Biomass Densification Workshop Overview
"Transforming Biomass to Feedstocks"

Workshop – August 23-24, 2011
Idaho Falls, Idaho
Webinar – August 30, 2011

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BIOMASS PROGRAM

FOREWORD

Why raw biomass needs help becoming feedstock…

Whether producing biofuels, biopower, or other bioproducts, all bioenergy industries depend on supply systems that ensure high-volume, reliable, and on-spec availability of biomass feedstocks. The United States has a diverse and abundant potential of biomass resources (U.S. DOE 2011 [a]) that can be used as bioenergy feedstocks; however, biomass in its raw form is not necessarily good feedstock.

Biomass cannot be inserted into conversion infeed systems until it undergoes some level of size reduction and other preparation, depending on the type of conversion for which it is intended.

In its raw, "as-harvested" form, herbaceous biomass lacks both the bulk density and energy density necessary for cost-efficient bioenergy production. It also lacks flowability characteristics that allow it to be moved from location to location in existing transportation and handling infrastructures. Biomass must also be managed for chemical stability in aerobic storage environments so that the product can be stockpiled to enable a reliable year-round supply to biorefineries.

Other than a few niche resources, the U.S. biomass supply lacks spatial density across the landscape, with diverse supplies available in scattered locations and in varying quantities and qualities. This greatly restricts the development of national-scale biomass markets that can stabilize feedstock supply and demand and reduce risk for both feedstock producers and biorefineries.

Finally, the inherent diversity of the resource itself—with variability in material properties among species (e.g., wood vs. herbaceous material), genetic differences between varieties within each species, variability introduced by environmental differences (e.g., soil type, weather patterns), and management practices (e.g., plow vs. no-till, fertilizer and chemical applications, etc.)—can be a significant supply system barrier, depending on the sensitivities of the targeted end-use biorefining technology.

The viability of bioenergy industries is tightly coupled to successfully addressing these biomass densification and diversity challenges.

At a biomass workshop held at Idaho National Laboratory, August 23–24, 2011, experts from industry, DOE offices and DOE-funded laboratories, and academia met to explore approaches to address the densification challenge and provide high-volume on-spec feedstocks to enable cost-effective feedstock supply systems for biomass conversion technologies.

Workshop participants were selected from experts in diverse segments of industry, national laboratories, and academia, with a large contingent from DOE-funded Integrated Biorefinery projects.

The workshop was sponsored by the U.S. Department of Energy (DOE) Biomass Program, Office of Science, and ARPA-E.

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a U.S. DOE (2011) U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry. RD Perlack and BJ Stokes (Leads) ORNL/TM-2011/224. Oak Ridge National Laboratory, Oak Ridge TN.

BIOMASS DENSIFICATION WORKSHOP OVERVIEW
"Transforming Biomass into Feedstocks"

The Densification Challenge

Biomass, with its energy-rich stores of fixed carbon and volatiles, is estimated to have a worldwide bioenergy potential ranging from nearly 10% to more than 60% of primary energy consumption[b]. U.S. energy policy has set an aggressive goal for moving biofuels into the marketplace by increasing the supply of renewable transportation fuels to 36 billion gallons by 2022[c]. Realizing the potential of biomass at a meaningful scale will require broad industry scale up, including reliable, sustainable, and economical lignocellulosic feedstock supply systems.

As an energy source, biomass has benefits of renewability, abundant domestic production capacity in a variety of environments, versatility of end-product use, and carbon sequestration potential. There are also challenges to establishing an industrial-scale biomass feedstock supply system that is capable of offsetting conventional fossil energy consumption:

- Biomass is low in energy density and bulk density and has great variability of physical attributes, which can reduce the feedstock's energy value and make all supply system logistics more complex and expensive; biomass densification and feedstock format become critical industry enablers.
- Being an organic material, biomass is subject to degradation, which can result in material loss, reduced energy value, environmental concerns, and reduced logistics efficiencies; thus, cost-effective methods of minimizing degradation are imperative.

b Richard TL (2010) Challenges in scaling up biofuels infrastructure. Science, 13: 793:796.

c Energy Independence and Security Act of 2007, 42 USC § 17001 (2007).

Workshop Conclusions

(1) Increasing performance and reducing variability by converting "as-harvested" biomass into feedstocks will be important for developing industrial-scale bioenergy.

(2) There is a need for R&D focus on addressing tomorrow's barriers that have a positive impact on today's biorefineries and supply systems.

- Different types and sources of biomass can have significant variability in chemical composition and moisture content, and different supplies of raw, "as-harvested" biomass may require different preprocessing or upgrading treatments to meet the quality and format requirements of the end-use biorefinery.
- The resource supply is fragmented, and whether the feedstock will be converted locally or enter more distant markets, an optimized and well-coordinated supply system infrastructure will be required to maximize the energy value of the biomass and ensure sufficient resource availability.

All of these considerations are essentially risk factors for the biorefinery and the feedstock producer. Industrial-scale biorefineries require large volumes of feedstock (hundreds of thousands of dry tons per year) that meet their particular specifications. Currently, these biorefineries are generally restricted to single-species niche resources that are produced close by and undergo some level of preprocessing to achieve the required quality standard. Expanding bioenergy industries beyond these niche resource pools introduces additional logistics challenges, including cost, biomass degradation during storage, and unstable supply and demand balance.

Together, industry, government laboratories, and academia have made good progress in addressing these challenges through optimizing supply system logistics and defining feedstock attributes that are compatible with existing solids-handling infrastructures. Biomass densification has become an increasingly important focus of feedstock supply system development for its potential impact on managing moisture content, reducing transportation costs, and improving the physical properties of the feedstock, among other benefits.

Secretary of Energy Steven Chu named "densification of biomass" as one of the key research challenges facing biofuels[d] (Chu 2011). The IEA report, *Bioenergy Status and Prospects,* cites "development of advanced densification and other pre-treatment technologies" as crucial to future deployment of biorefineries and bioenergy trade[e] (IEA 2009).

On August 23–24, 2011, experts from industry, government, and academia gathered for a biomass workshop held at Idaho National Laboratory to discuss potential solutions to address the densification challenge and accelerate bioenergy industry expansion. Sponsored by the Department of Energy (DOE)–Biomass Program, the workshop gave participants the opportunity to explore the theme "Transforming Raw Biomass to Feedstock" through presentations, demonstrations, and a tour of the Feedstock Process Demonstration Unit (PDU).

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d Chu S (2011) Key Note Address. Biomass 2011: Replace the Whole Barrel, Supply the Whole Market, July 26-27, 2011, National Harbor MD.

e IEA Bioenergy (2009) Bioenergy: A Sustainable and Reliable Energy Source. ExCo: 2009:06.

Participant Affiliations

The workshop was designed to gather input from a variety of interests in bioenergy development, with particular emphasis on industry, which was well represented during the proceedings (Figure 1).

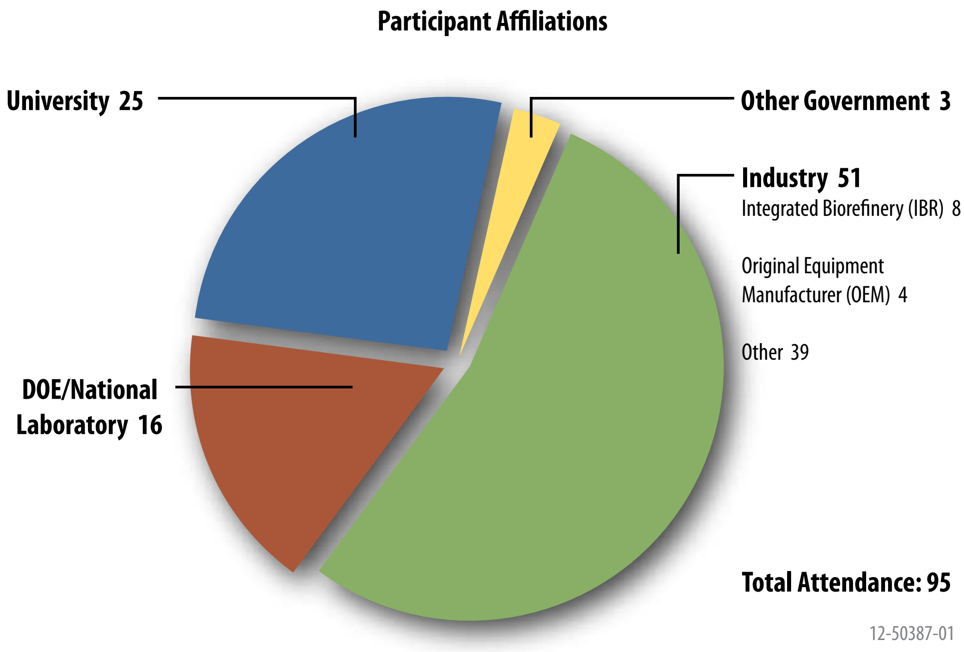

Figure 1. *Breakdown of workshop participant affiliations, with more than half of participants representing industry, including Integrated Biorefinery Partners.*

Integrated Biorefinery Partnerships

Biofuels are produced in integrated biorefineries that efficiently convert a broad range of biomass feedstocks into affordable biofuels, bioproducts, and heat and power. The Biomass Program focuses its efforts on key supply chain challenges. These include developing replicable feedstock supply systems and innovative conversion technologies, both of which result in lower production costs.

The success of the U.S. bioenergy industry depends in part on the quantity and quality of biomass available, as well as the industry's ability to collect, store, and cost-effectively transport it. In cooperation with several partners, the program is identifying sustainable biomass feedstock resources, developing economically viable and environmentally sound production methods, and designing feedstock logistics systems to ensure resource readiness.

Workshop Purpose and Structure

The Densification Workshop began with an opening session in which DOE Biomass Program officials and INL managmement welcomed attendees. John Ferrell, Supervisor, Feedstock Supply and Logistics, presented the biomass R&D focus areas and objectives for the workshop:

Focus Areas

- Increasing the bulk and energy density of biomass resources for improved logistics
- Upgrading biomass through preconversion and formulation for improved performance in bioenergy applications.

Objectives

- Generate a report for Secretary Chu that includes bioenergy industry feedback
- Broaden the view of biomass densification to include preconversion and formulation concepts
- Demonstrate the Feedstock PDU
- Integrate plant genetics that improve biomass productivity/energy density and ease of conversion
- Solicit industry opinions on the concepts of preconversion, formulation, and densification
- Encourage partnership opportunities for use of the Feedstock PDU.

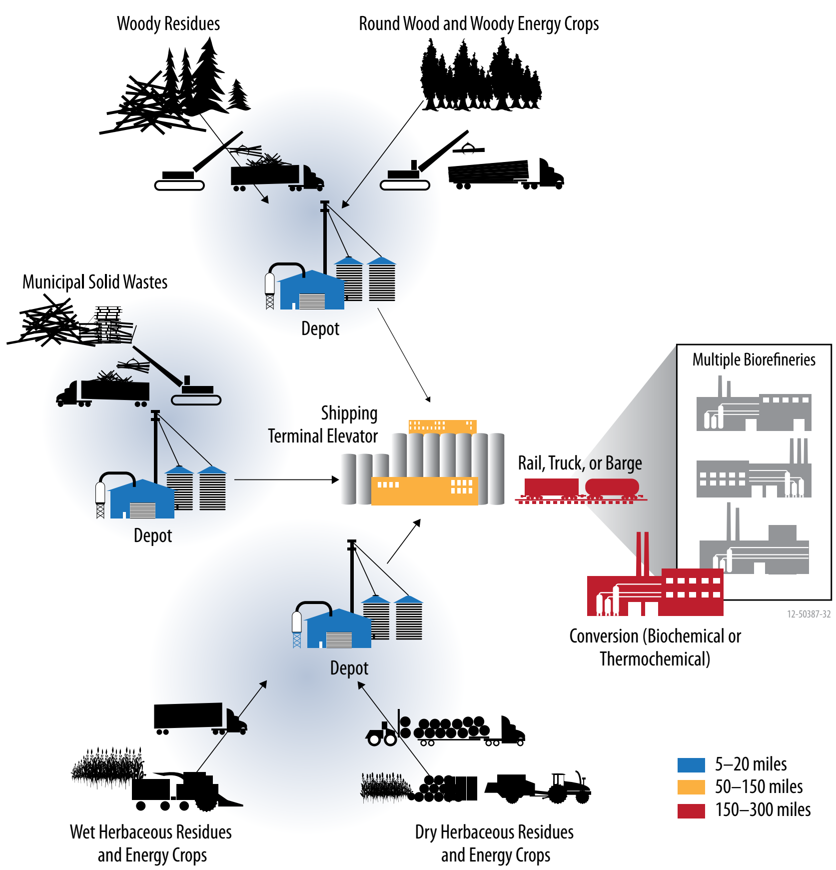

Figure 2. *Conceptual advanced uniform-format feedstock supply system design that incorporates distributed biomass preprocessing depots as closely as possible to biomass production locations and supports feedstock commodity trade.*

R&D Vision to Address the Challenge: Feedstock Commodities

Ferrell introduced a sustainable feedstock supply vision that included development of advanced uniform-format supply system designs and improved capacity and efficiency of each feedstock logistics operation as important enablers of bioenergy industry expansion. The mature state of this vision provides the infrastructure necessary to access resources that are currently stranded due to poor economics and/or lack of market accessibility. It also provides flexibility for market integration as practical to help balance demand/supply disruptions and enable regional, national, and international trade. Figure 2 shows how an advanced uniform-format supply system with distributed preprocessing ("the depot") can increase the resource draw areas using the highly efficient, high-volume handling and transport systems that currently exist.

Ferrell described the Biomass Program activity areas of focus to address the major R&D challenges associated with developing production and logistics systems capable of supplying biorefineries with high-density, aerobically stable, and high-quality biomass feedstocks (Table 1).

Sam Tagore, Technology Manager, Feedstocks Logistics, discussed the role of feedstock density and quality in meeting biorefiners' feedstock specifications and introduced various preconversion, formulation, and densification approaches (Figure 3).

Table 1. *DOE Biomass Program Feedstock Supply and Logistics addresses supply system R&D in an incremental approach that supports supply chain stages of development.*

Platform Focus/Term	Resource Base	Moisture	Resource Variety
Existing supply systems near term (through 2012)	Access to a niche or limited resource	Based on dry supply system (i.e. field-dried)	Designed for specific feedstock (i.e. corn stover)
Depot supply systems longer term (2012+)	Access to a broader resource	Accepts higher-moisture feedstocks into system	Design addresses multiple feedstock types

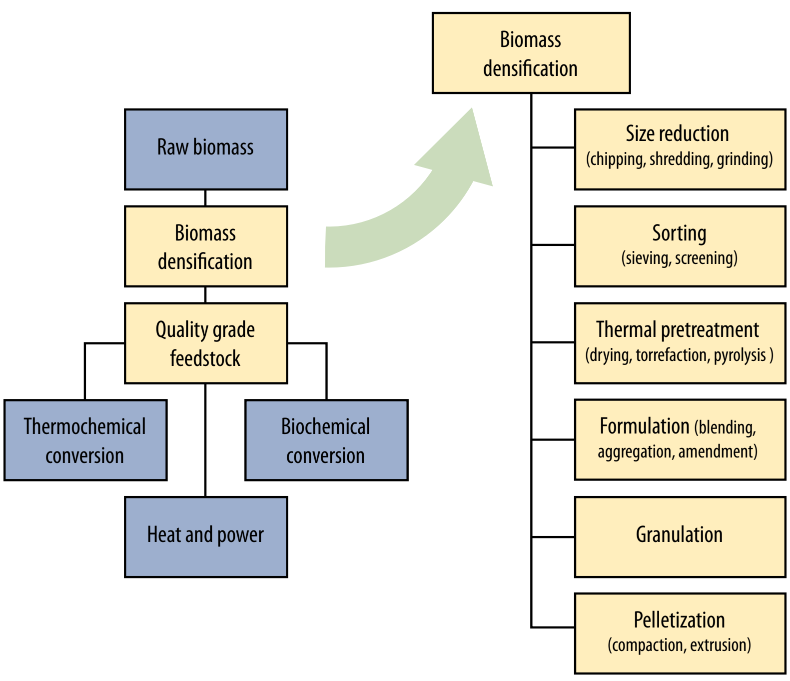

Figure 3. *The densification challenge can be addressed through a variety of technologies, depending on the end-user's specifications.*

Melissa Klembara, Technology Manager, Integrated Biorefineries, presented IBR project sensitivity analysis findings that feedstock cost and quality are the highest risk areas for biorefiners. This directly impacts their ability to get financing. The risks of feedstock cost, quality, and quantity need to be addressed, and biorefiners need to be able demonstrate the existence of a reliable and secure feedstock supply. Klembara suggested that the ideal feedstock would be dense, good quality, and aerobically stable so that it can be managed with existing infrastructure. From her IBR technical perspective, consistent physical and compositional attributes are also important to allow biorefineries to run on "autopilot" and still achieve consistent yields.

Mission Areas

J. Richard Hess, Biofuels and Renewable Energy Technologies Department Manager at INL, presented three mission areas that would help address the biomass densification and quality challenges and enable industry expansion:

- Improve biomass density, stability, and infrastructure compatibility
- Improve biomass quality and end-use performance
- Increase accessible biomass quantities/diversity, and supply stability.

Hess oriented these mission areas within the context of program accomplishments and proposed future directions. The DOE–Office of Biomass has shaped the vision of a national-scale bioenergy industry and supporting feedstock supply system that manages diversity and density early in the system to improve overall logistics costs.[f] He emphasized that much progress has been made in developing and reaching this vision through optimizing biomass logistics and defining product attributes compatible with existing high-volume, solids-handling infrastructure.

Now, this vision is expanding to include processes that ensure relieable, sustainable, and affordable supplies of feedstocks that not only meet biorefiners' specification requirements but are also optimized for supply system and conversion performance (Uniform Commodity Feedstocks). Constraints the vision must be accomplished within were presented: cost, energy balance, and green house gas and sustainability requirements.

The concept of distributed biomass preprocessing[f, g] was presented as part of a feedstock commodity infrastructure network to help achieve the vision within the vision constraints and support the mission areas. "Feedstock Preprocessing Depots" manage resource diversity and optimize logistics by decoupling preprocessing from centrally located conversion facilities and performing some of these functions at regionally distributed centers that are proximate to the biomass production sites. The objective of this approach is to achieve the feedstock quality and performance specifications required by biorefiners as near as practical to the site of production to benefit downstream logistics costs and overcome constraints.

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f Hess et al. (2009) Uniform-Format Solid Feedstock Supply System: Commodity-Scale Production of an Infrastructure-Compatible Bulk Solid from Herbaceous Lignocellulosic Biomass, Report INL/EXT-09-15423, Idaho National Laboratory, Idaho Falls, ID.

g Pragnya et al. (2010) Advanced regional biomass preprocessing depots: A key to the logistical challenges of the cellulosic industry. Biofuels, Bioprod, Biorefin, 5: 621-630.

The vision and mission areas were presented as hypotheses for addressing feedstock supply system challenges of today while enabling technologies, products, and markets of the future.

Research Elements to Accomplish Mission Areas

In literature, the terminology is inconsistent for describing the processes available to produce densified, on-spec feedstocks from raw, field-run biomass. To avoid confusion over frequently overlapping terms such as "logistics," "densification," "pretreatment," "preprocessing," and "upgrading," and to clearly distinguish supply system processes from conversion processes, the densification workshop was organized into six research elements, included in this report as chapters, that work together to transform biomass into easier to handle, denser, more homogenous feedstocks:

1. Biotechnology/Genetics
2. Mechanical Preprocessing
3. Thermal Preconversion
4. Chemical Preconversion
5. Formulation
6. Densification

Desired R&D Outcomes

The research elements explored during workshop presentations provide a framework to achieve critical industry-enabling production, supply, and logistics outcomes. Advancements in the research elements individually or collectively roll up to these outcomes, as shown in Table 2.

Table 2. *Desired R&D outcomes to help establish sustainable, economically viable feedstock supply systems that meet biorefiner's specifications and enable industry expansion.*

PRODUCTION	SUPPLY	LOGISTICS
Maximize gross and functional yield	**Improve conversion performance**	**Develop infrastructure-compatible logistics systems**
Increase biomass yield	Reduce/manage variability	Extend biomass stability
Ensure sustainable production systems	Maintain/recover biomass purity	Improve logistics efficiency
	Preserve/improve reactivity	Increase mass density
		Increase energy density

Workshop sessions discussed R&D currently underway that focused on achieving these outcomes by (1) improving biomass yield and quality through crop development and science-based best management practices and (2) managing resource diversity/upgrading biomass to achieve feedstock specifications, via R&D in preconversion, formulation, and densification technologies.

During the course of workshop presentations, participants considered feedstock cost, handling format, and chemical composition specifications required by biorefineries and innovative applications of science and engineering that might be used to address the biomass densification challenge and produce consistent, economical, high-energy-value feedstocks from "as-harvested" biomass.

WORKSHOP SUMMARY AND CONCLUSIONS

Densification is generally associated with those processes that increase bulk density (mass per unit volume) of bulk solid materials including pelletization, briquetting, and granulation. For this workshop, densification concepts were expanded to include (1) liquefaction processes, such as pyrolysis that produces a bio-oil of increased bulk and energy density compared to the biomass feedstock from which it is produced, as well as (2) biomass yield improvements that, in effect, increase both mass and energy density on a per-unit-area of production (e.g., ton/ac).

These concepts of densification to transform raw biomass to feedstock provide many benefits to the biofuels production chain, including improvements to logistics systems through improved stability, handling, and transportability (including higher payloads and reduced supply areas), as well as improvements to conversion systems through improved feeding, more consistent and uniform feedstocks, and, in some cases, improved conversion performance. Based on these wide-ranging benefits, the concept of densification was used as a springboard to introduce and discuss other advanced preprocessing concepts—referred to as "preconversion" and "formulation"—that also offer potential improvements to biomass logistics and conversion systems. The term "preconversion" refers to those biomass preprocessing operations that occur prior to primary conversion to improve and/or stabilize biomass to achieve biorefinery quality specifications.

Common Themes

The recurring message received from workshop participants was that technologies exist and can be optimized to address the densification challenge. Participant input indicated strong support of the DOE–Biomass Program vision and mission areas presented, with 85% agreeing that "…increasing performance and reducing variability by converting raw biomass into feedstocks will be important for developing a national-scale bioenergy industry." They also expressed caution about making feedstock commodity supply system economics viable for a self-sustaining bioenergy industry.

Biotechnology/Genetics

Several presentations discussed current research and trends in biotechnology to genetically modify biomass crops for improved yield and conversion performance. Over 60% of participants believed that plant breeding and biotechnology would have a beneficial impact on supply system and conversion performance. Because of the abililty of biotechnology to target specific biomass traits, it was regarded by workshop participants to be most impactful to biochemical conversion pathways that involve more intricate deconstruction processes compared to thermochemical conversion. Participants were evenly split regarding the time frame in which plant breeding will have a significant impact on the bioenergy industry; half considered this to occur within 10 years and half considered it to be beyond a 10-year horizon. In both cases, the long time frame is driven by socio-econonic constraints associated with the adoption and regulation of genetically modified crops.

Mechanical Preprocessing

Two presentations were given related to the mechanical preprocessing approaches to producing feedstocks with consistent particle size and handling characteristics (i.e., flowability). Workshop participants generally agreed that many mechanical preprocessing treatments related to size reduction and impurity removal, such as grinding and bark removal, are already in place today. These operations were generally regarded as standard preprocessing operations, and not transformational technologies that will have a significant impact on future biofuels production.

Thermal Preconversion

This topic area included thermal treatments over the full spectrum of temperatures, with and without oxygen, which were defined as non-reactive, reactive, and destructive drying regimes (i.e., torrefaction) to produce a thermally treated solid feedstocks, as well as pyrolysis to produce a liquid intermediate bio-oil. Workshop participants noted the benefits of thermal treatments to improve biomass stability in storage. However, participants also agreed that the thermally treated biomass had advantages if being used in thermochemical conversions such as pyrolysis, gasification or combustion, but due largely to the destructive nature of more common and aggressive treatements such as torrefaction, they expressed concern of the effects on biochemical conversion processes.

Chemical Preconversion

Two specific technologies were presented to demonstrate chemical preconversion concepts. Chemical leaching was presented as an example of non-destructive treatment for removing ash-related contaminants common in raw biomass. Ammonia Fiber Expansion (AFEX) was presented as an example of a destructive treatment for imparting structural changes to biomass to improve subsequent preprocessing and biochemical conversion performance. Participants believed chemical preconversion has the potential to improve feedstock value for biochemical, thermochemical, and biopower conversion processes, as well as improving feedstock stability. Participants were divided as to where chemical preprocessing would be best located with suggestions for both decentralized depot locations and proximate to the conversion refinery. Waste water treatment was the biggest concern for locating chemical preconversion at a depot.

Formulation

Research results on pretreatment of blended feedstocks (a mixture of corn stover, switchgrass, eucalyptus, and pine) was presented as a specific example of formulation. The production of this blended feedstock was also demonstrated on the Feedstock PDU. Some participants saw formulation as an important aspect of reducing feedstock variability and as a key requirement for achieving uniform feedstocks. Many participants recognized that formulation is already practiced in biopower operations and discussed its potential benefits to biofuels production by reducing feedstock variability and mitigating the effects of undesirable components such as chlorine. In view of the blended feedstock presentation, some participants felt formulation may be limited by geographic co-location of biomass resources. Overall, participants felt that more information was necessary in order to fully understand the value of formulation.

Densification

Pelleting was discussed with an emphasis on optimizing process parmeters to affect physical characteristics (density, durability), solid fuel properties, and biochemical conversion performance. Preliminary research results on the pretreatability of pelletized corn stover were presented, and process development technologies using a laboratory-scale pellet mill were demonstrated. For the most part, the need for densification was seen as a way to facilitate logistical improvements, primarily transportation, storage, and handling. Despite the presentation reporting laboratory results that indicated no negative pretreatment impact, the potential for densification to be a detriment to feedstock performance was a recurring theme.

Points of Emphasis

Many of the advanced preprocessing technologies presented were considered by participants to be beter suited for either biochemical or thermochemical conversion pathways; however, in most cases, research is lacking to support these conclusions. Participant feedback consistently raised questions and concerns regarding the cost-to-value relationship of the advanced preprocessing technologies and concepts presented, with a need to balance increased cost and energy requirements with gains and improvements to logistics and conversion processes. A common theme among all workshop sessions was that additional research, process data, and economic analysis is needed to better understand the potential of preconversion, formulation, and densfication technologies and their value for both the feedstock supply system and conversion performance.

FEEDSTOCK R&D TOOLS

Feedstock PDU

One of the highlights of the workshop was demonstration of the DOE–OBP's Feedstock Process Demonstration Unit (PDU), which is managed and operated by INL's Bioenergy Program (Figure 4). Transforming raw biomass into uniform-format commodity feedstocks is the focus of the Bioenergy program at INL, and the Feedstock PDU provides a venue for bioenergy developers to work with OBP and INL to test preprocessing technologies and advance feedstock engineering into the development phase.

The scale of the PDU (nominally 5 ton/hr) allows larger volumes to be produced in a reasonable time and provides processing data and information about scale up issues from laboratory- and bench-scale systems.

For the Densification Workshop, the Feedstock PDU was demonstrated using a formulation of four types of biomass (corn stover, switchgrass, pine, and eucalyptus), which were preprocessed in a 1-1-1-1 ratio and densified into a pelletized product (Figure 5). The same formula was demonstrated using laboratory-scale equipment on the previous day, which helped to identify initial operating conditions for the larger system. This particular formulation was developed by a customer who determined this mixture provided beneficial results in their conversion process.

Figure 4. *The Feedstock PDU is a flexible research system developed to test feedstock formulation processes, collect process data, and produce large quantities of formulated feedstocks for conversion testing.*

Figure 5. *The Feedstock PDU formulation demonstration used four types of biomass (corn stover, switchgrass, pine, and eucalyptus), which were processed in a 1-1-1-1 ratio and densified into a pelletized product.*

Biomass Resource Library

Feedstock characteristics have a significant impact on conversion performance, and understanding performance-based relationships between specific feedstock specifications and conversion performance is crucial to the success of bioenergy development. A cornerstone of this effort is the DOE Biomass Resource Library and Biomass Characterization Capabilities, which were presented as part of the workshop demonstrations (Figure 6).

The Biomass Resource Library includes specification-performance data for a variety of feedstocks and processed intermediates to enable better understanding of the relationship of how specific supply chain operations (process-to-intermediate-to-specifications) influence conversion processes. Figure 7 shows examples of biomass variability relative to a biochemical (BC) and thermochemical (TC) specification.

Figure 6. *The Biomass Resource Library provides bioenergy conversion platform developers with valuable understanding of the differing chemical and material characteristics between "as-harvested" biomass materials and the pristine biomass feedstocks that conversion technologies have been designed around.*

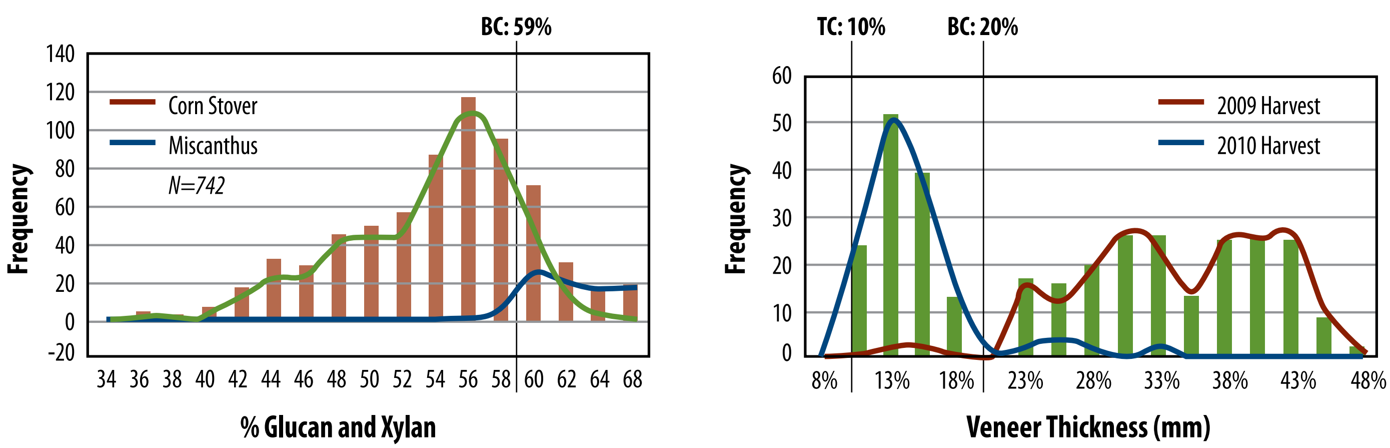

Figure 7. *Feedstock variability in composition (a) and moisture (b) can have significant impact on biorefinery operations.*

DENSIFICATION WORKSHOP SUMMARY REPORT

The Densification Workshop Summary Report, available at www.inl.gov/bioenergy, provides a discussion of each of the research elements explored at the workshop. Research element chapters also include an overview of the workshop technology presentations, demonstrations, discussions, and participant feedback. The research element chapters are organized in two sections: (1) Improving Biomass Yield and Quality and (2) Managing Resource Diversity/Upgrading Biomass to Achieve Feedstock Specifications.

Section 1 – Improving Biomass Yield and Quality

"Chapter 1: Biotechnology/Genetics" captures the concepts presented in the joint session on opportunities for biotechnology and genetics to increase resource availablity and address supply system and conversion performance issues.

Section 2 – Managing Resource Diversity/Upgrading Biomass to Achieve Feedstock Specifications

Section 2 captures the workshop breakout session concepts and provides a more detailed exploration of the diversity management and biomass upgrading research elements. These research elements are explored in more depth in "Chapter 2: Mechanical Preprocessing," "Chapter 3: Thermal Preconversion," "Chapter 4: Chemical Preconversion," "Chapter 5: Formulation," and "Chapter 6: Densification." Each chapter provides a mini-review of the research element in terms of its application to development of advanced feedstocks that are energy-dense, on-spec, and affordable for biorefineries.

Appendixes

Participant comments are referenced as end notes and included in the appendixes, as are the workshop agenda, survey, and information about the Feedstock PDU and Biomass Resource Library demonstrations.

Densification Workshop Summary Report
available at www.inl.gov/bioenergy

STREAMLINING CUSTOMIZED FEEDSTOCK SUPPLY SYSTEM RESEARCH AND DEVELOPMENT

About the Office of Biomass Program (OBP)

The Office of Energy Efficiency and Renewable Energy's (EERE's) Biomass Program works with industry, academia, and our national laboratory partners on a balanced portfolio of research in biomass feedstocks and conversion technologies. Through research, development, and demonstration efforts geared toward the development of integrated biorefineries, the Biomass Program is helping transform the nation's renewable and abundant biomass resources into commercially viable, high-performance biofuels, bioproducts, and biopower.

Program Vision

A viable, sustainable domestic biomass industry that produces renewable biofuels, bioproducts, and biopower; enhances U.S. energy security; reduces U.S. oil dependence; provides environmental benefits (e.g. reduced greenhouse gas emissions); and creates nationwide economic opportunities.

OBP's Feedstock Supply and Logistics Area

OBP's Feedstock Supply and Logistics Area research and development activities enable collaboration and sharing of feedstock development knowledge. The collaborative feedstock research cycle (Figure 8) includes laboratory-scale feedstock formulation development. Large volumes of selected formulations can then be produced using the Feedstock PDU, which incorporates size reduction, preconversion, fractionation, blending, and densification treatments as engineered for the feedstock recipe. The feedstock undergoes compositional and attribute characterization prior to conversion performance testing. After conversion, the performance results are then analyzed to help identify needed refinements and determine when feedstocks are ready for scale up.

Figure 8. *The DOE Biomass Program has capabilities and facilities to engineer and produce feedstocks at a pilot-scale for testing preprocessing technologies and advancing feedstock engineering into the development phase.*

HOW TO COLLABORATE

For information on working with DOE--OBP's Feedstock Supply and Logistics:

Biomass Program
Energy Efficiency and Renewable Energy
U.S. Department of Energy
1000 Independence Ave., SW
Washington, DC 20585
eere.energy.gov/biomass

For information on working with INL's Bioenergy Program and accessing the Feedstock PDU and Biomass Resource Library:

Idaho National Laboratory
Biofuels and Renewable Energy Technologies
PO Box 1625
Idaho Falls, ID 83415
inl.gov/bioenergy

BIOMASS DENSIFICATION WORKSHOP
"Transforming Biomass into Feedstocks"

Sponsored by the U.S. Department of Energy—Biomass Program, Office of Science, and the Advanced Research Projects Agency-Energy (ARPA-E).

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Densification Workshop
Summary Report

Available at www.inl.gov/bioenergy

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