UGA ENGINEERING

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THE NEWSLETTER OF THE UNIVERSITY OF GEORGIA FACULTY OF ENGINEERING

APRIL/MAY 2004 VOLUME 3 . NUMBER 4

UGA Site to Host Georgia's First Biorefinery

On Whitehall Road in Athens, two buildings among the pines adjacent to the forest and across from the pastoral UGA stables represent a visionary commitment of UGA Engineering Outreach to public-private technology partnerships. The high-bay space for the pyrolysis refinery equipment, the most promising technology in a generation for reducing global warming and our dependence on fossil fuels, is abutted by classrooms and office space, demonstrating the interrelationship of research, instruction and outreach that is the story of the site's evolution.

With the creation of the Georgia Research Alliance (GRA), and subsequently programs for building research facilities and equipment for generating new technology and technology transfer to assist Georgia's traditional industries, a new opportunity arose: to address comprehensively the need to reduce the amount of waste going to lined landfills and the potential new industrial uses for biomass in Georgia. In 1997, when construction on the UGA Bioconversion Research and Education Center (BREC) was completed, solid waste disposal in the state was a primary problem that required immediate solutions. Some proponents envisioned this might also unleash long-term economic development potential.

In minimizing landfill volume, the easiest materials to exclude, yard trimmings and storm debris, were identified. But once they were separated, alternative means were needed to process these materials. "One of the drawbacks for handling, processing, storing and transporting biological materials is their low bulk-density," says Tom Adams, Director of the UGA Engineering Outreach Service. "It's not economical to transport these materials long distances," he explains. Cities and communities all across the state were looking for a way to decrease the volume of these materials, and composting was the natural answer. "By composting, which reduces the volume of dry biological materials by half, you suddenly have a material that is desirable, used by homeowners, the green industry and farmers," says Adams. So with one answer to the solid waste problem in the state, the potential of creating new value-added products from biomass was realized.

Aerial View of the UGA Bioconversion Research and Education Center

With support from the GRA, UGA's engineering faculty connected the environmental concerns with economic development needs of the state to cement the idea of the Bioconversion Research and Education Center. "Engineering faculty envisioned a unique, statewide bioconversion program and the innovative GRA initiatives provided the funding," says Faculty of Engineering Director Dale Threadgill. With traditional industries in Georgia – forest products, pulp and paper, food processing, textiles and carpet – at a crossroads, the time was right for UGA Engineering Outreach to establish a site to prototype, test and transfer enabling technologies. Since its inception in 1997, the Bioconversion Center has been a resource for the state's bioconversion efforts focusing on composting technology and innovative bioproducts development. In the meanwhile, the potential for biomass has grown up around a crop of urgent environmental and energy concerns, working its way into cutting-edge research and the private sector search for profitable new green technologies.

Biomass as a resource for producing fuel, soil amendments and a variety of useful products is analogous to petroleum. These primary and secondary products from biomass can be realized in much the same way as the tens of thousands of petroleum products have been – through a biorefinery.

"Although the funding for the facility came to the University with the mission that we would develop the solid waste technology to support industries, municipalities and agriculture in the state – the needs have broadened to biomass in general," says K.C. Das, who, as the lead engineer in designing the Center facilities and the bioconversion program, is the Center's director.

To pursue the development of technology for producing a variety of bio-products, in 2001 a consortium was established between Clark Atlanta University, Georgia Tech and Eprida. A small company in Blakely, Georgia, Eprida had adapted technology developed at the DOE National Renewable Energy Lab using pyrolysis to produce hydrogen from biomass and advanced it to the pre-commercial stage. The group came to Athens looking for a more central

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What I Dream about Engineering

by John Stickney, PhD

I enjoy listening to President Adams at convocations at the beginning of the year. It is a concise abstract of the positive state of the University. It makes me feel good to be a part of this institution, and I hope it does the same for the entering class. I have watched the student body get better and better, due in large part to the Hope scholarship program. At the same time, I have seen my faculty drop from 32 to 25 faculty here in Chemistry and our departmental budget drop by 40%, but still improve as we build, what I feel is, a stronger Chemistry department. I am the new Department Head of Chemistry, so I cannot take any responsibility for these improvements, but I do feel pride in this University for the faculty pitching in, standing strong, stepping up (I am a bulldog fan) to increased teaching loads. I look to the future with optimism at what the University can do. With help from the top, and energy from the bottom, I want to see what this University can do to become one of the best, not only undergraduate institutions, but one of the best research institutions in the land. We know what we need to do, we just need some help, from the Governor on down.

However, when I think of what I can do to help, I am somewhat depressed. A few years back, the Faculty of Engineering was created with the energy of Brahm Verma and Dale Threadgill, and the help of Karen Holbrook. I was excited; everything I heard from Brahm rang crystal clear in my mind, it was a bandwagon that I wanted to push. You see, I am a chemist, but in my lab carbon is a contaminant. I do not do bio. This University is and has been a bio place for a long time, and is excellent at it, and I want to see that continue. But what of faculty that make things, which deal with materials, who study fundamental physics? We have representative faculty in these areas; the undergraduate students can get the education they need. But what about when I need a device designed from one of my materials? What do I do when I need to collaborate with faculty with expertise in electronics, optoelectronics, computers, mechanical engineering and materials? I have to look to other universities. Sure I can, but that is nothing like working with someone across the street. I have considered leaving for the sole reason of working at a University with a full-featured engineering program, but UGA is where I have been for 19 years, and it is my home. That is why I wanted to push the wagon. It was like a beam of light, the idea of a real full-featured engineering program where people would do science and engineering that I was interested in, where the best young faculty would apply to this university. Where there were classes in topics I want my graduate students to learn, where we can prepare engineering majors as well as pre-meds and biologists.

I feel like this all came to an end as Karen left the University, and the economy tanked. Yes, gloom and doom are prevalent, not knowing if you are going to be able cover all the classes needed for the ever-increasing freshman class. But at some point you hit bottom. Recently, as I noted, I became department head, and began to talk to more people that seem to have some control over what happens at this University. I have been told that if we have ideas and energy, the University will listen. I have decided to look up and dream.

I dream of an engineering department on this campus that is more than Ag and Bio. I dream of an engineering school with some faculty who don't like carbon, just like me. I dream of students having a choice in Georgia, going to the big top engineering program in the big city, or going to the country for an innovative, fresh, diverse program at the state's flagship University.

> "We need to view the future as an opportunity."

We need to look at the recent trials, and view the future as an opportunity. After having lost 230 faculty, we can't go anywhere but up. We need the administration to take some of the resources that must come in the near future, and work to help build that missing organ, the engineering program here at Georgia. We need the Administration to figure out what is holding up our new programs in engineering, while Georgia Tech is rapidly building the bio programs thought to be the purview of UGA, in some cases, by taking our faculty. GT is a mighty well-oiled machine, which has nothing to fear from UGA and a nascent engineering program, but as Brahm will tell you, the students in the State of Georgia have everything to gain by having an instate choice.

We need state officials to open their minds, and plan for a better future, and UGA administrators to think of cluster hiring, directed hires between departments and the Engineering school, to build Engineering as we rebuild the decimated departments, in the wake of recent budget cuts. We need to think about what areas to build in, and not just evenly redistribute positions across the university because it keeps everybody happy. We need some new directions. Faculty last for 30-40 years, and the ideas people came in with are not those presently at the edges of science and engineering. We have excellent faculty, who have changed the edges of science and engineering, but the nature of research and funding these days is in multi-investigator projects and awards. Hiring just one faculty in a specific area can be a problem. To have a chance, we need a nucleus of young energetic faculty, and other faculty they can work with, to push programs. This happens all the time in the biological sciences on this campus, the CCRC being one of our biggest success stories. We do not necessarily need more centers, but we do need the flexibility to create strong points in the University for the future, we need to consider cluster hiring in engineering and the physical sciences if these schools and departments are to be strong enough organs to support the University body.

John Stickney is Professor and Head of UGA Chemistry.

Faculty News

Congratulations to **Sid Thompson**, who was named Engineer of the Year in Education for 2004 by the Georgia Engineering Alliance...**Uwe Happek** of UGA Physics and Astronomy received a Creative Research Medal from the UGA Research Foundation... Engineering professor **Takoi Hamrita** hosted 30 professors from Tunisia as part of the UGA -Tunisia Educational Partnership... Engineering professor **Bill Tollner** hosted a Dean and the Director of Fisheries from Kenya as part of preparations for doing a watershed assessment on the Nzoia River .

Grant Proposals

The Office of the Vice President for Research is now accepting proposals from UGA faculty for the university-wide engineering grants program. The deadline for proposals is May 28. Guidelines for proposals can be found at *www.ovpr.uga.edu/forms/UGA_EngineeringGrants.doc*

UV-Ozone Prototype Advances Wastewater Recycling

One of the most distinguished members of the entire UGA Faculty continues to discover challenging new engineering ideas. **S. Edward Law**, Brooks Distinguished Professor and member of the National Academy of Engineering is world renowned for developing electrostatics technology for a vast array of applications, from applying pesticides to biological decontamination. Now, Law and his graduate assistants have brought a multi-year project to fruition: harnessing electric-discharge generated ozone and ultraviolet radiation to treat industrial wastewater from food processing.

The 2-ton, mobile pilot unit to field test the concept features sanitary-grade stainless steel with no threads or hidden pockets to shield or hide bacteria. Since April, the pilot unit has been field testing at a GoldKist poultry processing plant in Athens.

"Thesis research by one of my students showed that using either technique is effective, and using them one after the other is advantageous; but if you apply them simultaneously, you get a synergism," Law explains, which was the point behind designing and building this pilot scale prototype, UV enhanced ozonation.

Ultraviolet radiation is harmful to cells, to the point of breaking up DNA; ozone irreparably damages cell walls. With the two together in water as the system is designed, ozone in the presence of a certain wavelength of UV energy goes through a breakdown process that builds up a high excess of free radicals. "You'd prefer not to have these in your body," Law says, "but that's what we're producing here with this synergism." Indeed, under laboratory conditions on salmonella, a 14-fold greater killing of these bacteria cells was observed with this combined process.

UV-O_3 mobile pilot unit

The research equipment designed and built by Law has many more features than would a similar model installed in a plant. The prototype is outfitted to observe all of the significant physical parameters to implement appropriate control strategies. "On site we will pull about ten percent of their stream and treat it to validate our process at pilot scale," Law says.

Graduate student Sean Ireland has designed the hardware and software on the Programmable Logic Control (PLC) system. This involves making a series of independent water treatment processes – three stages of particulate removal, ozone injection, contact columns, UV radiation and all output parameters – into a system, and is at the heart of his thesis. "It's the brains of the system," Ireland says, "and designing it correctly is one of the keys to scaling up the project."

Law's career is distinguished by his creating advanced technology and his experience and success define engineering opportunity both in and outside the classroom. Inspired by his patented discoveries, Law's former students have started new companies that sell products and services worldwide. The impact of his contributions will continue to be felt in academia and industry, and this latest foray into waste water treatment continues the trend. "Benjamin Franklin would not at all be surprised to see us using what he called the 'power of points' or 'corona wind' as the basis for generating the ozone we apply as a bacterial agent," says Law.

From UGA to Yale in 4 Years

Steven Jay came to UGA four years ago as an Honors student with a firm idea of what he wanted to accomplish: pursue research opportunities in preparation for grad school. A biological engineering major originally from Lexington, KY, Jay approached several faculty members including Professor **William Kisaalita** with the idea of gaining some lab experience. "He talked to me early and to other faculty, not just about a job," says Kisaalita, who eventually accepted Jay into his lab and became a guiding force in his career at UGA. "Steven showed a real interest in the work," he says. His experience at UGA is coming to a close this May as a new chapter begins; Jay has accepted a University fellowship and will be attending Yale University's Biomedical Engineering Graduate program, with research focusing on drug delivery systems and tissue engineering.

Kisaalita recalls Jay as ambitious for an undergraduate, though not in the way third- and fourth-year students approaching the job market often gain a sense of urgency. "He decided to spend a semester getting used to the lab procedures and techniques before coming to work with me," Kisaalita says. In addition, Jay expressed an interest in publishing a paper and worked with Kisaalita to spend more time in the lab in order to do something of value. "I found that very insightful," says Kisaalita, "he was looking far ahead and saying, 'I want to be there, so what do I need to do now, to get there?'"

When it came time for a summer job, Jay looked outside the university to both diversify his experience and test his acumen, taking a position in the NSF Undergraduate Research Program at Clemson. "With all the work he had done applying for these fellowships, it became very easy to apply for graduate school," recalls Kisaalita.

It is no coincidence that in April 2004 William Kisaalita received the CURO **Faculty Award for Excellence in Undergraduate Research Mentoring**; he has sent graduate students to prestigious institutions such as Columbia, MIT, Stanford and more than a few startup companies. But for Kisaalita this is not just about a bright student being paired with a caring and engaged faculty member: "These steps are open to any student who has the foresight to plan their undergraduate experience," he says.

Jay realizes how valuable the combination of a great teacher and a strong department emphasizing the fundamentals of engineering sciences can be. "Dr. Kisaalita took the time to teach me cell culture technique first-hand and he trusted me to design and perform experiments independently. In many ways he really helped prepare me for graduate school," Jay says.

Steven Jay

It has been noted how critical it is to embrace teaching and research as two sides of the same coin, that without both, excellence is unlikely in either. Steven Jay's undergraduate experience at UGA and the mentoring of William Kisaalita in shaping it demonstrate the many factors that go into a successful engineering program, and the long term bonds they build with the professor and the institution. "I want our students to see him as an example," Kisaalita says. "We have faculty who feel like they can be instrumental in shaping a student's future, beyond just teaching their regular classes."

***Refinery*, from p.1**

location and new partners for a scale-up of the project. By scaling up the operation, Eprida could demonstrate that it would be effective at producing value-added bio-products, particularly hydrogen.

Identified as one of the highest priorities by Georgia's biomass producing industries, the consortium's projects for developing scale-up technology are the initial thrust of its biorefinery research. Research plans are being developed with Georgia forest products and other biomass industries through the Georgia Industrial Technology Partnership (GITP), an organization of industry, government and academia headed and administered by the UGA Engineering Outreach Service.

Bringing Nano to Biomass

With UGA engineering taking the lead, suddenly this technology's commercial uses could be taken further. Chemistry Professor John Stickney, a member of the Faculty of Engineering, held a key to that connection: fuel cell technology to use the hydrogen from a functional biorefinery.

Hydrogen, one of the many potential products of the biorefinery, is a key input for producing electrical power when used in fuel cells. However, current limitations prevent it from becoming a commercially viable alternative source for energy. One important need in this area is to improve fuel cell electrode surfaces to optimize catalysis and minimize the amount of precious metal needed, thereby reducing the cost. Ideally a nanometer of a structured catalytic alloy could be formed on a less expensive substrate metal, achieving the cost savings and increasing the efficiency of conversion. The UGA patented ElectroChemical Atomic Layer Epitaxy (EC-ALE) method provides atomic layer control for ion growth of potentials. This provides the necessary control for systematic investigations of structures and alloys while enabling scale-up for commercialization.

"Electro-chemists have an interface between a metal electrode and a solution," says Stickney, whose method of electrochemical deposition of atomic layers both predates and succeeds his work on compound semi-conductors. His collaboration at the scale-up stage is one of many growing links of new scientific research with engineering at UGA, significant evidence that engineering holds the key for reaffirming the university's land grant mission.

"The infrastructure is there to shift the focus of some of Georgia's traditional industries and re-invigorate rural economies throughout the state," says Threadgill. The Engineering Outreach Service and the Center for Agribusiness and Economic Development will organize the technology transfer, training, business service and promotions to foster rural economic development using the technology once the bio-refinery is functional. Part of the charge behind the biorefinery is to produce fuel and add value to the abundant biological resources in Georgia; another part is demonstrating that producing hydrogen can be done safely, efficiently and profitably. These two aspects will enable traditional industries to embrace this new technology and create jobs that will remain in the state.

"This is truly processing at the molecular level," Adams says of the biomass pyrolysis refining technology, "and with the biorefinery, the promise and potential of the BREC will be advanced."

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