

BioCentury Research Farm Summary

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Introduction

The BioCentury Research Farm (BCRF) had a diversity of users in 2016. Iowa State University (ISU) faculty and staff from the Departments of Agricultural and Biosystems Engineering (ABE); Agronomy; Biochemistry; Chemical and Biological Engineering (CBE); Civil, Construction, and Environmental Engineering (CCEE); and Food Science and Human Nutrition (FSHN), as well as the Bioeconomy Institute (BEI), Center for Crops Utilization Research (CCUR), College of Agriculture and Life Sciences (CALs), and Extension and Outreach conducted research, teaching, and/or outreach at the BCRF. Private industry users of the BCRF included ARGO, Deere & Company, DuPont Cellulosic Ethanol, Phillips 66, and many others. By the end of 2016, the BCRF had more than 80 full- and part-time users with projects in all available space.

The BCRF Advisory Council was established in the first quarter of 2016. The first meeting was held May 17–18. The council discussed the BCRF's strengths and weaknesses to help identify short- and long-term goals and developed an action plan for future work.

Research, Education, and Equipment

A great deal of project activity occurred in the following areas:

- Algae research and production methods
- Biochemical research
- Biomass feedstock logistics research
- Biomass preparation
- Biopolymer research

- Thermochemical research that included biomass gasification, pyrolysis, and solvent liquefaction processes
- Educational support
- Infrastructure and equipment
- Grants, appropriations, donations, and awards

Algae. Various production systems, including flat panel bioreactors, two raceway pond systems, a novel revolving algal biofilm (RAB) system, and various lab-scale reactors located in the BCRF Algae Facility are being used to grow algae. The major focus for these algal growth systems is removal of nutrients (nitrogen and phosphorus) and toxic metals from municipal and industrial wastewaters. A mobile pilot-scale RAB system was developed in 2015 to treat wastewater on site at municipalities and industrial processors. Offsite projects in Fort Dodge and Dallas Center, Iowa, and numerous demonstrations employed this mobile unit in 2016.

Additionally, newer belt designs were added and further research was conducted on component materials and processes. Projects with municipal and industrial groups continued throughout the year to include private companies and the City of Chicago, (Illinois) water treatment plant. The researchers led by Zhiyou Wen, FSHN, can produce 1.3 to 4.5 kg of dried algae biomass/week in the BCRF facility.

The diverse algae species grown in the facility are suited for different end uses. Algae with high lipid levels are best for producing biodiesel, and algae with high protein levels and good amino acid profiles are used for livestock feed. Algae biomass grown on wastewater is being studied as an organic fertilizer.

Biochemical. Work expanded in this area in 2016. Bench-scale projects continued on campus and there is the potential for scaling these up at the BCRF in 2017. In February, a project to grow a single cell microbe was completed in the 500-liter fermentor for an industrial client. In the fourth quarter, work began on several week-long fermentations in the 1,000-liter fermentor for another industrial client. This work continued into 2017. Steam tube drying testing was completed in August.

Biomass feedstock logistics. Multiple projects continued in this area in 2016 with the most notable ones related to the DuPont Cellulosic Ethanol (DCE) and POET-DSM Advanced Biofuels research led by Matt Darr and Stuart Birrell, ABE.

For the DCE project, work continued in the area of corn stover bale collection and quality assessment, and added bale processing at the inlet of the plant. The BCRF received numerous bales for observation, stack testing, ash and moisture content sampling, and other attribute testing. Over 11,000 bale samples were processed during the 2016 harvest. This is a typical number of samples processed.

The DCE plant continued to be commissioned with a projected date of operation of mid-year 2017.

Agricultural product development and research support for and from several major agricultural equipment manufacturers such as AGCO, John Deere, New Holland Agriculture, and Vermeer continued in 2016. In particular, New Holland Agriculture continued to provide ISU with equipment for quantifying the efficiency of harvesting biomass crops.

The New Holland equipment enabled the BCRF to continue helping Emily Heaton's research group (Agronomy) plant *Miscanthus*

spp. rhizomes with a semi-automated planter at three locations in Iowa. This project, the Long-Term Assessment of *Miscanthus* Productivity and Sustainability (LAMPS), is designed to answer several questions about *Miscanthus* × *giganteus* production. The overarching goal for LAMPS is to answer the questions farmers are asking about *Miscanthus*, especially those concerning fertility rates and quantifying yields using commercial harvesting equipment.

LAMPS has several partners and sponsors to accomplish its project goals. ISU and the University of Iowa assisted with planting costs; Repreve Renewables, LLC provided plant material and planting equipment; New Holland Agriculture provided equipment leases; and the Bioeconomy Institute, Department of Agronomy, Iowa Energy Center, and Leopold Center for Sustainable Agriculture provided funding and support.

Biomass preparation. The BCRF prepared biomass feedstocks for several internal and external clients (e.g., universities, national laboratories). The farm's biomass preparation lab was used to fine grind, screen, and size the feedstocks. Biomass drying projects also were completed. In separate projects, 10 different entities received processed material totaling over 19 tons of various feedstocks milled with 0.5 to 19 millimeter screens.

In one particular project, the BCRF milled 15 tons of corn stover and switchgrass for an off-campus industry client. The material was milled using a round bale processor adapted to milling square bales. The biomass was used by the client to test processing equipment performance.

Drying projects were completed throughout the year and used several different methods. Biomass materials such as wood chips, corn stover, and switchgrass were dried using a

combination of different drying methods such as oven, belt conveyor, and rotary steam tube dryers.

Biopolymer research. The Bio-Polymer Processing Facility was completed and dedicated August 26, 2015. The project was led by Eric Cochran (CBE) and Chris Williams (CCEE) in collaboration with Argo Genesis Chemical, LLC, an affiliated company of Seneca Petroleum, Crestwood, Illinois. System commissioning, cold weather repairs, and an extensive process safety review were completed in 2016. Research will begin in 2017.

Thermochemical. Robert Brown's (BEI, Mechanical Engineering) fast pyrolysis unit located at the BCRF was used for bio-oil production from red oak and corn stover for internal and external projects. This work was done to explore possible uses for individual fractions, including a path to fermentable sugars and generation of pilot-plant data for system scale up. Excellent progress was made in increased throughput using autothermal pyrolytic processes, sustainable corn stover processing, and alternative collection stage design.

BEI's research continued in the area of gasification gas cleanup for syngas fermentation. Simulated contaminants were removed from bottle gas using a slipstream-scale scrubbing column test rig. The gasifier process development unit is ready for the next potential project in 2017.

The solvent liquefaction pilot plant became fully operational in late 2015. Work on a battery of tests began near the end of the first quarter and continued to the end of the year and will continue through summer 2017. This is a BEI and Chevron collaborative project.

Educational support. The BCRF hosted many ISU class tours. In 2016, over 200 students

from ABE, Agronomy, FSHN, and Plant Pathology and Microbiology, as well as the CyBiz Program, visited the farm.

The BCRF also supported several capstone projects that included development of a low-temperature grain drying system, a *Miscanthus* single pass harvester, a zipline retrieval system, and a baler bearing wear measurement test program.

Infrastructure and equipment. The DuPont soil separator was delivered to the BCRF in mid-year 2016. Concrete footings were installed in late 2016 and the system will be reassembled in 2017.

Grants, appropriations, donations, and awards. The BCRF has been well supported by private industry donations. In 2016, DuPont Cellulosic Ethanol (DCE) donated a one-of-a-kind soil separator processing plant valued at \$219,000. This addition allows the BCRF to provide stover at ash content rates below typically harvested material.

In 2010, the BCRF was recognized by Biofuels Digest as the Institutional Research Facility of the Year. In 2016, the Association of Public and Land-grant Universities designated Iowa State as an Innovation and Economic Prosperity University citing the BCRF as one of its noteworthy accomplishments.

Outreach, Visitors, and Tours

Information dissemination and promotion was accomplished through tours, conferences, and symposia. Tours were provided for 103 groups with approximately 1,505 visitors in 2016. Since the dedication in 2009, BCRF has hosted 787 tours with 13,073 visitors.

The 2016 tours included visits by American Association of State Highway and Transportation Officials, Ames Chamber of Commerce, Australian farmers, Boone

Chamber of Commerce Leadership Group, Boone County Disaster Assistance Committee, Des Moines Engineering Club, Farm Progress Show, Hebei Province (China), IEEE, International Farmers Aid Association, Iowa Economic Development Authority, Iowa Farm Bureau, Iowa Governor Terry Branstad, Iowa Lieutenant Governor Kim Reynolds, former Iowa Lieutenant Governor and U.S. Senate candidate Patty Judge, KWQC-TV, Kyrgyz Republic group, SBIR/STTR National Road Tour, U.S. Congressman David Young, U.S. Department of Commerce, U.S. Senators Charles Grassley and Pat Roberts, and a West Africa group.

Several companies and other organizations also visited including the following:

- Annikki GmbH
- Arvegenix
- AVEKA, Inc.
- Bayer Crop Science
- Biova
- Context
- Deere and Company
- Doerfer
- Dreamfield Ventures
- DuPont
- Emerson
- Enginity
- Fraunhofer-Gesellschaft
- General Mills
- Grain Processing Corp.
- Harima Chemicals Group
- Kemin Industries
- Nationwide Insurance
- Nelson Engineering
- New Holland
- PepsiCo
- Phillips 66 Company
- Quaker Oats
- Renewable Energy Group
- Renmatix
- Roeslein

- Roquette
- Valent Biosciences

The BCRF also gave numerous tours to students and teachers from K-12 schools as well as the following groups and workshops:

- CBiRC Biorenewables Workshop for Elementary Teachers
- CBiRC Summer Academy
- FFA Students
- Waterloo West High School
- Waukee APEX students

Tours were given for students and professors from DMACC, Iowa Central, University of Michigan, and foreign universities in Belarus, Brazil, Costa Rica, India, Korea, and Thailand.

The BCRF participated in two conferences. In August, the Biofuels: Science and Sustainability Tour group of approximately 50 congressional aides and federal agency staffers visited. In September, groups from the Petroleum Marketers and Convenience Stores of Iowa Energy Conference were given guided tours.

The BCRF was an exhibitor at the 2016 Iowa Renewable Fuels Summit and Trade Show January 19 in Altoona, Iowa. Many attendees visited the exhibit and were able to see samples of materials produced at the BCRF including algae, ground feedstocks, bio-oil, biochar, and torrefied corn stover pellets.

Through close cooperation with the ISU Research Farms, ISU Center for Crops Utilization Research, Ames Convention and Visitors Bureau, BEI, and ISU Foundation, many public organizations, private companies, international organizations, and citizens of Iowa have visited the BCRF.