Checking in with CenUSA

Sustainable Production and Distribution of Bioenergy for the Central US

CenUSA Bioenergy is a multidisciplinary project funded by the U.S. Department of Agriculture-National Institute of Food and Agriculture (USDA-NIFA). The goal of the project is to research the production and use of perennial grasses on marginal lands for use as alternative biofuels and bioproducts. Learn more about CenUSA at www.cenusa.iastate.edu.

Robert Brown[1], director of the Iowa State University Bioeconomy Institute and the Anson Marston Distinguished Professor in Engineering, spoke about his work and experience as a CenUSA co-project director focused on feedstock conversion with CenUSA Communications Tyler Worsham in April 2019. [2] Brown described how a cost-efficient fast pyrolysis process is essential in order mainstream viable alternative biofuels.

Ash represents a problem, but it set us to the task of figuring out how we can do better with these high-ash feedstocks. Today, I can say that we know how to process them. In some cases, we can get yields that are comparable to what we can get with wood. *Robert Brown*

How did you initially get involved with CenUSA?

"My staff realized that there was an opportunity through the USDA to do a big project. We did some negotiations through some other schools, concluded that Iowa State University would take the lead and that Ken Moore would be the leader."

What made you an ideal candidate for your co-project leadership position with CenUSA?

"These large CAP projects required a systems approach. In other words, we had to do the agronomy, processing, and logistics. I'm a process guy, so I was interested in bringing thermo-chemical processes to the project. That's why I ended up leading that part of the project."

In what ways did the project challenge and broaden your professional knowledge and skill set?

"It was interesting that we went in with a specific technology called fast pyrolysis. We had to see how these herbaceous feedstocks that were being proposed for this CenUSA project would work with that (fast

[1] Learn more about Robert Brown at https://www.me.iastate.edu/directory/faculty/robert-c-brown/.
[2] All of the words and ideas expressed in this interview fairly and accurately represent the speaker. Some quotes may be paraphrased for brevity and clarity. The opinions expressed herein do not necessarily reflect those of Iowa State University, USDA-NIFA, Purdue University, Ohio State University, USDA-ARS, University of Minnesota, University of Nebraska-Lincoln, University of Vermont or the University of Wisconsin.

pyrolysis). Most of the previous research in the field suggested that we should be using woody biomass over herbaceous biomass. Of course, it would have been a hard sell to say that wood was a major feedstock for the Midwest, certainly for Iowa, so we spent some of our efforts learning how we could use these herbaceous materials instead."

Have you worked in any other project as large or well-funded as CenUSA?

"There were some of comparable scale. One was with the National Science Foundation. It was called an EPSCoR (Established Program to Stimulate Competitive Research) project, and it was a little bit smaller in scale. It was focused on renewable energy: wind, energy efficiency and bioenergy. It was more diffuse than CenUSA.

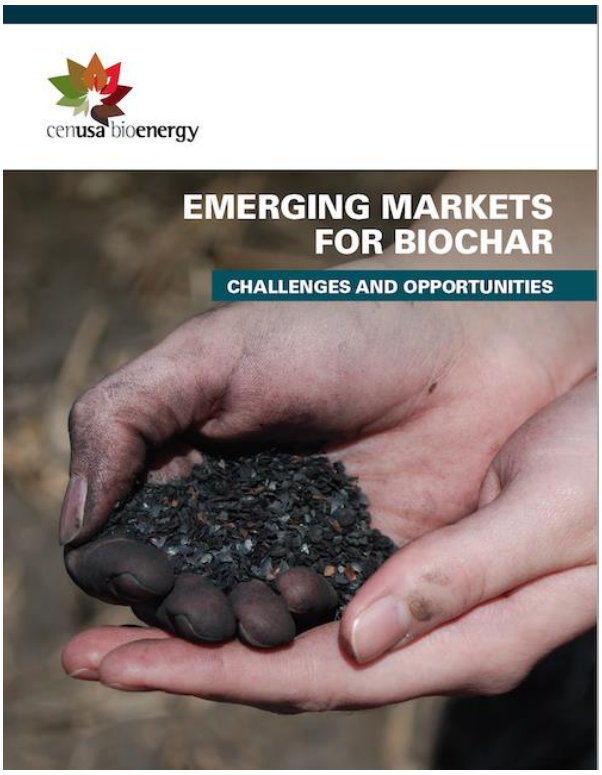
We also had another large industry project focused on biofuels. It resembles CenUSA in some ways, but it was more focused on the conversion technologies. CenUSA was very much about adding value to agriculture. The other projects tended to be about the technology as opposed to the impact on agriculture, farmers and communities. CenUSA was much more broad, and it had Extension involved in it."

To what new ideas and disciplines were you exposed in your work?

"For a long time, I took pride in getting to meet people from other disciplines. I'm a mechanical engineer by training, so I've mostly dealt with mechanical engineers. It was after I started working in bioenergy that I realized that I had to talk to agronomists, land engineers, chemical engineers, economists, and even the political scientists. This project let me use those skills and practice them a lot, because this most certainly was an interdisciplinary project."

Did you and your team encounter any obstacles in your work, whether expected or unforeseen?

"Absolutely. An obstacle was the drop in the price of gasoline and diesel when we were supposed to be producing alternative fuels. We suddenly had to produce fuels that were much cheaper than anticipated. We spent a lot of our time making decisions. Farmers are trying to produce an inexpensive feedstock while still turning a profit. The conversion system needs to make a profit as well, but maybe technological innovations could reduce the cost. Ultimately, the problem was petroleum. The price stayed too low over the course of our project. We're just now starting to see prices go up and starting to make these other processes look more cost-effective."



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How did your research with CenUSA help make the pyrolysis process more effective?

"I alluded to it earlier. Almost everyone in the field has said that pyrolysis was just for wood. You get higher oil yields, and it just works out a lot better, but we were challenged with herbaceous materials like switchgrass that contain more ash than wood does. Ash represents a problem, but it set us to the task of figuring out how we can do better with these high-ash feedstocks. Today, I can say that we know how to process them. In some cases, we can get yields that are comparable to what we can get with wood."

What were some noteworthy discoveries and successes you achieved in your research?

"I would say it was how we learned to pyrolyze high-ash feedstocks and economically produce good oil yields. We think it looks good compared to other approaches of turning these biofeedstocks into biofuels and products."

What were the most significant obstacles to the commercialization of the biomass-fueled pyrolysis process?

"In terms of commercialization, of course there is the issue of the ultimate cost compared to gasoline and diesel. Another obstacle to commercialization of all bioenergy systems is the capital cost, so going into this program, the estimates were that you would spend a half-billion dollars to build a system that would convert biomass into biofuels. That's five times higher than what an ethanol plant would cost, so our strategy was not only to intensify the process to reduce those capital costs, but also to go to smaller-scale systems instead of what had typically been said about what bioenergy should be. We scale that down by about a factor of 10 to what we think is the appropriate size. Now you're talking about a fraction of the capital cost that people envisioned. It suddenly becomes possible for investors to say that they're not risking a half-billion dollars, we're risking $50 million instead."

When do you think is the earliest that we could see the commercialization of the biomass-fueled pyrolysis process?

"The first thing that has to happen is that we take pilot-scale work, demonstrate it at a scale that is about 50 tons per day. Right now, we are working on the order of a half-ton per day. We want to scale that to 50 tons per day. That will give us the data necessary to scale up to the range of 200 or 250 tons per day. By December 2020, we will have a demonstration project at 50 tons per day set up here in Iowa. We've also got a demonstration project set up for Florida. They want us to use wood which also advances this.

We're also talking with other potential commercial partners about other applications in other parts of the United States and North America in general. With those kinds of demonstration projects in the next couple of years, it's a very viable notion that we could go commercial in the next five years if the markets allow it. Then we'd be looking at if there are going to be carbon taxes and if there are going to be increases in petroleum costs that would make this (carbon taxes) feasible."

Could you go into more detail about these demonstration projects?

"One of these projects is being financed by Harry Stine who has money in corn and soybean seeds. He's interested in herbaceous material, but it's called corn stover instead of switchgrass. Switchgrass is a more challenging feedstock because of the ash content. His interest started in the production of biochar which is a byproduct (of switchgrass in the pyrolysis process). If biochar can be applied back onto the soil, it brings back the nutrients that you took off by

removing the biomass. It can also improve soil quality in that biochar acts very much like a soil-carbon. That was his primary interest, but he also realized that to make it commercially viable, you have to get higher-value energy products.

While he's providing the finances to fund this first demonstration unit, we've contracted with a company located here in Ames called Frontline Bioenergy, an engineering firm doing the design and construction. The California project is being funded by the California Energy Commission. This is a project being led by the Lawrence Livermore National Laboratory, but the technology exclusively comes from Iowa State University. We are actually going to be borrowing what we call the Stine pyrolizer. It's a modular system that we can take apart, take it over to California, evaluate it for several weeks, and then bring it back to Iowa."

What is the most interesting or most important facet of your work that you want the general public to understand about your work?

"I've always been fascinated by biochar ever since I learned about its properties. I would say that the most interesting facet is the notion that we can perform a process that not only produces an energy product, but that also produces a material that will actually improve the productivity of agriculture and can sequester a charcoal product into the soils for hundreds or thousands of years. We envision what we call a carbon-negative energy system. Instead of thinking of a process that emits a net-negative carbon output into the atmosphere through photosynthesis, we can pull carbon out of the atmosphere and sequester some of it as biochar in agricultural lands where it has a good and useful purpose."

How will you take your experience with CenUSA and put it to use in future research projects?

"Well, we are already doing that. These two demonstration projects came after CenUSA. We are certainly using what we learned about herbaceous materials with the Stine pyrolizer, but it has also allowed us to develop improved pyrolysis systems that are improved through the simplicity of how they operate. One of the problems with technologies that convert biomass into energy products is that they can be very complicated, so we had a dramatic simplification of this technology that we are using for these new projects."

In what new directions do you hope to take your own work in the future?

"I'm advocating for something we call 'agriculture-based carbon dioxide removal and reliable sequestration.' We call that Ag-CDRRS, but to put it more simply, it's a carbon removal concept. Let's look at ways that agriculture can contribute to reducing the amount of carbon in the atmosphere. You will often see agriculture blamed for increased emissions of carbon in the atmosphere. We want to turn this on its head and show that agriculture can actually contribute to reducing that. This is the spirit of the whole CenUSA project."

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Robert Brown CenUSA Bioenergy Work Product

Extension and Outreach

- ✓ Fact Sheet: Fast Pyrolysis Efficiently Turns Biomass into Renewable Fuels. Robert Brown, Iowa State Univ. 2015. https://cenusa.iastate.edu/files/cenusa_2019_005.pdf
- ✓ Webinar: Thermochemical Conversion of Biomass to Drop-In Biofuels. 2012. (51:36).https://www.youtube.com/watch?v=Ua8She55qTc
- ✓ Webinar: The Thermochemical Option: Thermochemical Conversion of Biomass to Fuel. 2012. (31:29). https://www.youtube.com/watch?v=6dkV9OKw2F8

Publications

- ✓ Bakshi, Santanu & **Robert C. Brown**, "Iowa State Researchers Studying Slow-release Fertilizer to Feed Crops, Improve Water Quality," Iowa State University Bioeconomy Institute, last updated June 17, 2019, https://www.news.iastate.edu/news/2019/06/17/biochar-slowrelease.
- ✓ Bbosa, D., **R.C. Brown** & M. MBA Wright. 2018. More than ethanol: A Techno-Economic Analysis of a corn stover Ethanol Biorefinery Integrated with Hydrothermal liquefaction to convert lignin into biochemicals. Biofuels Bioproducts and Biorefining 12(3) doi: 10.1002/bbb.1866
- ✓ Brown, T. & **R.C. Brown**. 2013. A review of cellulosic biofuel commercial-scale projects in the United States. Biofuels. Bioproducts & Biorefineries 7(3): 235-245
- ✓ Brown, T. R., R. Thilakaratne, **R.C. Brown** & G. Hu. 2013. Techno-economic analysis of biomass to transportation fuels and electricity via fast pyrolysis and hydroprocessing. Fuel. 106: 463–469
- ✓ Dang, Q., W. Hu, M. Rover, **R.C. Brown** & M.M. Wright. 2016. Economics of biofuels and bioproducts from an integrated pyrolysis biorefinery. Biofuels, Bioprod. Bioref. 10: 790-803. doi: 10.1002/bbb.1681
- ✓ Dang, Q., M.M. Wright & **R.C. Brown**. 2015. Ultra-low carbon emissions from coal-fired power plants through bio-oil co-firing and biochar sequestration. Environ. Sci. Technol. 49 (24): 14688-14695
- ✓ Davis, K.M., M. Rover, **R.C. Brown**, X. Bai, Z. Wen & L.R. Jarboe. 2016. Recovery and Utilization of Lignin as Monomers as Part of the Biorefinery Approach. Energies 9(10): 808. doi:10.3390/en9100808. http://www.mdpi.com/1996-1073/9/10/808. (Open access)
- ✓ Fidel, R., S. Archontoulis, B. Babcock, **R.C. Brown**, H. Dokoohaki, D. Hayes, D.A. Laird, F. Miguez, & M. Mba Wright. 2017. Commentary on 'Current economic obstacles to biochar use in agriculture and climate change mitigation' regarding uncertainty, context-specificity and alternative value sources. Carbon Manage. 2: 215-217. doi. 10.1080/17583004.2017.1306408

- ✓ Hu, W., Q. Dang, M. Rover, **R.C. Brown** & M.M. Wright. 2016. Comparative techno-economic analysis of advanced biofuels, biochemicals, and hydrocarbon chemicals via the fast pyrolysis platform. Biofuels, Bioprod. Bioref. 7(1): 57-67. doi: 10.1002/bbb.1681

- ✓ Kauffman, N., J. Dumortier, D.J. Hayes, **R.C. Brown** & D.A. Laird. 2014. Producing energy while sequestering carbon? The relationship between biochar and agricultural productivity. Biomass Bioenergy 63: 167-176

- ✓ Li, W., Q. Dang, R. Smith, **R.C. Brown** & M. Mba Wright. 2016. Techno-economic analysis of the stabilization of bio-oil fractions for insertion into petroleum refineries. ACS Sustainable Chem. Eng. 2017(5): 1528-1537. doi. 10.1021/acssuschemeng.6b02222. http://pubs.acs.org/doi/ipdf/10.1021/acssuschemeng.6b02222

- ✓ Li, B., O. Longwen, Q. Dang, M. Pimphan, S. Jones, **R.C. Brown** & M.M. Wright. 2015. Techno-economic and uncertainty analysis of in situ and ex situ fast pyrolysis for biofuel production. Bioresour. Techn. 196: 49-56

- ✓ Li, W., Q. Dang, D. Laird, **R.C. Brown**, & M. Mba Wright. 2017. The impacts of biomass properties on pyrolysis yields, economic and environmental performance of the pyrolysis-bioenergy-biochar platform to carbon negative energy. Bioresour. Technol. 241: 959-968. doi: 10.1016/j.biortech.2017.06.049

- ✓ Moore, K.J., S. Birrell, **R.C. Brown**, M.D. Casler, J.E. Euken, H.M. Hanna, D.J. Hayes, J.D. Hill, K.L. Jacobs, C.L. Kling, D. Laird, R.B. Mitchell, P.T. Murphy, D.R. Raman, C.V. Schwab, K.J. Shinners, K.P. Vogel, J.J. Volenec. 2014. Midwest Vision for Sustainable Fuel Production. Biofuels 5(6): 687-702. doi: 10.1080/17597269.2015.1015312

- ✓ Thilakaratne, R., T. Brown, Y. Li, Y., G. Hu & **R.C. Brown**. 2014. Mild catalytic pyrolysis of biomass for production of transportation fuels: a techno-economic analysis. Green Chem. 16: 627-636

- ✓ Thilakaratne R, M.M. Wright & **R.C. Brown**. 2014. A techno-economic analysis of microalgae remnant catalytic pyrolysis and upgrading to fuels. Fuel. 128:104-112

- ✓ Zhang, Y., Hu, G., & **R.C. Brown**. 2013. Life cycle assessment of the production of hydrogen and transportation fuels from corn stover via fast pyrolysis. Environ. Res. Lett. 8(2)

- ✓ Zhou, S., **R.C. Brown** & X. Bai. 2015. The use of calcium hydroxide pretreatment to overcome agglomeration of technical lignin during fast pyrolysis. Green Chem. 17: 4748-4759. doi:10.1039/C5GC01611H. https://doi.org/10.1021/acssuschemeng.6b02222

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