

**Biomass Research and Development
Technical Advisory Committee**

November 17–18, 2016

Meeting Summary

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List of Acronyms

ATIP – Agricultural Technology Innovation Partnership
BETO – Bioenergy Technologies Office
Board – Biomass Research and Development Board
BRDI – Biomass Research and Development Initiative
CAAFI – Commercial Aviation Alternative Fuels Initiative
Committee – Biomass Research and Development Technical Advisory Committee
DOE – U.S. Department of Energy
FOA – funding opportunity announcement
FY – fiscal year
JGI – Joint Genome Institute
NIFA – National Institute for Food and Agriculture
NPL – National Program Leader
R&D – research and development
RFI – request for information
SBV – Small Business Voucher
SC – Office of Science
USDA – U.S. Department of Agriculture

I. Purpose

On November 17–18, 2016, the Biomass Research and Development Technical Advisory Committee (Committee) held its fourth meeting of 2016. The Committee received updates from the U.S. Department of Energy’s (DOE’s) Bioenergy Technologies Office (BETO), as well as U.S. Department of Agriculture (USDA) representatives delivering presentations about current USDA activities. The Committee also finalized and voted on their 2016 recommendations.

See Appendix A for a list of meeting attendees. See Appendix B to review the meeting agenda. Meeting presentations can be viewed on the Biomass Research and Development Initiative (BRDI) website at the following link: <http://biomassboard.gov/committee/meetings.html>.

Background: The Committee was established by the *Biomass Research and Development Act of 2000*, which was later repealed and replaced by Section 9008 of the *Food, Conservation, and Energy Act of 2008*. The Biomass Research and Development Board (Board) was established under the same legislation to coordinate activities across federal agencies. The *Food, Conservation, and Energy Act* has recently been amended by the *Agricultural Act of 2014*. The Committee is tasked with advising the Secretary of Energy and the Secretary of Agriculture on the direction of biomass research and development (R&D).

II. Welcome

Kevin Kephart, Committee Co-Chair

Paul Bryan, Committee Co-Chair

Dr. Kephart and Dr. Bryan welcomed the Committee to the fourth meeting of the year and called the meeting to order.

III. Committee Business for 2015 and DOE Updates

Elliott Levine, Designated Federal Officer, DOE

Mr. Levine provided an update and overview of the Committee activities. He started with talking about the key challenge for innovation, which is the need for BETO to lower risk for new technologies through demonstration, with greater integration and scale. He then highlighted the partnerships BETO has with other DOE offices, other federal agencies, and the national laboratories to achieve U.S. goals on bioenergy. Next, he provided a summary of BETO’s 2016 accomplishments and 2017 planned highlights. From there, Mr. Levine transitioned to recent BETO undertakings, including the Co-Optimization of Fuels and Engines, Agile BioFoundry, Separations Collaboration, and Chemical Catalysis for Bioenergy Consortium.

Mr. Levine then provided updates on recent funding opportunity announcements (FOAs):

- On May 16, 2016, BETO announced up to \$10 million in funding for six projects for Incubator 2

to advance the production of advanced biofuels, substitutes for petroleum-based feedstocks, and bioproducts made from renewable, non-food-based biomass, such as algae, agricultural residues, and woody biomass.

- On July 14, 2016, BETO announced up to \$15 million for three projects for Advancements in Algal Biomass Yield Phase II, aimed at reducing the costs of production of algae-based biofuels and bioproducts through improvements in algal biomass yields.
- The joint BETO-Vehicle Technologies Office FOA was released August 1, 2016. It was a \$7 million university-focused FOA to accelerate the introduction of affordable, scalable, and sustainable high-performance fuels for use in high-efficiency, low-emissions engines. The submission deadline for full applications was October 16, 2016. Applications received are currently undergoing compliance and merit review.
- On August 2, 2016, BETO announced \$11.3 million for MEGA-BIO Projects. BETO awarded three projects that support the development of biomass-to-hydrocarbon biofuels-conversion pathways that can produce variable amounts of fuels and/or products based on external factors, such as market demand.
- On August 19, 2016, BETO announced \$1 million in Small Business Vouchers (SBV) to assist five companies through the SBV Pilot, which is part of the National Laboratory Impact Initiative through the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy. In collaboration with national laboratories, the SBV Pilot supports small businesses to advance energy technology and help transform our biomass resources into commercially successful, high-performance biofuels, bioproducts, and biopower.

Mr. Levine then provide a summary of recent workshops:

- Understanding Scale-Up and Operational Challenges for Integrated Biorefinery Optimization – This workshop was held October 5–6, 2016, in Rosemont, Illinois, and aimed to gather information on challenges encountered with the successful scale-up and reliable operation of integrated biorefineries.
- Alternative Aviation Fuel Workshop – This workshop was held on September 14–15, 2016, in Macon, Georgia, to advance the understanding of current technical barriers for increasing the competitiveness of aviation biofuels. The workshop was organized into three parallel breakout sessions that will focus on the following technical areas related to aviation biofuels from lignocellulosic biomass.
- Commercial Aviation Alternative Fuels Initiative (CAAFI) General Meeting – The meeting was held October 25–27, 2016. CAAFI is a coalition that focuses the efforts of commercial aviation to engage the emerging alternative fuels industry.

- International Energy Agency Webinar: Biomass Torrefaction: Technology Status and Commercialization, Applications for Torrefied Biomass and Its Role in Logistics and Trade – The webinar was held on October 27, 2016, and discussed many topics, including challenges faced by torrefaction developers and commercialization of the torrefied product and its technology.

Mr. Levine announced that the 2017 BETO Peer Review will be held on March 5–10, 2017, at the Sheraton Downtown Denver (1550 Court Pl, Denver, CO 80202). Approximately 90% of projects in BETO’s research, development, and demonstration portfolio will be reviewed by external subject-matter experts from industry, academia, and federal agencies.

Finally, Mr. Levine thanked the departing members of the Committee for their service. Departing members include the following individuals:

- **Dr. Kevin Kephart (Co-Chair)**, Vice President for Research, and Dean of Graduate School, South Dakota State University
- **Dr. Maureen McCann**, Professor, Director of the Energy Center, Discovery Park, Purdue University
- **David Nothmann**, Vice President, AgriFood, Battelle Memorial Institute
- **Dr. William Provine**, Director of DuPont Biochemical Science and Engineering – BioFuels
- **Dr. James N. Seiber**, Chair, Department of Food Science and Technology, University of California, Davis
- **Dr. John Tao**, Chief Executive Officer, O-Innovation Advisors LLC.

IV. USDA Update on Biomass R&D Activities

Todd Campbell, U.S. Department of Agriculture

Mr. Campbell began by stating the USDA’s commitment to the expansion of the biobased economy and said that he considers it to be one of four pillars of agriculture and rural economic development—creating jobs and wealth in rural America. Establishment of the Coordinated Regional Biomass Research Centers (through the Agriculture Research Service and Forest Service) will use the science necessary to ensure the production of profitable biofuels and biobased products from a diverse range of feedstocks across the nation. USDA has invested \$332 million to accelerate research on renewable energy, ranging from genomic research on bioenergy feedstock crops, to the development of biofuel-conversion processes, and cost/benefit estimates of renewable energy production.

To ensure innovation continues in renewable energy R&D, USDA has invested more than \$237 million in research, education, and extension grants through the Agriculture and Food Research Initiative’s Sustainable Bioenergy and Bioproducts Challenge Area. These projects partner academic institutions, feedstock suppliers, conversion/technology companies, and airlines across multiple state boundaries—with the primary objective being to develop regional supply chains, sustainable feedstock/fuel production, sound science, and partnerships.

USDA has encouraged feedstock production by establishing the Biomass Crop Assistance Program through the Farm Service Agency, which is incentivizing nearly 1,000 growers, farming nearly 50,000 acres, to establish and produce dedicated, non-food energy crops for delivery to conversion facilities.

USDA is supporting farmers who are producing biomass for renewable energy by offering insurance coverage for biofuel crops like switchgrass and camelina. USDA is also helping identify American farmland that is most suitable for growing energy crops, and it has expanded the Noninsured Crop Disaster Assistance Program to cover bioenergy crops that are not covered under USDA's crop insurance program.

USDA is also investing in next-generation fuels. Since 2009, USDA has provided \$844 million in loan commitments to businesses to develop and produce advanced biofuels. Companies receiving these commitments are projected to produce 159 million gallons of advanced biofuels.

The increased use of biobased products has the potential to reduce greenhouse gas emissions by an estimated 10 million metric tons of carbon dioxide equivalents per year. And, USDA's BioPreferred program has continued to grow by leaps and bounds, with an online catalog of more than 15,000 products—of which, 2,700 have been tested and feature the USDA Certified Biobased Product label. That list includes everything from plastics and packaging to everyday cleaning supplies—all of which help Americans make choices that lessen their carbon footprint, while simultaneously investing in new opportunities for working families in America's rural communities.

The U.S. biobased economy, worth \$393 billion and more than 4.2 million jobs, is generating considerable opportunities for American jobs and economic mobility in rural America. In fact, estimates show that shifting just 20% of the current plastics produced to bioplastics could create 104,000 jobs. Every 1,000 jobs in the biobased industry supported 1,760 additional jobs in other parts of the economy.

V. Biomass Research and Development Initialize (BRDI) Update

Daniel Cassidy, National Institute of Food and Agriculture, U.S. Department of Agriculture

Mr. Cassidy provided the latest update on the BRDI initiative. BRDI has filled a significant gap in the continuum of technology development and commercialization supported by USDA, DOE, and other federal programs. USDA had shaped the program to be a source of bridge funding for developing and emerging technologies to cross the "economic valley of death." The intent of the program was to help develop and demonstrate technologies to the point that they might attract additional private or public financing to scale up and/or produce commercial quantities of biomass-based energy and/or materials.

For the latest solicitation, 414 pre-applications were received. Of those, 47 full proposals were submitted. This resulted in a \$67.72 million request for funding. Currently, USDA's combined-year budget from Fiscal Year (FY) 2014 and FY 2015 was about \$7.2 million with DOE funds up to \$3 million. Of the 47 proposals, 7 focused on Feedstock Development, 36 on Biofuels/Bioproducts Development, and 4 on Systems Analysis.

The 14-member committee that reviewed the proposals comprised 3 federal scientists, 3 industry representatives, 6 academia representatives, and 2 private consultants.

The awards made are as follows:

USDA Awards

- “Integrated Biorefinery To Produce Ethanol, High-Value Polymers, and Chemicals from Lignocellulosic Biomass,” University of California-Riverside and University of Tennessee
- “Cotreatment for Low-Cost Fermentation of Cellulosic Biomass,” Dartmouth College, Penn State University, Bioenergy Science Center, and Enchi Corporation
- “Development of Stochastic Techno-Economic and Life Cycle Models for Quantifying the Economic and Environmental Costs of Cellulosic Bioenergy,” State University of New York
- “Forest Bioenergy and Biofuels Integration: Sustainability, Energy Balance, and Emissions from Forest Restoration in the Southern Rocky Mountains,” University of Montana; Northern Arizona University; and U.S. Forest Service, Rocky Mountain Research Station
- “Mid-Atlantic Biomass Sorghum Collaborative To Optimize Agronomic Production and Grower Profitability,” North Carolina State University, North Carolina Biotechnology Center; Virginia Tech, and Chemtex International.

DOE Awards

- “Improving Tolerance of Yeast to Lignocellulosic Feedstocks and Products,” Massachusetts Institute of Technology
- “Biomass Gasification for Chemical Production Using Chemical Looping Techniques,” Ohio State University with eight industrial partners.

The next BRDI solicitation draft for FY 2016 and FY 2017 funds has been developed and is undergoing approval. It has incorporated Committee recommendations to help streamline the process and timeline. USDA hopes to release the solicitation soon, as this will be the last BRDI solicitation under the current Farm Bill.

Mr. Cassidy then provided an update on NIFA, which is the extramural funding arm of USDA on research, education, and extension. NIFA has four institutes and the Center for International Programs. NIFA Competitive Programs include the following:

- Agriculture and Food Research Initiative
- Biodiesel Education Program
- Joint Feedstock Genomics with DOE
- Sun Grant Initiative
- Critical Agricultural Materials Program
- Forest Research Initiative
- Innovation at the Nexus of Food, Energy, and Water.

Currently, NIFA is hiring a new Division Director, National Program Leader (NPL) for Logistics, and they recently just hired a new NPL for Agricultural Bioproducts.

VI. Release of the Bioeconomy Challenges and Opportunities Report

Dr. Cathie Woteki, Under Secretary for Research, Education, and Economics, U.S. Department of Agriculture

Dr. Woteki announced the release of the latest report on the Billion-Ton Bioeconomy Vision. *The Bioeconomy Initiative: A National Strategy for the Billion-Ton Vision* address barriers and opportunities to meeting the vision (initiative) goals. It focuses on strategic buckets including the following:

- Techno-economic barriers
- Policy barriers
- Market barriers
- Financial investment barriers
- Workforce barriers
- Crosscutting strategy buckets
- Public awareness/acceptance.

This report discusses seven of the high-priority challenges recognized by the bioeconomy stakeholder community, identified below:

- Major technical hurdles for development and scale
- Steep competition from traditional petroleum-derived resources
- A lack of necessary infrastructure
- Access to capital for large financial investments
- Uncertainties about sustainability—understanding environmental, social, and economic outcomes
- Growth instability and increased investment risk caused by policy uncertainty
- The need for a strong and capable workforce.

Specific opportunities within each challenge as potential growth areas for the future of BRDI are listed below:

- Develop feedstock and fundamental innovations that reduce cost and technology risk in the supply chain.
- Seek opportunities to utilize low-cost waste resources.
- Quantify, communicate, and enhance beneficial effects and minimize negative impacts.
- Create increased public demand for biomass-derived products in a bioeconomy.
- Develop bioproducts that can accelerate biofuel production.
- Enable the testing and approval of new biofuels and bioproducts.
- Expand the market potential for biomass.
- Encourage private-sector financing

- Support stable, long-term policies.
- Ensure a ready workforce to meet the needs of the bioeconomy.

VI. Update on the BRD Board Bioeconomy Initiative and Review of Listening Session

Todd Campbell, U.S. Department of Agriculture

Wes Jurey, Agricultural Technology Innovation Partnership, U.S. Department of Agriculture

Mr. Campbell introduced Wes Jurey from the Agricultural Technology Innovation Partnership (ATIP) Foundation, a consortium of state economic development organizations. They co-hosted a series of regional Bioeconomy Forums with a coordinating entity to garner input from a broad range of stakeholders, relative to the initiative's vision, strategies, and implementation to help shape a multi-year implementation plan being prepared by the Biomass R&D Board. **The 5 regional forums each had 40–60 attendees representing 6 sectors:**

- Industry
- State and local government
- Economic and workforce development
- Investment and finance
- Academia
- Agricultural and environmental organizations.

The five sessions were held at the following locations with regional co-hosts:

- **Southeast: September 16, Atlanta, Georgia** (Georgia Institute of Technology)
- **Southwest: September 29, Mineral Wells, Texas** (Chamber of Commerce)
- **Northwest: October 3, Seattle-Tacoma, Washington** (Washington State University)
- **Northeast: October 18, Orono, Maine** (University of Maine)
- **Midwest: November 15, Columbus, Ohio** (The Ohio State University)

Common inputs from each session were calorized in the following themes. Mr. Jurey then went through and provided details for each theme:

- Finance (U.S. Treasury)
- Education and awareness
- Policy
- Supply chain
- Workforce (U.S. Departments of Labor and Education)
- Federal resources.

VIII. 2016 Committee Recommendations

Committee

The following recommendations were voted on and approved by the Committee:

Implementation and Conduct of the Biomass Research and Development Initiative

The Committee's 2016 reporting obligations and recommendations for BRDI are as follows:

1. *Funds authorized are distributed and used in a manner that is consistent with the objectives, purposes, and considerations of BRDI.*
 - The Committee found that the funds were distributed and used appropriately. Of the 414 pre-applications received, 7 awards were made in 2016, and they were consistent with the requirements of the Act.
2. *Solicitations are open and competitive with awards made annually.*
 - The Committee found that the combined FY 2014 and FY 2015 solicitation was open and competitive; however, though the awards that have been made were open and competitive, awards have not been made annually. The Committee concurs with the decision to combine two years of funding (FY 2016 and FY 2017) because of the relatively small level of annual funds available. Combining two fiscal years is necessary at the current funding levels. Sufficient funding would allow BRDI to again make awards annually.
3. *Objectives and evaluation criteria of the solicitations are clearly stated and minimally prescriptive, with no areas of special interest.*
 - The Committee is satisfied that USDA's NIFA and DOE's BETO are fulfilling this requirement.
4. *The points of contact [§(c)(2)(A)] are funding proposals under this title that are selected on the basis of merit, as determined by an independent panel of scientific and technical peers predominantly from outside the Departments of Agriculture and Energy.*
 - The Committee commends USDA-NIFA and DOE-BETO for the selection process they have implemented for BRDI.
 - The Committee recognizes that the pre-application review process effectively down-selects the number of proposals that will be considered during the full application process; however, the Committee recommends that DOE and USDA provide more feedback to applicants who were not recommended to submit a full proposal. Also, more transparency in the details of the pre-application selection process is needed.
5. *Activities under this title are carried out in accordance with the title.*
 - The Committee found that the activities are being carried out in accordance with the title.

The Committee makes the following additional recommendations for further improving BRDI:

- The goals of BRDI are important to the Billion-Ton Bioeconomy Initiative, supporting job creation, rural development, and national security. This importance should be reflected in meaningful funding levels. If the nation places a high priority on accelerating the development of a secure, biobased economy, BRDI will require appropriations that are similar to what was provided prior to the funding cuts (from the previous \$40 million annually) implemented in December 2012. Even after combining the appropriations from two fiscal years (summing to \$6 million), BRDI could fund only 7 awards out of 414 applications. BRDI represents an important translational portion of the federal research portfolio, and \$3 million annually will limit the progress of basic research toward strategic applications.
- The last year for BRDI funding will be 2017 unless it is reauthorized. The Committee recommends that funding for BRDI be reauthorized.
- BRDI should document how projects have impacted the commercial state of technology and the bioeconomy to better publicize the successes of the BRDI projects.
 - As per the Biomass Research and Development Act section[§(e)(2)]:

“The objectives of the Initiative are to develop

 - Technologies and processes necessary for abundant commercial production of biofuels at prices competitive with fossil fuels
 - High-value biobased products
 - A diversity of economically and environmentally sustainable domestic sources of renewable biomass for conversion to biofuels, bioenergy, and biobased products.”
- The Committee recognizes the planned efforts to streamline the application submission process. The Committee suggests that BRDI continues to reduce the time from proposal submission to award selection.

2016 Recommendations on the Bioeconomy

Key Themes and Problem Statements

During Committee discussions in 2016, the Committee felt that key themes and problem statements from 2015, with minor adjustments to better convey the proper messaging, were still relevant and appropriate. These key themes and problem statements frame the Committee recommendations and apply to all bioeconomy stakeholders, including federal R&D agencies and private industry. The revised 2016 key themes and problem statements are as follows:

1. *Key Theme: Improve Profitability and Commercial Viability of Bioeconomy Industries*

- **Problem Statement:** Costs attributed to biomass feedstocks in the bioeconomy value chain are too high, feedstock composition is too variable, and supplies are inconsistent for biorefinery operations. Low-cost feedstocks are available only in isolated cases. Feedstock producers must

have sufficient confidence that economic returns will be realized and that they have access to risk-mitigation tools before they will commit to establishing new feedstock production systems.

- **Problem Statement:** The Committee has recognized each year since the 2013 report that capital and operating expenses for conversion facilities have been the primary factors limiting the growth of advanced biofuels and commodity bioproducts. Conversion facilities encounter substantially higher capital costs per gallon of capacity than do starch/sugar ethanol plants or conventional petroleum refineries, and they involve less-efficient unit operations than conventional refining. Higher capital costs increase project-completion risks, and, thereby, reduce the likelihood of obtaining investment funding from the private sector. Additionally, large petroleum companies are reducing commitments to ongoing biofuels ventures and are making virtually no new investments.

2. *Key Theme: Develop and Support Market Drivers of the Bioeconomy*

- **Problem Statement:** Feedstock value is insufficient—and potential market risks associated with switching or rotating to new dedicated feedstocks are too high—to convince producers to dedicate acres to biomass production. The risks associated with perennial small-seeded species are often high relative to the existing commodity crops that benefit from many decades of R&D investment. There are existing federal programs that help to cross that divide (e.g., the Biomass Crop Assistance Program and 508(h) Risk Management Agency); however, additional effort is needed.
- **Problem Statement:** The social, economic, and environmental benefits of the bioeconomy are not sufficiently understood, making it difficult to understand the true value of transitioning to a sustainable bioeconomy from a fossil-fuel-based economy. This lack of understanding also complicates policy decisions regarding incentives to support the bioeconomy.
- **Problem Statement:** More economic and risk-mitigation innovations for biorefineries, such as the joint Defense Production Act (DPA) program with the Navy, are needed to buy down costs enough, so the project awardees (and their private-sector investors) can continue to move forward.
- **Problem Statement:** Some regulatory and policy issues impede the growth of the bioeconomy. On the basis of production cost alone, biofuels cannot compete with low-cost producers, and, therefore, cannot displace their market share.

3. *Key Theme: Stimulate Public Awareness and Support*

- **Problem Statement:** The benefits of the bioeconomy must be made evident to the public, elected officials, and policy makers. There are many other benefits of the bioeconomy beyond competitive replacement in petroleum markets. Without public support, the larger policy changes that are necessary for an expanded bioeconomy will be difficult to implement.

Recommendations

The 2016 recommendations to the Board are as follows:

For each key theme, recommendations were developed in 2016. Also included in each section below are related 2015 recommendations to provide continuity and show the relationship with the 2016 recommendations.

1. Recommendations To Improve Profitability and Commercial Viability of Bioeconomy Industries:

- Expand R&D to reduce feedstock, capital, operating costs, and risks; support efforts to increase yields, improve efficiencies, and innovate around bottlenecks.
- Take advantage of existing infrastructure.
 - In the current environment where small refineries are challenged, help foster public-private partnerships for ongoing, essential R&D to help integrate the existing petroleum industry with the bioeconomy (e.g., refining of bio-oil derived from pyrolysis).
 - Pulp and paper mills are biorefineries that are currently struggling in international markets and could diversify to produce new or additional bioproducts.
- Use existing and new programs focused on de-risking technologies and feedstock production.
 - Leverage existing USDA and DOE programs, such as crop insurance and the BioPreferred program, and develop new programs in order to incentivize private investment and financing for feedstock supply.
- Enhance the ability to implement sustainable landscape design by emphasizing low-carbon-intensive crops and further considering nutrient and land-management best practices.
- Manage all research funding to maximize the efficiency of the entire biomass supply chain, including means to increase the efficiency of harvest, storage, and transportation logistics for biomass and bio-intermediates (e.g., biomass densification, stabilization, and standardization).
- For commercial-scale systems, breakthrough technologies are needed to reduce capital and operating costs.
 - The Billion-Ton Bioeconomy will require novel and disruptive technologies to be commercially successful, and too little is known about specific, future breakthroughs. A request for information (RFI) on novel and disruptive technologies is advised by the Committee. The Committee recommends that the Board release a RFI (or similar mechanism) to solicit new information on these technologies and work with the Committee on future R&D areas for consideration.
 - Increase research investments in smaller modular systems as another path to cost reduction. Leverage existing infrastructure to reduce costs, particularly in the area of product distribution.
 - Better enable the approval and certification process of bio-replacements, either direct replacements or functional replacements (i.e., American Society for Testing and Materials). This can be done through better standardization of requirements across the value chain.

- Fund programs to reduce operating costs of biorefining processes, such as, technologies to aid in the depolymerization of recalcitrant forms of cellulose, heterogeneous and homogeneous catalysis, advanced enzymatic treatment, fermentation and separation technologies, bioproduct integration, and biorefinery process synthesis and analysis.
- Create a new formal network with an open-access environment to build upon and share knowledge, services, facilities, and capabilities to support the growth of the bioeconomy.
 - Leverage existing information and networks such as Biotechnology Innovation Organization, ATIP, and Biomass Board reports.

Related 2015 Recommendations:

- Encourage cropping systems that increase biomass productivity. For example, develop profitable cropping systems that include periods for cover crop production when primary crops are not being grown.
- Encourage the integration of technologies and pathways that use existing infrastructure (e.g., refineries, filling stations, storage, and distribution infrastructure). Expanded research is needed to better integrate biomass processing in the petroleum industry and to incentivize petroleum companies to make investments in biofuels and bioproducts.
- Focus public R&D on feedstocks and production processes that require minimal inputs (e.g., water, nutrients, chemicals, and energy) to achieve socially, economically, and environmentally sustainable yields.
- Develop post-harvest processing and logistics systems that continuously provide feedstocks to processors. For example, develop and demonstrate improved feedstock logistics via better approaches to aggregating, processing, blending, and storage.
- Established specifications, standards, and mature technologies to create a biomass feedstock industrial commodity. Specifications should include limits for water content, chemical composition, and purity. Inexpensive tools for high-throughput, rapid-screening technologies that measure specifications related to quality assurance must be developed.
- Fund and manage a greater number of smaller R&D projects to establish a balanced R&D portfolio that will identify disruptive technologies offering the greatest opportunities for cost reduction. Technological breakthroughs are especially needed in the following fields:
 - Feedstock densification, storage, and transport
 - Pretreatments of raw feedstocks
 - Fermentation
 - Thermochemical processes
 - Catalysis
 - Separations.
- Establish and fund advanced manufacturing innovation centers. Emphasize centers where teams of researchers and projects can be coordinated for further testing in an integrated process context.
- Fund projects involving integrated pilot/demonstration processes only when all of the components have been proven at a scale in which there is confidence that the integrated process will work, and only when process-integration issues are the final major risks to commercialization.
- Demonstrate individual unit operations up to the smallest scale necessary to predictably scale up for commercial purposes before attempting large-scale integration.
- Fund technologies at appropriate scale. Large-scale demonstrations and pioneer plants should be funded only if early indicators show that the costs and integration risks are all that remain to be established. Integrated demonstrations should be scaled up only if all components are known and proven.
- The government should develop advanced computational technologies on modeling and simulation of processes relevant to manufacturing of biobased products and fuels.

2. *Recommendations To Develop and Support Market Drivers of the Bioeconomy*

- Support actions that enhance the growth of the bioeconomy, such as implementing the Renewable Fuel Standard mandate; increasing federal funding for research; incentivizing use of bioproducts and biofuels; and expanding the BioPreferred program.
- Focus research on areas where we know the market is ready to accept and promote bioproducts/biofuels as they are available. Support initiatives for product and market development.
- Support emerging business innovation and development through collaborations, Cooperative Research and Development Agreements, shared equipment, and access to national laboratories via new programs such as the Small Business Vouchers Pilot.
- Use government purchasing power and authority to develop market pull in the current low-petroleum price, low-carbon price environment.
 - To improve the competitiveness of biofuels with fossil fuels, focus on promising biofuel and bioproduct market segments, including high-octane, renewable diesel, biochar, biochemicals, bioplastics, and aviation fuels.
- Create a global feedstock commodity market by identifying and promoting exports of feedstocks, biofuels, and bioproducts where market conditions are more favorable.
- Promote long-term stable policies to reduce market uncertainty and to de-risk investments required to grow the bioeconomy.

Related 2015 Recommendations:

- The Department of Defense and General Services Administration should explore an increase in the number and duration of purchasing agreements for biofuels and biobased products.

3. *Recommendations To Stimulate Public Awareness and Support*

- The bioeconomy requires a value proposition that is better understood and embraced by the public. Conduct analysis to determine a framework to characterize and quantify the job creation, economic, rural development, public health, national security, and environmental benefits of the bioeconomy.
- Improve the science and understanding of indirect land-use change.
- Assess the economic effects, such as wealth and job creation, rural development, and resource and supply diversity.

Related 2015 Recommendations:

- Provide incentives for the large, established companies to invest through focused efforts to build demand for biofuels/products.
 - Develop fuel products that are compatible with the existing infrastructure, including new technologies that focus on alignment with existing petroleum infrastructure—for example, the efforts currently under way to develop renewable diesel and jet fuels.
 - Enable biomass technologies to take advantage of underutilized infrastructure and established facilities. For example, co-locate biomass post-harvest processing facilities with existing conversion facilities that offer synergies with biomass.
- Research socioeconomic drivers that influence producer decisions about feedstock production. For example, determine how feedstock production for the bioeconomy affects biomass utilization for wildlife habitat, management of concentrated animal feeding operation drainage areas, production field waterways, and riparian buffer zones.
- Analyze on a national scale (in addition to local/regional tools development) the effects of optimizing land and resource use for farm sustainability.

VIII. Advanced Feedstocks Opportunities

*Catherine M. Ronning, Ph.D., Program Manager, DOE, Office of Biological and Environmental Research
Biological Systems Science Division*

Dr. Ronning started with an overview of the DOE Office of Biological and Environmental Research approach. This includes understanding complex biological and environmental systems across many spatial and temporal scales; integrating science by tightly coupling theory, observations, experiments, models, and simulations; supporting interdisciplinary research to address critical national needs; and engaging national laboratories, universities, and the private sector to generate the best possible science. She then went through the DOE Genomic Science Program Research areas:

- Bioenergy Research Centers – Team-based, multi-institutional, cross-disciplinary, integrated systems research centers. Annual budgets for centers may range from \$12.5–\$30 million for up to 5 years. A FOA was posted March 30, 2016, and applications were received September 30, 2016.
- Systems Biology for Bioenergy – Research to enable the integrated development of sustainable bioenergy feedstock systems in terrestrial environments within the ecosystem. Awards were made in FY 2015.
- Plant Feedstocks Genomics – A joint competitive grants program initiated in 2006 with DOE’s Office of Science (SC), Office of Biological and Environmental Research, and USDA National Institute of Food and Agriculture (NIFA). The FOA was issued November 9, 2016, pre-applications were due December 7, 2016, and proposals were due February 15, 2017.

- Biosystems Design – Supports research on design of new biological systems that address challenges associated with the production of biofuels and related coproducts from renewable resources. The FOA was issued October 12, 2016, pre-applications were due December 19, 2016, and proposals were due March 20, 2017.
- Sustainability Research for Bioenergy – Investigate molecular and physiological mechanisms controlling bioenergy crop vigor, resource-use efficiency, and adaptability to abiotic stress, to increase biomass productivity under changing and, at times, suboptimal conditions; and investigate role(s) of microbial and microbial communities in plant-soil-environment interactions, bioenergy feedstock plant performance, adaptation, and resilience under changing environmental conditions and abiotic stressors. Six awards were issued totaling \$66.4 million (FY 15–FY 19).

Another facility for SC is the Joint Genome Institute (JGI). Their mission is to enable advances in energy and environmental science by providing access to state-of-the-art genomic capabilities in support of DOE’s national research agenda. The Community Science Program Annual Call for 2017 had eight awards. The Facilities Integrating Collaborations for User Science, a collaboration between JGI and the Environmental Molecular Science Laboratory, made three awards in 2016 and 2017.

SC’s Early Career Research Program supports the development of individual research programs of outstanding scientists early in their careers and stimulates research careers in the disciplines supported by SC. Four awards were made in 2016. The DOE Office of Science Graduate Student Research Program provides supplemental awards to outstanding graduate students to spend 3 to 12 months conducting part of their doctoral thesis/dissertation research at a DOE national laboratory in collaboration with a DOE laboratory scientist. Applications were due November 21, 2016.

XVI. Closing Comments

The meeting was adjourned.

Appendix A: Committee Member Attendance—November 17–18, 2016

Co-Chairs	Affiliation	Attended?
Kevin Kephart	South Dakota State University	Yes
Paul Bryan	Consultant	Yes
Members	Affiliation	Attended?
Dean Benjamin	Verso Corporation	Yes
Esteban Chornet	Enerkem	Yes
Steve Csonka	Commercial Aviation Alternative Fuels Initiative	Yes
Vonnie Estes	Consultant	Yes
Emily Heaton	Iowa State University	Yes
Joseph James	Agri-Tech Producers, LLC	Yes
Randy Jennings	Tennessee Department of Agriculture	Yes
Coleman Jones	General Motors Corporation	No
Man Kit Lau	BioAmber Inc.	Yes
Maureen McCann	Purdue University	Yes
Bruce McCarl	Texas A&M University	No
Christine McKiernan	BIOFerm Energy Systems	No
Ray Miller	Michigan State University	Yes
Shelie Miller	University of Michigan	Yes
Marina Moses	American Academy of Microbiology	Yes
Neil Murphy	State University of New York	Yes
David Nothmann	Valent USA	Yes
Kimberly Ogden	University of Arizona	No
Manuel Garcia-Pérez	Washington State University	Yes
William Provine	Dupont	Yes
Anna Rath	NexSteppe	Yes
Patricia Scanlan	Black & Veatch	Yes
James Seiber	University of California	No
Abolghasem Shahbazi	North Carolina A&T State University	Yes
Don Stevens	Cascade Science and Technology Research	Yes
John Tao	O-Innovation Advisors LLC	Yes
Kelly Tiller	Genera Energy, Inc.	Yes
Valerie Thomas	Georgia Institute of Technology	Yes
Alan Weber	MARC-IV Consulting/Weber Farms	Yes

Total: 26 of 31 members attended

Appendix B: Agenda—November 17–18, 2016

Day 1: Technical Advisory Committee Meeting: Thursday, November 17, 2016

8:00 a.m. – 8:30 a.m.	<i>Breakfast (to be provided for Committee)</i>
8:30 a.m. – 8:40 a.m.	<u>Introduction and Welcome</u> <i>Committee Co-Chairs</i>
8:40 a.m. – 9:05 a.m.	<u>Presentation</u> : U.S. Department of Energy and U.S. Department of Agriculture Updates <ul style="list-style-type: none">• <i>Elliott Levine, U.S. Department of Energy</i>• <i>Todd Campbell, U.S. Department of Agriculture</i>
9:05 a.m. – 9:30 a.m.	<u>Discussion</u> : 2016 Biomass Research and Development Initiative (BRDI) Committee Recommendations Process <i>Committee Co-Chairs</i>
9:30 a.m. – 10:00 a.m.	<u>Presentation</u> : BRDI Update <i>Daniel Cassidy, National Institute of Food and Agriculture, U.S. Department of Agriculture</i>
10:00 a.m. – 10:10 a.m.	<u>Presentation</u> : Release of the <i>Billion Ton Bioeconomy Initiative: Bioeconomy Challenges and Opportunities</i> Report <i>Dr. Cathie Woteki, Under Secretary for Research, Education, and Economics, U.S. Department of Agriculture</i>
10:10 a.m. – 10:50 a.m.	<u>Presentation</u> : Update on the Biomass Research and Development Board Bioeconomy Initiative and Review of Listening Sessions <ul style="list-style-type: none">• <i>Todd Campbell, U.S. Department of Agriculture</i>• <i>Wes Jurey, Agricultural Technology Innovation Partnership, U.S. Department of Agriculture</i>
10:50 a.m. – 11:00 a.m.	<i>Break</i>
11:00 a.m. – 11:15 a.m.	<u>Public Comment</u>
11:15 a.m. – 12:00 p.m.	<u>Subcommittee Breakouts</u> (<i>closed session</i>)
12:00 p.m. – 1:00 p.m.	<i>Lunch (to be provided for Committee)</i>
1:00 p.m. – 5:30 p.m.	<u>Subcommittee Breakouts</u> (<i>closed session</i>)

Day 2: Technical Advisory Committee Meeting: Friday, November 18, 2016

8:00 a.m. – 8:30 a.m.	<i>Breakfast (to be provided for Committee)</i>
8:30 a.m. – 10:30 a.m.	<u>Discussion</u> : Subcommittee Reports
10:30 a.m. – 10:45 a.m.	<u>Vote</u> : 2016 Committee Recommendations to Biomass Board and Secretaries of Energy and Agriculture <i>Committee Co-Chairs</i>
10:45 a.m. – 11:00 a.m.	<i>Break</i>
11:00 a.m. – 12:00 p.m.	<u>Discussion</u> : 2016 Presentation to the Board and Secretaries of Energy and Agriculture <i>Committee Co-Chairs</i>
12:00 p.m. – 1:00 p.m.	<i>Lunch (to be provided for Committee)</i>
1:00 p.m. – 2:00 p.m.	<u>Presentations</u> : Potential Topics for Discussion in 2017 <i>Committee Co-Chairs</i> <ul style="list-style-type: none">• <i>Advanced Feedstock Opportunities, Catherine Ronning, U.S. Department of Energy, Office of Biological and Environmental Research</i>
2:00 p.m. – 3:00 p.m.	<u>Discussion</u> : Technical Advisory Committee Process for 2017 <i>Committee Co-Chairs</i>
3:00 p.m.	Adjourn