Uniform-Format Solid Feedstock Supply System:

A Commodity-Scale Design to Produce an Infrastructure-Compatible Bulk Solid from Lignocellulosic Biomass

Executive Summary

April 2009

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INL/EXT-09-15423

Executive Summary

The United States is increasing the use of lignocellulosic biomass as part of a portfolio of solutions to address climate change and improve energy security, in addition to other benefits that an invigorated agricultural industry can provide. One of the principle challenges of establishing lignocellulosic biofuels as a self-sustaining enterprise is organizing the logistics of the biomass feedstock supply system in a way that maintains the economic and ecological viability of supply system infrastructures while providing the needed quantities of resources.

This report, *Uniform-Format Solid Feedstock Supply System: A Commodity-Scale Design to Produce an Infrastructure-Compatible Bulk Solid from Lignocellulosic Biomass*, prepared by Idaho National Laboratory (INL), acknowledges the need and provides supportive designs for an evolutionary progression from present day conventional bale-based supply systems to a uniform-format, bulk solid supply system that transitions incrementally as the industry launches and matures. These designs couple to and build from current state of technology and address science and engineering constraints that have been identified by rigorous sensitivity analyses as having the greatest impact on feedstock supply system efficiencies and costs.

An evolution to uniform-format biomass feedstock supply systems, specifically the Advanced Uniform-Format design, will allow lignocellulosic biomass to be traded and supplied to biorefineries in a commodity-type market similar to grain. In addition, the Advanced Uniform-Format supply system will stimulate rural economies as a vast network of biomass depots are deployed across the nation to convert a diverse, low-density, perishable feedstock resource into an aerobically stable, dense, uniform-format, bulk solid resource that can enter the existing agricultural bulk solid commodity infrastructure. This approach will advance the bioenergy industry in a logical, cost-effective manner.

Uniform-Format supply system design strategies are based on the following assumptions:

- A highly efficient, large capacity, dependable feedstock supply system for biomass already exists with the nation's commodity-scale grain handling and storage infrastructure.
- No alternate supply system design for lignocellulosic biomass is capable of handling the large quantities at the same or greater efficiencies and reliability than the existing grain handling infrastructure.
- The national goal of annually supplying approximately 530 million dry matter tons of lignocellulosic biomass to a bioenergy industry can only be effectively accomplished through the development of harvesting and preprocessing systems that reformat lignocellulosic biomass resources into a "uniform-format bulk solid" that can be stored and handled in an expanded grain (i.e., bulk solids) commodity infrastructure.

Motivation for a Commodity-Driven System

The U.S. Department of Energy (DOE) aims to displace 30% of the 2004 gasoline use with biofuels (60 billion gal/yr) by 2030 as outlined in the Energy Independence and Security Act of 2007. Fifteen billion gal/yr are projected to come from grains, and the remaining 45 billion gal/yr will be produced from lignocellulosic biomass resources, requiring approximately 530 million tons of lignocellulosic biomass to be sustainably delivered to biorefineries annually (700 million tons total biomass when grain is included). In order for the biofuels industry to be an economically viable enterprise, the feedstock supply system (i.e., moving the biomass from the field to the refinery) cannot consume more that 25% of the total cost of the biofuel production.

While national assessments identify sufficient biomass resource to meet the production targets, much of that resource is inaccessible using current biomass supply systems because of unfavorable economics. Therefore, existing biomass supply systems are incapable of meeting these long-term biomass use goals. Increasing the demand for lignocellulosic biomass introduces many logistical challenges to providing an economic, efficient, and reliable supply of quality feedstock to the biorefineries.

This report documents a strategy to address these logistic challenges by implementing an incremental change from existing biomass supply systems to economic and reliable commodity-scale supply systems that provide uniform, aerobically stable, quality-controlled feedstocks to biorefineries. This type of approach has been demonstrated and proven very successful for feed grains.

This report details two feedstock supply system designs: the Conventional Bale Feedstock Supply System Design (Conventional Bale) that reflects current practice, and the Uniform-Format Supply System Design (Uniform-Format) that locates the preprocessing unit operation as early in the supply system as practically possible, minimizing logistical issues with transporting and handling dispersed, low-density, often aerobically unstable biomass. The Uniform-Format system is presented in two implementations: (1) a Pioneer Uniform system that uses current or very near-term technologies and offers incremental improvements over the Conventional Bale system and (2) an Advanced Uniform system that meets all cost and supply targets and requires some conceptual equipment, such as advanced processing systems, to provide a commodity-scale bulk solid feedstock.

The Pioneer Uniform design enables the transition from the Conventional Bale to the Advanced Uniform supply system by developing the supply chain infrastructure required for forward-deployed preprocessing.

The Advanced Uniform system changes biomass of various types (i.e., corn stover, switchgrass, etc.) and physical characteristics (i.e., bulk densities, moisture content, etc.) into a standardized format early in the supply chain. This uniform material format allows biomass to be handled as a commodity that can be bought and sold in a market, vastly increasing its availability to the biorefinery and enabling large-scale facilities to operate with a continuous, consistent, and economic feedstock supply. The commodity-scale system also removes the obligation for local farmers to contract directly with the biorefineries for biomass feedstocks.

Biomass commodities are storable, transportable, and have many end uses. Implementing a commodity-based feedstock supply system promotes cropping options beyond local markets, which in turn promotes crop diversity and enhances crop rotation practices. Figure 1 shows a schematic of the end-state commodity supply system.

The supply system represented in Figure 1 incorporates many species and types of lignocellulosic biomass that can be formatted at specialized biomass depots. The preprocessed biomass is transported from the depots to a central shipping terminal, where it may be blended to end-use specifications to form one of several consistent, uniformly formatted and aerobically stable intermediate feedstock products. The intermediate feedstock products are then managed as commodities to be distributed to the biorefinery or other facilities.

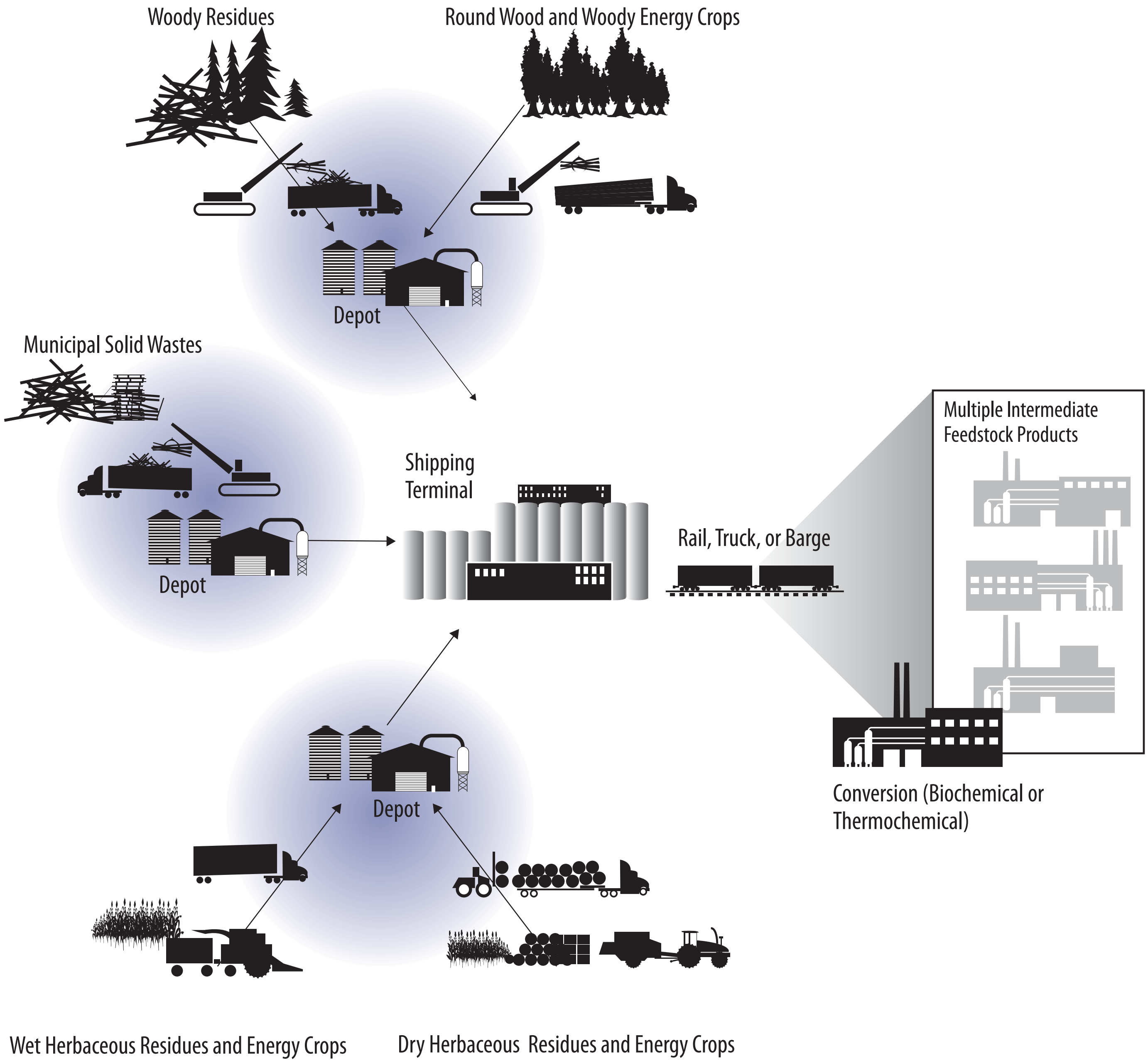

Figure 1. *The Advanced Uniform-Format Feedstock Supply System (Advanced Uniform) design emulates the current grain commodity supply system, which manages crop diversity at the point of harvest and at the storage elevator (in this case, biomass depot), allowing subsequent supply system infrastructure to be similar for all biomass resources, and infrastructure-compatible with existing high-capacity grain handling equipment.*

Uniform-Format Solid System Overcomes Feedstock Supply Barriers

The current Conventional Bale feedstock supply system is not capable of supplying the U.S. DOE target of 530 million tons of lignocellulosic biomass annually for less than 25% of the ethanol production cost. The proposed Uniform-Format supply system meets the biomass cost, quantity, and quality supply goals. Transitioning from the Conventional Bale to the Uniform-Format system, however, presents many challenges, including limitations in existing harvesting and collection equipment and incorporation of biomass depots and blending terminals early in the feedstock supply chain. Figure 2 shows the current least-cost feedstock supply system path and barriers that need to be overcome for the incremental progression toward meeting performance targets.

The three dashed lines in the left half of Figure 2 represent improvements needed in feedstock bulk density, preprocessing capacity and efficiency, and harvest and collection efficiency to transition from the Conventional Bale to the Pioneer Uniform system. For example, first implementation of the Uniform-Format design could be achieved by (1) increasing mass bulk density from 9 to 14 lb/ft^3, (2) increasing capacity for a fixed kWh grinder input from 17 to 22 DM ton/hr, and (3) increasing harvest and collection efficiencies from a collective 38 to 50% recovery. By making these improvements, the Pioneer Uniform system is expected to achieve the 2012 cost and capacity targets.

The six dashed lines in the right half of Figure 2 represent the incremental improvements required to transition from the Pioneer Uniform to the Advanced Uniform system, the final implementation of the Uniform-Format design.

Progression to the Uniform-Format system will result in a long-term decrease in the delivered cost of biomass sufficient to achieve cost targets while increasing supply volume. This will be accomplished by addressing key material property and machine/ engineering barriers to achieve more efficient biomass supply logistics. Table 1 compares attributes of the

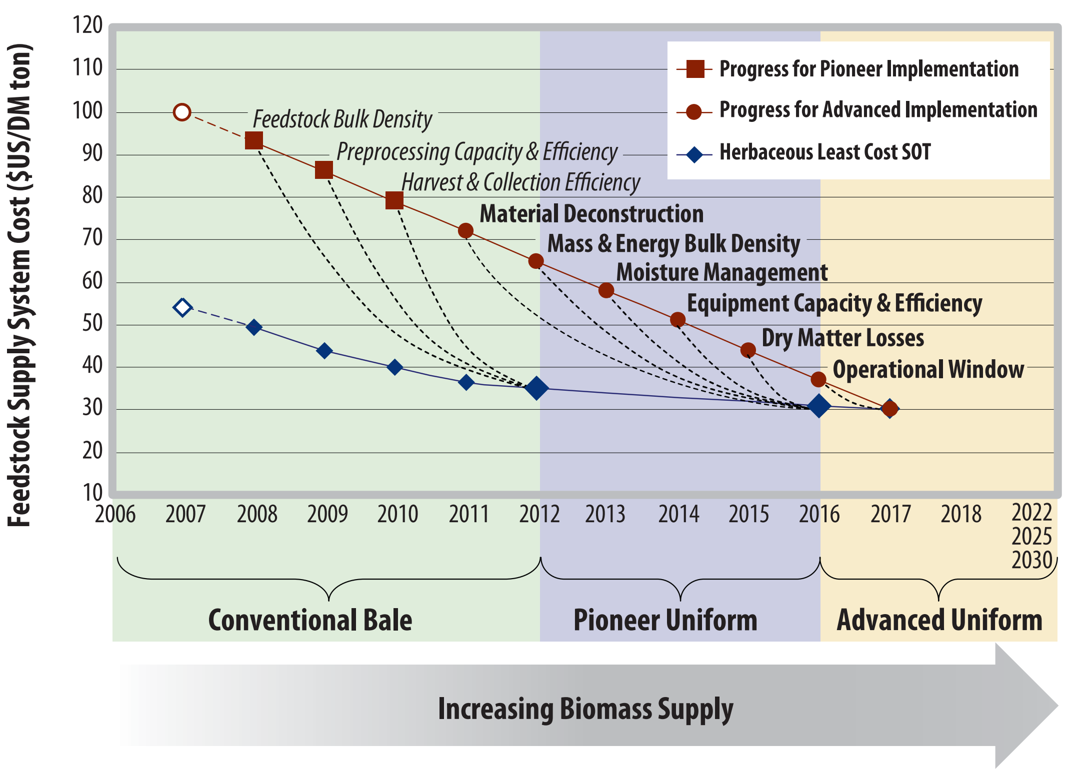

Figure 2. *The estimated progression in herbaceous feedstock logistic costs moving from the Conventional Bale to the Uniform-Format supply system.*

Table 1. *Comparison of the attributes of Conventional and Uniform-Format feedstock supply systems.*[a]

	Non-Uniform	Uniform-Format	
Design Attributes	**Conventional**	**Pioneer**	**Advanced**
National Goals			
Can be economically scaled up to help meet DOE-projected biofuel production goal to displace 30% of 2004 gasoline use by 2030	○	○	●
Can meet 2012 ($35/DM ton) and 2017 (25% of ethanol production cost) DOE cost targets[b] for delivered biomass[c] to the conversion process	○	◒	●
Barriers: Material Properties			
Produces aerobically stable material for all feedstock types (moisture content of 15—20% or less for all resources)	○	○	●
Achieves target dry matter bulk density of >30 lb/ft^3 after preprocessing	○	○	●
Leverages biomass material deconstruction properties to improve capacity and efficiency of all engineered systems and matches systems to material composition	○	◒	●
Barriers: Machine/Engineering			
Optimizes all machinery operation and capital for operational window	○	◒	●
Achieves all equipment efficiency/capacity goals within cost and energy consumption targets (i.e., target harvesting efficiency of 35 DMT[d]/hr)	○	◒	●
Can meet total supply chain material loss of <5%	○	●	●
Commodity System Attributes			
Ensures reliable feedstock supply (biomass can be acquired from many sources beyond 200 miles, reducing supply risk)	○	○	●
Produces aerobically stable and flowable product	○	◒	●
Formats material to fit all common high-capacity solids handling equipment	○	◒	●
Broadens feedstock accessibility (biomass can be purchased and sold through regional and national markets)	○	◒	●
Sustainability			
Expands regional cropping options (handles various biomass formats, moisture content, and composition)	○	○	●
Enables access to remote biomass resources (able to reach DOE goal of 25 M dry ton biomass by 2012, 110 M dry ton by 2017, and 530 M dry ton by 2030)	○	◒	●
Allows efficient transport of feedstock beyond a 200-mile supply radius	○	◒	●
Addresses feedstock supply risks associated with weather, competition, pests, and other local issues	○	◒	●

[a] ○ = does not meet requirement; ◒ = partially meets requirement; ● = meets requirement
[b] DOE-EERE Office of the Biomass Program (OBP), 2007. Biomass Multi-Year Program Plan, October 2007.
[c] Includes harvesting and collection, storage and queuing, preprocessing, and transportation and handling costs, in 2007 $U.S.
[d] Dry matter ton.

three systems and shows that the Advanced Uniform system is the only one that achieves all national cost and supply goals while overcoming material property and engineering barriers and addressing long-term sustainability issues.

Only the Uniform-Format design can overcome the physical and equipment barriers inherent in working with biomass. This is accomplished by increasing the material dry matter bulk density through size reduction, reducing moisture content through drying, improving equipment performance to minimize dry matter losses, and taking advantage of biomass material properties to facilitate material deconstruction. The Uniform-Format system produces a commodity product, reduces plant handling costs, and is conducive to long-term biomass supply sustainability required to help meet the annual biofuel production goals of 60 billion gallons by 2030. This commodity system promotes cropping options beyond local markets by providing access to diverse markets, and increasing cropping options to promote enhanced sustainable crop rotation practices.

Engineering Approach to Uniform-Format Feedstock Supply System

For maximum supply system efficiency, handling and transportation costs must be minimized by reducing the variety of equipment necessary to move biomass from the field to the biorefinery. For example, a Conventional Bale feedstock supply system changes the biomass format at least three times from the field to the biorefinery (standing crop ⇨ bale ⇨ shredded bale). Each biomass format requires unique equipment that cannot be interchanged or used to handle other feedstock formats. To complicate the issue, there are multiple bale formats (round and square in a variety of sizes) with their respective lines of harvesting and handling equipment. Thus, the efficiency of supply logistics can be greatly improved by increasing bulk density and flowability as near to the production location as is practical. However, the cost and energy inputs required to reformat biomass and achieve optimum densities and product quality must also be improved.

Supply logistics costs vary substantially between regions and are impacted by weather, crop species, moisture content, and feedstock types, as well as transportation highway load limits and other regulations. Cropping systems and storage methods also can change supply logistics costs substantially. It is necessary to manage these inherent complexities and diverse feedstock types to optimize supply logistics and therefore minimize costs in the biofuel production system. However, this design document discusses an industry-wide set of feedstock supply chains; therefore, site-specific logistical solutions are not always preeminent. When considering the development of an entire industry that can be rapidly deployed, a uniform-format feedstock supply system becomes key for both conversion facilities and equipment manufacturers, who require capital assets to be broadly applicable across the industry for optimization on a national scale. Modularized feedstock supply systems, such as the Uniform-Format system, are better suited to handle feedstock diversity than capital-intensive systems located at biorefineries.

Figure 3 shows a high-level schematic of the feedstock supply systems described in the design report. The preprocessing operation is advanced incrementally in the feedstock supply chain in the two implementations of the Uniform-Format design.

> Achieving national biofuel goals can only be accomplished through development of a uniform-format feedstock supply system consisting of modularized harvesting and preprocessing systems that can be adapted to the diversity of feedstocks and yet are infrastructure-compatible with uniform-format receiving systems of standardized and highly replicable biorefinery designs.

The Conventional Bale system represents present technology and practices. The Pioneer Uniform system represents the first implementation of the Uniform-Format supply system design; it employs existing or very near-term equipment and locates the preprocessing step earlier in the supply chain, enabling a transition to the commodity-based Advanced Uniform design. The Advanced Uniform supply system concept requires new equipment and achieves all long-term biomass supply targets.

Conventional Bale Feedstock Supply System

The Conventional Bale design represents feedstock supply system technologies, costs, and logistics that are achievable today for supplying lignocellulosic feedstocks to first generation biorefineries. The general architecture of these designs locates the preprocessing operation inside the biorefinery receiving gate. Because each biorefinery will be designed to accept a specific local feedstock, the burden of adapting to the diverse feedstock resources is assumed primarily by the biorefinery. Supply logistic operations could likely be performed by any number of business entities

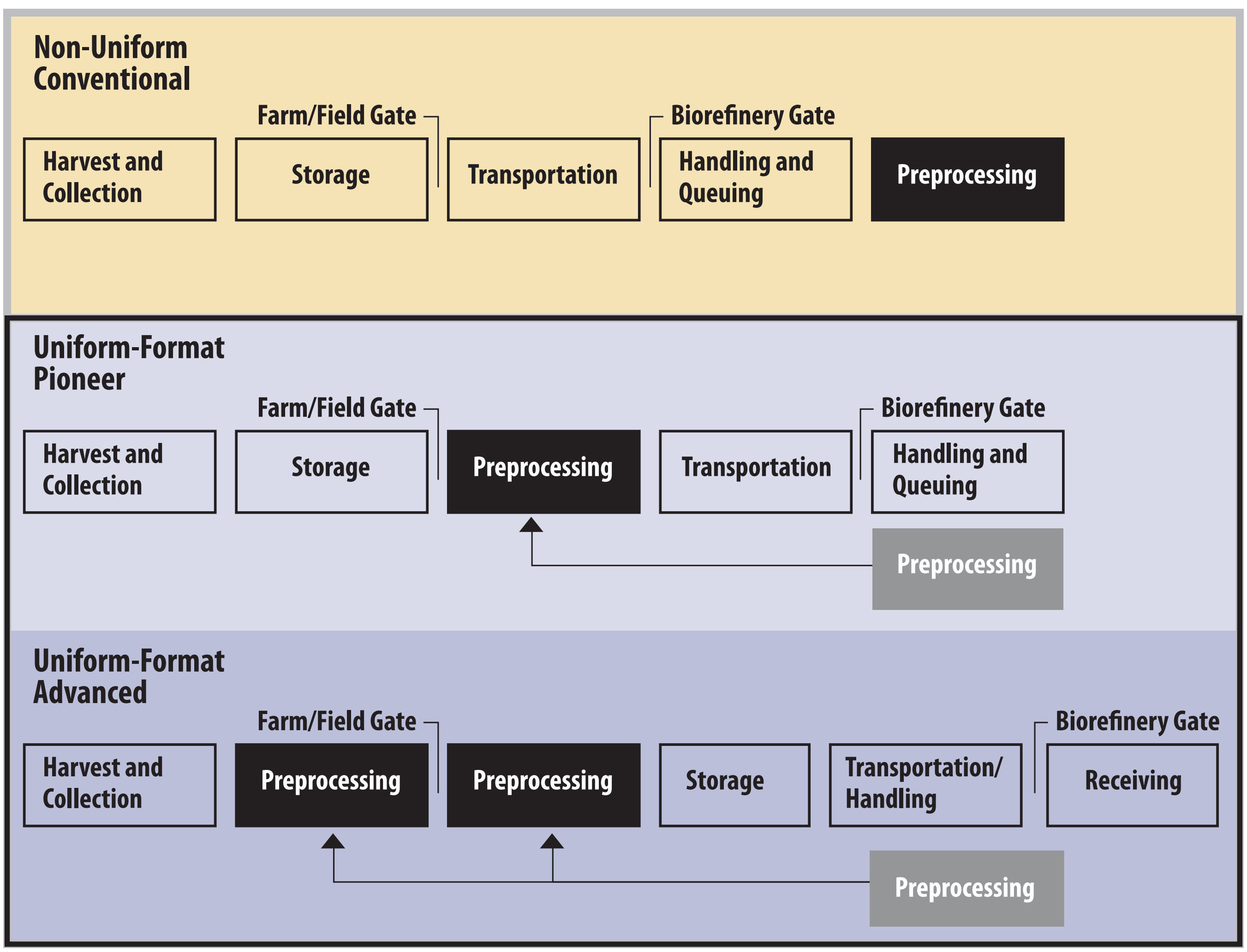

Figure 3. *Feedstock supply systems analyzed in this document.*

such as a co-op of small-farm operators, large-farm operators, custom operators, and large commodity-handling agribusinesses. Over time, these operators will select and invest in more efficient and higher capacity systems. The supply systems will then handle more feedstock diversity issues, allowing biorefineries to focus on biomass compositional and recalcitrance diversity, while implementing innovations for increasingly greater efficiencies and capacities.

Uniform-Format Solid Feedstock Supply System

As Uniform-Format feedstock supply systems emerge, all feedstocks will arrive at the biorefinery gate in a quality-assured and quality-controlled uniform format, such that the diversity of biomass formats (not biomass composition) will be managed primarily by the feedstock supply system rather than the biorefinery. This will be accomplished by deploying the preprocessing operation earlier in the supply system.

The Pioneer Uniform design concept reduces the resource formats handled by the biorefinery to two moisture contents of bulk flowable types, termed dry or wet as defined by aerobic stability or instability, respectively. A key feature of the Pioneer Uniform design is the flexibility of the system to interface with a wide variety of feedstock resource supplies and formats that are not optimized for downstream transportation; they are designed to deliver a standardized format material to the biorefinery. The Pioneer Uniform design also overcomes the diverse design approaches of pioneer biorefinery and feedstock infrastructures, which will facilitate the more rapid deployment of biorefinery facilities across the United States. The Pioneer Uniform system enables an incremental transition between the Conventional Bale and Advanced Uniform feedstock supply systems, incorporating technological improvements as they become available.

The fundamental premise of the Advanced Uniform design concept is that high-capacity and high-efficiency supply logistic systems already exist (e.g., grain commodity market systems) and that handling low-density and aerobically unstable material is inherently inefficient. As such, the Advanced Uniform design develops harvesting and preprocessing technologies to remedy the density and stability issues that prevent lignocellulosic biomass from being handled in high-efficiency bulk dry solid logistic systems. The bulk solid design produces a single, uniform-format feedstock supply system in which the diversity of biomass formats will be eliminated as early in the supply system as is practically possible through some type of preprocessing. The preprocessing may occur during harvest and collection or at centralized preprocessing sites (or biomass depots), which are envisioned to resemble existing depot-type systems like the grain elevator. From the depot, biomass will be transferred to a shipping terminal, transitioning downstream feedstock supply systems and infrastructure into uniform, commodity-scale equipment and handling systems (Figure 1).

The Advanced Uniform design concept changes lignocellulosic biomass from a local bought and sold product to a large-scale commodity, thereby allowing for long distance transportation (beyond 200 miles), bulk-flowable handling, and feedstock blending to achieve standardized feedstock targets and other target properties beneficial to the conversion process. The Advanced Uniform design concept does not have both wet and dry supply delivery lines. Instead, all biomass will be preprocessed into one flowable, aerobically stable format. In the case of the bulk solid system, this is a high-density dry solid product (i.e., flour, granules, select pellet concepts). The production of a high-density liquid product (i.e., biocrude) is the subject of future work at INL.

The feedstock supply systems employed today are not capable of meeting the lignocellulosic biomass supply required to achieve national biofuel production goals.

This report, *Uniform-Format Solid Feedstock Supply System: A Commodity-Scale Design to Produce an Infrastructure-Compatible Bulk Solid from Lignocellulosic Biomass*, analyzes inefficiencies of existing biomass supply systems, identifies opportunities for system innovation, and describes the steps necessary to achieve logistical goals.

Scope of the Document

This design report, *Uniform-Format Solid Feedstock Supply System: A Commodity-Scale Design to Produce an Infrastructure-Compatible Bulk Solid from Lignocellulosic Biomass*, considers all supply system elements, from the biomass standing in the field to the point of insertion into the biorefinery conversion process reactors. The content boundaries are as follows:

- The designs are modeled as dry herbaceous feedstock supply systems, with some inclusion of wet/dry hybrid feedstock systems in the Uniform-Format design concepts.

- Woody feedstocks are recognized resource inputs into these designs but are not presented in detail or as a modeled scenario resource input. Harvesting and preprocessing systems that make these resources available and adaptable to the current and future uniform-format feedstock supply chains are the subject of future INL work.

- While these designs encompass all feedstock logistics activities from harvest to insertion into the conversion process, the feedstock production costs and quantity issues (i.e., resource production) are not addressed in this report and will be covered more thoroughly in a grower payment analysis report prepared by Oak Ridge National Laboratory.

- The grower payment, which represents resource cost and availability, is purposely omitted from the scope of this design document because these payments do not describe or directly constrain the engineering operations or the logistics of the supply system.

- This report assumes that all feedstocks passing through the supply system meet conversion process quality specifications, and that supply system quality control measures are inherently acceptable for all designs. This is a recognized over-simplification requiring that these design elements be more fully addressed in future studies.

- Only the high-density bulk solid feedstock design concept will be presented in this report. The liquid format will be addressed in a forthcoming report, *Uniform-Format Liquid Feedstock Supply System: A Commodity-Scale Design to Produce an Infrastructure-Compatible Biocrude from Lignocellulosic Biomass*, prepared by INL.

Document Content

This document describes in detail the need for the Advanced Uniform-Format feedstock supply system design to meet national goals and promote the sustainable development of a near-term lignocellulosic biorefining industry. The document has four sections:

(1) Introduction and Background

(2) Conventional Bale Solid Feedstock Supply System

(3) Pioneer Uniform-Format Solid Feedstock Supply System

(4) Advanced Uniform-Format Solid Feedstock Supply System.

Section 1 provides the justification, background information, and scope relevant to the development of a lignocellulosic feedstock supply system. Sections 2 and 3 describe in detail the unit operations of the supply chain, including harvest and collection, storage, handling and transportation, preprocessing, and receiving. Sections 2 and 3 also describe equipment cost and performance parameters and feedstock properties, in particular, those that are responsible for design barriers, such as bulk density, deconstruction tendencies, moisture content changes, and dry matter losses as they relate to specific supply system designs. These parameters and properties are used to model the total supply system costs and form the basis for a detailed sensitivity analysis that identifies the parameters and properties that have the highest influence on the system costs and logistics.
Section 4 contains a detailed comparison of each supply system design and provides a clear path forward in terms of feedstock physical property and equipment performance parameter targets required to reach cost, quantity, and quality goals.

Section 1: Introduction and Background

Section 1 justifies the need for an incrementally staged feedstock supply system design to meet cost, quantity, and quality targets. This section defines unit operations and other industry terminology and identifies parameters for system analysis. It also outlines the design basis, design scope, and analysis approach (including resource and biorefinery coupling and economic, energy use, and sensitivity analysis approaches) for the Uniform-Format Feedstock Supply System.

Section 2: Conventional Bale Solid Feedstock Supply System

Section 2 models and analyzes conventional square bale supply system designs for an agricultural residue (corn stover) and an energy crop (switchgrass), which provide the baseline for subsequent design improvements. This section investigates logistics challenges within each unit operation and identifies opportunities for innovation and improved efficiency in biomass material handling. Only aerobically stable, dry herbaceous material is considered.

While harvest and collection equipment choices in the Conventional Bale design vary by crop species, regional agronomic markets, and user preference, sensitivity analyses indicate that the efficiency of most systems can be improved by optimizing machine capacity and operational windows and mitigating losses. In this design, harvested biomass is stored near the point of harvest. Storage facilities differ with crop species, ambient conditions, and costs necessary for managing moisture stability. Analysis suggests that Conventional Bale systems can often employ inexpensive mitigation strategies, like field drying and bale wrapping, to cost-effectively reduce material degradation.

The fixed and variable costs of handling and transportation in Conventional Bale supply systems limit the distance that biomass can be cost-effectively transported. Feedstock format, bulk density, moisture content, transportation distance, load capacity and weight limits, and dry matter losses all impact the cost efficiencies of handling and transportation. Costs are analyzed to determine the break-even points in various handling and transportation configurations and distances.

In the Conventional Bale system, preprocessing occurs at or near the biorefinery. Biomass resources must be stored and queued in sufficient quantities to keep the biorefinery supplied and minimize down time. Conventional Bale systems will rely on high-integrity bales, good quality biomass, and specialized equipment to handle and convey the resource cost-effectively. Biomass will be preprocessed by grinding or other means to make a bulk-flowable product that can be fed into the conversion process. Analysis indicates that potential material losses during preprocessing will require that dust control functions are included in the designs to reduce losses, meet regulatory requirements, and minimize impacts to air quality.

The parameters of highest influence on the system, identified through a rigorous sensitivity analysis, are bale bulk density, baler and shredder efficiency, crop yield, shredder speed, and moisture content. Therefore, the focus of the Pioneer Uniform system is to minimize the impact of these parameters on supply system costs.

Section 3: Pioneer Uniform-Format Solid Feedstock Supply System

Section 3 models and analyzes the Pioneer Uniform system, an interim-stage Uniform-Format supply system design, for two agricultural residues (corn stover and corn cob) and an energy crop (switchgrass) for both round and square bale formats.

The Pioneer Uniform system addresses two fundamental constraints that add significant costs and logistical barriers to Conventional Bale supply systems:

- Inefficiencies in the handling and transport of baled biomass due to a combination of low bulk densities and bale size and shape

- Complex, capital-intensive feed systems at the receiving area of the biorefinery that limit the transferability of biorefinery designs from one location to another.

As the first implementation of the Uniform-Format system, the Pioneer Uniform harvest and collection systems are the same as those for Conventional Bale designs, but impacts of alternate material formats (i.e., round bales) are explored. Round bales were chosen for a case study scenario because many producers already have the equipment for creating and handling round bales. Round bales are also more resistant to water penetration than square bales, and savings in loss mitigation costs may help offset increased transportation costs in comparison with square bales, which are easier and more efficient to transport due to their shape and higher bulk density. Other expanded harvest and collection equipment choices are also analyzed to enable supply system coupling to existing agronomic systems and increase resource options. For example, in the corn cob scenario, harvest and collection of corn cobs is performed using a cob caddy, and cobs are piled at the roadside.

The Pioneer Uniform storage requirements are the same as those for Conventional Bale storage.

In the Pioneer Uniform design, the preprocessing operation is implemented earlier in the supply chain, at a biomass depot. The biomass depot effectively transfers the preprocessing operation from the biorefinery in the Conventional Bale design to a forward-deployed location while providing the same biomass size reduction and dust collection capabilities that are available in the Conventional Bale system.

The Pioneer Uniform system does not incorporate drying into the preprocessing operation. The densified biomass is transported to the biorefinery at a lower unit transportation cost than the biomass in the Conventional Bale scenario, and plant handling costs are reduced because the received material is more consistent in format.

Section 4: Advanced Uniform-Format Solid Feedstock Supply System

Section 4 presents the Advanced Uniform supply system design concept, which formats all biomass types into a consistent, uniform format early in the supply chain. Material format and handling targets can be achieved with existing or near-term technology and are discussed in the state-of-technology (SOT) Uniform-Format design. However, a cost analysis indicates that the SOT scenario does not meet cost targets.

This prompts a discussion on the Advanced Uniform design concept and factors that enable it to meet all cost and material targets set out by DOE. A comparison of the attributes of both the Conventional Bale and Pioneer/Advanced Uniform-Format designs is presented and shows why (1) the Conventional Bale system does not meet any of the material or cost targets, (2) the Pioneer Uniform system meets some of the material property targets but fails to sustainably provide a sufficient, cost-effective feedstock supply, and (3) the Advanced Uniform system is capable of hitting all identified materials and cost targets.

The Advanced Uniform design could vastly increase the availability of biomass resources and enable DOE biomass supply targets to be met. The commodity-based system produces a stable, storable, flowable product early in the supply chain. This system may promote diversity in cropping systems and prevent the stranding of biomass resources, which can occur for remote pockets of biomass resources located away from biorefineries.

While increasing plant size decreases the unit output cost, it also requires a larger supply of biomass. Securing a sustainable biomass feedstock supply to biorefineries allows scaling based on capital economy rather than resource availability.

Uniform-Format Feedstock Supply Model

The Uniform-Format Feedstock Supply Model focuses on improving feedstock logistics, efficiencies, and costs, and uses a baseline feedstock production quantity/cost input. Feedstock inputs (influenced by materials, supplies, labor, logistical issues, and material losses) and outputs (material throughput of particular equipment) are used for comparing and optimizing the logistics of different supply systems.

The model contains equipment cost, operation efficiency, hours of operation, and various other parameters for several feedstock formats, including:

- Conventional Bale feedstock supply system (square bale only)
  - Switchgrass, the modeled low-moisture herbaceous energy crop
  - Corn stover, the modeled low-moisture herbaceous residue
- Pioneer Uniform feedstock supply system
  - Corn cobs
  - Switchgrass (both round and square bales)
  - Corn stover (both round and square bales)
- Advanced Uniform feedstock supply system
  - Switchgrass (both round and square bales)
  - Corn stover (both round and square bales).

The model also contains @Risk© sensitivity analyses, as well as regional labor and transportation databases.

Accessing the Full Report and Uniform-Format Feedstock Supply Model

The full version of the report and the Uniform-Format Feedstock Supply Model can be accessed at:
www.inl.gov/bioenergy/uniform-feedstock

Prepared for the
U.S. Department of Energy
Office of Biomass Program
Under DOE Idaho Operations Office
Contract DE-AC07-05ID14517

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