BALES Biomass Alliance for Logistics Efficiency and Specifications

DOE Bioenergy Technologies Office (BETO)
2017 Project Peer Review

2017 BALES Project Review

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Feedstock Supply & Logistics Session

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Project Summary

- 4 Year Development and Demonstration Project, Began Sept 2013
- Develop and demonstrate new and improved harvest and processing technologies that will reduce biomass supply chain costs while meeting quality specifications of biomass end users (round and square bale systems)



FDC Enterprises Grasslands Services
POET Energy inspired.
ANTARES Group Incorporated
Vermeer
CLARIANT
B Hames Consulting
Pellet technology
kelderman
ADM
SEA BOX Intermodal Concepts - ISO Shipping Containers
MONSANTO
AGSOLVER
Biomass Toolbox
Biomass Market Access Standards (BMAS) Group
MacDon
IOWA FARM BUREAU PEOPLE. PROGRESS. PRIDE.
IOWA CORN
INL Idaho National Laboratory
ASD Inc.
VT

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Poet-DSM's Project Liberty – Emmetsburg, IA

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Goal Statement

- To develop and demonstrate new and improved harvest and processing technologies that will **lower biomass supply chain costs** to $53/DT (harvest and transport to "throat of conversion reactor") while **improving feedstock quality**, **validating improvements and remaining gaps**, and **addressing key sustainability issues** in order to promote a sustainable and scalable advanced biofuels industry.

Targeted Project Outcomes

- Cost reductions for advanced large scale feedstock delivery and processing estimated to be ~$18 per ton (conservative)
  - Worth $5.4 million/yr at 300,000 ton/yr scale
- Identify and measure all supply chain costs
- Improve feedstock quality measurement through rapid NIR spectroscopy
- Improve automated multi-bale receiving, handling, processing systems

Successful demonstration of these technologies in a commercial environment will support the increased production of cellulosic biofuels/bioproducts in the United States.

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Quad Chart Overview

Timeline

- Project start date: 9/30/2013
- Project end date: 9/30/2017
- Percent complete: 84%

Barriers

- Ft-L. Biomass Material Handling and Transportation
- Ft-M. Overall Integration and Scale-Up
- Ft-D. Sustainable Harvesting

Budget

	Total Costs FY 12 –FY 14	FY 15 Costs	FY 16 Costs	Total Planned Funding (FY 17-Project End Date)
DOE Funded	$1,325,114	$2,787,150	$1,076,558	$1,093,460
Project Cost Share by Contributing Partner				
Vermeer	$993,977	$2,558,905	$1,713,970	$1,275,649
Kelderman Mfg.	$109,144	$155,332	$317,552	$336,973
Feedstox	$153,197	$0	$0	$0
Poet Biomass	$53,989	$283,873	$0	$0
John Cundiff	$0	$24,338	$3,523	$0
ASDI	$0	$1,276	$0	$0
Virginia Tech	$0	$16,648	$23,055	$0
Collaborators	$0	$1,055,336	$336,686	$0
Monsanto	$0	$469,187	$412,565	$0

Partners

- Vermeer (42.9%)
- FDC Enterprises (13.4%)
- Collaborators (12.4%)
- Kelderman Manufacturing (8.6%)
- Monsanto (7.8%)
- Antares Group Inc. (4.8%)
- Poet Biomass (2.5%)
- Idaho National Laboratory (2.0%)
- John Cundiff (1.8%)
- Virginia Tech (1.8%)
- B Hames Consulting (1.6%)
- AgSolver (0.2%)
- ASDI (0.02%)

1 - Project Overview

- Leveraging team member's operational experience, knowledge, and capabilities to identify and resolve existing supply chain challenges.
- Building on team's prior square bale system development work
- Address opportunities in round bale systems
  - Over 90% of existing baling stock are round balers. (big factor for scale-up)
- High-volume, multi-bale handling systems are needed to reduce trucking costs and wait times.
- Dirt reduction early in supply chain is critical
  - Harvest improvements and advanced instrumentation targeted
- Automated bale handling systems need to be capable of handling extremes, not average delivered biomass
- Particle size control and uniformity improvements targeted
  - Continued improvements will be needed

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Examples High-volume Unloading Systems

Cotton Gin

Log Trailers

Sugar Mill

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Example High-volume Infeed Systems

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2 – Approach (Management)

- ***Team members planned development and testing schedule for 4 yr period.***
- ***Used DOE budget and progress reporting system to track and report progress.***

PROJECT ROLES:

FDC Enterprises: Prime contractor, lead harvest & logistics operations

POET, Clariant, ADM: Biorefiner team members, provide process material spec's

POET: Biomass harvest end-user

Vermeer: Equipment development for round bale harvest, logistics, processing

Kelderman Manufacturing: Equipment development for square bale harvest, logistics, at-plant bale handling

MacDon: Collaboration with Kelderman on windrow merger

Bonnie Hames: Lead NIR expert for calibration model for bale probe development

ASDI: Spectroscopy equipment vendor, bale probe development

Monsanto: Facilitated access to multi-year bale storage study; Lab analysis for NIR

INL: Bale probe sampling, lab analysis, pilot-scale process demonstration testing

John Cundiff, SeaBox, Virginia Tech: Round bale hauling and rapid-unloading system

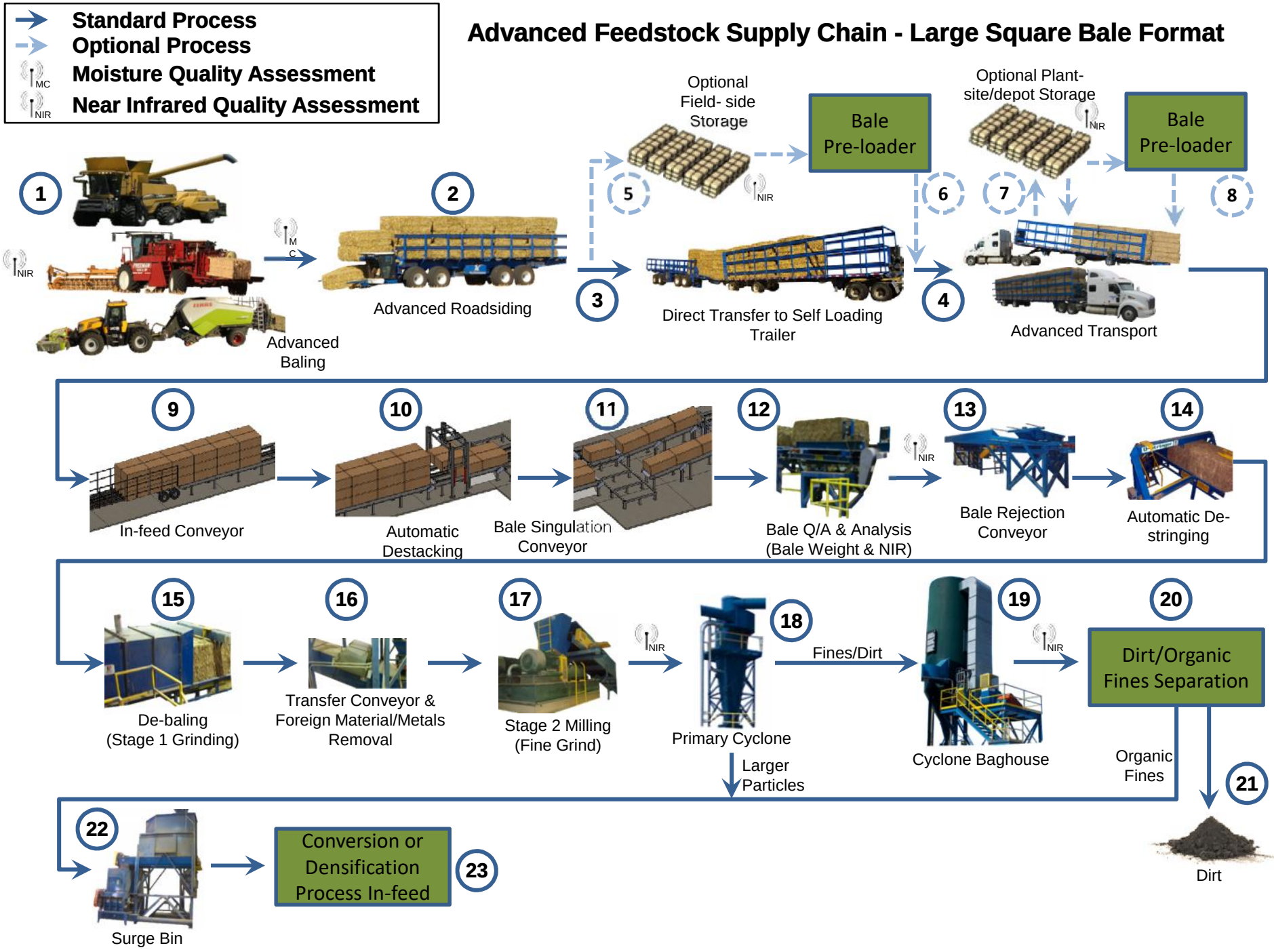
Antares Group: Project management and coordination, data collection & analysis

2 – Approach (Technical)

- Develop and Demonstrate New or Improved Biomass Harvesting, Logistics, Processing, and Analysis Equipment
  - Designed equipment to fill gaps in the biomass supply chain (harvest and processing), for square and round bale systems
  - Continuous development cycle (Design → Build → Test → Learn → Improve)
  - Improved in-field harvest data collection systems to build a more robust set of cost and performance data (share data with National Labs)

- Critical Success Factors and Key Challenges
  - Prototype equipment and innovations fabricated and tested.
  - Proving equipment reliability to meet commercial product requirements.
  - Need continued demonstration and development platforms/opportunities, supplemental funding.
  - For process technologies: Need regularly operating demonstration facilities with local biomass supplies and nearby offtake opportunities, supplemental funding. (Demonstration test-beds needed.)

Advanced Feedstock Supply Chain - Large Square Bale Format



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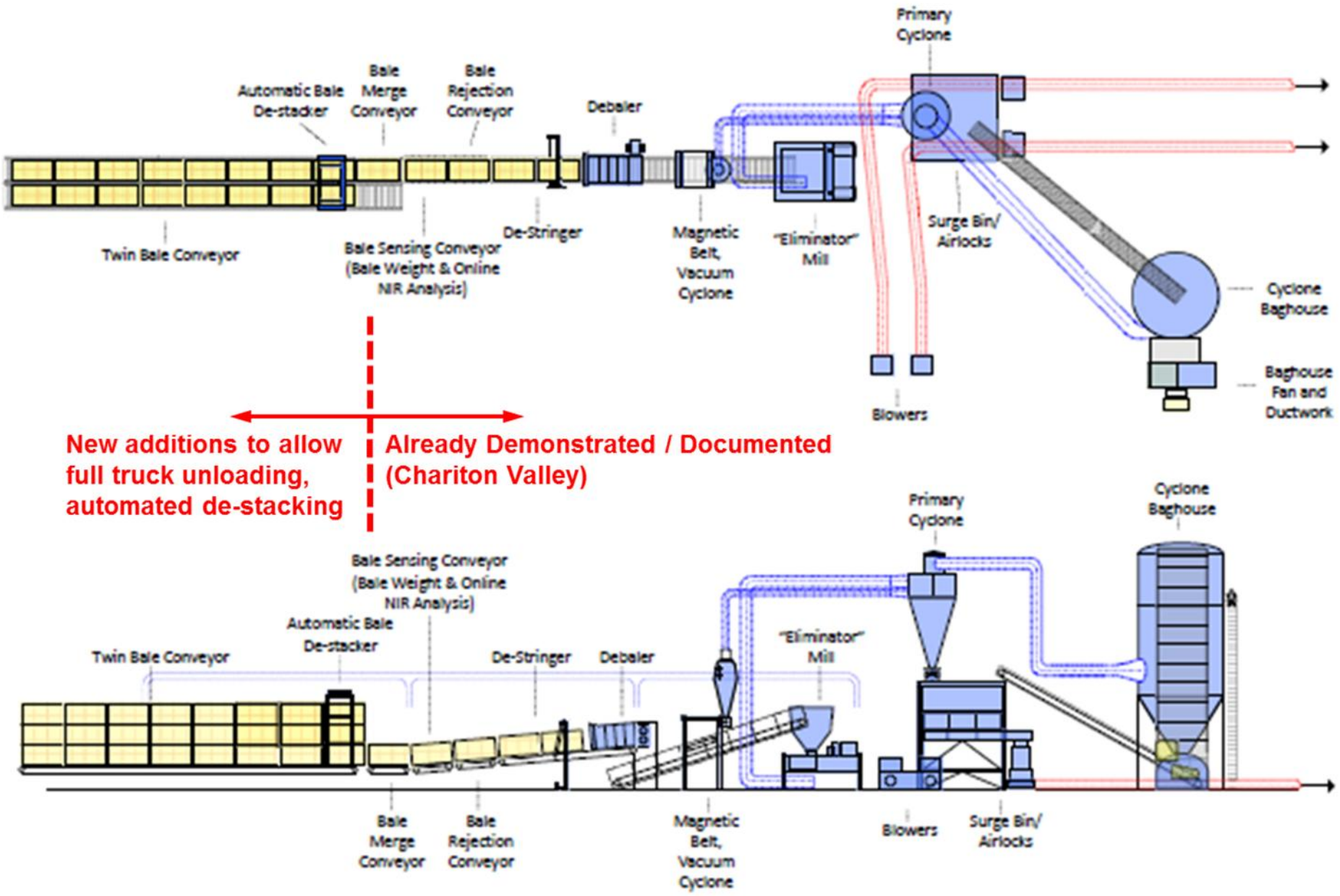
Process Line Concept Drawing



Initial Prototype Testing

Rapid multi-bale infeed system under development by other team members

Final Prototype Testing at Biorefinery (now operating)

Bale Handling System

Vermeer

EQUIPPED TO DO MORE.

3 - TECHNICAL ACCOMPLISHMENTS / PROGRESS / RESULTS

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3 – Technical Accomplishments

"EZ-Bale"; ~ 1 ton/acre; No separate shredding

Separate shredding operation;
~ 2 ton/acre or more

Shredding in new header;
Optimized biomass removal rates;
Avoids separate shredding operation

Increased bale densities

Square Bales ⟷ Round Bales

10%+ more tons per truckload, 10%+ fewer trucks

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3 – Technical Accomplishments

Reduced Dirt Content in Bales:

Previous norms: 8-10% (at best) ash

Current Potential: as low as 3% ash

AGCO Your Agriculture Company · John Deere · Hillco Technologies · New Holland Agriculture · Vermeer · Kelderman

Non-accumulated baling, 1 bale per drop

Baling one windrow at a time

Accumulated baling, 6 bales/drop

Kelderman · MacDon

Windrow merger; combines 2 windrows into a single baling pass; ½ baler travel

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3 – Technical Accomplishments

Current Bale Gathering; 1 bale at a time; ~8-12 bales per trip

Bale Picking Truck; picks up to 6 bales at a time; 36 bales per trip

Typical trailer loading / unloading; 1 to 6 bales at a time; 20-40 minutes

Self-Loading / Unloading trailers; 36 bales at a time; 5-10 minutes

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Progress towards commercial supply chain

Feedstock quality

- Bale density testing
- Ash analysis – variables
  - Equipment settings
  - Field – soil type, conditions
  - Weather – before, during harvest
- Operator experience impact
  - Bales/hour
  - Maintenance & repair

# of Bales	Average Density % increase
80	-11%
87	0%
82	11%
83	9%
72	12%
11	28%

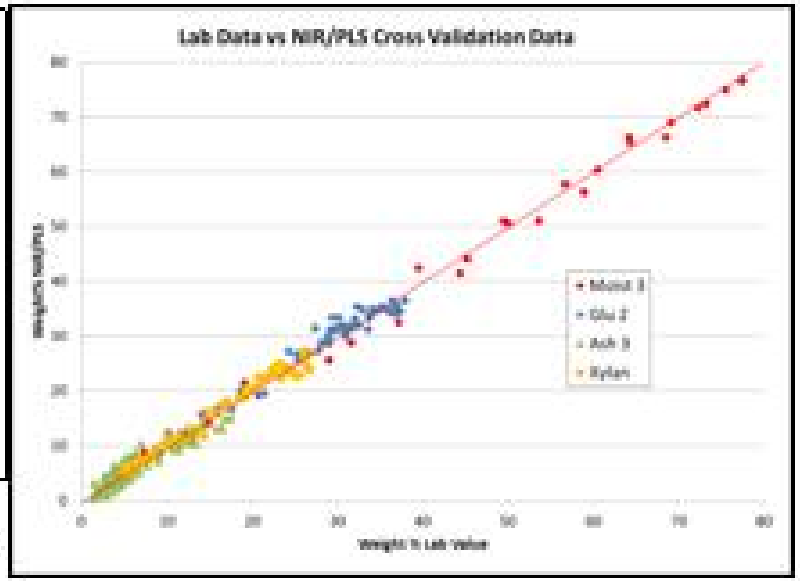
Reducing cost of harvest

- Durability
  - Belt analysis
  - Pickup shut off during wrap
  - Drive system enhancements
- Analyze stop time causes
  - Replace netwrap roll was the top reason (16%)
  - Non-baler reasons (34%) operator, tractor
- Mapping harvest path
  - Custom harvesters travelled in excess of 1000 miles. Roughly 50% were road miles
- Continuous round baler prototype
  - Collected harvest data in 2016.

NIR Bale Probe Development and Demonstration

NIR/PLS Model	Moist 4	Glu 2	Xyl 2	Ash 3
Cal. Range (%)	4 - 80	5 - 40	5-27	0.5 - 19
RMSECV (%)	2.4	1.5	1.1	1.3
Factors	1	3	3	1
R^2	0.985	0.969	0.977	0.787
N	33	68	54	162
Moist. Range (%)		4-60	4-60	4-70

Calibration Stats.



Comparison of Lab and NIR analysis

- ASDI, INL and BHC have designed and calibrated a NIR Bale Probe accessory for the ASDI Field Spec.
- Updated PLS methods measure moisture, ash, glucan and xylan in corn stover.
- Proprietary techniques allow for constituent analysis at moisture levels up to 60%
- Probe design updated to make it more rugged for in-field use and transport

4 – Relevance

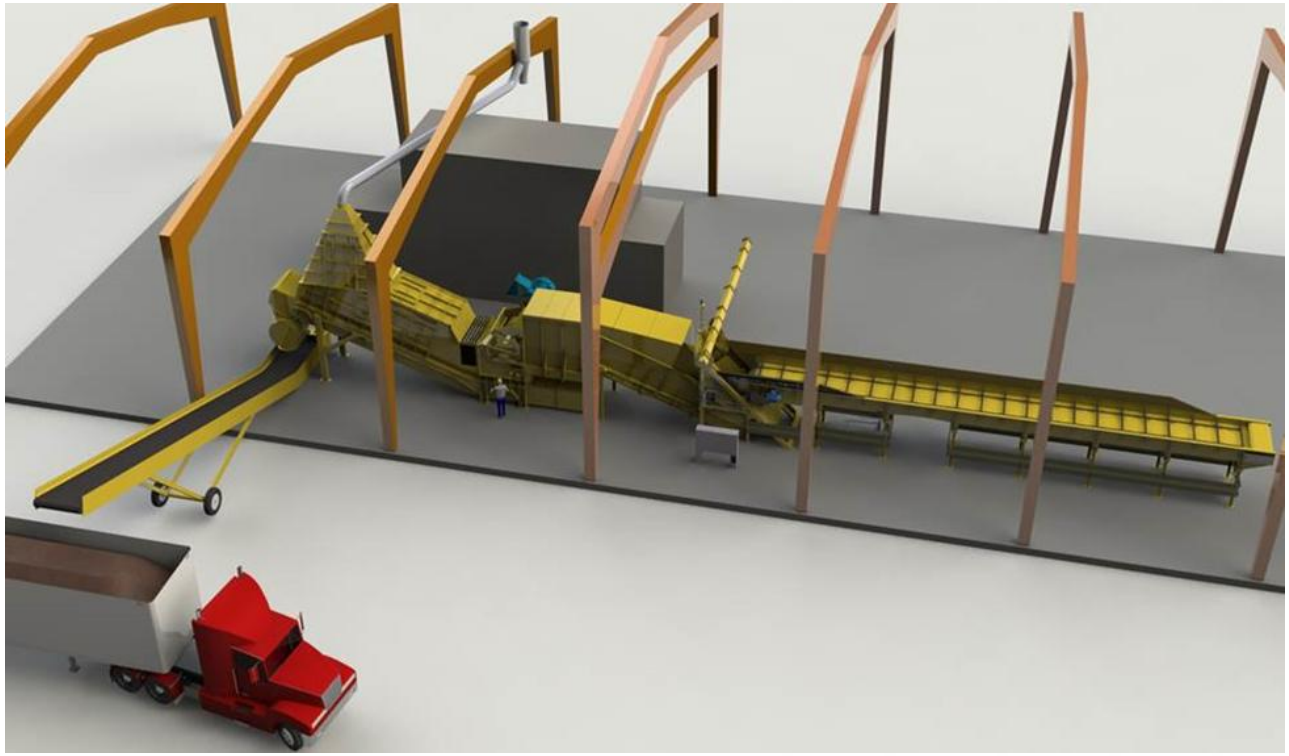
- The project's objectives align with the BETO's goals to provide biomass feedstocks at or below $80/DT.
  - The biomass harvesting and processing equipment being developed and demonstrated under this project has demonstrated potential to help reach this goal.

- Developing rapid analysis tools and methods to enable more-efficient and lower-cost feedstock quality assessment throughout the supply chain.
  - This aligns with BETO's goals for "Terrestrial Feedstocks" (found in Biomass Program Multi-Year Program Plan)

Source: *http://www1.eere.energy.gov/bioenergy/pdfs/mypp_may_2013.pdf*

5 – Future Work

- Development and Testing of new harvest and processing innovations
  - Square bale pre-loader, square bale infeed & handling system
- Final harvest demonstration and data collection activities
- Install and test optimization of a new grinder design, commercial-scale (Vermeer)



- Square bale batch testing at INL Process Demonstration Unit

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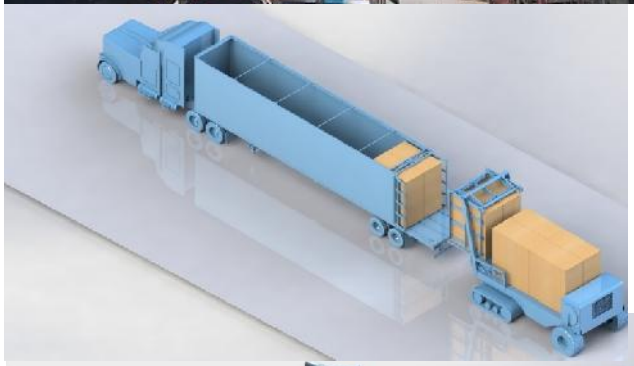
Kelderman Pre-Loader

Loader arms and mast fabrication



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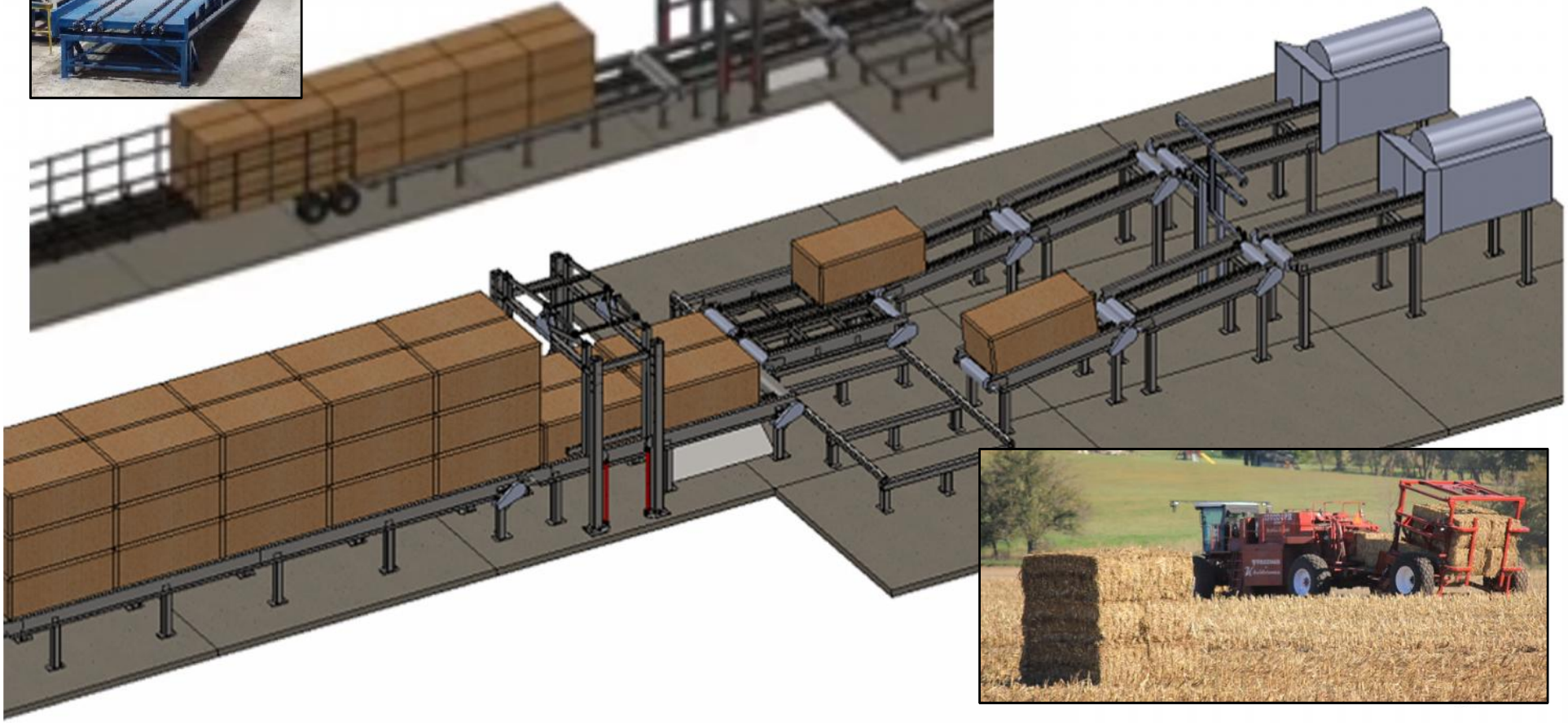
Square Bale Infeed, De-stacking, Conveyance System



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Summary

1. **Approach**:
   - Aggressive set of equipment development goals and objectives, round and square bales.
2. **Accomplishments**:
   - All scheduled equipment developed and demonstrated, improvements are in-progress
   - Demonstrated results in NIR spectroscopy for rapid biomass quality analysis, improvements ongoing
   - Significant equipment performance and biomass quality data collection
3. **Relevance**:
   - Significant cost reductions and reliability improvements are needed in feedstock delivery and processing systems—primary focus of this project.
4. **Success Factors and Challenges:**
   - Success Factors: Collaboration, Team capabilities and breadth
   - Challenges: More heavy crop acres desired, more demonstration activities needed, continued refinement of equipment
5. **Future Work:**
   - Final harvest demonstration and data collection activities
   - Square bale pre-loader, square bale infeed & handling system
   - Install and test optimization of new grinder design, commercial-scale (Vermeer)
   - Square bale batch testing at INL Process Demonstration Unit