Design and Demonstration of a Comprehensive Biomass Feedstock Supply System

May 2013
Feedstocks Platform

Presented By: Kevin Comer
Antares Group, Inc.

Principle Investigator: Fred Circle
FDC Enterprises

Goal Statement (Project Objectives)

Demonstrate all aspects of an innovative industrial-scale feedstock supply system for industrial-scale (>500,000 tons/year) biomass end-users.

- Cost reductions for large scale feedstock delivery estimated to be ~$13.00 per ton (conservative)
- Identify and measure economic costs for all stakeholders
- Support development of material quality and sustainability specifications

Goal Statement (Project Objectives)

Demonstrate all aspects of an innovative industrial-scale feedstock supply system for Abengoa's Hugoton, KS Biorefinery (and others to follow)

- Key equipment development
  - Improved Industrial Grade Baler
  - Self Loading Trailer
  - Bale Picking Truck
  - Single-pass Harvest Systems
  - Improved Header for Heavy Crops

Timeline

- Project Kickoff September 2010
- Continues through 2013
- ~90% complete to date

Barriers addressed

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

Budget

Funding for FY11:
- DOE share: $1,788,139
- Cost share: $1,414,079

Funding for FY12:
- DOE share: $1,437,544
- Cost share: $1,893,544

Funding for FY13:
- DOE share: $701,118
- Cost share: $36,184

3 Years at $2,423,536 per year (average)

Partners

FDC Enterprises (Prime Contractor)
Equipment Manufacturers:
- Kelderman Manufacturing
- Allied Systems / Freeman
- MacDon
- Assistance from others:
  - Vermeer, JCB, Rotochopper

Abengoa Bioenergy (Initial End-User)
Antares Group (Mgt. & Tech. Services)
INL (Lab Analysis, Sustainability)
Kansas State (Sustainability)
Noble Foundation (Agronomics)

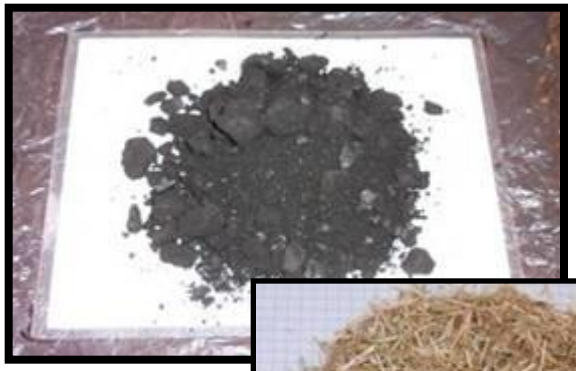
Collaborative Development Team

Project Overview

TEAM GENESIS / BACKGROUND

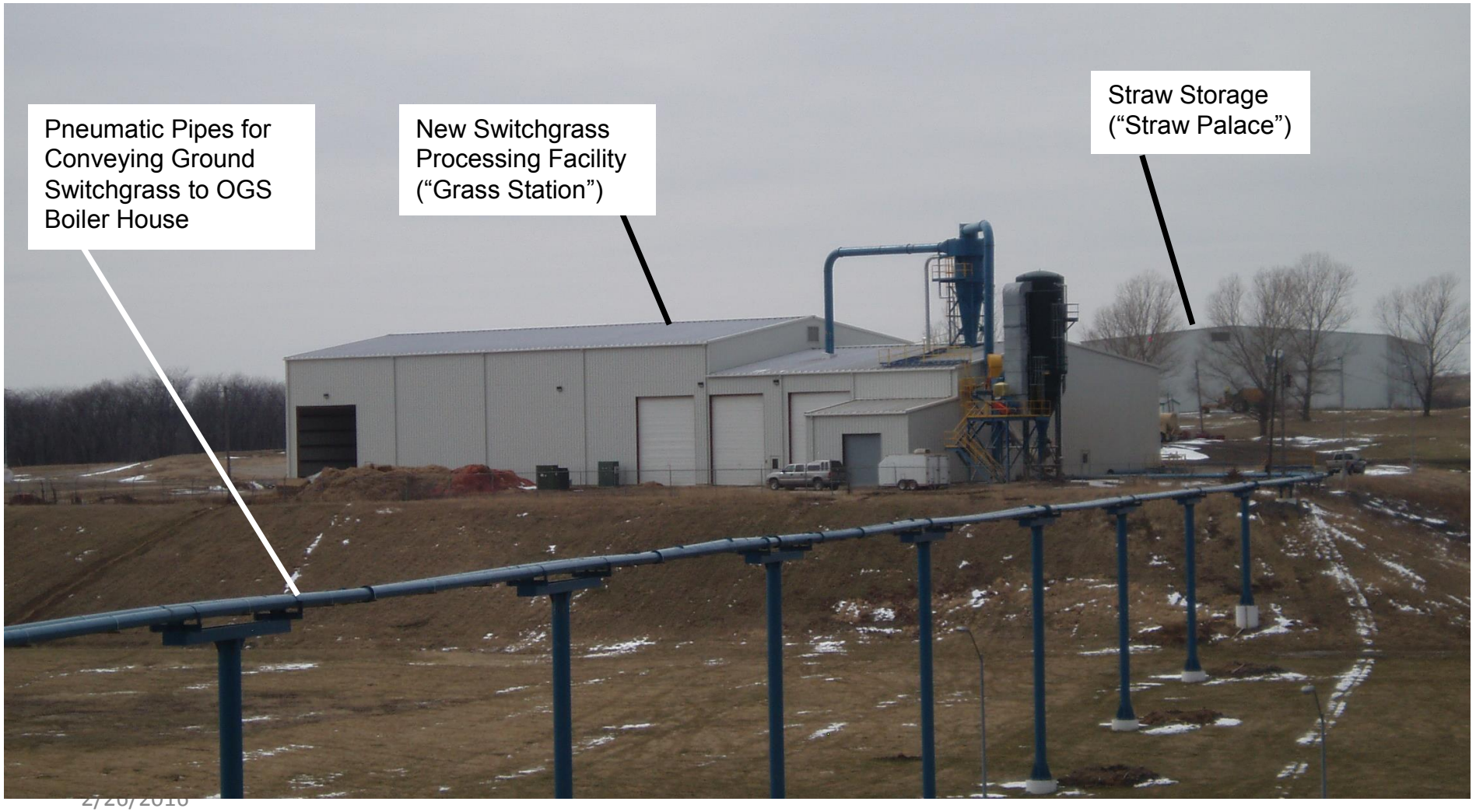
Switchgrass Cofiring

Ottumwa, Iowa



- Ottumwa Generating Station
  - Alliant Energy / Mid-American
  - 726 MW, PRB Coal, 1982 startup
  - Twin furnace T-fired PC boiler
  - 2.5 to 5% heat input from switchgrass, 12.5 to 25 ton/hr
  - Separate biomass injection, 2 - 4 ports
- Fuel
  - 3’ x 4’ x 8’ switchgrass bales
  - 2-step milling process to 1/8” minus
- Current Project Plan based on Lessons Learned (Teaming, Equipment Needs)

Project Overview (Team History)



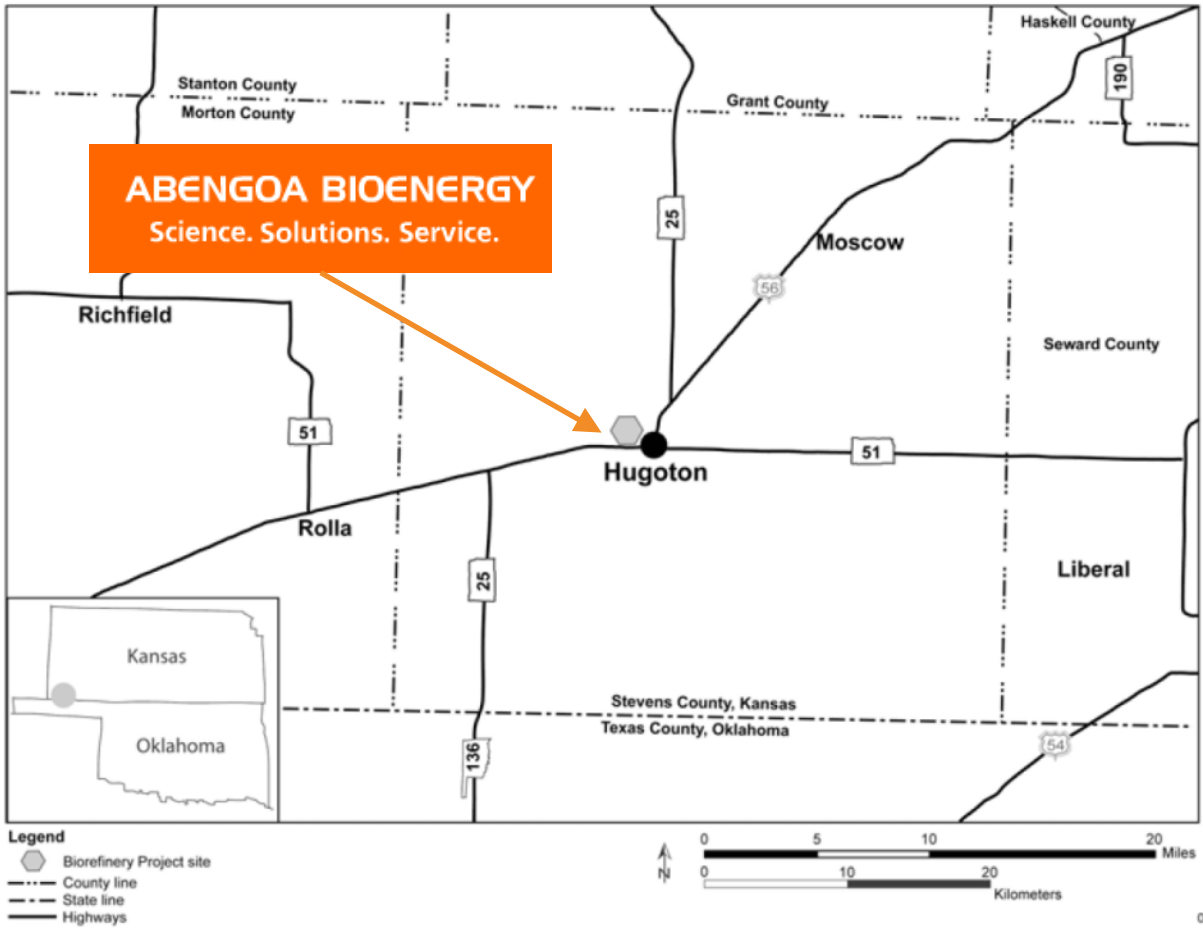
Project Overview (Team History)

Replacing up to 5% of this . . . .

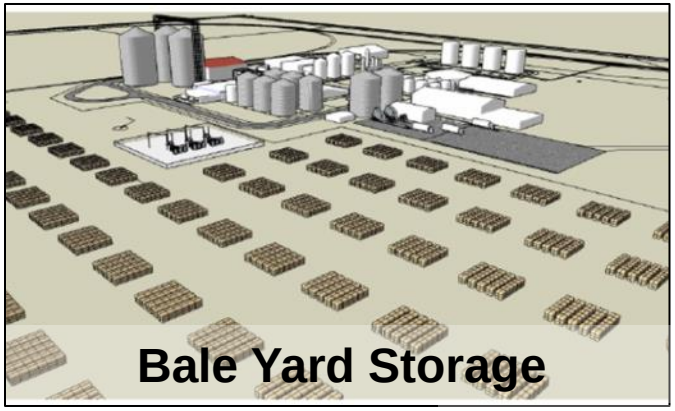
with this . . . .

Initial Target System Application

- Feedstock Required:
  - ~560,000 ton/yr or more
  - ~ 80 or more deliveries per day
- Focus Feedstocks:
  - Corn stover
  - Wheat straw
  - Milo stubble
  - Energy crops (Switchgrass, Miscanthus, Biosorghum)



Conventional Equipment (One Example)



Load Into Process Line

Proposed / Developing System

Establishment

Single Pass Harvesting

Freeman 1592D Self-Propelled

Removes one pass through the field

Roadsiding

Bale Picking Truck

Reduces # trips in the field by 67%

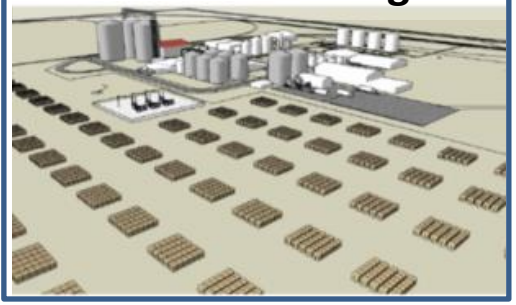
Transport

Self Loading Trailer

Removes loading and unloading operations

Load Directly Onto Process Line

Bale Yard Storage



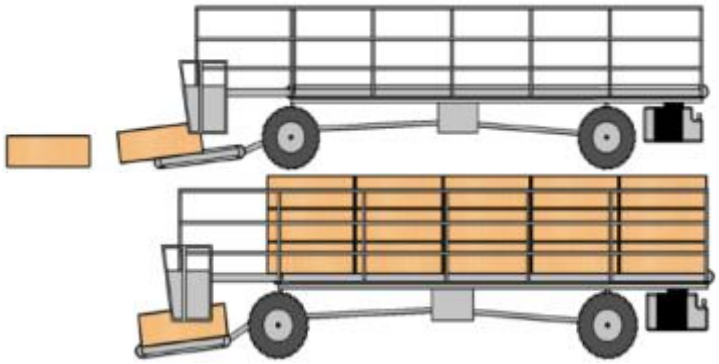
1 - Approach

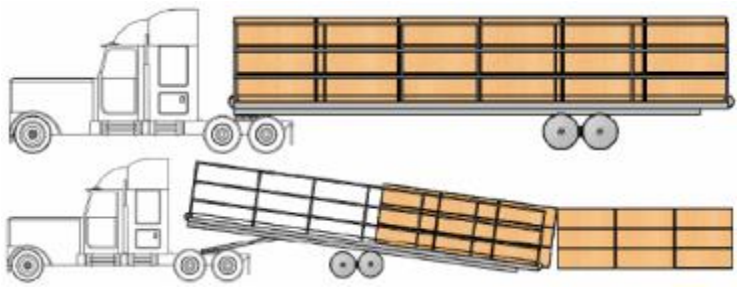
- ***Assembled a proven multi-disciplinary team, with complimentary capabilities to perform all required functions from crop establishment to delivery and processing at the end-use facility.***
- ***Planned equipment development schedule for 3 yr period.***
- ***Annual Planning Cycle:***
  - ***Plan annual harvests to maximize tonnage through equipment each year (within budget contraints), and harvest opportunities with more rare crops (miscanthus, biosorghum)***
  - ***Deploy harvest crews and available equipment when crop and field conditions permit – note required equipment improvements***
  - ***Collect extensive data during harvests***
    - ***Costs, labor, fuel, performance, sustainability, material properties***
  - ***Data analysis, reporting, presentation – compare to baseline results***
  - ***Upgrade existing equipment, develop new equipment for the year***
  - ***Repeat annual cycle, with periodic planning meetings as needed***
- ***Using DOE budget and progress reporting system to track and report progress***

2 - TECHNICAL ACCOMPLISHMENTS/ PROGRESS/RESULTS

ANTARES Group Incorporated | MacDon | kelderman | FREEMAN A Division of Allied Systems Company | FDC Enterprises Grasslands Services

We Have Come a Long Way…



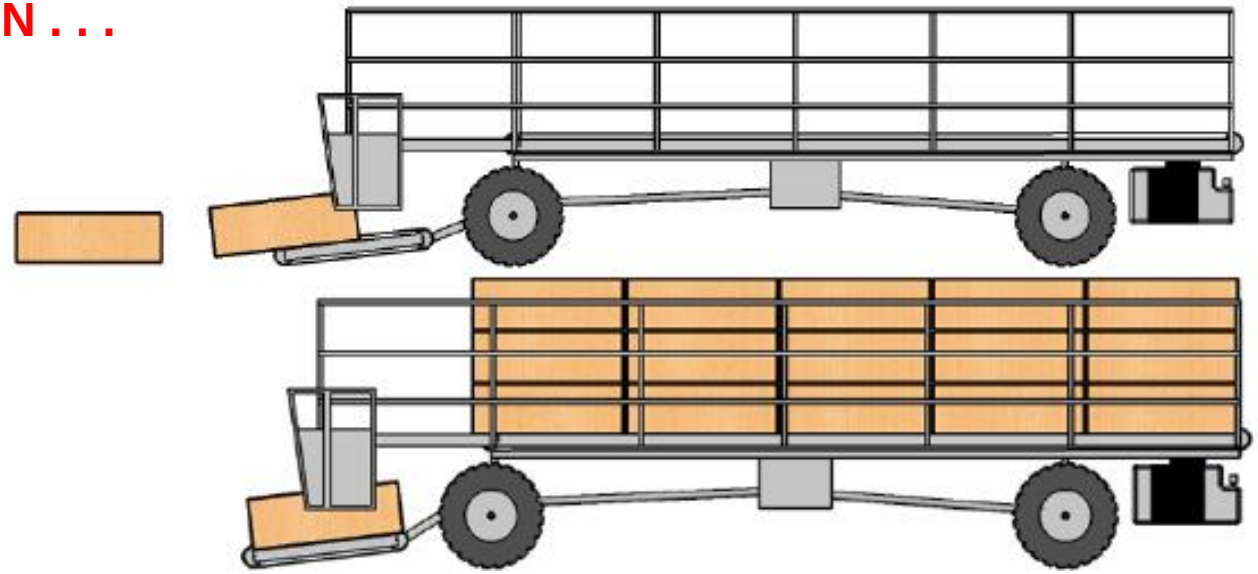


ANTARES Group Incorporated | MacDon | kelderman | FREEMAN A Division of Allied Systems Company | FDC Enterprises Grasslands Services

Self-propelled Baler with Vermeer Basket Rake

Bale Picking Trailer (Kelderman)

THEN . . .

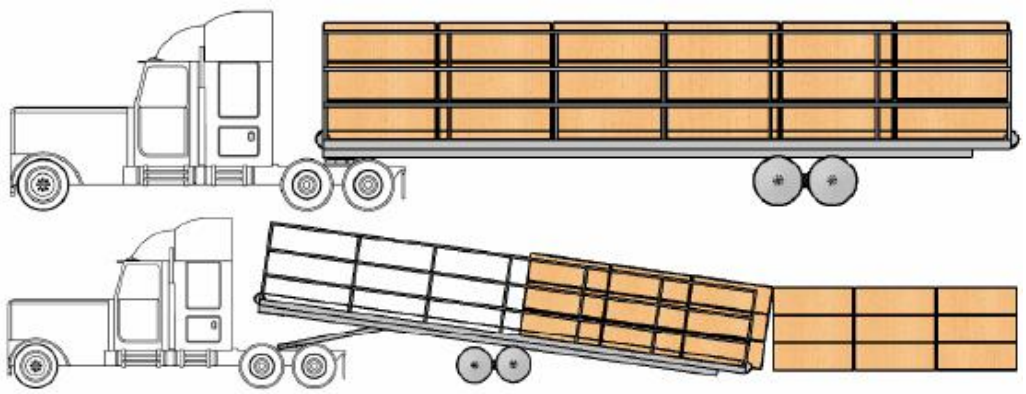


NOW . . .

Field demonstrations are ongoing.

Self-Loading Trailer (Kelderman)

THEN . . .



NOW . . .

Fundamental Load / Unload Times (~5 minutes) and operation confirmed. Field demonstrations are ongoing.

ANTARES Group Incorporated | MacDon | kelderman | FREEMAN A Division of Allied Systems Company | FDC Enterprises Grasslands Services

Heavy Crop Header

ANTARES Group Incorporated | MacDon | kelderman | FREEMAN A Division of Allied Systems Company | FDC Enterprises Grasslands Services

Single-Pass Harvest System (FDCE)

Initial Data Collection Items

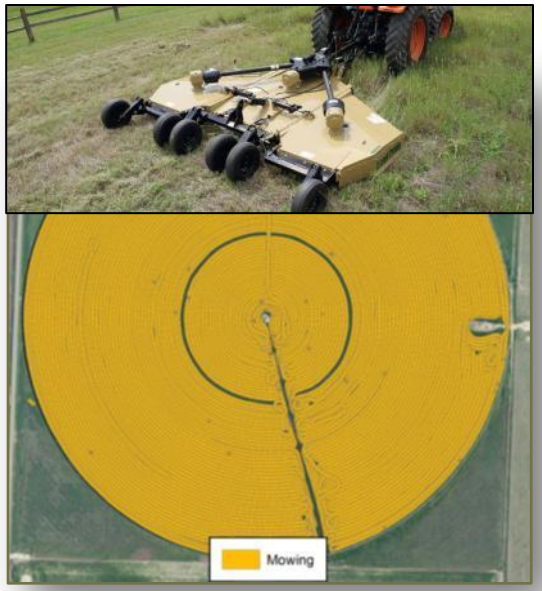
- Multiple rake / tractor / baler combinations
  - Field rates per operation
  - Time, labor, fuel requirements per operation
  - Maintenance issues / costs (including downtime)
- Bale properties (10% of bales)
  - Ash (biomass + dirt)
  - Moisture
- GIS-Based System Development
  - Inventory mgt, chain of custody, GHG tracking, sustainability tracking & reporting

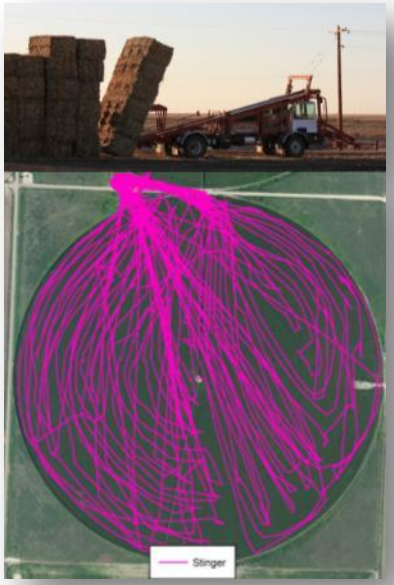
Accomplishments to Date

- All equipment fabricated and demonstrated
  - SPB: Removed one pass through the field
  - BPT: Required fewer trips through the field (vs. baseline) and packages 36 – 42 bales into one "module"
  - SLT: Loaded/unloaded a bale "module" in 5 – 8 minutes and removed the need for additional loading/unloading equipment
  - Heavy Crop Header: Operated at 4 to 6 mph in dense energy crops while conditioning crop well for efficient baler pick-up
- Collected performance and cost data on all operations
- Measured baseline and advanced harvesting costs and performance
- Met cost reduction target ($13.00/ton)
- +~15,000 acres of corn stover and grasses harvested & extensive data collection & sampling

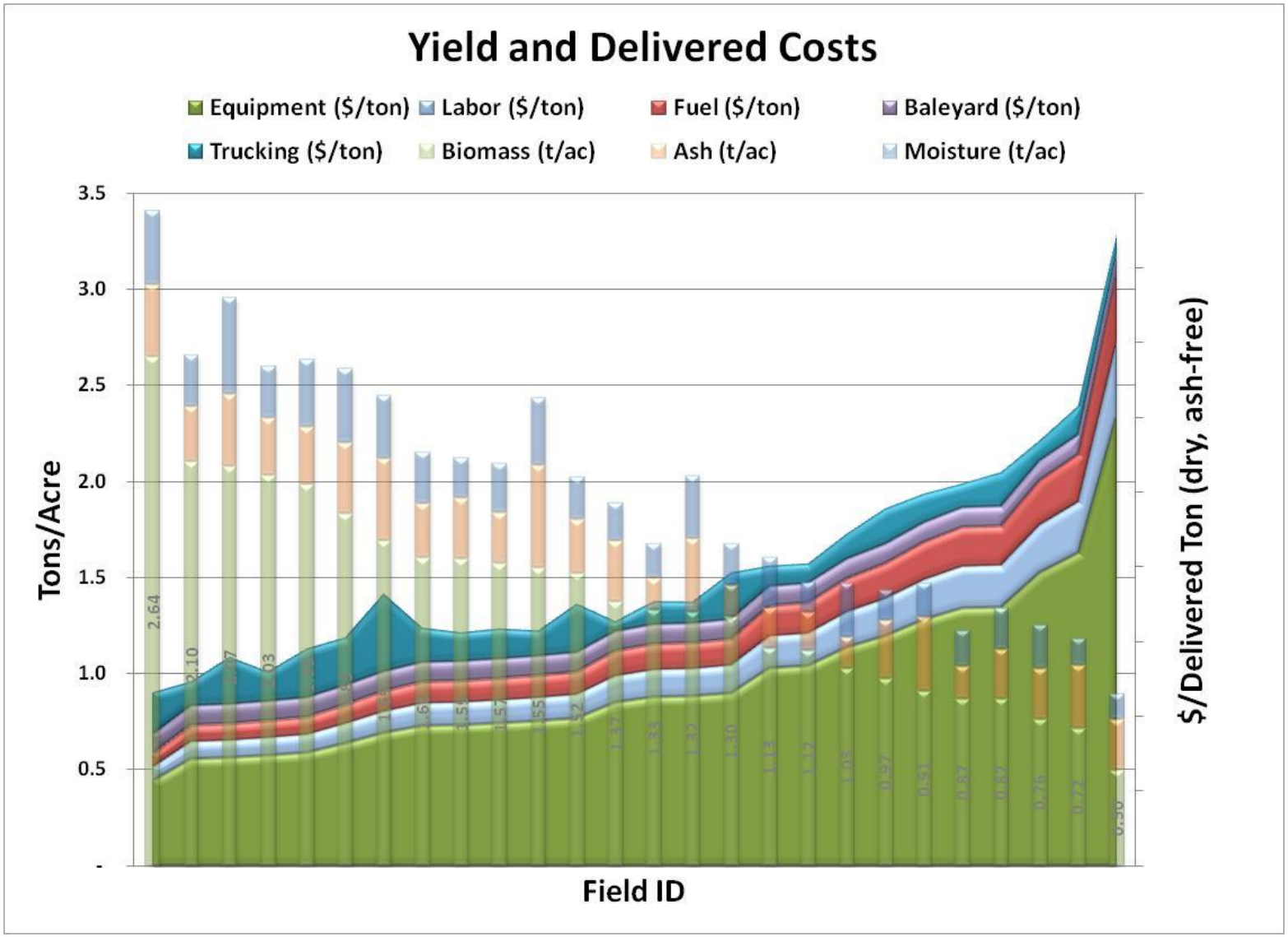
Detailed Cost & Performance Data Collection

- Labor, Fuel, Equipment, Parts, Travel, Freight, Field Rates





The Importance of Biomass Yield



3 - Relevance

- The project's objectives align with the BETO's goals to provide biomass feedstocks at or below $80/DT. The equipment developed under this project will change the face of feedstock harvesting.
- Independent modeling (IBSAL) verified that cost reduction goals ($13/DT) were accomplished, which align with BETO's goals for "Terrestrial Feedstocks" (found in Biomass Program Multi-Year Program Plan)

4 - Critical Success Factors

- Critical success factors and challenges that had to be overcome included:
  - On-time equipment design and fabrication
  - Demonstrating the technical and economic viability of the equipment
  - Management and coordination of harvest plans, equipment availability, and available budget

- The equipment developed under this project is unlike any other biomass harvesting and transportation equipment available to the industry. Preliminary results from prototype units show that they significantly reduce the feedstock supply costs.

5. Future Work

- All critical project milestones have been accomplished. The project is now in the final data analysis and reporting stage and will officially end in December 2013.

- Final deliverables include:
  - Final performance/cost analyses and reporting

- Equipment OEMs will continue to upgrade and improve the equipment to meet the needs of the industry.

Summary

1. Approach:
   - We measured everything possible while also monitoring sustainability issues
2. Accomplishments:
   - All equipment developed and demonstrated, improvements ongoing
   - Data analysis and final reporting are in the works
3. Relevance:
   - Significant cost reductions and reliability improvements are needed in feedstock delivery systems—primary focus of this project.
4. Success Factors and Challenges
   - Success Factors: Collaboration, Team capabilities and breadth
   - Challenges: More heavy crop acres desired; Much still to do . . . . .
5. Future Work/Technology Transfer
   - All project objectives have been satisfied
   - Final project tasks include final performance/cost analyses and reporting
   - Equipment manufacturers are undergoing commercialization

Publications and Presentations

- **No publications have been made to date.**
- **Presentations to Date:**
  - Agricultural Equipment Technology Conference, January 7, 2011 - Atlanta, GA.
  - DOE Peer Review Meeting, April 8, 2011
  - Stage Gate Review (Go/No-go) Meeting, April 26, 2011
  - Many to potential end users and industry interests.
- **Several patents have been filed:**
  - Self-propelled Baler
  - Self-Loading Trailer
  - Bale Picking Truck
  - Heavy Crop Header
  - Unloading & De-stacking conveyor line at process facility