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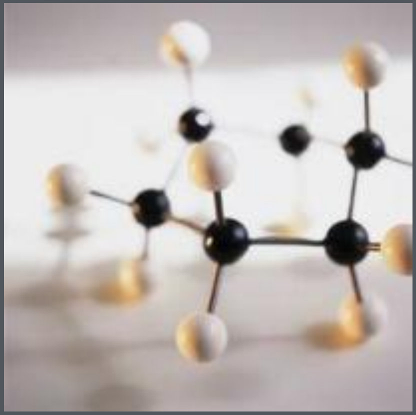


Advanced Feedstock Supply System

Erin M Searcy, PhD

November 27, 2012

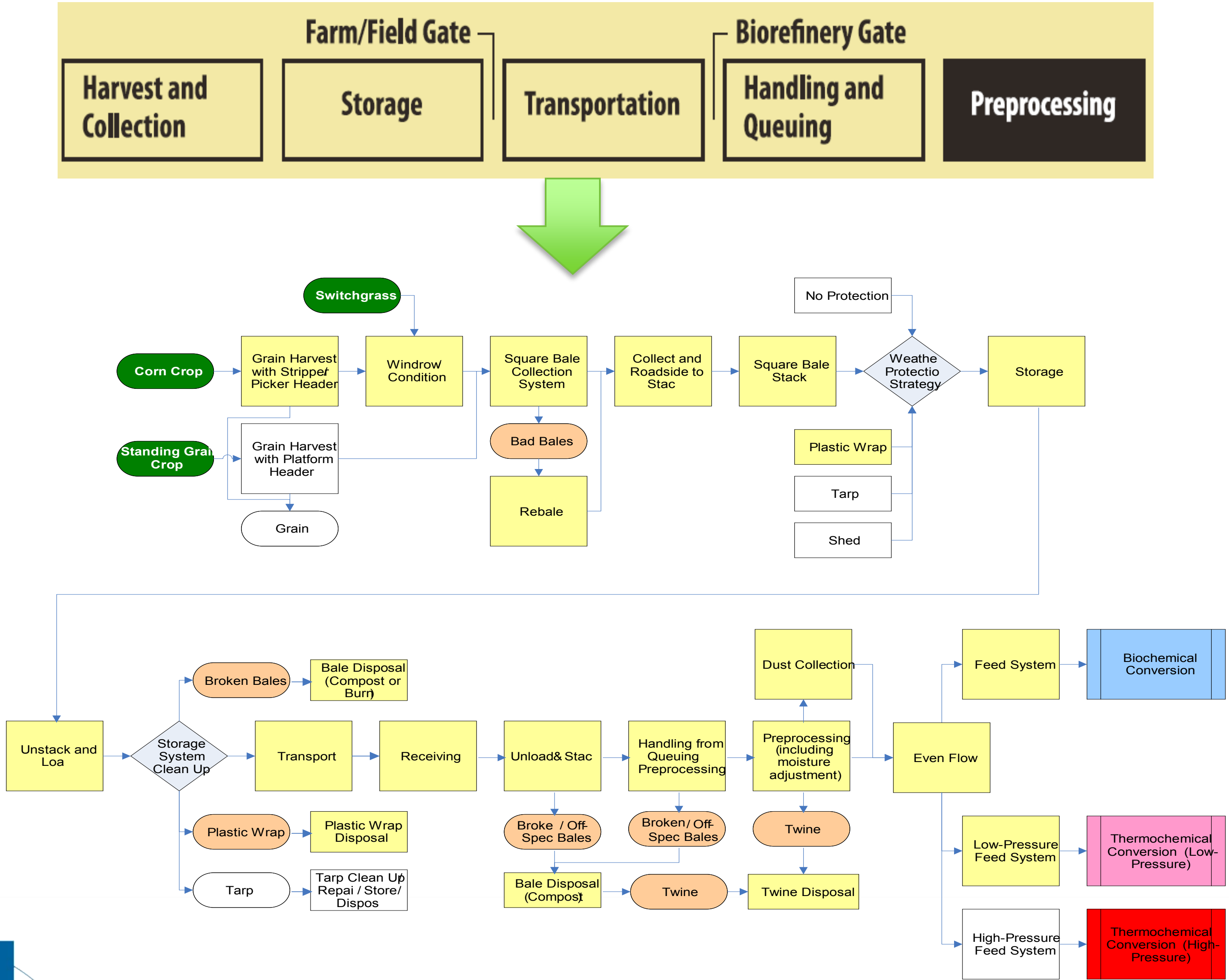
Key Point

- **Technologies exist to supply biomass for energy production, but they have limits**
  - **Cost, quantity, quality**
- **I'll present a potential solution: biomass commoditization**

Current State of Logistics

- **There are a variety of lignocellulosic biomass sources that could be used for energy production**
  - **Unstable, bulky, heterogeneous (format and quality), poor flowability**
    - **Creates logistics challenges**
- **Current supply chain models generally situate the biorefinery near the feedstock resource ("Conventional")**
  - **Minimizes transport cost**
- **Example: Corn stover in Iowa**

Example: 2012 Herbaceous (Corn Stover) Feedstock Design



Cost Improvement Pathway (2007 $)

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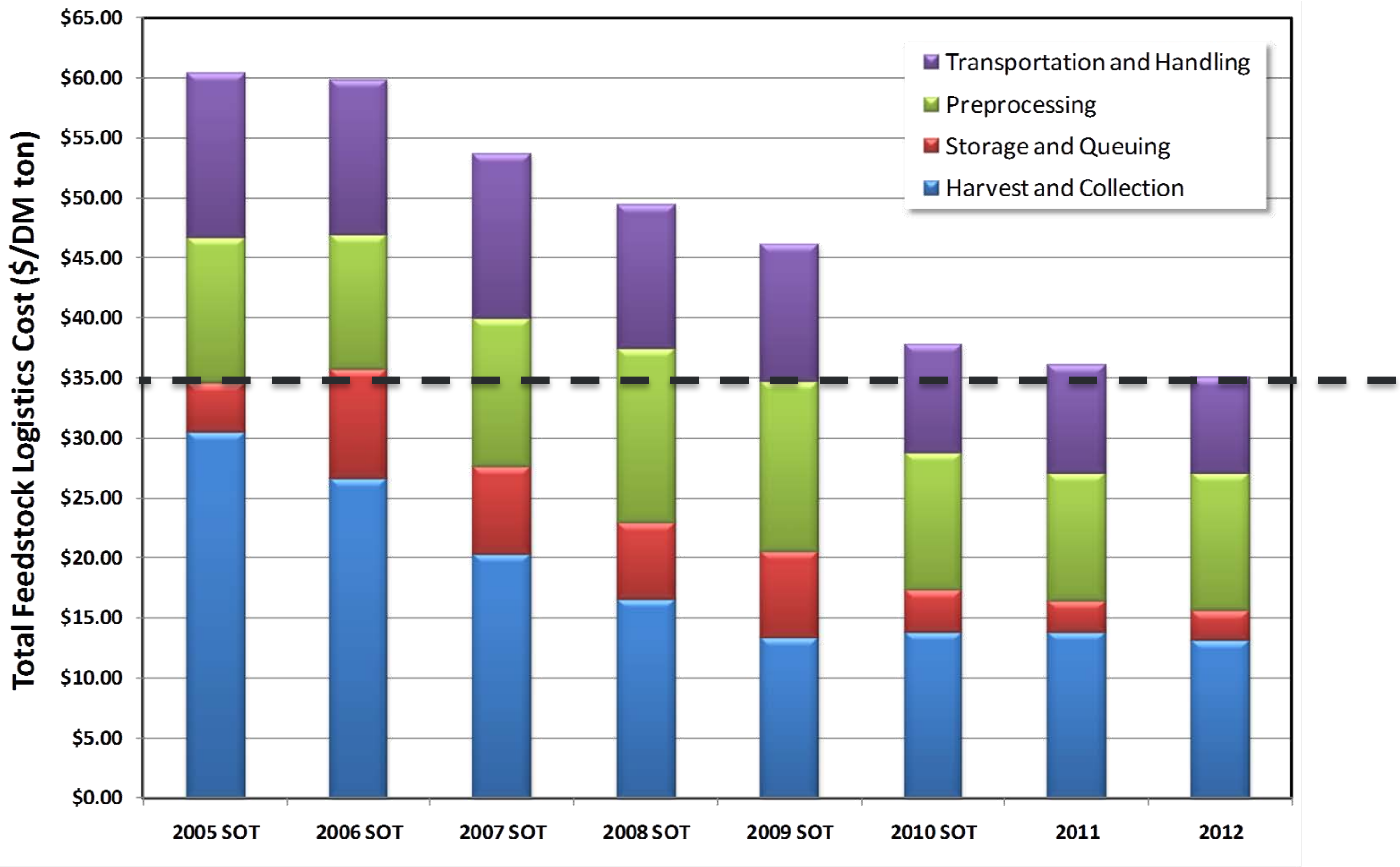


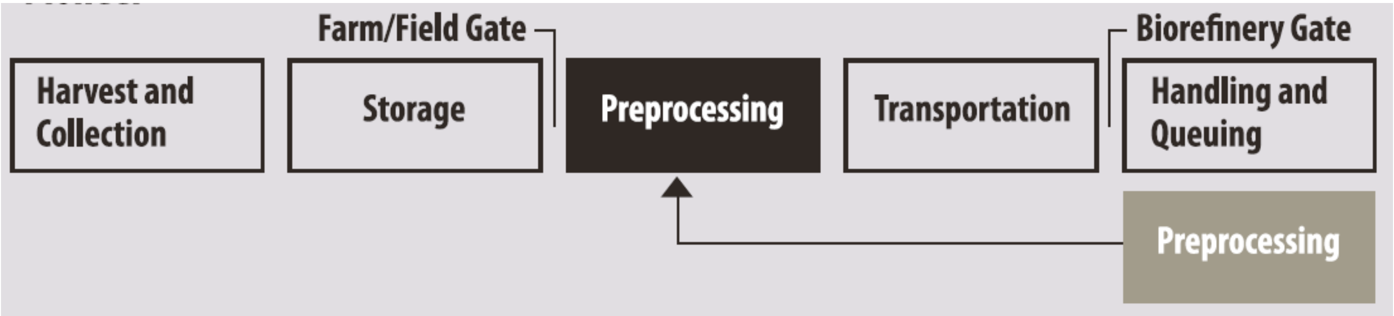
Target: $35/DM ton to support meeting ethanol production cost target

Risk

- Biorefinery is vulnerable to supply chain upsets
- The biomass resources available are limited
  - stranded resources
- Burden of variability is on biorefinery
- Limited opportunity to address quality
- Limits biorefinery size

Key Challenge: **Biomass is not where it needs to be (dispersed, often remote) or what it needs to be (quality);** ***Cost***

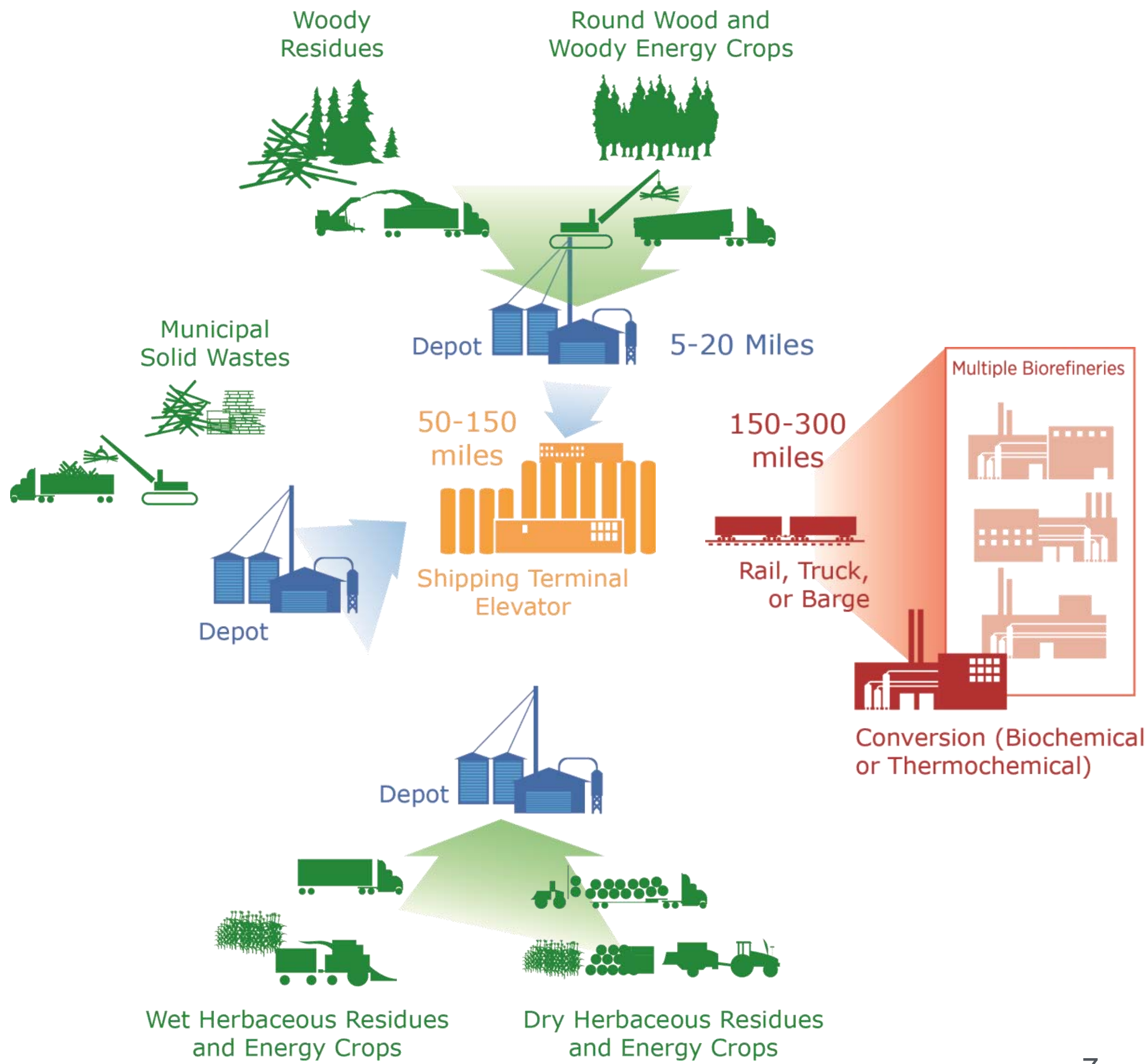
Potential solution: **Biomass commoditization**



Uniform-Format Feedstocks

Commodity Vision for Infrastructure Compatibility

Commodity Attributes
Standardized material formats are compatible with existing solid and liquid supply handling systems and infrastructures
Feedstock quality is assured through national and international standards
National market systems secure supply and demand in a sustainable way
Biomass feedstocks futures contracts are tradable on commodity exchanges.



Vision and Mission Areas

Vision: Transform Raw Biomass into High-Density, Stable, Commodity Feedstocks

Mission Areas:

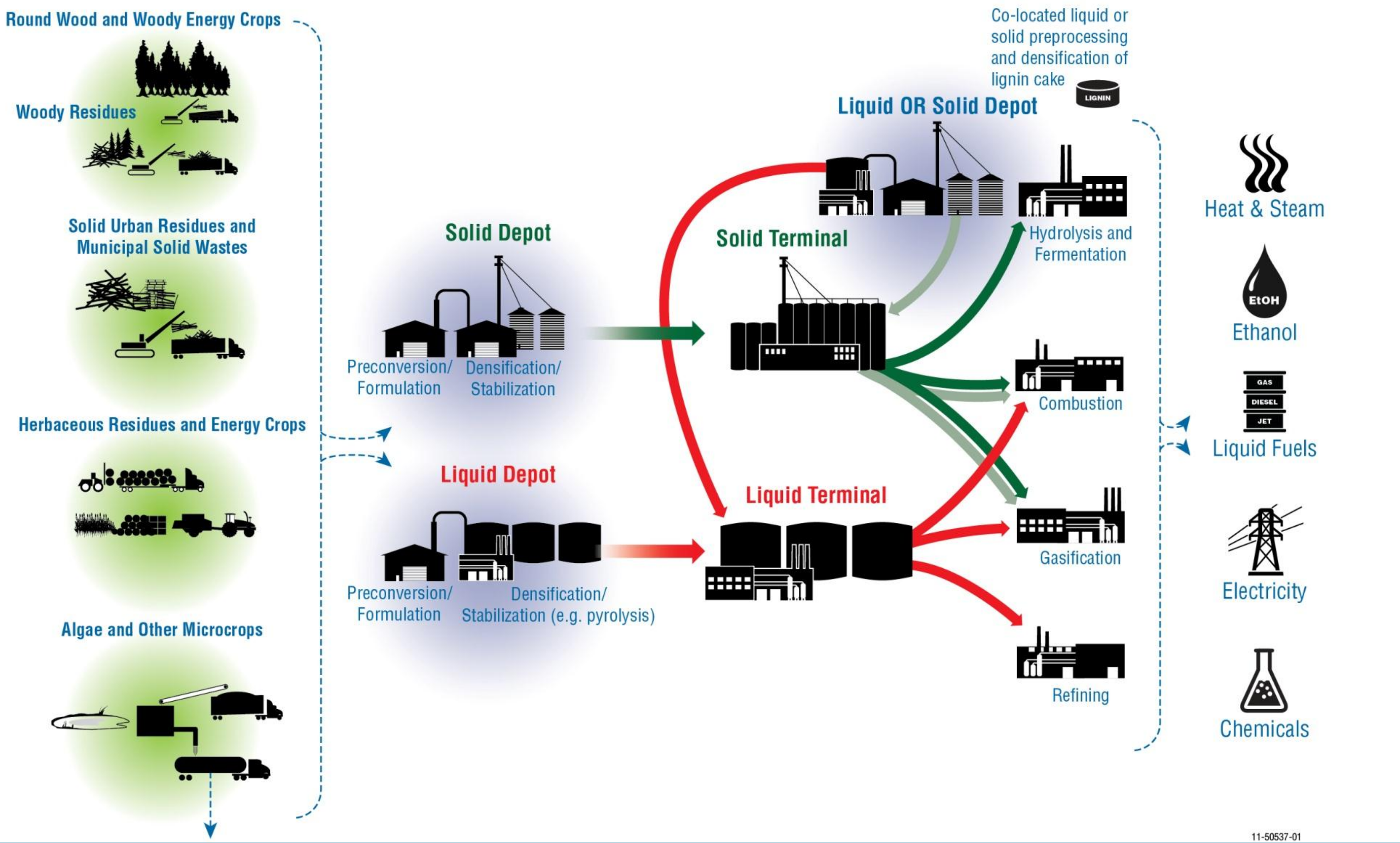
- Improve Biomass Quality and End-use Performance
- Improve Biomass Density, Stability and Infrastructure Compatibility
- Increase Accessible Biomass Quantities/Diversity and Supply Stability

Vision Constraints:

- Cost
- Sustainability/GHG

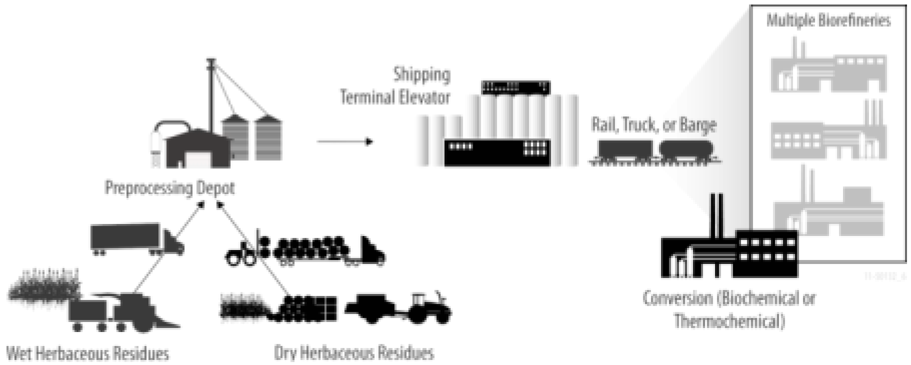
Conceptual Implementation of the Commodity Feedstocks Vision

PRODUCTION SYSTEM	PREPROCESSING DEPOT	TERMINAL	REFINERY
Production/Harvest/ Collection/Short-Term Storage	Preconversion/Formulation/ Stabilization/Densification	Aggregation/Blending/ Upgrading/Long-Term Storage	Conversion/Utilization



Grand Challenges

1. Density and Stability



1. Infrastructure Compatible (16 lbs/ft^3 in field to >48 lbs/ft^3 in supply system)
2. Long-term stability in supply system (years, like grain or coal)

2. Conversion Performance

Grade A Feedstock

(Material the conversion process was developed around)

Commodity Attributes
- On-spec quality
- Uniform density
- Consistent format
- Stable
- Reliable supply
- Infrastructure compatible

Upgrade

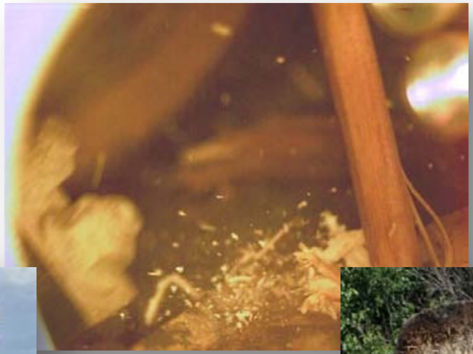
Manage
- Moisture content
- Ash
- Sugar

Field Run Biomass

Diverse
- Format
- Density
- Compositional properties (does not meet conversion spec)

Addressing Challenges

- **Iteration between field work, lab work, and analysis**
- **Partnerships with industry, academia, and other National Labs**

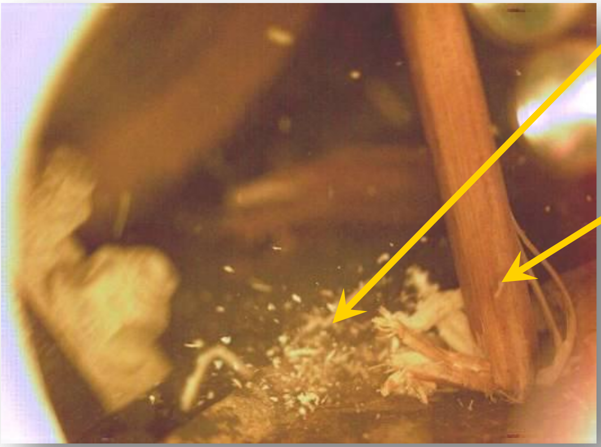


One Research Tool: PDU

- Process Demonstration Unit (PDU) is a modular and reconfigurable biomass preprocessing system that is highly instrumented for data collection (depot)
- The design allows testing and comparing technologies in a fixed system
- Allows equipment to be swapped out or operated independently
- Modules are portable allowing deployment in any location with adequate space and available utilities

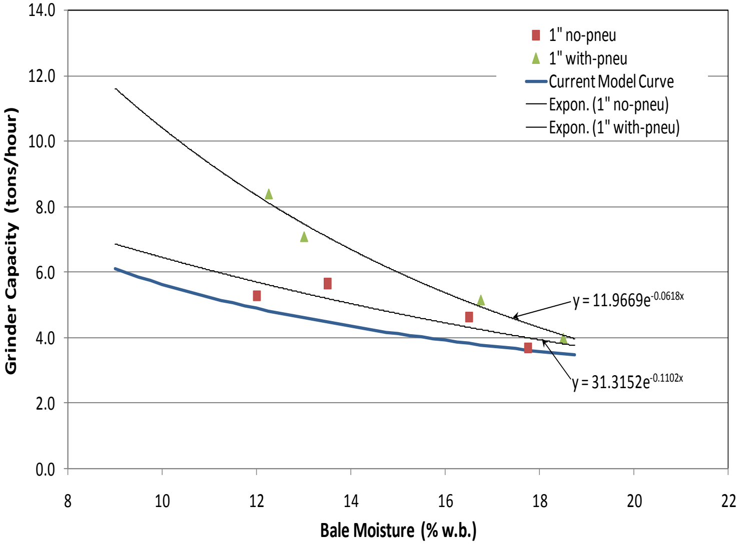
Examples of Improvement: Grinder Capacity/Efficiency

- Start: 17.6 DMT/hr
- Current: 31.2 DMT/hr
- Successes:
  - 77% increase in grinder capacity due to:
    - Improved grinder operation
    - Pneumatic conveyance
  - Improved understanding of particle size distribution



Pith and other tissues rapidly deconstruct upon impact

Rind and vascular tissues hold together under impact forces and require shear / torsion forces to effectively size reduce



Addressing Near-term Barriers that Allow an Industry to Grow

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2007-2012 Niche Resources

2012-2017 Local Utilization

2017-2022 National Industry

Reduce Costs Through Improved Logistics

- Effeciency and capacity (machinery performance)
- Losses
- Operational window

Resource

IMPROVE CONVERSION PERFORMACE

Raw Biomass ▶ Feedstock

- Reduce feedstock variability (composition, moisture, physical and mechanical properties
- Minimize carbohydrate losses
- Transform to feedstock classes and grades

Years 1-5
Achieve Grade A feedstock standards from field-run biomass resource

Years 5-10
Upgrade and achieve absolute specifications (advanced feedstocks for advanced biofuels)

Years 10+
Develop new customized feedstocks for optimized conversion

Infrastructure

DEVELOP INFRASTRUCTURE-COMPATIBLE LOGISTICS SYSTEMS

Feedstock ▶ Commodity Feedstocks

- Develop harvest, collection, and storage systems optimized for biomass
- Network flexibility for both local and national markets
- Implement industrial scalability and efficiency from field to conversion infeed
- Couple to existing high-capacity solid/liquid infrastructure
- Transform to uniform handling formats

Years 1-5
Develop infrastructure-compatible biomass-specific equipment/ processes

Years 5-10
Develop infrastructure-compatible biomass-specific equipment/ processes that accept multiple resource types

Years 10+
Optimize processes/ infrastructure based on market drivers

Production

MAXIMIZE GROSS AND FUNCTIONAL YIELD

Residues ▶ Billion Ton

- Scale up sustainable resource production to meet future demand

Years 1-5
Leverage/build on existing crop develop-ment and biotechnology from other agricultural industries

Years 5-10
Develop crops and cropping systems that are optimized for bioenergy production

Years 10+
Maximize sustainable biomass production/ yield of multiple resource types

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Contribution to $3/gal target: FSL 2017 Pathway

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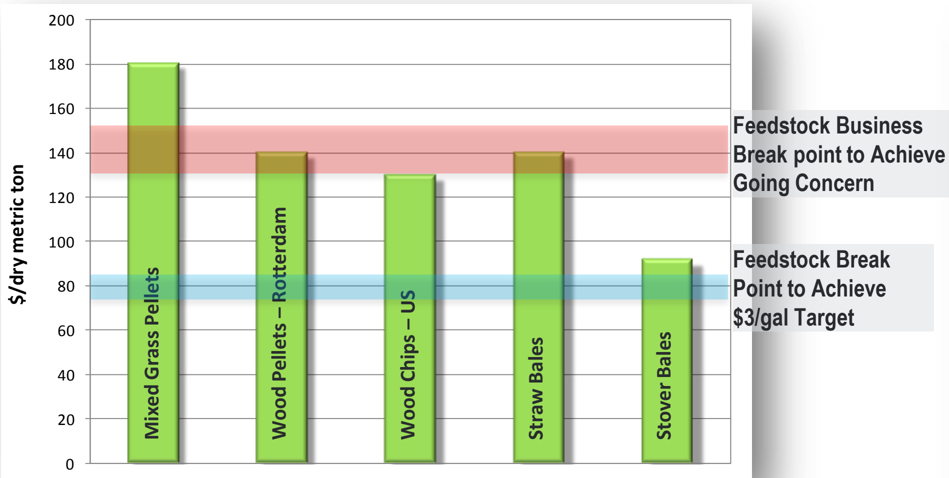
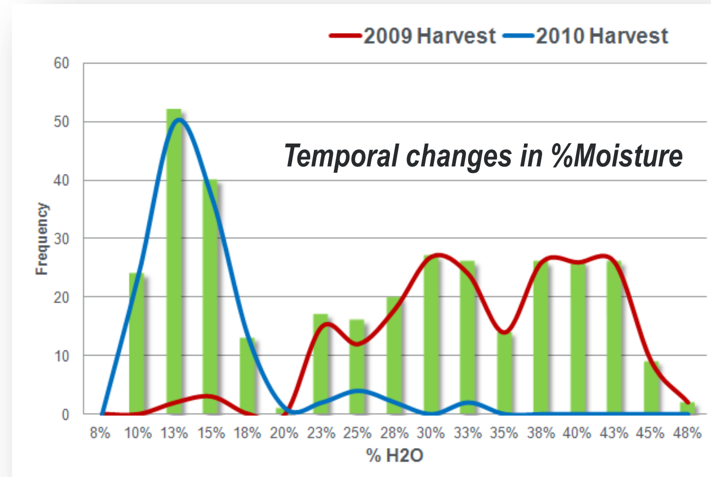
Feedstock Cost Challenge



Feedstock Quality Challenge



Approach

- 2015 – Validate a suite of advanced preprocessing systems
- 2017 – Implement advanced preprocessing within the $80/ton reactor throat target (Strategy: blending/formulation of low-cost resources)
- 2022 – Fully integrated advanced feedstock system for all resources (Strategy: fractionation/merchandizing feedstock intermediates to multiple markets/customers)

Getting There from Here

How do we transition from:

- Today's vertically integrated supply systems
  - Designed around limited markets, specific feedstocks and conversion facilities, and a constrained supply radius
- To tomorrow's commodity supply system
  - Designed around scaled-up, fully networked, commodity supply system infrastructures and markets

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