Researchers Get Bio Ready

The world's appetite for energy continues to expand. And while demand for oil and natural gas isn't likely to wane any time soon, there's also a growing hunger for energy sources that are renewable and eco-friendly. A team of UL Lafayette experts is exploring some intriguing alternatives to fossil fuels.

BY SARAH SPELL

PHOTOGRAPHY BY DOUG DUGAS

Dr. Barbara Benson leans forward, taking a closer look at a tabletop aquarium in an engineering lab in UL Lafayette's Madison Hall. ● To the untrained eye, the tank filled with olive green slime may look like a science experiment run amok. To Benson, the algae growing inside are a beautiful sight. In the murky water, she sees a source of renewable energy. ● Benson is an assistant professor of environmental science in the Department of Renewable Resources. She is part of UL Lafayette's Bioprocessing Research Laboratory, a multidisciplinary effort involving more than 20 faculty members from the College of Engineering, the Ray P. Authement College of Sciences and the B.I. Moody III College of Business Administration. The engineers, chemists, biologists, economists and the students who study with them, are investigating alternatives to petroleum-based fuels. ● The Bioprocessing Research Laboratory encompasses several facilities across campus where experiments are under way to unlock power from a variety of materials, from algae to alligator fat, from sweet potatoes to sausages.

Left: Dried, crushed algae. Opposite page: Vaughn Hulin, a freshman chemical engineering student, takes a sample from a 10-liter biodiesel reactor in a Madison Hall lab.

BIOFUELS GLOSSARY

biofuel: fuel made from renewable biological resources

biodiesel: liquid fuel produced by the separation of fats and glycerin in biological material. It can be used in diesel engines.

biomass: biological source material. Biomass can include but is not limited to wood; grasses and woody plants; food crops; animal parts; algae; and the organic components of municipal and industrial waste.

energy crops: agricultural crops grown specifically for their energy value

ethanol: liquid fuel produced from the fermentation of sugar that can be used in gasoline engines

feedstock: biological material used in the creation of a particular biofuel

gasification: heat process used to convert carbon-based materials into a gas that contains carbon monoxide, carbon dioxide and hydrogen

green diesel: liquid fuel derived from biomass. Unlike biodiesel, green diesel is compatible with exisiting petroleum industry infrastructure.

syngas: synthesis gas; gas produced from biomass through the gasification process. Syngas can be used to produce liquid fuels, including ethanol and green diesel, as well as other chemicals and products, such as biodegradable plastics.

transesterification: the chemical process in which alcohol reacts with trigylcerides in vegetable oil or animal fats, separating the glycerin and producing biodiesel

DR. MARK ZAPPI, dean of the College of Engineering and leader of the research team, describes the quest for alternative energy as a "horse race" of competing technologies. "It's too early to tell how that race will end. So, we're spreading our bets, collaborating on several possible solutions," he said.

Dr. Mark Zappi, Dean of the College of Engineering

When Zappi was named dean in 2005, he was well-qualified to establish high-level biofuels research. He earned a bachelor's degree in civil engineering from UL Lafayette and then began more than a decade of work as an environmental engineer at the U.S. Army Corps of Engineers' Waterways Experiment Station in Vicksburg, Miss. While working there, he completed master's and doctoral degrees in chemical engineering at Mississippi State University. In 1995, he began his academic career at MSU.

While at MSU, Zappi conducted research, taught classes and was director of the Mississippi University Research Consortium for the Utilization of Biomass and director of the MSU Environmental Technology Research Laboratory. During his career, he's helped secure $30 million for projects ranging from basic technology research and development to industrial economic development.

He serves as an advisor to several Mississippi companies involved with biofuels and bioproduct development.

At MSU, Zappi and other scientists created a manure biorefinery on a poultry farm in south Mississippi to conduct to research poultry litter as a power source. The biorefinery on the 1,000-acre farm transforms chicken

LOUISIANA'S REGIONAL ADVANTAGES & POTENTIAL ENERGY SOURCES

Acadiana is an international hub of the oil-and-gas industry. Its infrastructure and shipping capabilities could be used to produce and distribute alternative energy.

Dr. Barbara Benson, assistant professor of environmental science, and chemical engineering graduate student Harry Daultani inoculate a bioreactor tank with algae.

litter into a methane-rich biogas, which is then used to generate electricity. Solids and liquids left over from the process can be used as fertilizer.

"To see a project like that move from idea to reality is extremely rewarding. But what's more exciting is that it shows the potential for biofuels research in general," he said.

ZAPPI SAID UL LAFAYETTE RESEARCHERS ARE "RE-thinking and rebuilding" Louisiana's energy industry. "Louisiana is well-positioned to make an economic and industrial transition to biofuels. We have the infrastructure and industry already in place, along with research capabilities."

UL Lafayette is a member of the statewide Clean Power and Energy Research Consortium, which includes Tulane University, Louisiana State University, Nicholls State University, Southern University, the University of New Orleans and the LSU AgCenter. The consortium supports interdisciplinary research to improve existing energy technology and to explore alternative energy sources.

"Petroleum is a finite resource," Zappi said. "Expert opinions differ as to when petroleum supplies will be depleted but I think the economics of petroleum will play out before the world actually runs out of petroleum. There will be an economic shift toward renewable fuels. We're preparing for that shift by conducting a broad range of research."

He points to a number of indicators that suggest that shift may already have started. For instance, the Obama administration's economic stimulus bill, signed into law in February, has earmarked billions of dollars for grants, tax credits and investments in clean energy development and training. And, noted Zappi, "oil and gas companies are redefining themselves as energy companies." Last year, Exxon Mobil announced it would invest $600 million to produce fuel from algae. Chevron and Weyerhaeuser have a partnership to develop biofuels from wood waste.

Non-toxic and biodegradable, biofuels can be made from any biomass, or biological source. Two of the most promising options are

COMPONENTS OF A SUCCESSFUL BIOFUEL INDUSTRY

Renewable Feedstocks
Long-term availability
Chemical stability
Suitable land

Resource Collection
Harvesting
Storage and handling
Transportation

Product Conversion
Processing and waste management
Potential to create secondary products
Profit analysis

Product Distribution/Usage
Market development
Price
Product performance

Judith Adewusi, a chemical engineering graduate student, compares the amount of oil produced by yeast grown on rice versus yeast grown on sweet potatoes.

ethanol and biodiesel. Consumers are likely familiar with ethanol, which is often blended into gasoline at the pump. Ethanol is an alcohol, but it is also a hydrocarbon, which makes it compatible with gasoline.

Ethanol can be made from three types of feedstock: sugars, starches and cellulosic, or plant, material. Brazil, the world's largest exporter of ethanol, produces the fuel from sugar cane. In the United States, corn has been the staple ingredient in ethanol. Unlike sugar cane, corn requires an additional processing step of fermentation – to convert the cornstarch into sugar – before it can become fuel.

"There's at least one other drawback, Zappi said. "Using corn as a feedstock has really spurred the food-versus-fuel debate."

Louisiana moved away from corn-based ethanol in 2008 with the creation of the Advanced Biofuel Industry Initiative, signed into law by Gov. Bobby Jindal. The legislation created a pilot program that combines research, production and distribution of non-corn based ethanol.

Zappi said the UL Lafayette team is exploring sources such as cultivated plant materials and waste materials that don't compete with food supply.

Plants can be cost-efficient to grow and harvest for biomass feedstock and can provide a desirable feedstock-to-fuel ratio. UL Lafayette researchers are also exploring the use of low-grade rice and waste sweet potatoes to produce ethanol.

SWEET POTATOES

RICE

Biodiesel is made from plant or animal oils through a chemical process called transesterification, which transforms fats into fuel. Green diesel, or renewable diesel, is made through catalytic processing of the oils produced from biomass, a process that's similar to the traditional refining process for petroleum crude oils.

Dr. Stephen Dufreche, an assistant professor of chemical engineering at UL Lafayette, said biodiesel is relatively simple to make. "With the right equipment and materials, you could make it at home," he said. In the engineering lab, researchers use a portable reactor to produce biodiesel.

That fuel could go into a standard diesel engine, but might cause some problems, said Dufreche. The fats congeal in cold temperatures, changing the liquid fuel to a gel. And because biodiesel is a solvent, it will break down deposits of residue left by diesel, clogging fuel lines.

Green diesel is chemically similar to traditional

Continued on page 28

'THERE WILL BE AN ECONOMIC SHIFT TOWARD RENEWABLE FUELS. WE'RE PREPARING FOR THAT SHIFT BY CONDUCTING A BROAD RANGE OF RESEARCH.'

DR. MARK ZAPPI, DEAN OF THE COLLEGE OF ENGINEERING

TECHNOLOGY ENABLES RESEARCHERS TO SEE MOLECULES IN A NEW LIGHT

An interdisciplinary team of top researchers at the University of Louisiana at Lafayette is exploring a "green" way to use glycerol, a byproduct of biodiesel manufacturing.

Its members are identifying and testing enzymes present in bacteria commonly found in soil. An enzyme is a protein that speeds up chemical processes. These scientists are working to develop enzymes that are able to convert glycerol into compounds with much higher value for the chemical industry.

They are harnessing the power of Zeke, UL Lafayette's supercomputer, to make mind-boggling computations and then convert these data into images that can be examined using virtual reality at the Louisiana Immersive Technologies Enterprise on campus.

LITE is one of only a few public facilities that combine high-speed networks and high-performance computing with 3-D visualization and immersive technologies.

"So this enzyme project is an amazing confluence of brainpower, computer horsepower, computational chemistry and advanced immersive visualization," said Dr. Bradd Clark, dean of the Ray P. Authement College of Sciences at UL Lafayette.

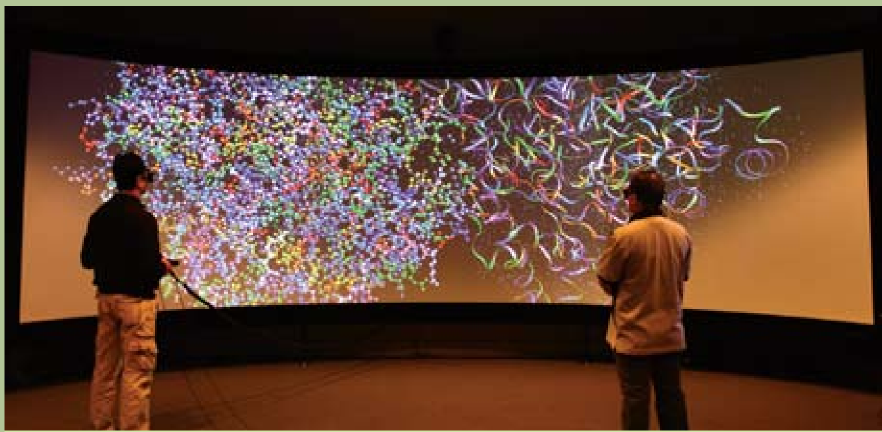
As the volume of biodiesel, an alternative to fossil fuels, has increased dramatically worldwide, the amount of glycerol produced has grown too. For every 10 pounds of biodiesel, about a pound of glycerol is created. So glycerol is abundant and inexpensive but of limited use.

Dr. Rakesh K. Bajpai is a professor of chemical engineering and holds UL Lafayette's endowed chair in bioprocessing. He is also associate director of the Bioprocessing Research Laboratory in the university's College of Engineering.

Using a chemically modified enzyme to convert glycerol would be a "green" alternative to chemical processes that require more energy, Bajpai said. "Using this modified enzyme, we would not be producing anything harmful and we would reduce waste."

Enzyme development is of great interest in Europe and the United States. In 1994, a French group of scientists sequenced the gene of an enzyme that was capable of converting glycerol. Last year, a patent was granted for improvements of the enzyme's properties. When a patent is obtained, future work on that enzyme becomes off limits to other researchers.

Clark said Dr. Wu Xu, an associate professor of biochemistry at UL Lafayette, is working to improve a different type of enzyme, one that is even more efficient than the patented one.



SI FENG

Dr. Dipesh Bhattarai, left, and Si Feng use The Flex, an immersive visualization tool, to get a 3-D look at a glycerol dehydratase protein molecule.

Xu has identified about 25 similar enzymes. However, testing each enzyme using traditional chemistry would be expensive and time consuming. So scientists at UL Lafayette's Center for Advanced Computer Studies are using its supercomputer, Zeke, to come up with calculations and visualizations of enzymes ideal for glycerol conversion.

Bajpai explained that enzymes fit chemical compounds "like a key in a lock." The desired product of the enzyme is obtained when a water molecule is removed from glycerol. "If the glycerol fits exactly, the enzyme can unlock the water molecule. If it doesn't match up precisely, nothing will happen," he said.

Dr. Dipesh Bhattarai and Si Feng, UL Lafayette research scientists, used the computations of Dr. Yen-Shan Liu, a researcher in Dr. Wu's lab, to develop 3-D images of the enzyme with the most potential.

These enzyme molecules are large. That may seem like an oxymoron, but in the overall scheme of tiny particles that make up matter, enzyme molecules are giants.

Some molecules are composed of only a few atoms. The enzymes that the UL Lafayette team is studying are made up of about 15,000 atoms.

The images can be displayed in The Flex, an interactive 3-D immersive space in LITE that has a three-projector curved screen, motion tracking and an immersive sound system. The researchers can add and subtract atoms; the images morph to illustrate the new configurations.

When viewed through special eyeglasses, the images are three-dimensional. "You actually feel like you can touch the molecule. That's the exciting part," Bhattarai said.

When the scientists find the virtual enzyme they want to produce in the laboratory, they will turn to another team member, Dr. Andrei Chistoserdov, an associate professor of biology and microbiology, to genetically modify the bacteria so they will produce desired enzymes.

LITE's technology may be used in another enzyme-related project. Dr. Stephen Dufreche, an assistant professor of chemical engineering, is exploring the use of enzymes to create trinitrotoluene, better known as TNT.

Chemical processes have been used to make the explosive for the past 80 or 90 years. "But with those processes, we make an undesirable byproduct in environmentally unacceptable quantities," Bajpai said. "We think that if we can make it enzymatically, we can make it in an environmentally safe manner."

POWERFUL PARTNERSHIP

An alternative energy production facility planned for Acadia Parish will provide UL faculty and students with research opportunities while generating power for Louisiana utility customers.

Cleco Power LLC will build a $1.5 million gasifier on a five-acre site in Acadia Parish Industrial Park, adjacent to interstate and rail transportation. The project is a partnership among Cleco, NorthStar Resources LLC, Acadia Parish and UL Lafayette's College of Engineering. Construction is set to begin this summer.

Dr. John Guillory, associate professor and acting head of UL Lafayette's Department of Mechanical Engineering, is the lead designer of the facility. He collaborated with EDG Inc., an international engineering firm based in Louisiana.

Dr. Mark Zappi, dean of UL Lafayettte's College of Engineering said the gasifier will be a training facility where students learn to make fuels.

"A gasifier can transform any combustible material," he explained. Material is burned at high temperatures with low levels of oxygen. Instead of burning completely, the raw material is converted into syngas, or synthesis gas, a mixture of hydrogen, carbon monoxide and carbon dioxide. Syngas can be processed further to generate electricity or create liquid fuels or other chemical compounds.

"We're essentially ripping apart complex chemicals and reducing them to their building blocks. Then we can reassemble those chemicals into compounds we want to produce," Zappi said.

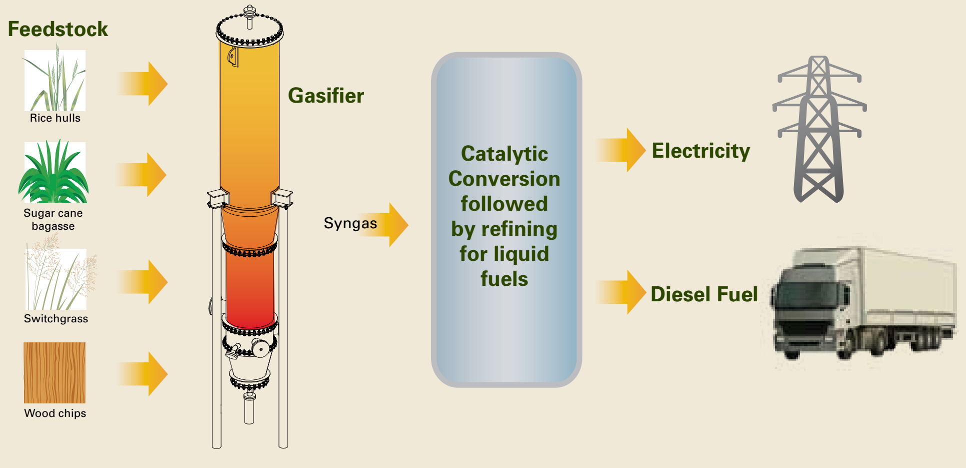
Students and faculty will explore the energy potential of rice hulls, sugar cane bagasse, poultry litter and sewage sludge. Researchers are also considering cultivated energy crops, such as switchgrass, a perennial grass native to Louisiana's coastal prairie, and giant reed, a grass that produces a bamboo-like stalk. The facility is designed to process three tons of material each day.

"UL Lafayette will be one of a few institutions to have access to a large-scale facility," said Zappi. The facility will be a model for commercialization of full-scale gasifiers. "It is designed exactly as an industrial facility, with all of the safety systems and protocols in place," he said.

Ben Russo, director of market development for Cleco, said the research and development facility will help his company form long-range plans for investment in alternative energy. "We've been moving in this direction for about two years, but we still have lots of unanswered questions about what materials will work best and what the overall cost may be.

"We want to look at a wide variety of renewable energy sources. Ultimately, the research conducted by the UL Lafayette group will help us determine a cost-benefit ratio for a variety of materials. We want to know, for instance, how much energy we can produce from a ton of rice hulls or a ton of wood chips."

FEEDSTOCK TO FUEL



Continued from page 26

diesel, so it doesn't present those challenges. It remains fluid in cold temperatures and can be used in existing industry infrastructure. It can be blended with diesel and produces lower emissions than traditional diesel.

"Because of the obvious advantages, energy companies are moving away from investing in biodiesel development in favor of renewable diesel," Dufreche said.

UL Lafayette scientists are addressing two primary challenges in biofuels research: developing high-yield feedstocks, or biological source material, and cost-effective extraction and refining methods. *(See related article, page 27.)*

The most desirable feedstocks for biodiesel contain high amounts of fat, which can be refined into fuel. Chinese tallow trees, for example, are "an almost perfect feedstock" for green diesel, Dufreche said. That's because their white, waxy seeds yield large amounts of polysaturated fat.

"To produce renewable diesel, you have to introduce high levels of hydrogen into the refining process. If you're working with a highly saturated feedstock, it's already full of hydrogen to begin with," he said.

In addition to tallow trees, the UL Lafayette research team is analyzing alligator fat as a fuel source, Dufreche said. "We can look at almost any oil as a basis for research. What we want to know is: Can we develop technology to produce that fuel in a way that is both cost efficient and environmentally responsible?"

Louisiana sweet potatoes may be a source of fuel, according to research under way in UL Lafayette laboratories. The work is being led by Dr. Rakesh K. Bajpai, a professor of chemical engineering. Bajpai, who came to UL Lafayette from the University of Missouri-Columbia, is an internationally known biofuels expert.

Satish Patil is a graduate student working in Bajpai's lab.

“We are focusing on sweet potato starch because we are in Louisiana, partnering with local industry,” Patil said.

Each fall, part of the crop is left in the field because it doesn’t measure up to food-grade standards. Researchers are using sweet potato waste — raw sweet potatoes and sweet potato peels — as food for yeast.

CHINESE TALLOW TREE

LOUISIANA ALLIGATOR

LAFAYETTE CONVENTION & VISITORS COMMISSION

“The yeast we are using for our research has strong extracellular enzyme activity, which means it has the ability to break down the sweet potato starch and consume it,” Patil explained. As the yeast, or fungi, feed on the starch, they produce oil.

He measures the amounts of carbon and nitrogen as the fermentation process unfolds. As the yeast deplete the carbon in the starch, nitrogen levels rise. “As long as carbon is present, the yeast are multiplying. But when they

Top: Chemical engineering graduate student Satish Patil takes a sample of algae grown under fluorescent light. Patil built the reactors, which are used in a Madison Hall laboratory. Above: Srividya Ayalasomayajula filters oil from alligator fat.

Chemical engineering student Bridget Meaux measures the amount of methane being produced by fermenting sewage sludge.

start feeding on nitrogen, the oil globules become bigger and bigger."

Patil is also exploring ways to extract the oil, including using ultrasonic waves to break open the cells, and using solvents to remove the oil through a chemical reaction.

ZAPPI SAID WHEN RESEARCHERS CAN "TAKE SOMEthing out of the waste stream and convert it to energy, they know they're on the right track. Waste disposal is often a major cost to industry. We can take that waste and turn it into a product that has value."

He and his team are taking samples of sewage sludge from the Lafayette Utilities System's wastewater treat-

'WASTE DISPOSAL IS OFTEN A MAJOR COST TO INDUSTRY. WE CAN TAKE THAT WASTE AND TURN IT INTO A PRODUCT THAT HAS VALUE.'

DR. MARK ZAPPI, DEAN OF THE COLLEGE OF ENGINEERING

LUS WASTEWATER POND

ment plants to explore the potential to make fuels and other products. Oil can be harvested from the sludge for biodiesel or green diesel. The sludge can also be used as a fuel source in a gasifier, a facility that burns biological matter to produce synthesis gas, or syngas *(See related story on page 28 for more information.)*

Bridget Meaux, a chemical engineering undergraduate, has conducted experiments to measure the amount of methane produced by sewage sludge and other materials. To take those measurements, she uses a small bioreactor, a glass vial topped with an air-pressure gauge. "We built these bioreactors to find out how much gas is being produced. Whatever's in there, it will release gas under airtight conditions," she said. Bacteria digest the biological material, producing methane.

Meaux has worked with algae, sewage sludge and other ingredients. "We added chicken blood, old meat, chicken litter. It was disgusting, but it created more gas," she observed.

"We also added vitamin solutions to the reactors. Just as the function of a human body is improved and enhanced with vitamins, so are the bacteria's."

ONE OF THE MOST PROMISING SOURCES OF ALTERnative fuel is algae. The microorganisms produce lipids, natural oils that can be converted into biodiesel and green diesel.

Dr. Barbara Benson said algae "don't require much. They need sunlight and water, carbon dioxide and trace nutrients to grow." They aren't picky about water conditions either. Algae are found in saltwater, freshwater and brackish water.

Benson and her students are cultivating and evaluating multiple strains of algae, measuring and analyzing their growth rates and levels of oil production.

"I was originally interested in algae as a source of pharmaceuticals and nutritional supplements. When I came to UL Lafayette, Dean Zappi steered me in the

STUDENTS CREATE VEHICLE FOR SERVICE LEARNING

UL Lafayette students are preparing to hit the road to educate others about sustainable living. The RUNbus, a modified school bus, will serve as a mobile classroom for demonstrations of clean energy, energy-efficient building strategies and community-based food production. It will include seating, cooking and sleeping facilities, and a 12-foot-square, foldout stage.

UL Lafayette student Chance Gabehart organized the Resourceful University Network, a non-profit student group devoted to environmental awareness, in 2008. "We were looking for a fun way to network with other people with the same interests. During one of our meetings, someone suggested a bus that could run on used cooking oil."

Gabehart purchased a used bus for $1,500 and donated it to the non-profit group. "We wrote three grants, none of which were funded, but we learned a lot in the grant-writing process. It forced us to solidify our ideas," he said. Gabehart is a senior majoring in general studies, with a focus on liberal arts and a minor in business.

Dr. Barbara Benson, an assistant professor of environmental science in the Department of Renewable Resources, became the group's faculty liaison last year. She wrote a successful $12,655 grant, funded by the University of Louisiana System's service learning program. RUN also has received more than $15,000 in donated matching contributions from community sponsors, Benson said.

Chance Gabehart, founder of the Resourceful University Network

Students have been involved in every step of the process. More than 100 of them have contributed to the project. Some received course credit for designing components of the exhibition vehicle.

"Industrial design students worked out the plans for the interior and the aesthetics of the exterior of the bus. Mechanical engineering students designed the fold-out stage and civil engineering students developed plans to elevate the roof," Benson said. The bus will also include solar panels.

Students at Louisiana Technical College, who are following designs created by UL Lafayette students, are modifying the bus. Students at the Teche Area Campus in New Iberia raised the roofline and created the framework for the stage, which will fold out from the side of the bus. Students at the Evangeline Campus in St. Martinville prepared the exterior of the bus for painting. The project is expected to be complete by this summer.

The RUNbus will be used in a variety of settings, including schools, university campuses and community events. It will also be available to transport UL Lafayette students to competitions and conferences.

"Our students have shown creativity in their work on this project. With the RUNbus, they will be able demonstrate practical, affordable strategies to solve real-world problems, while highlighting local resources," Benson said.

direction of alternative fuels and I got real fired up about that," Benson said.

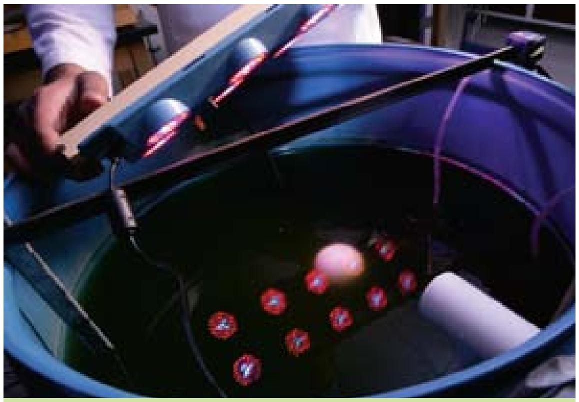
She brings real-world experience to her classroom and laboratory. In the 1980s, she worked for the Louisiana Department of Natural Resources, where she oversaw one of the state's coastal management programs. She also worked for the Louisiana Department of Environmental Quality, as a program manager for its Hazardous Waste Division.

In 2003, she earned a doctoral degree from Louisiana State University in civil engineering, with an emphasis on ecological engineering. "I ended up doing my dissertation on growing algae," she said.

At UL Lafayette, she's growing and testing algae collected in the water of the Gulf of Mexico's dead zone, which forms at the mouth of the Mississippi River each spring and grows throughout each summer. In the spring, water flowing from streams and rivers to the gulf is overloaded with nutrients from agricultural runoff, wastewater treatment plants, septic tanks and industrial waste.

The excess nutrients cause an overgrowth of algae, which bloom then die. They sink to the bottom, where they decompose, robbing the water of oxygen. Without oxygen, the water cannot support fish, shrimp

Above: Bryant Meyer, a senior studying natural resources and environmental quality, checks a sample of algae being grown in sugar-mill wastewater in an incubator that uses LED lighting. Right: This algae bioreactor, made from a 55-gallon drum, is used to study how LED light affects algae growth at various water depths.



and other species.

Benson is interested in dead zone water because "it is like wastewater. It's very high in nitrogen, phosphorus and carbon dioxide." She hopes to develop wastewater remediation processes, using algae to improve water quality, while producing oil.

Benson used samples of algae and water taken from the dead zone and cultured them in the lab. "We were impressed with the levels of growth of biomass, and they also produced a decent amount of lipids."

She's looking more closely at a type of algae found in the dead zone, cyanobacteria, or blue-green algae.

"It's an amazingly adaptable organism," she said. Like most algae, cyanobacteria grows in light. But it also grows in darkness. When it does, it increases oil production and also produces ethanol.

"So, there's a possibility you could create a mixed scenario. Cultivate them phototrophically for a while, to encourage growth, then grow them under stressed conditions to get the lipid content and ethanol production you want," Benson said.

She also plans to study the growth of algae in wastewater generated during sugarcane processing. "A certain amount of sugar is left behind in the waste stream. We want to know which strains of algae grow best in that type of wastewater."

The most cost-efficient way to grow algae commercially is in open ponds. Harry Daultani, a graduate student in chemical engineering at UL Lafayette, is investigating the potential for growing algae indoors, under LED lighting.

"If you're growing algae under a full-spectrum light, you're wasting energy, because algae doesn't need the full spectrum to grow. They mostly need red and blue light," he explained.

Light-emitting diodes use minimum energy and can be designed to emit light at specific frequencies, or colors.

In the algae lab, Daultani lowers a modified measuring stick into a blue plastic, 55-gallon drum, an algae bioreactor. A series of softly glowing red and blue lights are positioned across the top of the tank.

The light shining down in the water fades, or attenuates. Daultani uses light sensors, positioned inside the tank, to measure the strength of the light at different levels.

"I'm looking at light dynamics, how the light behaves in the reactor and how the algae respond to the light." Daultani is collecting data to design a large-scale, cost-effective reactor.

UL Lafayette is conducting research for Aquatic Energy LLC, testing solvents for algal oil extraction. The company, based in Lake Charles, La., is developing technology and facilities to turn freshwater algae into fuel and food.

Aquatic Energy operates pilot facilities in Cameron, Calcasieu and Allen parishes. "We've been selecting our algae strains, domesticating them, getting them to go

'LOUISIANA IS THE BEST AMONG ALL THE STATES FOR ALGAE PRODUCTION, BECAUSE OF ITS CLIMATE AND THE PRESENCE OF REFINERY AND DISTRIBUTION FACILITIES.'

DAVID JOHNSTON, CEO, AQUATIC ENERGY

through our system in just the right way," said CEO David Johnston.

"Louisiana is the best among all the states for algae production because of its climate and the presence of refinery and distribution facilities. With the existing aquaculture industry, you have the right climate and the right environment. So that makes it very advantageous to grow algae."

"There's also a great advantage in having an area where all the sciences and the engineering can be done very readily for renewable fuels."

UL Lafayette has provided "great support" in developing extraction technology for the company, Johnston said. "Probably the greatest strength of the research team is the understanding of commercial extraction and conversion of biofuels."

One of the challenges in harvesting oil from algae is the extraction process. Because algae have resilient cell structures, crushing or pressing the cells does not sufficiently release the oil. Instead, a chemical extraction process, using a solvent, is required.

Aaron Graham, a master's student in chemical engineering, has been working with algae grown by Aquatic Energy. The company sends samples of algae paste to the lab, where it's dried and prepared for experimentation. Graham has been testing various solvents, including hexane and isopropyl alcohol, along with high pressure and temperature, to release the oil from the algal cells.

"We wanted to keep an industrial focus for this project, so we were using chemicals that are cheap and relatively easy to use," Graham said.

Johnston said the company's goal is to develop a "drop-in fuel," compatible with existing industry infrastructure. He envisions "an integrated industry where you're growing the algae on site, harvesting and drying it, creating algal oil and algal meal through the extraction process, then sending the algal oil to a refinery.

"Our work with UL Lafayette is helping us build a new generation of biofuels that plays well to the existing energy industry here in Louisiana." ∎

DRIED ALGAE

Top: Molli Dugas, a sophomore studying chemical engineering, and Kiran Pathapati, a graduate student in chemical engineering, refine and analyze a sample of tall oil, a paper manufacturing byproduct. The tabletop unit is a small-scale refinery that breaks oil down into fuel and other chemicals for analysis. Bottom: Chemical engineering graduate student Aaron Graham places a sample of dried algae into an oil extractor that uses chemical solvents. Graham compares the effectiveness of various solvents in removing oil from algae.