Overview: Bioenergy Workshop

held on
June 23-24, 2014
Renaissance Marriott Hotel
Washington, DC

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Department of Energy
Office of Biological & Environmental Research (BER)
Bioenergy Funding in BER

• BER supports basic research in bioenergy
  – Three Bioenergy Research Centers (BRC)
  – Annual Plant Feedstocks through joint FOA with USDA
  – Genomic Science FOA on bioenergy-relevant microbes and microbial systems
  – National Laboratory Biofuels Science Focus Area (SFA) programs
  – Biosystems Design projects
  – SBIR grants
Bioenergy Research Center Program

• BER supports basic research in bioenergy
• Original Goals of the BRCs
  – Feedstocks
  – Enhance Deconstruction
  – Fuel Synthesis (lignocellulosic ethanol → advanced biofuels
  – Enabling Technologies
  – Technology Transfer
• Annual reviews document success of BRCs at meeting stated goals
• BRCs finishing year 7 of a second 5-year funding period
• Need to define the state-of-the-science, and remaining gaps and barriers to inform BER future of funding basic bioenergy research
Workshop Participants

• Co-Chairs
  – Dr. Kristala Jones-Prather, Massachusetts Institute of Technology
  – Dr. Erich Grotewold, Ohio State University

• 45 Participants
  – 4 Industry
  – 7 DOE National Laboratories
  – 34 Academic institutions
Workshop Organization

• Presentations with Break-Out Discussions

• Speakers
  – Chris Somerville, Energy Bioscience Institute, University of California - Berkeley
  – Maureen McCann, Purdue University, C3Bio
  – Greg Stephanopoulos, MIT
  – Jay Keasling, JBEI, LBNL
  – Lee Lynd, BESC, Dartmouth University
  – Ken Keegstra, GLBRC, Michigan State University
  – Michael Martin, Monsanto Corporation
Workshop Organization (cont)

• Break-Out Discussion Groups
  – Biomass Development
    • Thomas Brutnell – Danforth Center
    • David Braun – University of Missouri
  – Deconstruction of Biomass
    • Birgitte Ahring – Washington State University
    • Michael Ladisch, Purdue University
  – Specialty Fuels
    • Terry Papoutsakis, University of Delaware
    • Ryan Gill, University of Colorado
  – Bioproduct Development
    • Elizabeth Hood, Arkansas State University
    • Brent Shanks, Iowa State University
Expected Workshop Outcomes

• A report with
  – An assessment of the current state-of-the-science with regard to the production of advanced cellulosic biofuels and bioproducts,
  – Identification of remaining scientific and technical barriers to the establishment of a sustainable domestic next generation biofuels and bioproduct commercial sector,
  – Information and perspectives to inform BER’s bioenergy program goals.
Findings - Biomass Production

• Advances
  – Identification of genes involved in cell wall biosynthesis and their regulation
  – Demonstrated ability to genetically engineer biofuel crops for reduced recalcitrance and greater sugar yields
  – Demonstrated genetic engineering to alter lignin composition and hydrolizability

• Gaps and Barriers
  – Further work needed to optimize lignocellulosic biofuel and bioproduct crops
  – Continue work on switchgrass, Miscanthus, energy cane and poplar, to name the most prominent
  – Improve biofuel traits through a combination of selection of natural variants, genotype assisted breeding, and genetic engineering
  – Prioritized traits include reduced recalcitrance, water and nutrient recycling, and delayed flowering
Findings - Deconstruction

• Advances
  – Several effective pretreatment technologies
  – Better understanding of plant cell wall structure and origins of recalcitrance
  – Promise shown by consolidated bioprocessing with engineered thermophiles
  – Effective enzymes farming using metagenomics, genomic sequencing and gene synthesis

• Gaps and Barriers
  – Need for standardized biomass samples to use for comparative analysis
  – Better analytical tools for characterizing the lignocellulose and the break-down intermediates
  – Need deconstruction streams that provide for fermentable sugars as well as valorization of lignin
  – Establish a basic toolbox for lignin catabolism
Findings – Specialty Biofuels

• Advances
  – Engineered microbes with higher conversion efficiencies and greater inhibitor tolerance
  – Engineered thermophile to make lignocellulosic ethanol without pretreatment
  – New tools for synthetic biology and metabolic engineering resulting in an expanded suite of accessible molecules beyond ethanol to serve as biofuels or their precursors

• Gaps and Barriers
  – Selecting the appropriate targets, based on meaningful evaluation of the accessible markets, remains a challenge
  – Methods to test thousands of variants of a pathway in a high throughput manner will greatly impact the rate of discovery and optimization
  – It remains difficult to predict the performance of a microbe in industrial scale fermentation from benchtop scale experiments
Findings - Biomass Bioproducts

Gaps and Barriers

– Separation technologies- lack cost effective extraction of manufactured product or raw material
– Inadequate integration of manufacturing with the fuel production site
– Inadequate compositional analysis of potential byproduct streams
– Lack of efficient, stable and scalable biocatalysts for desired bioproducts
– Lack efficient and economical continuous processes
– Lack flexible process technology to accommodate multiple feedstock sources
– Lack synthetic biological and/or chemical chassis that only require minor modification for a range of bioproducts
Summary and Future Directions

• Continued support for biofuel crop development
• Continued support for improved deconstruction
• Expand to include specialty fuels and bioproducts
  – Replace petroleum as starting material for carbon-neutral production
  – Pathway to aromatics through less toxic intermediates than benzene and toluene
  – An infinite diversity of new products
• Continued value in vertical integration
Closing Comments

• An Executive Summary is available in the back of room etc.

• Draft report is back in the hands of the co-chairs before sending to professional editor/publisher
The End