



Engineering Solutions for Biomass Feedstock Production

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Liquid fuel—such as gasoline, diesel, aviation fuel, and ethanol—will continue to be important for powering our transportation systems in the foreseeable future. Transportation fuels derived from various forms of biomass have many obvious advantages. Obvious challenges also exist if biomass-derived transportation fuels are to substitute (on a large scale) for petroleum-based fuels. For example, how do we attain an annual production of 132.5 billion L (35 billion gal) of U.S. domestic renewable fuels by the year 2017?

The commonly understood value chain of biofuels starts with converting sunlight and other resources into biomass, and it ends with delivering liquid fuels to customers. This value chain includes several distinct yet interrelated subsystems. Two of these subsystems are biomass feedstock production and biomass conversion into liquid fuels. What follows describes a holistic research program on developing engineering solutions for successful provision of biomass feedstock from farms to biorefineries. The biomasses of interest are dedicated energy crops such as *Miscanthus* and switchgrass.

Energy Biosciences Institute

BP has provided funding to establish the Energy Biosciences Institute (EBI), a partnership established between and co-located at the University of California- Berkeley, the Lawrence Berkeley National Laboratory, and the University of Illinois (www.energybiosciencesinstitute.org).

The research activities within EBI are organized into five areas: feedstock development; biomass depolymerization; biofuels production; fossil fuel bioprocessing; and environmental, social, and economic dimensions. Each research area contains programs and projects. Each program is funded in a three-year rolling fashion and may last up to ten years if needed, while each project is funded for a fixed period of time to investigate a focused research topic. Currently, EBI funds 19 programs and 31 projects. “Engineering Solutions for Biomass Feedstock Production” is one of the programs in the feedstock development area.

Holistic approach to feedstock production

The biomass feedstock production (BFP) subsystem, within the bio-based energy system, provides the necessary material inputs to the conversion process of biomass into fuel, power, and value-added materials. This subsystem includes the agronomic production of energy crops and the physical handling and delivery of biomass, as well as other enabling logistics. To ensure effective and efficient production of biomass feedstock, biological, physical, and chemical sciences need to be integrated with engineering and technology. “External” interactions and influencing factors, such as social/economic considerations, environmental impact, and policy/regulatory issues, must also be kept in mind.

The objectives of the Engineering Solutions program are being accomplished through five interrelated and integrated tasks: (1) pre-harvest energy crop monitoring, (2) harvesting of energy crops, (3) transportation of biomass, (4) storage of biomass, and (5) systems informatics and analysis. For each task, systematic approaches are taken to characterize task features, evaluate existing technologies, identify information



Biomass feedstock production session, Agronomy Day, University of Illinois. (Photo courtesy of Luis Rodriguez, University of Illinois)

needs and researchable questions, develop prototypes and computer models, conduct experiments and computer simulations, analyze experimental data and simulation output, and contribute to the effort of systems integration. Results are being delivered in the forms of enabling technologies, operational machinery design and prototypes, informational databases, and decision support tools.

Five integrated and concurrent tasks

A team of faculty, post-doctoral research associates, graduate and undergraduate students, visiting scholars, and administrative and technical support specialists has been assembled to conduct the Engineering Solutions program. Many team members are ASABE members.

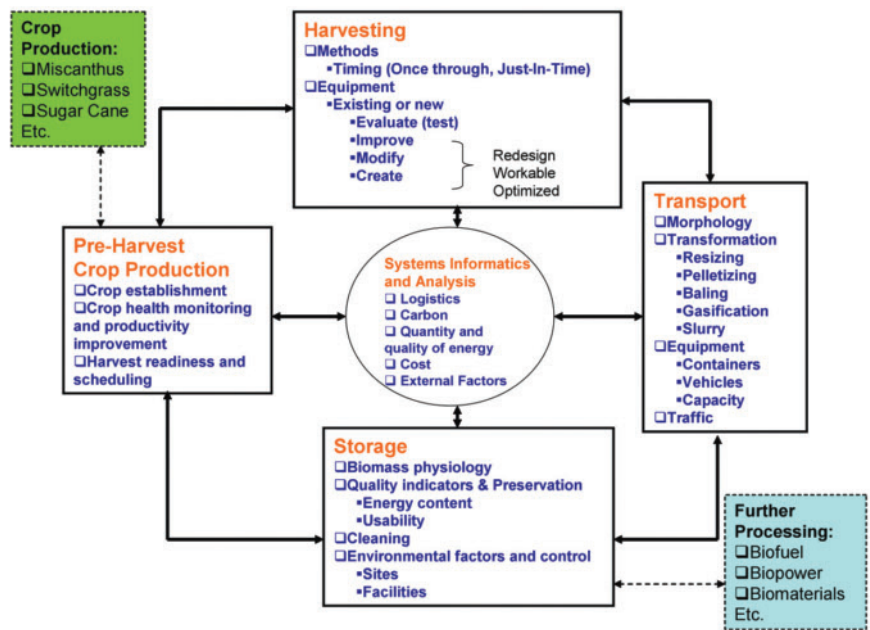
Each of the five tasks mentioned above is led by a faculty investigator. Most of the faculty investigators participate in multiple tasks, as do the post-doctoral research associates, who follow their respective faculty advisors. This organizational design provides multiple layers of synergy among the tasks for timely integration of research outcomes. This program team also proactively establishes effective collaborations with other EBI researchers. Of special relevance will be complementary research on feedstock genetics, biomass composition, biotic stress, ecosystem services and sustainability, socio-economic issues associated with biofuels, life-cycle analysis of environmental impact, and depolymerization of biomass.

One of the research efforts of the Systems Informatics and Analysis task team is to develop a concurrent science and engineering computational platform for mission-oriented integration of technologies and information resulting from the work of all task teams. In addition to being useful for dynamic analysis of biomass feedstock production systems, this platform will also serve to enhance communication and integration of technical information within this program and beyond. The objectives of the five tasks are described as follows:

Pre-harvest energy crop monitoring—To develop optimized instrumentation and data processing systems for crop growth, health, and stress monitoring, and to develop algorithms for precision and site-specific field operations.

Harvesting of energy crops—To develop sustainable and cost-effective processes and optimized equipment for harvesting and collecting biomass feedstock from the field.

Transportation of biomass—To provide practical solutions to conveying biomass feedstock from the field to storage locations and/or biorefineries in sufficient quantities and at high enough delivery rates to sustain biomass-to-energy conversion facilities.



Scope of the "Engineering Solutions for Biomass Feedstock Production" program.

Storage of biomass—To develop guidelines for locating and sizing storage facilities, as well as storage and preservation methods that will provide adequate supply of high-quality biomass to processing plants.

Systems informatics and analysis—To integrate information and knowledge from various sources related to the biomass feedstock production system in a real-time fashion, and to perform systems analysis, evaluate systems level performance, and deliver the results of analysis based on the most current information, also in a real-time fashion.

The program team

The program team includes investigators (**ASABE members in bold**): **K. C. Ting**, **Alan Hansen**, **Qin Zhang**, **Tony Grift**, **Lei Tian**, **Steven Eckhoff**, and **Luis Rodriguez**; collaborator **Vijay Singh**; post-doctoral research associates Konstantinos Domdouzis, **Hala Chaoui**, **Qingting Liu**, Yogendra Shastri, **Zewei Miao**, Tofael Ahamed, and **Ming-Che Hu**; graduate students Yung-Chen Liao, Candace Godbolt, and Bernardo Vidal; undergraduate students **Jude Holscher** and Sebastian Witkowski; visiting scholars **Francisco Pinto**, Yonghua Xiong, Jiang Yan, **Yuliang Zhang**, and Qingyuan Zhu; administrative support person Ronda Sullivan; and machine shop technician Dennis Mohr.

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Switchgrass image, pg. 12, courtesy of the Genome Management Information System, Oak Ridge National Laboratory.