use.

Ethanol

Ethanol is processed grain alcohol. To turn plant matter into alcohol, the plant's starch must be converted to sugar and then fermented and distilled, requiring heat and energy.

In the U.S., where most ethanol is currently made from corn, coal or natural gas is burned to turn the corn into grain alcohol, making this an environmentally undesirable process. This is why the energy balance, (the fossil fuel needed to make the renewable fuel) of corn ethanol, is unimpressive.

One gallon of fossil fuel makes only 1.3 gallons of ethanol. It is also why burning corn ethanol reduces CO2 emissions by only 22 percent. (One gallon of gas emits 20.4 pounds of CO2, while one gallon of corn ethanol emits 16.2 pounds of CO2.)

"Some models show the energy balance of corn ethanol at 1-to-1 or even less, meaning that, U.S. corn ethanol uses as much fossil fuel energy as it creates in renewable fuels," says Deana Aulisio, a doctorate candidate in sustainable energy at the University of New Hampshire and an expert in biofuels. "This field is wide open right now and there is a scramble to produce biofuels efficiently.

"There are many ways to do it, but currently the infrastructure is in place for corn ethanol and that is why it is getting so much play," Aulisio said. "It is certainly not because it is the most efficient source of fuel."

Most American consumers don't know that every gallon of gasoline currently on the market contains 10 percent corn ethanol. That makes it a biofuel we are all using every day.

Corn ethanol is made by using the whole cob. Ground corn is mixed with water and heated; enzymes are added to turn the corn's starch into sugar.

Yeast ferments the sugar into grain alcohol. This process gives off large amounts of CO2, the main gas responsible for climate change and it also uses massive amounts of water; a typical corn ethanol facility uses 500 gallons of water a minute.

Growing corn also requires nitrogen fertilizers which are made from natural gas. Corn planting, and harvesting demand the heavy use of machinery and degrade the quality of the soil.

"You need to use the actual kernels, which could serve as food, so you have corn ethanol competing with a food source which brings us into the whole food versus fuel argument," said Dr. Susan Leschine of Sun Ethanol in Hadley, Mass., a company leading the field of cellulosic ethanol technology development.

The corn ethanol currently available on the U.S. market is E85, which is 85 percent ethanol, 15 percent petroleum. While the "first" cars invented were originally designed to run on grain alcohol, (a crude form of ethanol), today's gas engines can not run on a high ethanol blend. Only vehicles that carry the "flexfuel" system can run E85.

There are approximately 5 million to 6 million flexfuel vehicles in the U.S., and while no sources of E85 currently exist on the Seacoast, one biofuels company is hoping to open a filling station in Dover this spring.

"The plans are on the drawing board," said Andrew Kellar of Stratham's Simply Green. "We had hoped for a filling station in Portsmouth, but now we are looking at a site in Dover.

"This is key for residents who want real renewable choices for their vehicles," said Kellar. "We will offer all blends of biodiesel as well as E85 ethanol for flexfuel vehicles."

Corn not only source

But corn is not the only source for ethanol. Brazil is the world's largest producer of ethanol from sugarcane and has become almost entirely energy independent. Making ethanol from sugarcane requires far less energy than from corn; the cane begins to ferment the moment the stalk is cut and there is no need to convert starch to sugar. The distillation and fermentation process is quick and easy and the heat orenergy needed for the process is generated not by fossil fuels but by cane ethanol. The ethanol yield per acre of sugarcane is more than twice that of corn; sugarcane can be harvested seven times a year compared to soy and corn's single yearly harvest. And, engines that run on cane ethanol crank out more power than typical gas engines because cane ethanol burns at a higher compression. Sound perfect? Perhaps for Brazil, but it would not be cost effective or environmentally sustainable to ship cane ethanol to other markets, and if rainforest is being leveled to plant the sugarcane, the net C02 gains vanish, (rainforest is a major digester of C02). But with an energy balance of 1 to 8, cane ethanol has definitely taken hold of the Brazilian economy. Greenhouse gas emissions are also lower than corn with nine pounds of CO2 per cane gallon for a 56 percent reduction of CO2 over regular gasoline, (again, if forest has not been cut to plant the sugarcane).

Biodiesel

Unlike ethanol, biodiesel is made from chemically altering plant oils — in the U.S. that usually involves soy. Here soy is grown mainly for livestock feed — the excess oil from the crushed soy husk is used to make biodiesel. Biodiesel's main strength rests on the fact that the fuel oil is just one of many uses derived from the same plant.

"This has to be one of biodiesels' primary attractions — the oil used to make the fuel is a by-product, so the food value is not lost," said Dorn Cox, a New Hampshire farmer and biodiesel pioneer, who grows a sunflower crop in conjunction with UNH that is being used both for food and fuel. "This is how the soy industry got into biodiesel; they had leftover oil after making their main product —

animal feed."

The making of biodiesel requires no starch-to-sugar conversion, distillation or fermentation, thus it inherently requires less energy than making corn ethanol. But, because vegetable or plant oil is too thick to run effectively in diesel engines, it must be altered to become fuel.

Plant oil consists of fatty acids and glycerin. The glycerin must be removed from the oil to convert it to fuel.

The process of removing that thickness is called transesterification and is done by mixing an alcohol and a catalyst with the oil to separate out the glycerin. Once the glycerin is removed from the oil, it can run smoothly in any diesel engine without major conversions or modifications.

Biodiesel can power any diesel vehicle, equipment or generator. It can also be used in any oil burning furnace because home heating oil is essentially diesel.

Biodiesel, at least for home heating purposes, can now be purchased from any number of Bioheat dealers on the Seacoast, including but not limited to, Simply Green, Proulx Oil, P. Gagnon and Lamprey Oil. There are currently no biodiesel filling stations on the Seacoast, but biodiesel will be offered at the new biofuels station slated for Dover.

"Seacoast residents and businesses with diesel vehicles don't have to wait for the filling station if they want to run biodiesel," Kellar said. "We can deliver barrels of 100 percent soy-based biodiesel, (B100), to any location, and you can pump it yourself right from the barrel with a hand-pump."

Cox believes producing biofuels locally is the key to any fuels' sustainability.

"Ultimately we want to have a biodiesel that can be grown, harvested and processed right here in New Hampshire. When you produce it locally you really begin to improve your energy equation," he said. "Biodiesel does not have to come from soy; there are so many different plant sources of fuel.

"The real future is local economies making their own, region- specific biofuel," he said. "That way you create local jobs while increasing the fuel's energy balance because it doesn't have to travel so far to get to the consumer."

Germany is the world's largest producer and user of biodiesel, using canola oil instead of soy. Waste vegetable oil is another source, as is palm oil and even tallow from animal fat.

Biodiesel's handicap is in yield per acre; one acre of soy yields only 60 gallons of biodiesel whereas corn yields 300 gallons of ethanol. And, biodiesel has a higher cloud point than regular diesel, meaning it is sensitive to cold.

In the cold New England winters, biodiesel users run a lower blend of the renewable fuel in vehicles or install a warming system. Biodiesel is available on the Seacoast in all blends ranging from B5 (5 percent biodiesel, 95 percent petrodiesel) to B100 (100 percent biodiesel) and is available for home heating (Bioheat) as 5 percent or 20 percent biodiesel blended with home heating oil.

Compared to corn ethanol, biodiesel emits far fewer greenhouse gases; only 7.6 pounds of C02 per gallon, for a 68 percent reduction in C02 over petrodiesel. The energy balance of biodiesel is also an improvement over corn ethanol with one unit of fossil fuel energy producing up to five units of biodiesel.

The future

And what is coming in the future? There is no question the race is on for more efficient biofuels that have better energy balances, emit lower amounts of CO2, don't compete with food stock, can be produced locally and are cost-competitive.

Scientists, environmentalists and energy entrepreneurs agree the future lies in cellulosic ethanol and

algae biodiesel; emerging biofuels still in the research and development stages.

Cellulosic ethanol is made from any plant by-products, including, but not limited to, agricultural residues (left over material from crops like stalks, leaves and husks), forestry waste (wood chips, sawdust, tree bark), municipal solid waste (household garbage and paper products), and paper pulp. Because it can be made from literally anything containing cellulose, cellulosic ethanol would not compete with food crops. Cellulose is the chain of sugar molecules that make up plant cell walls and in order for it to be turned into fuel it must be pretreated with heat and acid, mixed with enzymes and fermented.

Researchers at Dartmouth have teamed up with Boston-based renewable technology innovator, Mascoma to turn local plant life or biomass into fuel. Certain strains of willow are being studied for their biomass potential, and timber and paper waste are being tested, but cellulosic ethanol still has a long journey from the lab to your fuel tank.

"Cellulosic ethanol has potential in Maine and New Hampshire," Cox said. "We've got a timber industry, a paper industry — these can be tapped, but its going to require investment and innovation, not only in research and production, but also in infrastructure."

Cellulosic ethanol can also be made from fast growing perennial prairie grasses like switch grass and buffalo grass, which actually draw C02 into the soil and require little to no energy to grow and harvest. These grasses can be grown on land unfit for other crops, so again, there is no competition between food and fuel.

The energy balance of cellulosic ethanol can be as high as 1-to-36, depending on what's used and how it's produced. One ton of plant by-products or grasses can produce 70 gallons of cellulosic ethanol.

CO2 emissions are reduced by 91 percent — one gallon of cellulosic ethanol emits only 1.9 pounds of CO2. Yet, its main stumbling block remains the difficulty of converting the cellulose with effective enzymes into fuel.

Massachusetts-based Sun Ethanol has discovered a special microbe in mud called the Q enzyme that is breaking down that barrier.

"The Q microbe makes more ethanol than any other enzyme, eliminating or reducing the steps that have been cost prohibitive in the past for cellulosic ethanol production," said Q discoverer Dr. Susan Leschine.

But the real promise in biofuels comes from algae; those single-celled plants that grow in any wastewater and the ocean. Algae need only C02, sunlight and nutrients to grow. Algae make both starches that can be turned into ethanol and oil that can be converted to biodiesel (or jet fuel).

Algae doubles in mass within hours and it eats the greenhouse gas, CO2, as well as other pollutants. An acre of algae can possibly produce 5,000-15,000 gallons of biofuel yearly. It is harvested daily.

Algae biofuel production is still in development and is not available on the market. UNH is planning a research project to study the potential of growing algae in closed photo bioreactors for fuel.

Aulisio said she hopes to head this research project.

"The exciting part is that we would use waste gas (methane) from the Rochester landfill to feed our algae," she said. "It would be what is called a closed-loop energy system in which nothing is wasted — our algae greenhouse would be right there on the land fill gorging itself on the CO2 the landfill emits."

If the project is approved, the reactor would be constructed at the Turnkey Waste Management

landfill in Rochester. By using residual CO2 from the methane gas generation facility, as well as landfill leachate, as a nutrient source, UNH hopes to create a sustainable means of producing biodiesel feedstocks locally.

Other algae development schemes in the U.S are located right under fossil fuel burning power plants, rapidly consuming the CO2 they emit.

"We would like to be able to produce fuel right here in New Hampshire," said Aulisio. "Generally, algae fuel projects are done in warmer climates, but we want to see if it is feasible to create our own sustainable biofuel in a colder climate.

"This is the way of the future," she said. "Invest in local alternative fuels, jump-start our regional economy, alleviate our reliance on foreign extracted fossil fuels, and cut our CO2 — this is all possible with algae.

"Biofuel from algae could someday support the liquid fuel needs of the entire state," added Aulisio.