

Sustainability of Bioenergy Systems: Cradle to Grave

**A Workshop for Oak Ridge National Laboratory,
the US Environmental Protection Agency, and their collaborators
September 10 – 11, 2009, in Oak Ridge, Tennessee**

Workshop Steering Committee

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John Storey, Oak Ridge National Laboratory

Information about the workshop and participants can be found at the web site for
Oak Ridge National Laboratory's Center for BioEnergy Sustainability

<http://www.ornl.gov/sci/besd/cbes.shtml>

Suggested citation for this report: CBES (Center for BioEnergy Sustainability, Oak Ridge National Laboratory). 2009. Sustainability of Bioenergy Systems: Cradle to Grave: Report from the 2009 workshop, ORNL/CBES-002, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy and Oak Ridge National Laboratory, Center for Bioenergy Sustainability (<http://www.ornl.gov/sci/besd/cbes.shtml>).

October 2009

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WORKSHOP REPORT

A Workshop for Oak Ridge National Laboratory (ORNL), the US Environmental Protection Agency (EPA), and their collaborators was held on September 10-11, 2009 at ORNL. The informal workshop focused on “Sustainability of Bioenergy Systems: Cradle to Grave.” The topics covered included sustainability issues associated with feedstock production and transport, production of biofuels and by-products, and delivery and consumption by the end users. The workshop had two overall goals:

- to share information about their activities in this area.
- to identify immediate and long-term needs and opportunities for collaboration

The workshop also created opportunities:

- to present key issues of bioenergy sustainability and discuss work that is ongoing to address these issues
- to develop a systems perspective on bioenergy sustainability
- to identify questions that lead toward a workable definition of bioenergy sustainability.

Workshop participants shared their current research and perspectives in a format that promotes communication among all participants (the full agenda is in Appendix I). Presentations were made by representatives of ORNL and EPA for members of the two institutions to exchange information with the goal of increasing the awareness of what research is occurring in within the rapidly developing field of bioenergy sustainability. The presentations and discussions were organized around four topics areas:

- Biomass/feedstock production
- Feedstock logistics (harvesting, handling, processing, storage, transportation)
- Conversion technologies (biochemical, thermochemical and hybrid fuels and biomass power)
- Distribution and end use of fuel, energy, and co-products

Two overviews were presented for each topics followed by several short presentations that allowed members from each institution to share information on their current research and activities in each area. The presentations for each topic were followed by a group discussion, including remote participants, to identify opportunities, challenges, and constraints.

The discussion were based on the perspective that the advantages of a systems approach are that it considers both direct and indirect effects in a systematic manner and well as dynamic interactions in space and time. The systems perspective provides a means to captures the complexity of bioenergy issues including both direct and indirect impacts across the energy economy (e.g., agriculture is both an energy producer and consumer and biofuels both displace and use fossil energy). Furthermore, trade-offs in technological and economic feasibility often emerge only at the systems level.

An integrated perspective is required to account for the linkages between agricultural and energy markets, the impacts of those market dynamics on farm-level decision making, and the lack of market-based feedbacks from the environmental impacts of land management at a field scale to these macro-level drivers. Furthermore, a regional perspective is needed to

- Understand how regional variation can affect the production, distribution, and use of biofuels
- Evaluate how bioenergy production systems may evolve differently in each region as based on biomass feedstock potential, bioenergy outputs (e.g., fuels, electricity, heat, etc.), level of “investment” in fossil fuels needed to support a growing bioenergy system, and demand for biofuels and bioenergy – and competition with traditional fuels/energy
- Provide better estimates of transportation and distribution costs for both feedstocks and fuels and assess energy requirements, emissions, and bottlenecks.

A recurring theme in the discussions that followed each topic is the vital need to respond to the Congressional Agenda while developing the basic science that will shape the national agenda based on the current Energy Independence and Security Act, section 204 (Figure 1). The EISA needs headlined the list of gaps in bioenergy sustainability issues identified by the workshop participants. Those gaps include:

- Information needed for EPA’s report to Congress (Figure 1)
- Integration of disparate data layers into information more comprehensive picture
- Comparing pathways and life cycles (instead of thinking about one thing at a time) (e.g., what are alternative uses of wastes); co-products
- Setting priorities – sequential decision orientation, how to set priorities; decision making in facing in the face of uncertainties
- Monocultures versus diverse land-use scenarios pertaining to “appropriate” scale
- Identifying risks (social, economic and ecological risks) and what contributes to this risks; risk perception
- Land-use change issues
- Operational definition of sustainability (who are the stakeholders? How do we get stakeholder perspective into defining sustainability)
- Non-ethanol alternative fuels (e.g., butanol, mixed ethanols, etc, green hydrocarbons) what is competing with biofuels?
- Lifespan of biofuels
- Impact of nutrient/agrochemicals (N, P, atrozine) loading at watershed level and higher on environmental quality
- Energy security / transportation security
- Opportunities for diverse feedstocks (crops, wastes, etc.) to mitigate seasonality of feedstocks

Figure 1. EISA Impacts Reporting

Section 204. Environmental and Resource Conservation Impacts

EPA, in consultation with USDA and DOE, shall assess and report to Congress every 3 years on the impacts to date and likely future impacts of the requirements of the RFS on:

- (1) Environmental issues, including air quality, effects on hypoxia, pesticides, sediment, nutrient and pathogen levels in waters, acreage and function of waters, and soil environmental quality.
- (2) Resource conservation issues, including soil conservation, water availability, and ecosystem health and biodiversity, including impacts on forests, grasslands, and wetlands.
- (3) The growth and use of cultivated invasive or noxious plants and their impacts on the environment and agriculture.
 - EPA may seek the views of the NAS or another independent research institute
 - The report shall include the annual volume of imported renewable fuels and feedstocks for renewable fuels, and the environmental impacts outside the United States of producing such fuels and feedstocks.
 - The report shall include recommendations for actions to address any adverse impacts found.

Although the workshop was organized around the components of the bioenergy system, several cross-cutting themes emerged. These themes include:

- Water Quality
- Energy Security
- Soil
- Baselines
- Indicators
- Distributed versus centralized systems

Critical research needs that were discussed include

- Baseline assessments of our natural resource base
- Monitoring of environmental emissions from technologies and practices
- Effects of emissions of criteria pollutants and direct GHG emissions on environmental functions at individual and system levels
- Sensitivity analyses on what the greatest stressors are for system resiliency and under which circumstances
- Development and implementation of mitigation options
- Continuous monitoring of improvements or decline

- Fate and transport and biodegradability of biofuels
- Emergency response
- Emissions characterization
- Chemical mechanisms in air quality models
- Health assessment documents (IRIS) – ethanol, acetaldehyde and formaldehyde

The workshop concluded by a group discussion to identify concerns/uncertainties, state of knowledge, and overall gaps and to create committees to address the gaps and research needs identified in the course of the workshop. The following committees, their conveners, and initial members were defined and include members from both institutions. These committees will report back to the Steering Group by October 31, 2009, with an initial assessment of plans for the committee (including topics to be covered, anticipated products, and a timeline).

Communications: Bridging between science priorities and relevant policy findings and relating to major stakeholder groups

Convener: Amy Wolfe

Members: Donna Perla and Virginia Dale

Scale Issues: Identifying critical issues on how to deal with multiplication factors, resolution of data and models, and representativeness of data, models, and analyses

Convener: Rebecca Efroymsen

Members: Virginia Dale, Mike Hilliard, and Tim Johnson

Design of a Sustainability Roadmap: Considering sustainability across the full bioenergy supply chain including identifying and prioritizing components of EISA.

Convener: Rekha Pillai

Members: Randy Bruins, Donna Perla, Robin Graham, Paul Leiby, and Rebecca Efroymsen

Uncertainty/Sensitivity: Identifying potential effects, and their uncertainties and sensitivity as well as how they are assessed (including risk assessment approaches)

Convener: Andy Miller

Members: Tris West and Rekha Pillai

Comparative Analysis of Bioenergy Pathways: Identifying ethanol and other types of fuels, trade-offs, environmental outcomes with macro comparison of pathways.

Convener: Jeff Bielicki

Members: Gbadebo “Debo” Oladosu, Andy Miller, Rekha Pillai, Steve Peterson, Fran Kramer, Donna Perla, Brian Davison, Sujit Das, and Paul Leiby

Enablers to Implementation: Considering ways to move from research to implementation in terms of tradeoffs among ecosystems services and other costs and benefits. This committee may consider ways in which models are descriptive versus prescriptive. The challenge is to develop research that can be applied in a timely fashion in terms of development, pathways, and the life span of biofuels.

Convener: Tim Johnson,

Members: Andy Miller, Mike Hilliard, and Jeff Bielicki

Ecosystem Services: Identifying the broader framework of supply chain effects on ecosystems and to include health and safety issues. The challenge is to figure out how to appropriately integrate essential components of ecosystems.

Convener: Betsy Smith

Members: Yetta Jager, David Olszyk, Lidia Watrud, Rebecca Efroymsen, Randy Bruins, and Steve Peterson

Model Integration: Identifying components of models that are part of bioenergy systems

Convener: Mike Hilliard

Members: Ozge Kaplan, Tris West, Paul Leiby, and Gbadebo “Debo” Oladosu

Data/Information: Inventorying and documenting current information and models as well as what is an effective part of the documenting sustainability options in bioenergy systems. This will include relating information in the Knowledge Discovery Framework at ORNL to work in Region 4 of EPA. First priorities are to consider the needs for water (ground and surface), criteria issues, need for sensors, and how to manage useful models.

Convener: Sujit Das

Members: Alan Powell, Steve Peterson, Tris West, Michael Schultze, and Bruce Wilson

Indicators: Identifying useful sustainability metrics for bioenergy systems. How can these indicators best be monitored and modeled?

Convener: Rebecca Efroymsen

Members: Virginia Dale, Denice Shaw, and Raymond Smith

Scenarios: Characterizing scenarios that need to be considered in order to assess sustainable bioenergy options. This task will involve defining assumptions of each scenarios and what kind of information is available for baseline data.

Convener: John Storey

Members: Ozge Kaplan, Betsy Smith, Donna Perla, Keith Kline, and Yetta Jager

Appendix. Agenda for Sept 10-11, 2009, workshop in Oak Ridge, Tennessee

Introduction

- Welcome – Robin Graham
- Goals of the workshop – Virginia Dale
- A systems perspective for bioenergy
 - Donna Perla (EPA)
 - Paul Leiby (ORNL)
- Components of sustainability to consider relevant to bioenergy
 - Rebecca Efroymson (ORNL) - *A Framework for Selecting Sustainability Indicators for Bioenergy*
 - Denice Shaw (EPA) - *EISA Section 204. EPA Report to Congress*

Feedstock Production (includes types of feedstocks)

Overview

- Tris West (ORNL)
- Randy Bruins (EPA)

3 slides in 5 minutes presentation

- Robin Graham (ORNL) - *Carbon Sequestration in Terrestrial Ecosystems*
- Charles Garten (ORNL) - *Soil Organic Matter Inputs and Switchgrass Sustainability*
- Betsy Smith (EPA) - *Ecosystem services associated with changes in land management under EISA and conservation alternatives for the Midwest*
- Raymond Smith (EPA) – *Design of Sustainable Biofuel Supply Chains*
- Ozge Kaplan (EPA) - *Emerging Biomass Feedstocks: three perspectives*
- Chris Impellitteri (EPA) - *Biofuels: Water Resources, Reuse and Energy*
- Virginia Dale (ORNL) – *Designing a Landscape Approach to Bioenergy Choices*
- Esther Parish (ORNL) - *Incorporating Landscape Design into the Selection of Switchgrass Locations around Vonore, TN*
- Yetta Jager (ORNL) - *Regional assessment of sustainability for bioenergy production*
- Latha Baskaran (ORNL) - *Modeling the Impacts of Bioenergy Feedstock Driven Land-Use Changes on Habitat of Aquatic Insects*
- Keith Kline (ORNL) - *Bioenergy, Land Use and Indicators of ‘Sustainability’*
- Lidia S. Watrud and David Olszyk (EPA) - *Life Cycle Analysis of Ecological Effects of Biofuels Crops*

Feedstock Logistics (harvesting, handling, processing, storage, transportation)

Overview

- Erin Wilkerson (ORNL)
- Tim Johnson (EPA)

3 slides in 5 minutes presentation

- Mike Hilliard (ORNL) - *Evolution and Optimization of the Biofuel Supply Chain*
- Paul Leiby (ORNL) – *Decision Support Model for Secure and Sustainable Bioenergy System*
- Ray Smith (EPA) – *Design of Biofuel Supply Chains*
- Ozge Kaplan (EPA) – *Biofuel supply Chain Modeling*

Conversion Technologies (biochemical, thermochemical and hybrid fuels and biomass power)

Overview

- Andy Miller (EPA)
- Brian Davison (ORNL)

3 slides in 5 minutes presentation

- Kimberly Swanson (EPA consultant) – *End Use Combustion: The Final Environmental Input*
- Stuart Daw (ORNL) – *R&D Opportunities and Needs in Thermo-chemical (TC) Biomass Conversion*
- Stuart Daw (ORNL)- *R&D Opportunities with the New ORNL Biomass Steam Plant*
- Evelyn Hertzell (EPA) – *EPA’s Environmental Technology Verification Program (ETV): Waste-to-Energy Verifications under the ETV Greenhouse Gas (GHG) Technology Center*
- Lee Beck (EPA) - *ETV Environmental and Sustainable Technology Evaluation (ESTE) Biomass Co-Fired Boiler Project*
- Scott Curran (ORNL) - *Batch Scale Biodiesel Production at the University Level*

Distribution and end use of fuel, energy, and co-products

Overview

- Brian West (ORNL)
- Andrea Barbery (EPA)
- Kathryn Sargeant (EPA)

3 slides in 5 minutes presentation

- John Storey (ORNL) - *Mobile Source Air Toxics from Biofuels*
- Mike Kass (presentation by Brian West) (ORNL) - *Fuel Dispenser Compatibility Experiments Current Status and Results Summary*
- Jeff Herzog (presentation by Andrea Barbery) (EPA) – *Underwriters Laboratories (UL) Requirements for Ethanol Blend Dispensers*
- Evelyn Hartzell (EPA) - *Underground Storage Tank Leak Detection Equipment: Performance Verification with Ethanol-Blended Fuels*
- Steven Peterson (ORNL) - *Biofuels Distribution Analysis*
- Fran Kremer (EPA) - *Climate Change and Biofuels – Multi-Media Problems Requiring Multi-Media Solutions*

Workshop Wrap Up

- Discussion of path forward for systems perspective for bioenergy sustainability
- Closing
 - Lessons learned about sustainability of bioenergy
 - Insight provided by a whole systems approach to bioenergy
 - Cross cutting themes
 - Gaps and needed research
 - Actions and next steps