BALES Biomass Alliance for Logistics Efficiency and Specifications

DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

2015 "BALES" Project Review

February 23, 2015
Technology Area Review

Kevin Comer, Sr. Project Manager
Antares Group, Inc.

BALES Biomass Alliance for Logistics Efficiency and Specifications

Project Summary

- 3 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

FDC Enterprises Grasslands Services

POET Energy inspired.

ANTARES Group Incorporated

Vermeer

CLARIANT

B Hames Consulting

Pellet technology

kelderman

ADM

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

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**, **validate improvements and remaining gaps**, and **address key sustainability issues** in order to promote a sustainable and scalable advanced biofuels industry.

- 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 NIR spectroscopy, relative to the end-users' specifications.
- Successful demonstration of these technologies in a commercial environment will support the increased production of cellulosic ethanol in the United States.

All project objectives support key DOE BETO objectives.

BALES Biomass Alliance for Logistics Efficiency and Specifications

Quad Chart Overview

Timeline

- Project start date: 9/30/2013
- Project end date: 9/30/2016
- Percent complete: 45%

Barriers

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

Budget

	Total Costs FY 10 –FY 12	FY 13 Costs	FY 14 Costs	Total Planned Funding (FY 15-Project End Date
DOE Funded	$0.00	$0.00	$1,282,948	$4,117,052
Project Cost Share by Contributing Partner				
Vermeer	$0.00	$0.00	$993,977	$5,396,574
Kelderman Mfg.	$0.00	$0.00	$109,144	$700,713
Other	$0.00	$0.00	$153,197	$746,803
Poet Biomass	$0.00	$0.00	53,989	$646,011

Partners

- FDC Enterprises
- Vermeer
- Kelderman Manufacturing
- Antares Group Inc.
- B Hames Consulting
- Analytical Spectral Devices Inc.
- INL
- Poet Biomass
- Virginia Tech
- AgSolver
- Others (harvest collaborators)

1 - Project Overview

- Project Background and Team History

BALES

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Project Overview (Team History)

FREEMAN
A Division of Allied Systems Company

kelderman

ABENGOA BIOENERGY
Science. Solutions. Service.

MacDon
The harvesting specialists.

JCB

Project #1: Design and Demonstration of a Comprehensive Biomass Feedstock Supply System

FDC Enterprises
Grasslands
Services

ANTARES
Group Incorporated

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

Vermeer

Prairie Lands
Bio Products
Inc
Discovering solutions for the new millennium

ROTOCHOPPER
Inc.

THE SAMUEL ROBERTS
NOBLE
FOUNDATION

INL

K-STATE
Kansas State University

STAR
BRAND SEED

Mendel

IOWA FARM BUREAU
PEOPLE. PROGRESS. PRIDE.

Greenhouse
Gas Services
a GE AES venture

T.R. Miles Consulting
Engineering Consulting

ALLIANT
ENERGY.

Show Me
energy cooperative

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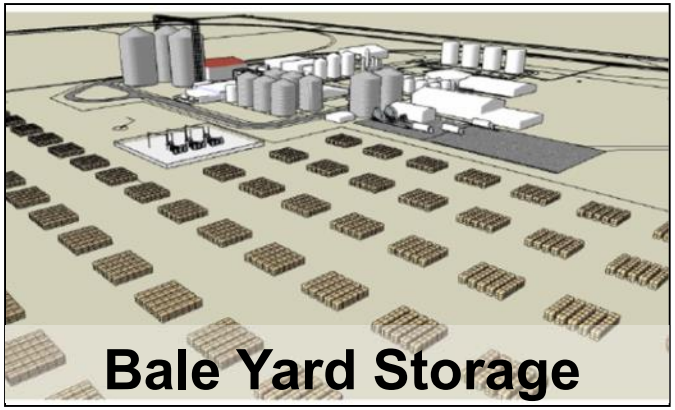
Project Overview

Seeking to replace this…

(Team History)



Load Into Process Line

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Project Overview

With this…

(Team History)

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

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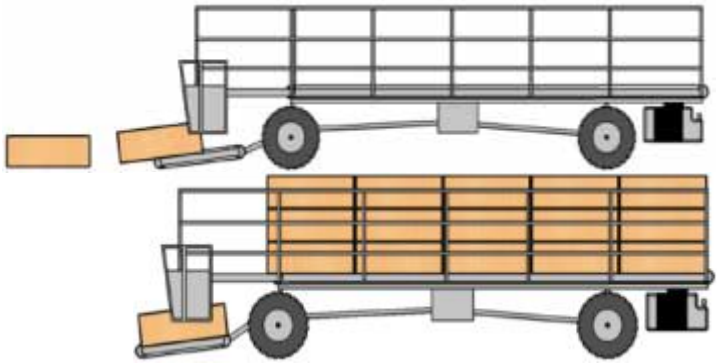
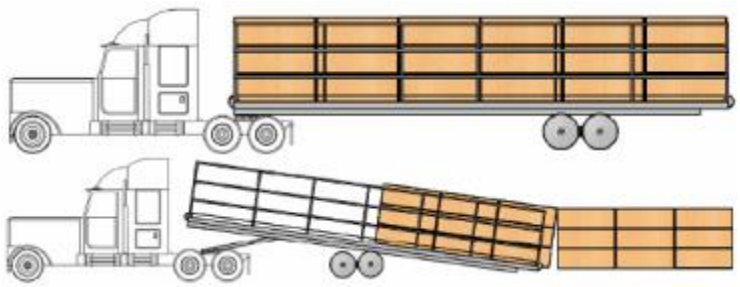
Project Overview

(Team History)





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Poet-DSM's Project Liberty – Emmetsburg, IA

2 – Approach (Technical)

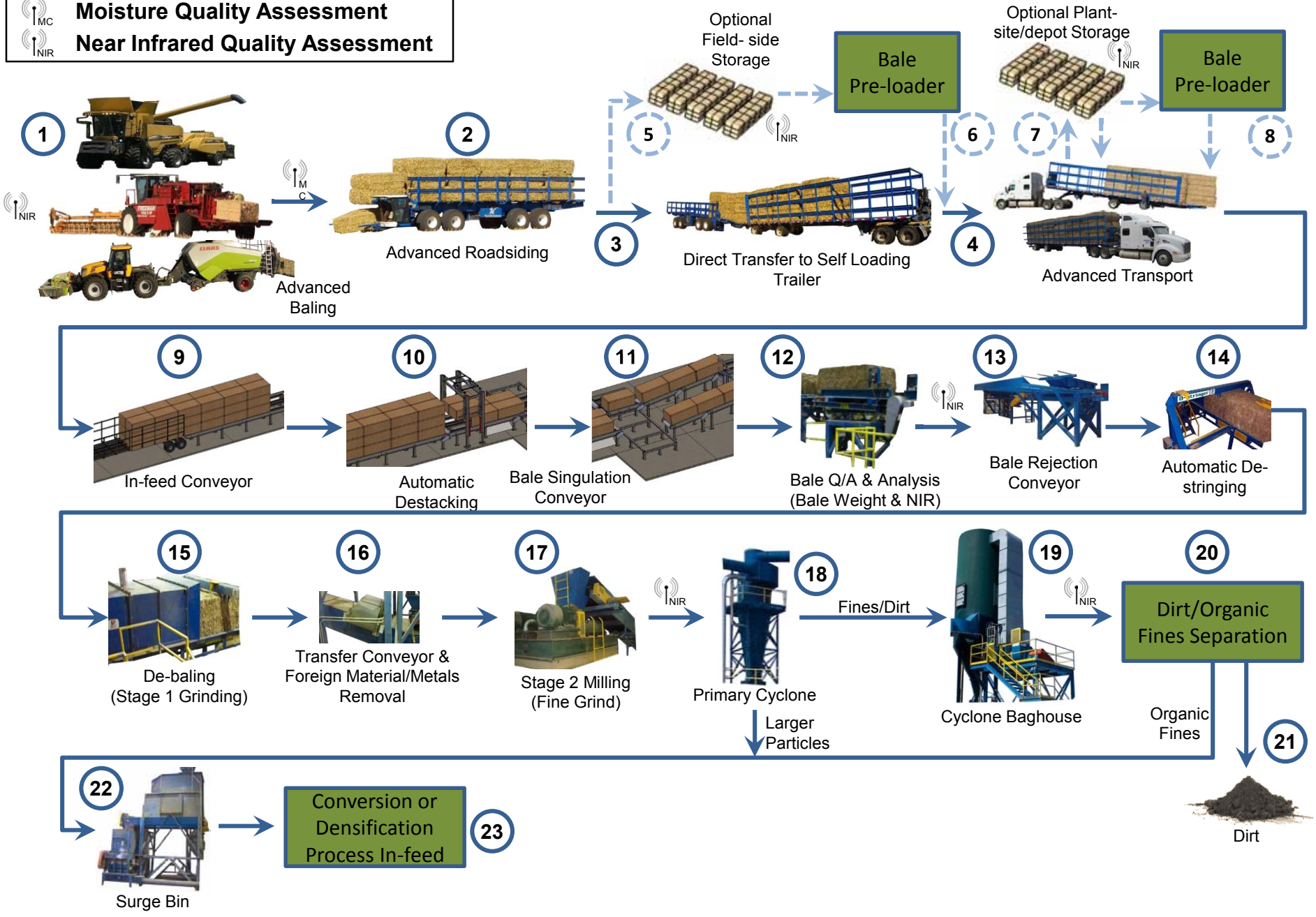
- Develop and Demonstrate New or Improved Biomass Harvesting and Processing Equipment
  - Designed equipment to fill gaps in the biomass supply chain (harvest and processing), for square and round bale systems
  - Continuous development cycle (Design → Build → Test → Improve)
  - Improved in-field harvest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

- Develop Rapid and Reliable Quality Assessment Tools
  - Collect biomass quality data (moisture, ash, carbohydrates) rapidly through in-field Near Infrared Spectroscopy and rapid analysis tools

- Critical Success Factors and Key Challenges
  - All prototype equipment and innovations fabricated and tested
  - Demonstrate feedstock cost reduction at the end users' specifications
  - Cultural changes and investment required to implement a new "system"

Advanced Feedstock Supply Chain - Large Square Bale Format

Standard Process
Optional Process
MC Moisture Quality Assessment
NIR Near Infrared Quality Assessment



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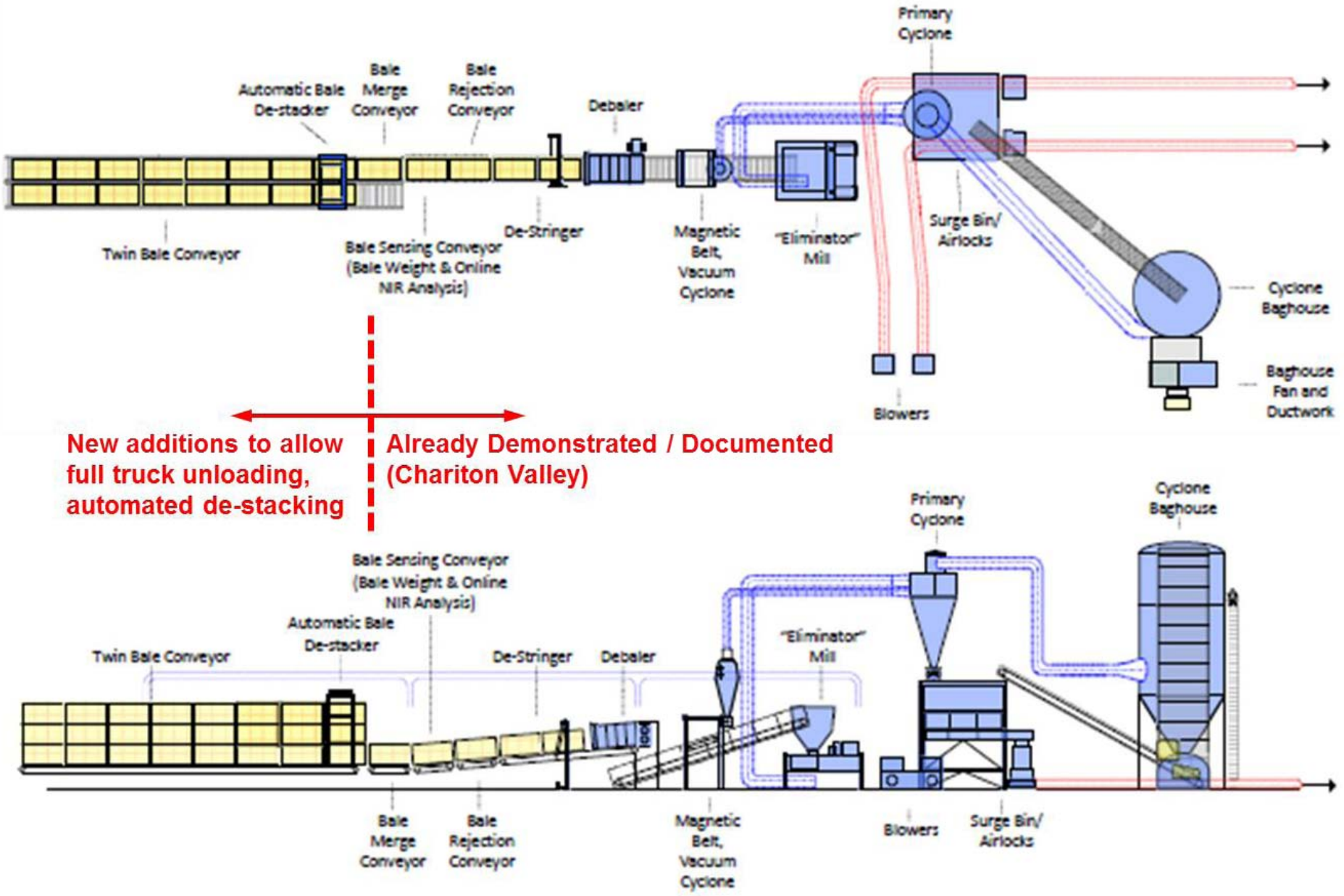
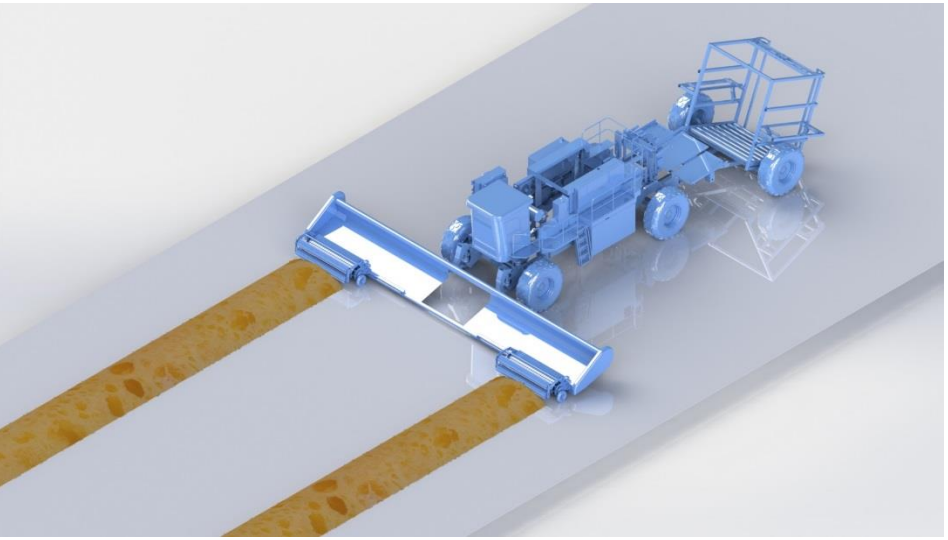
Process Line Concept Drawing

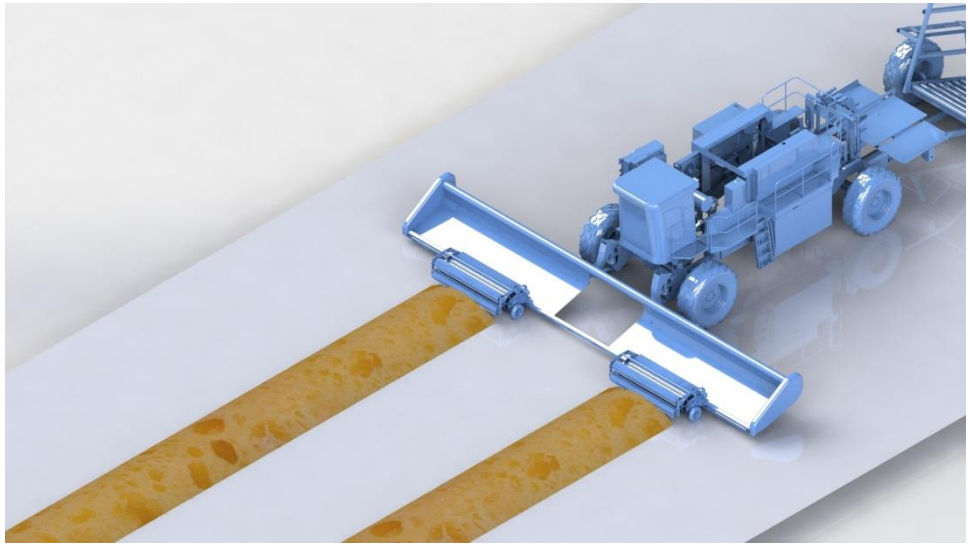


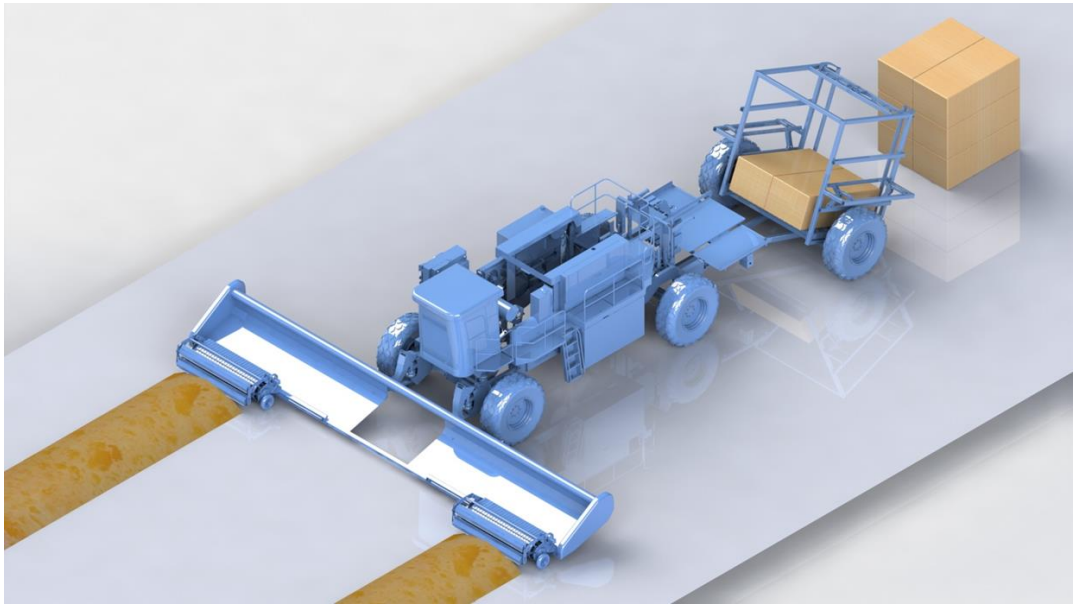
Kelderman "Projects"

- Self-Propelled Baler
  - Wind Row Merger
  - 6-Pack Stacker
- Pre-Loader
- Biomass Handling Trailer
- Bale-Picking Truck
- De-Stacker

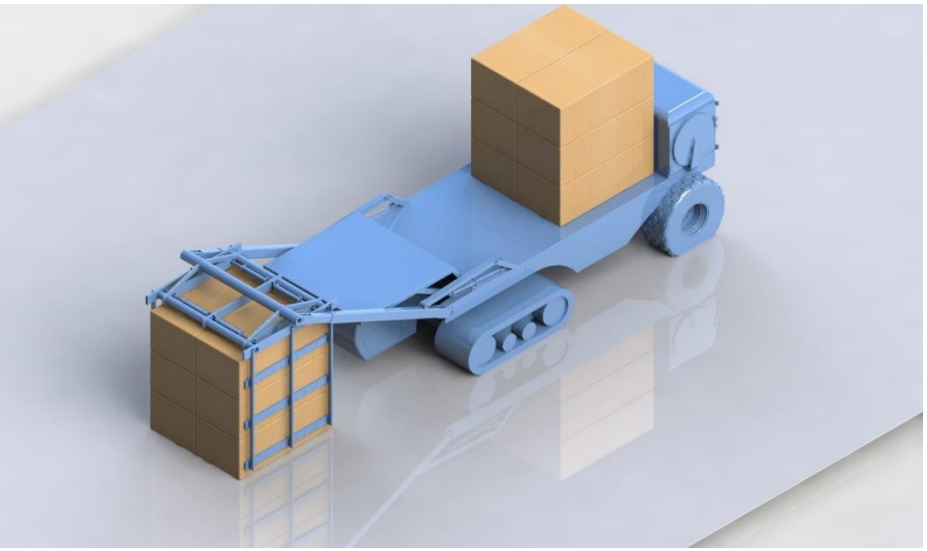
Kelderman SPB, Windrow Merger, 6-packer

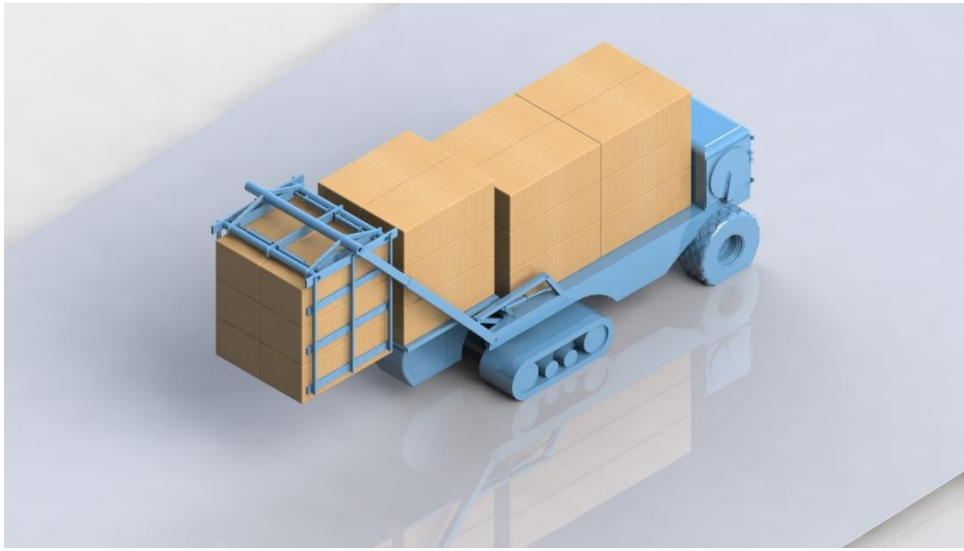


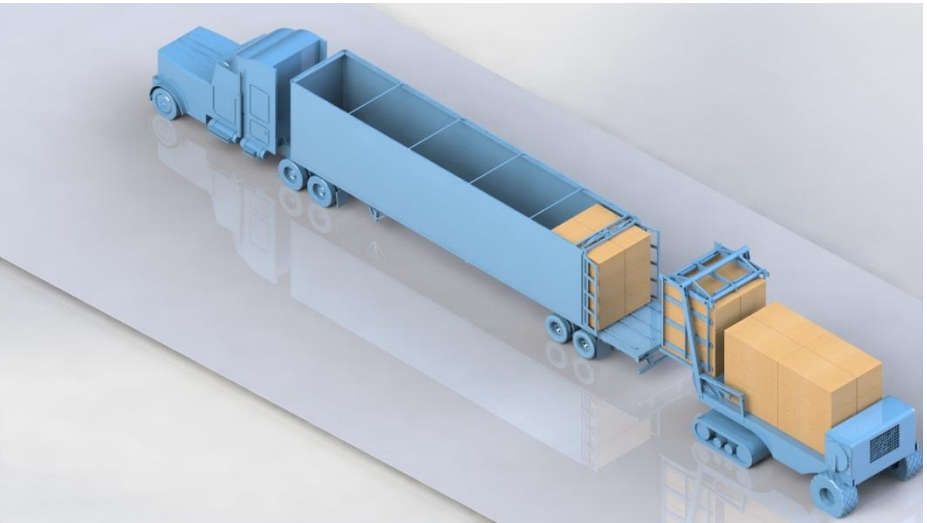


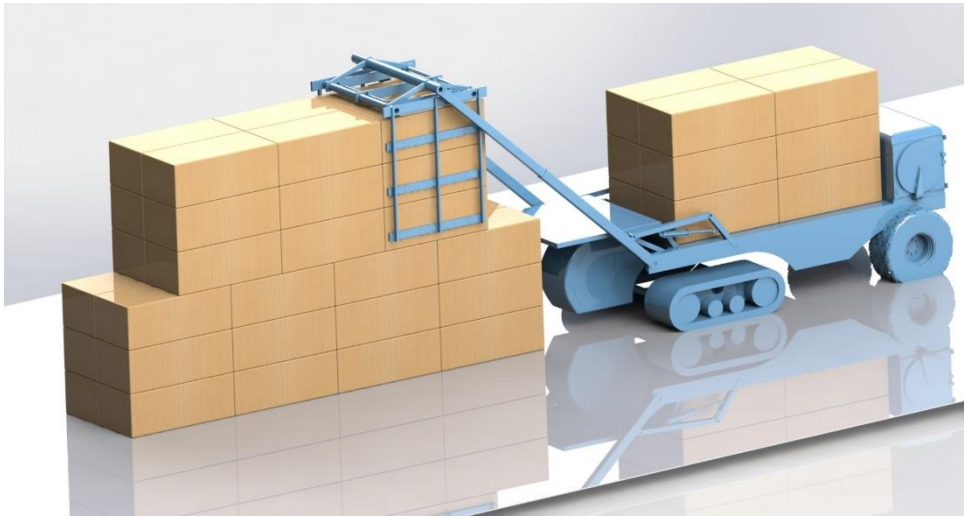


Kelderman Pre-Loader









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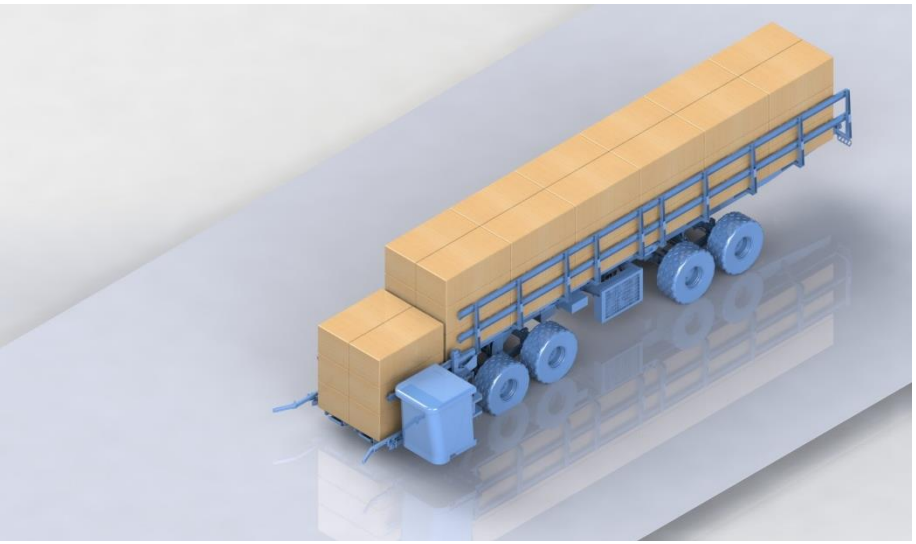
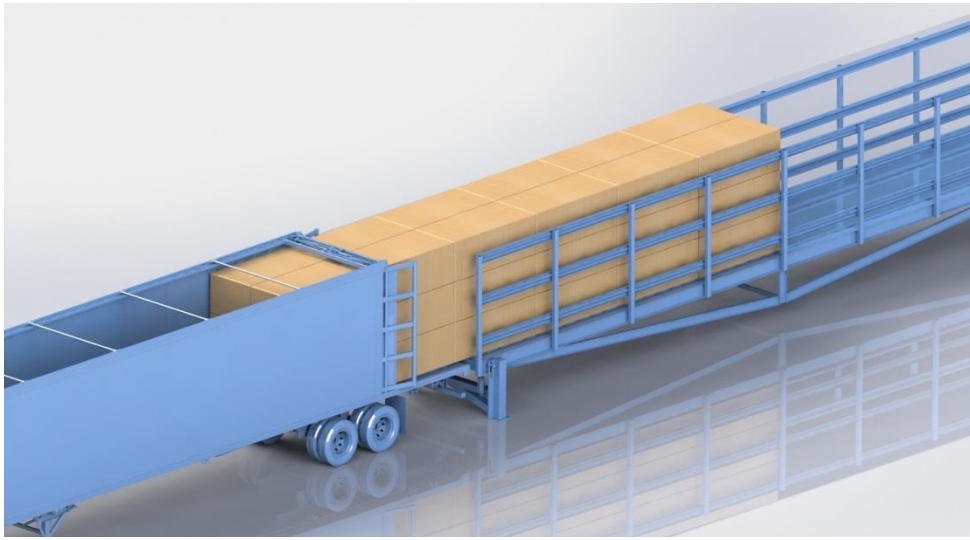
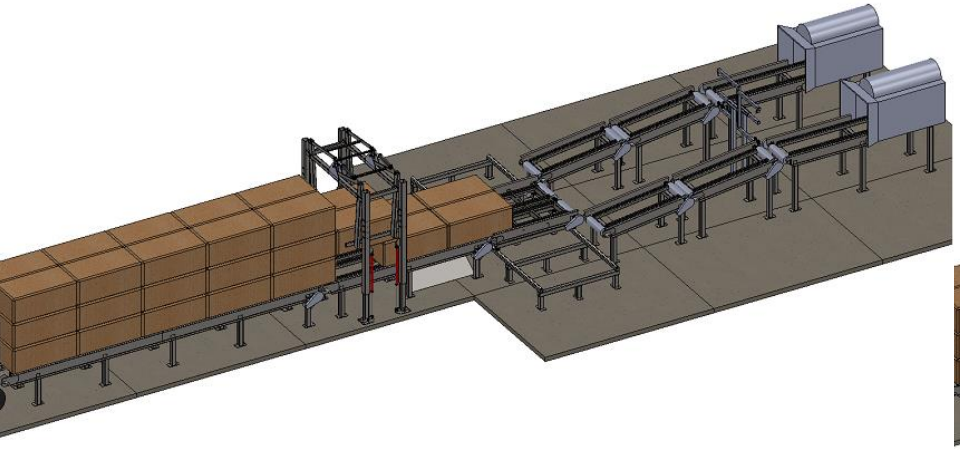
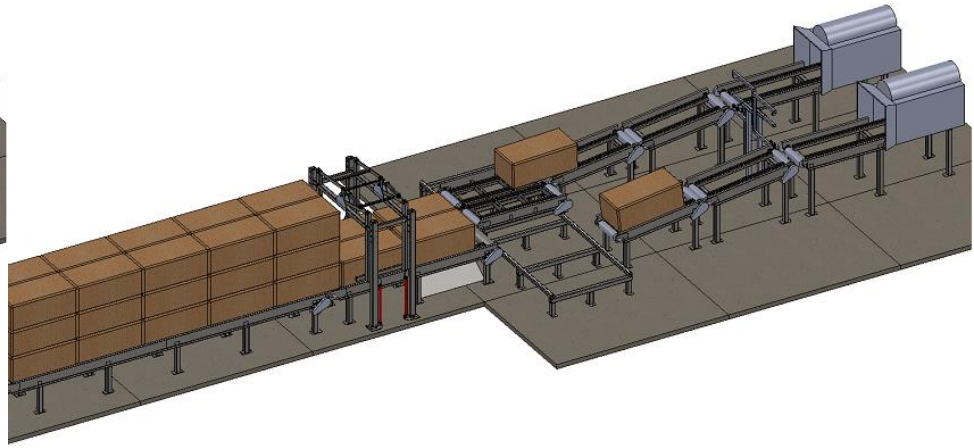
Bale-Picking Truck, Biomass Trailer, De-Stacker









Vermeer "Projects"

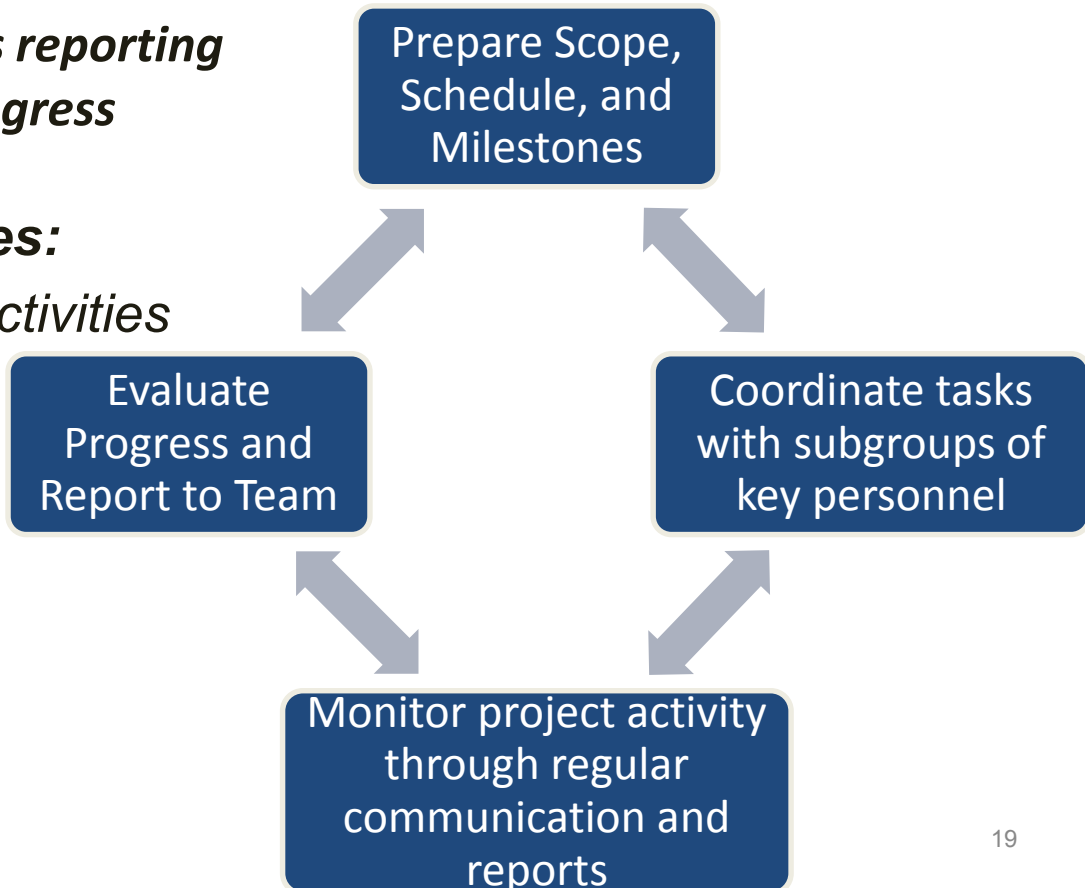
- Forage segment
  - Round bale harvest cost analysis
  - High capacity bale mover
  - Road transportation
  - Bale density
  - Reduce ash content in bale harvest
  - Reduce baler downtime
- Environmental segment
  - BG480 shredder
  - Bale shear
  - Automated de-baler system
  - Grinding/shredding improvements
  - Biomass shredder

2 – Management Approach

- ***Assembled a proven multi-disciplinary team, with complimentary capabilities to perform all required functions from initial conceptual design to delivery and processing of feedstocks at the end-user's facility.***
- ***Planned equipment development and testing schedule for 3 yr period.***
- ***Used DOE budget and progress reporting system to track and report progress***

Key Management Challenges:

- *Coordinating the project activities of 18 companies across 9 project tasks.*



3 – Technical Accomplishments/ Progress/Results

- Harvest/Logistics Equipment Development & Demonstration
  - Round Bale Harvest System Improvements
    - Advanced in-field Round Bale Removal – May not market
    - Advanced Round Bale Transportation – May not market
    - Reduced Ash Content
    - Increased Round Bale Density
    - Reduce baler downtime through design improvements
  - Harvest data (cost and performance) collection conducted and summarized for round and square bale operations
    - 76,441 bales harvested (43,192 dry tons)
    - ~51,000 acres
    - 4,278 engine hours
    - 23 pieces of harvesting equipment

3 – Technical Accomplishments/ Progress/Results (cont'd)

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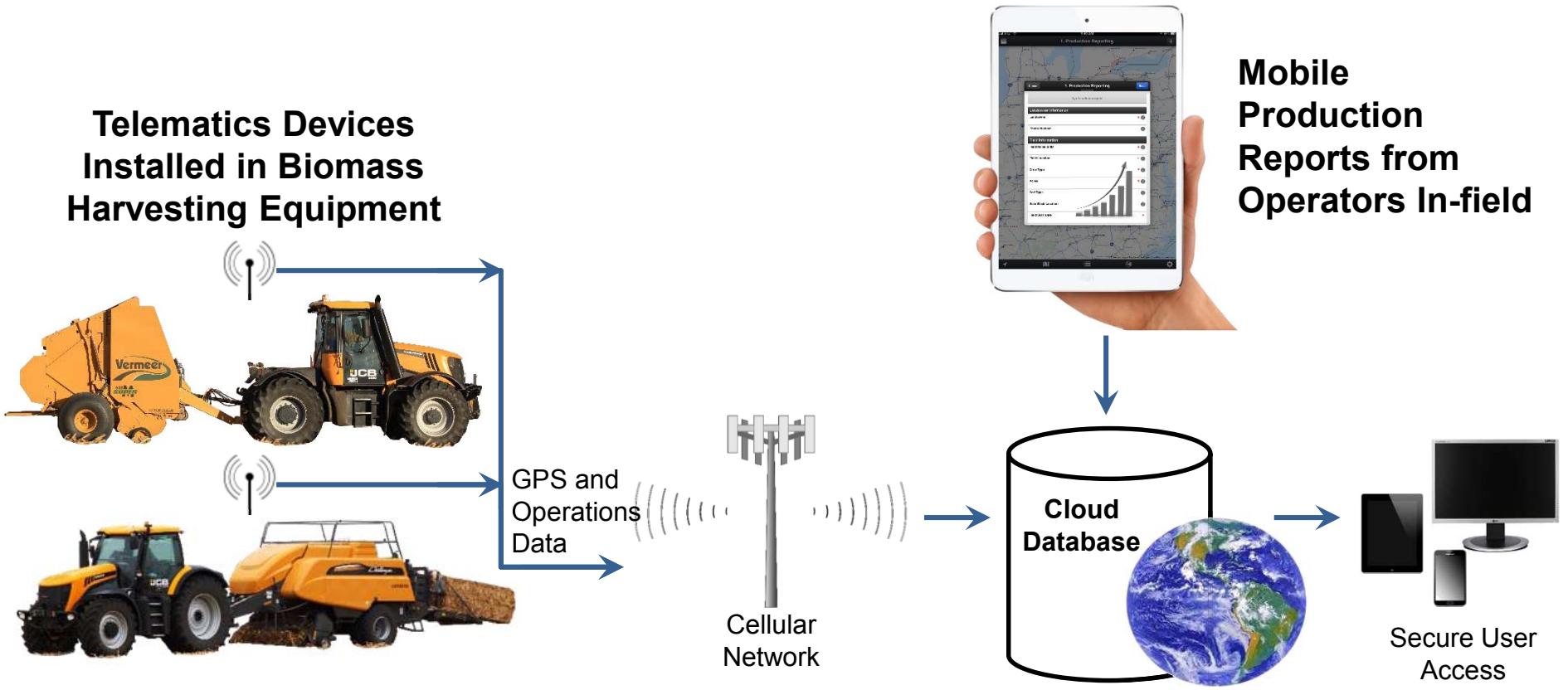
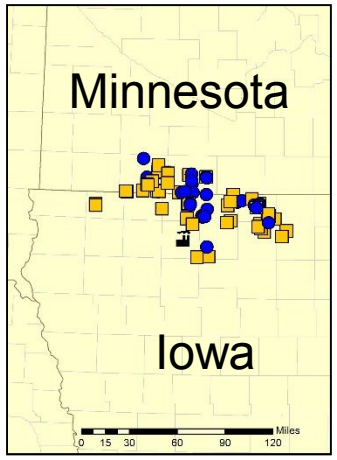
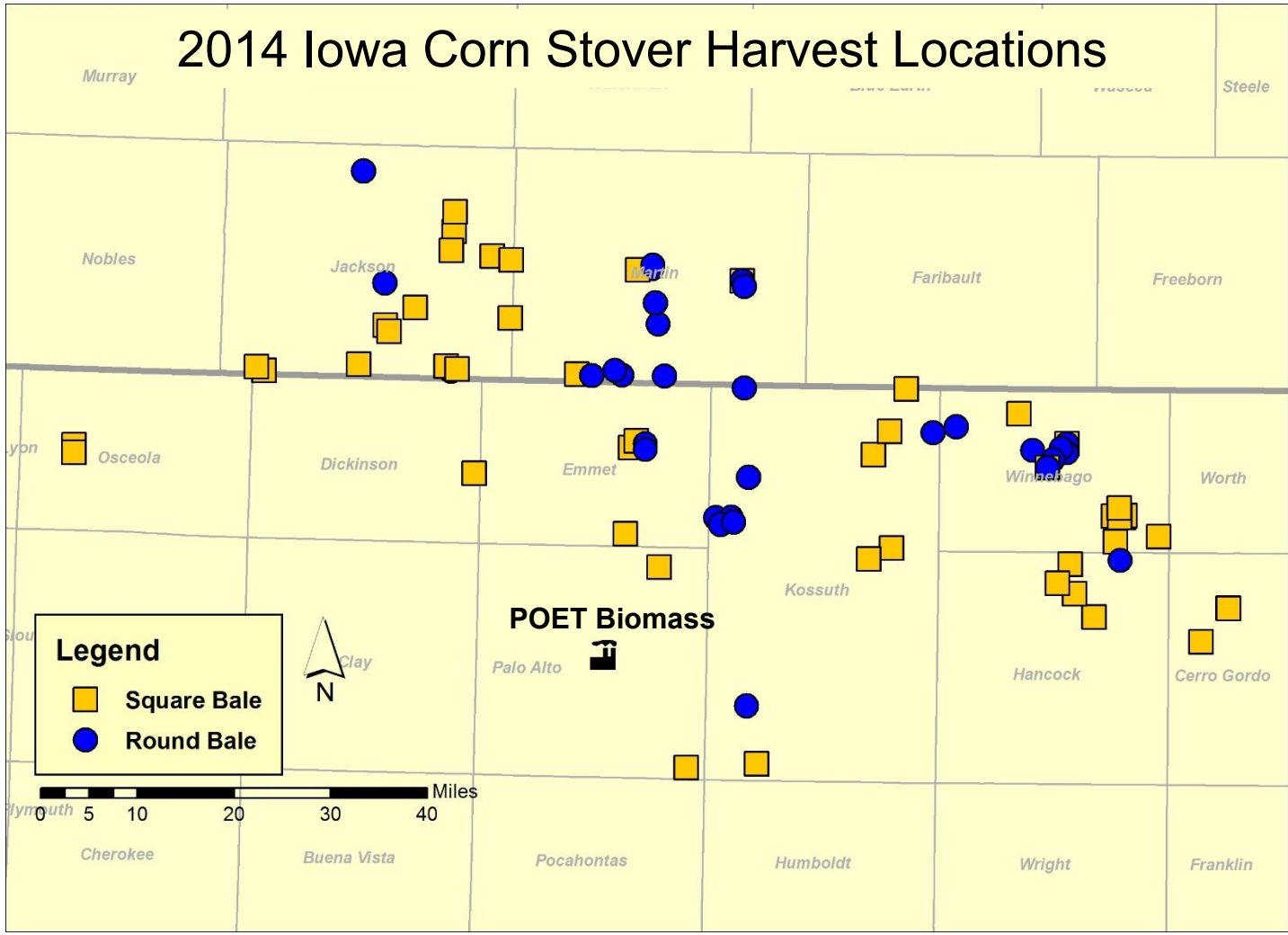


3 – Technical Accomplishments/ Progress/Results (cont'd)





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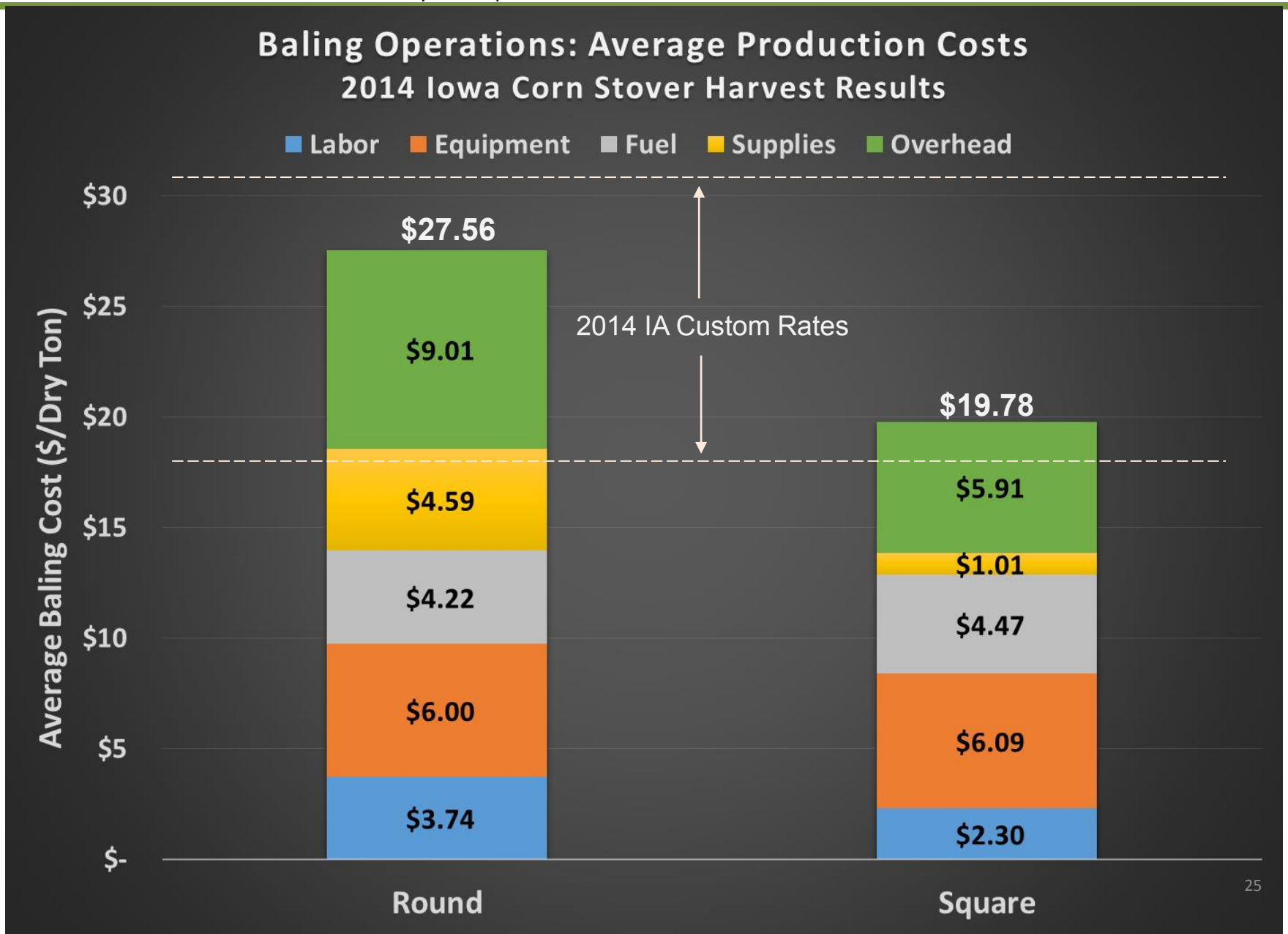
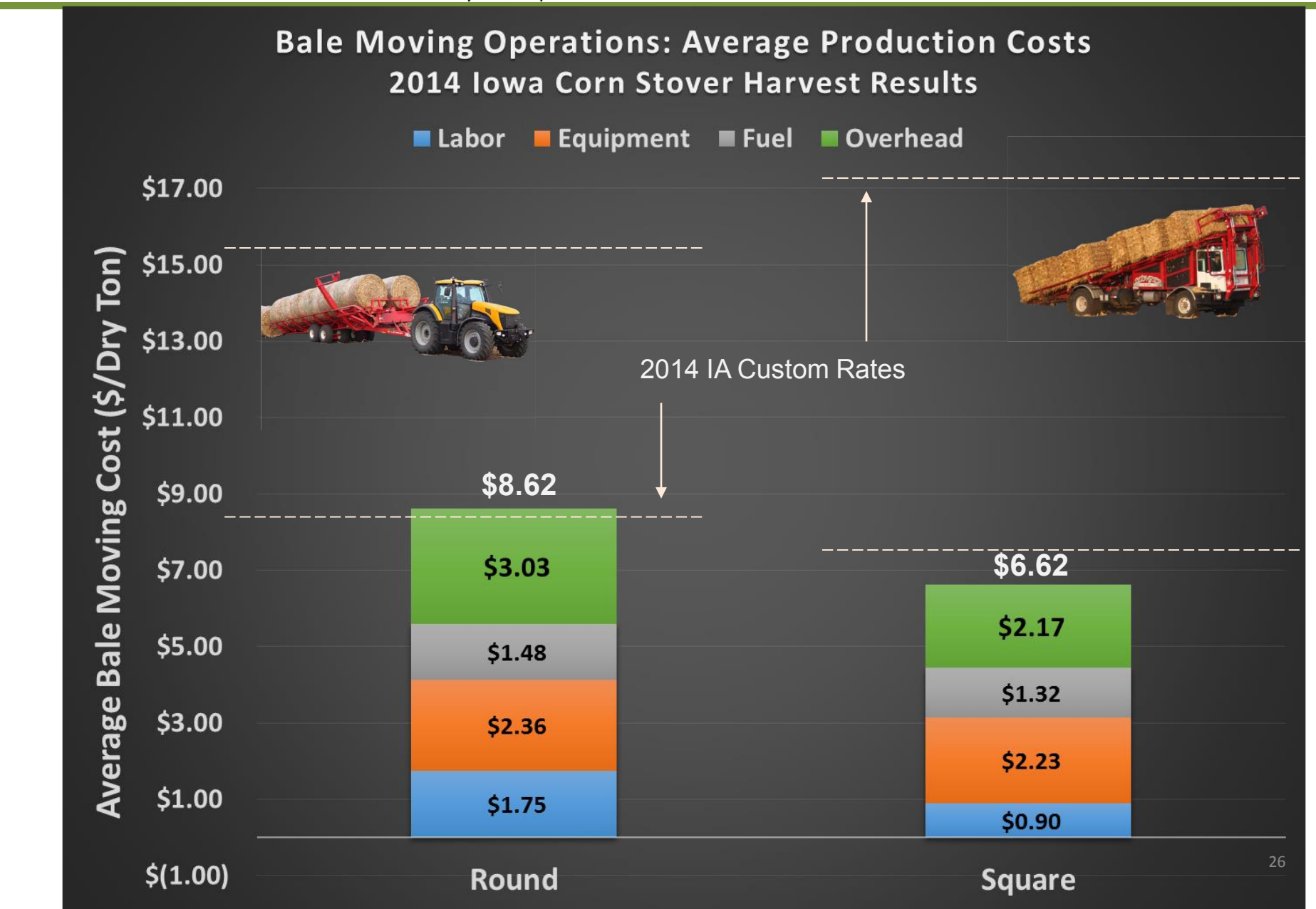
2014 Iowa Corn Stover Harvest Summary

- Followed "EZ Bale" Harvest Protocol – Square & Round Bales
  - 37,000 Acres
  - 53,492 Bales Harvested (31,175 dry tons @ 1,384 lbs/bale, avg.)
    - Round Bale Ave: 1,318 lb/bale; Square Bale Ave: 1,393 lb./bale
  - Ave. Moisture Content: 15%; Ave. Ash Content: 8.7%
  - Biomass Yield: 0.85 dry tons/acre

POET EZ Bale Protocol
Windrowing by combine only, no raking or shredding allowed.

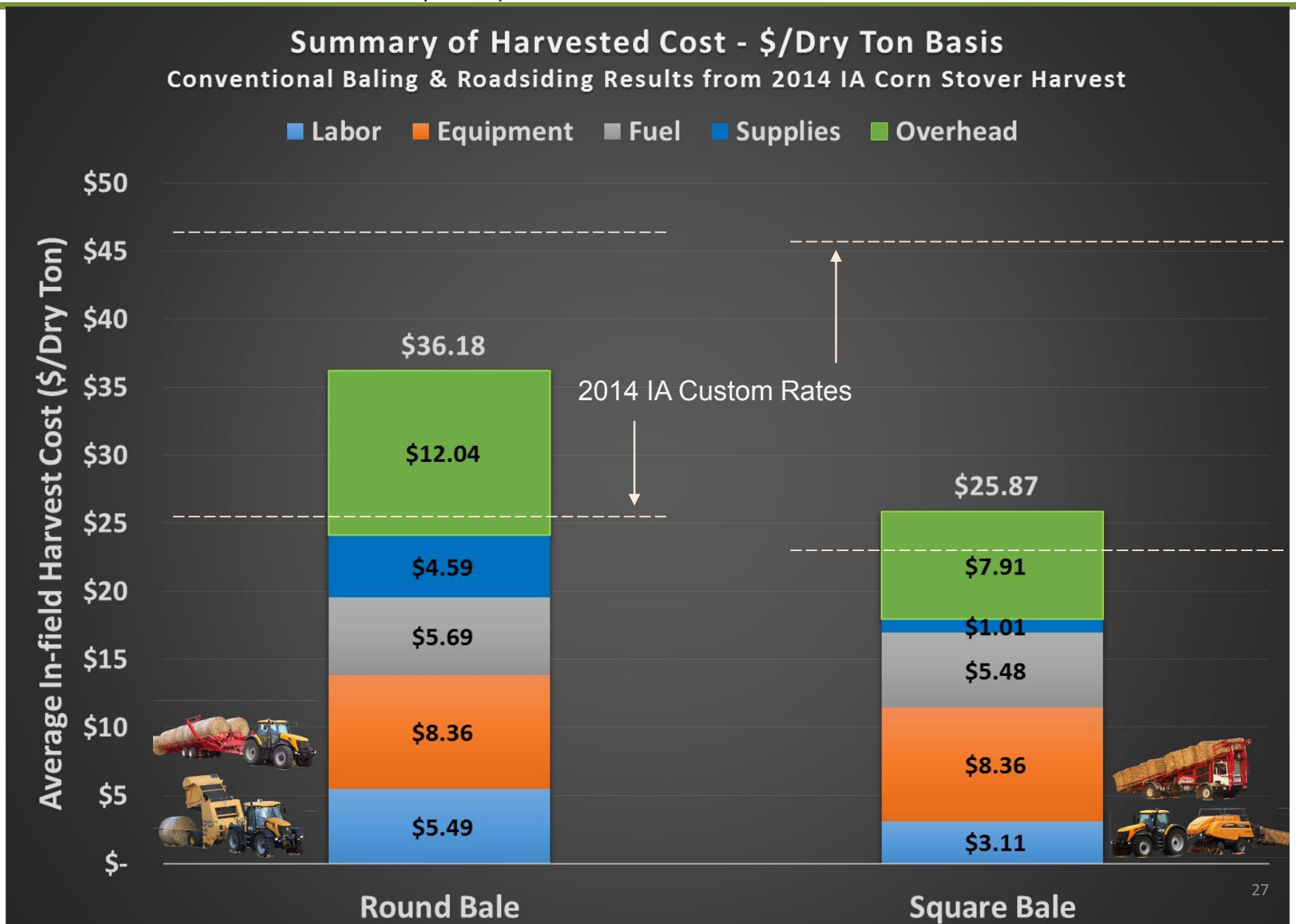

Baling Operations: Average Production Costs
2014 Iowa Corn Stover Harvest Results
Labor
Equipment
Fuel
Supplies
Overhead
Average Baling Cost ($/Dry Ton)
$30
$25
$20
$15
$10
$5
$-
$27.56
$9.01
$4.59
$4.22
$6.00
$3.74
2014 IA Custom Rates
$19.78
$5.91
$1.01
$4.47
$6.09
$2.30
Round
Square

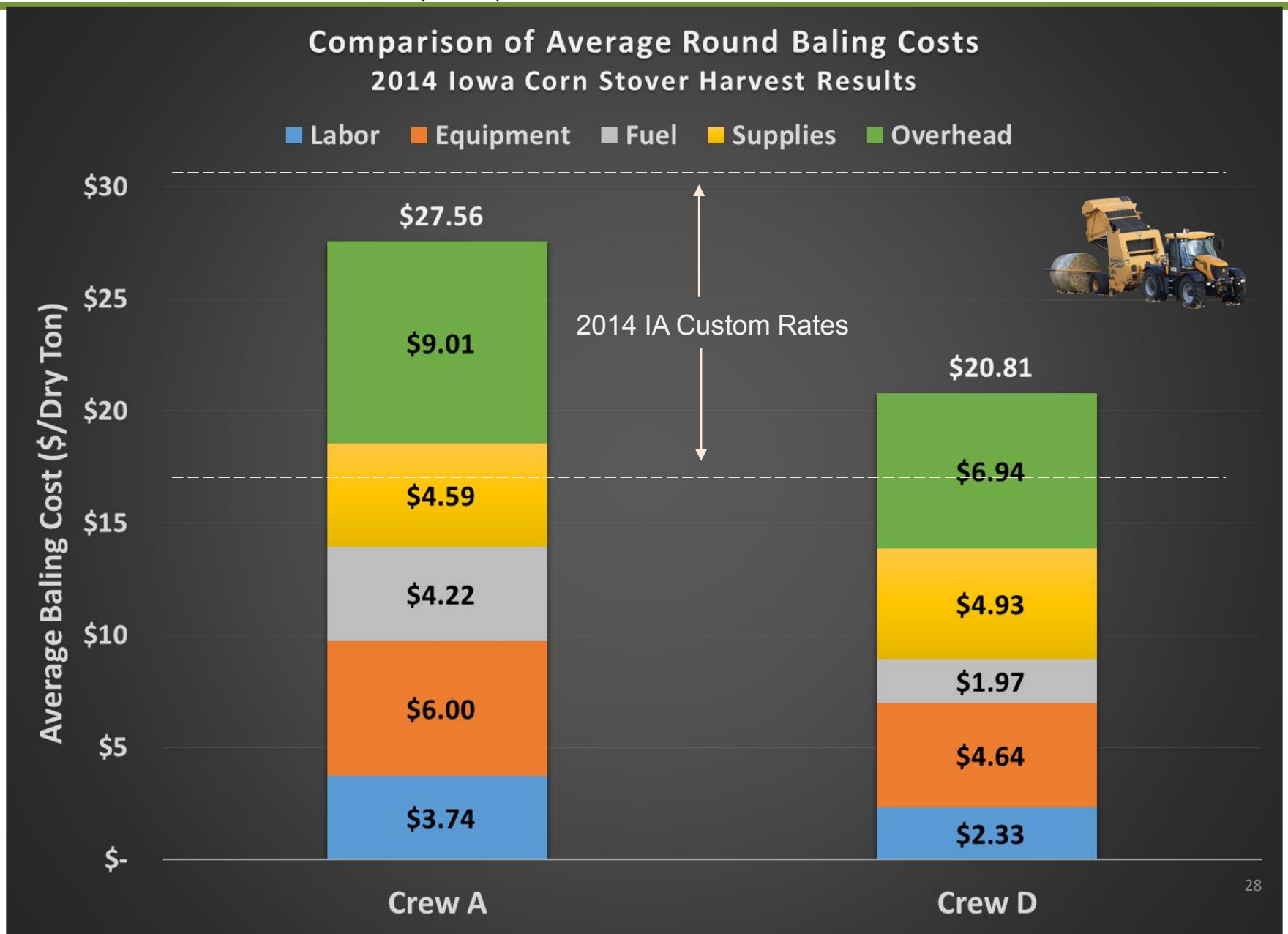
Bale Moving Operations: Average Production Costs
2014 Iowa Corn Stover Harvest Results

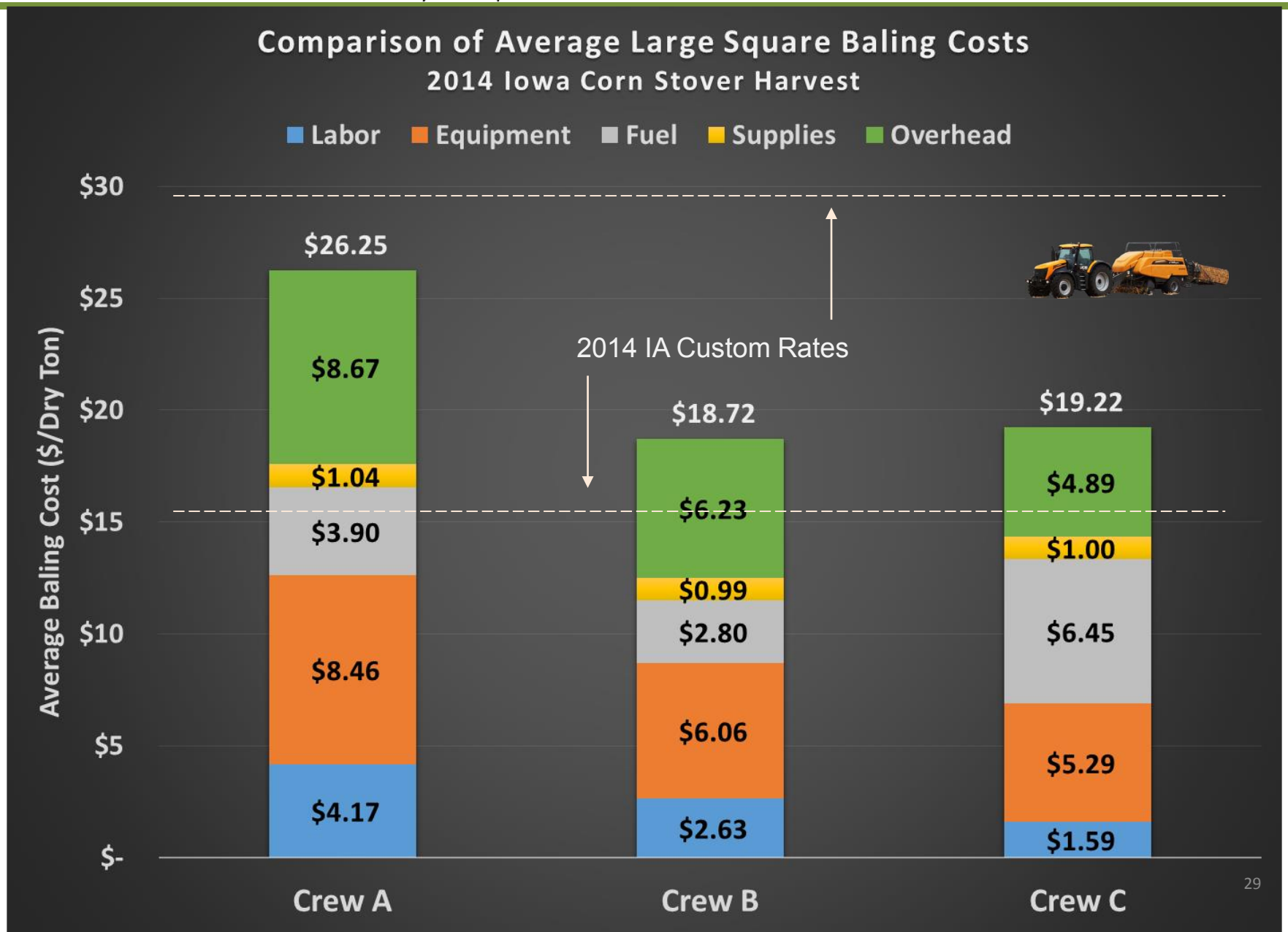


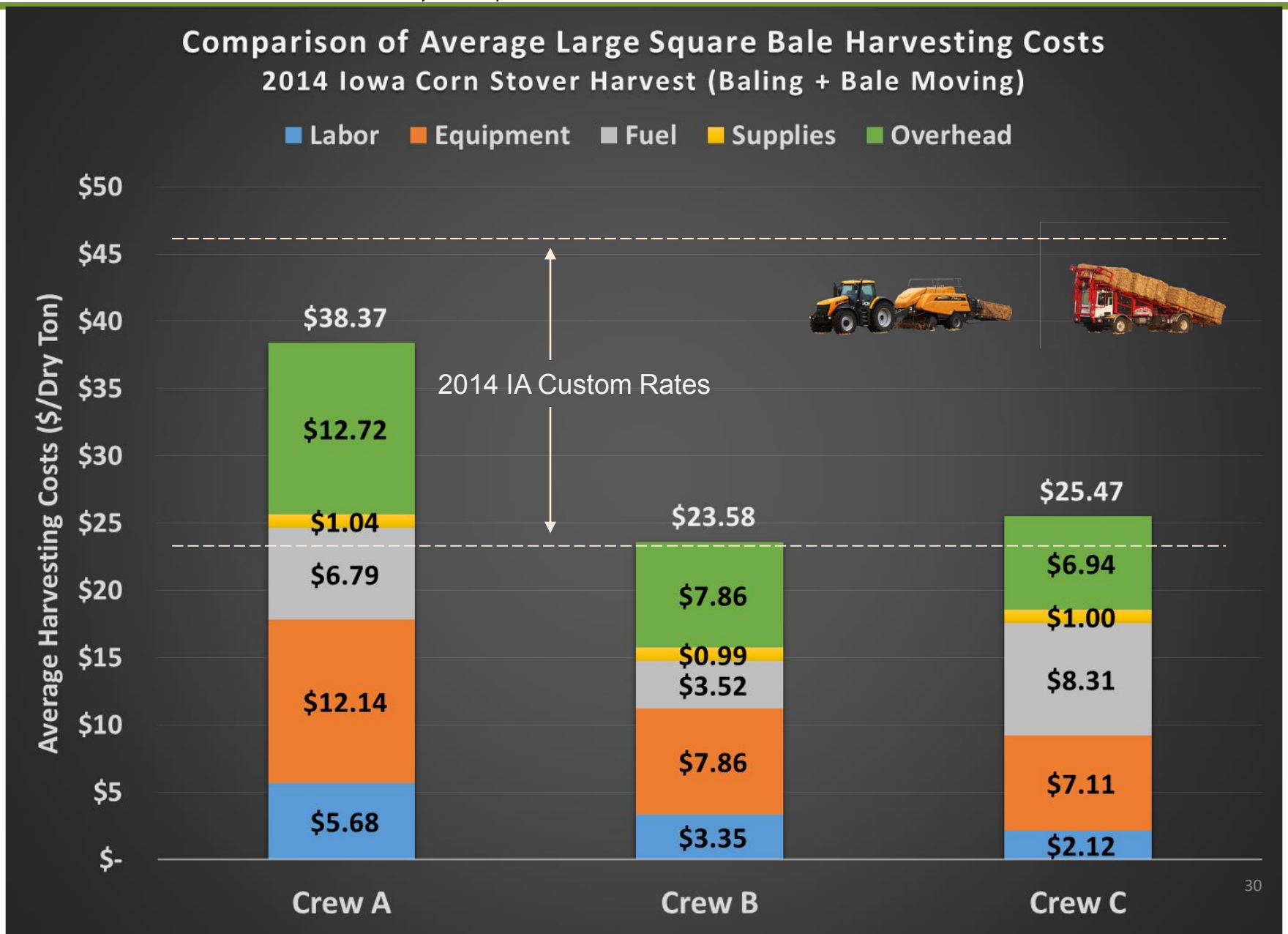
Summary of Harvested Cost - $/Dry Ton Basis

Conventional Baling & Roadsiding Results from 2014 IA Corn Stover Harvest



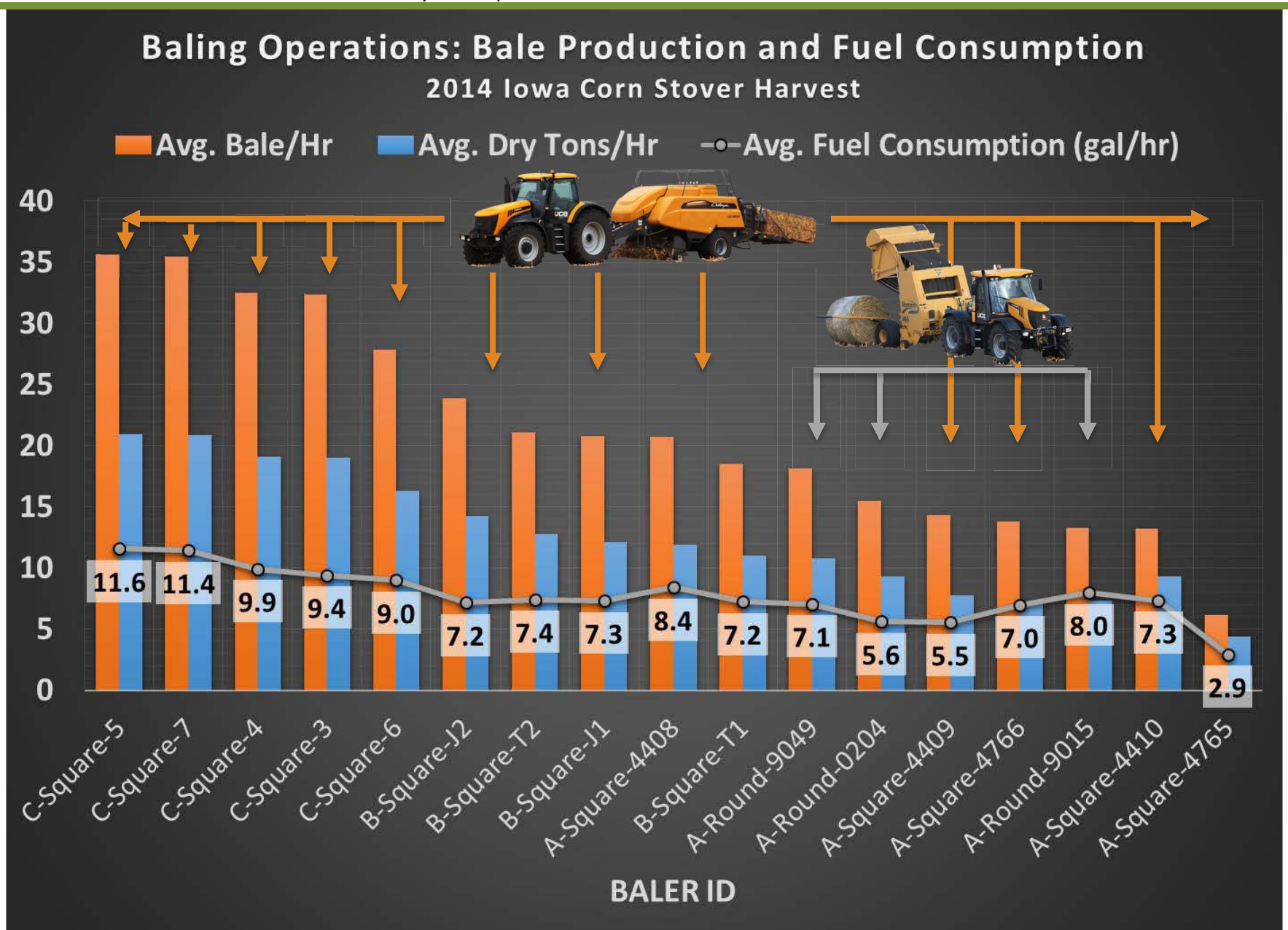

Comparison of Average Round Baling Costs
2014 Iowa Corn Stover Harvest Results
Labor
Equipment
Fuel
Supplies
Overhead
Average Baling Cost ($/Dry Ton)
$30
$25
$20
$15
$10
$5
$-
$27.56
$9.01
$4.59
$4.22
$6.00
$3.74
2014 IA Custom Rates
$20.81
$6.94
$4.93
$1.97
$4.64
$2.33
Crew A
Crew D

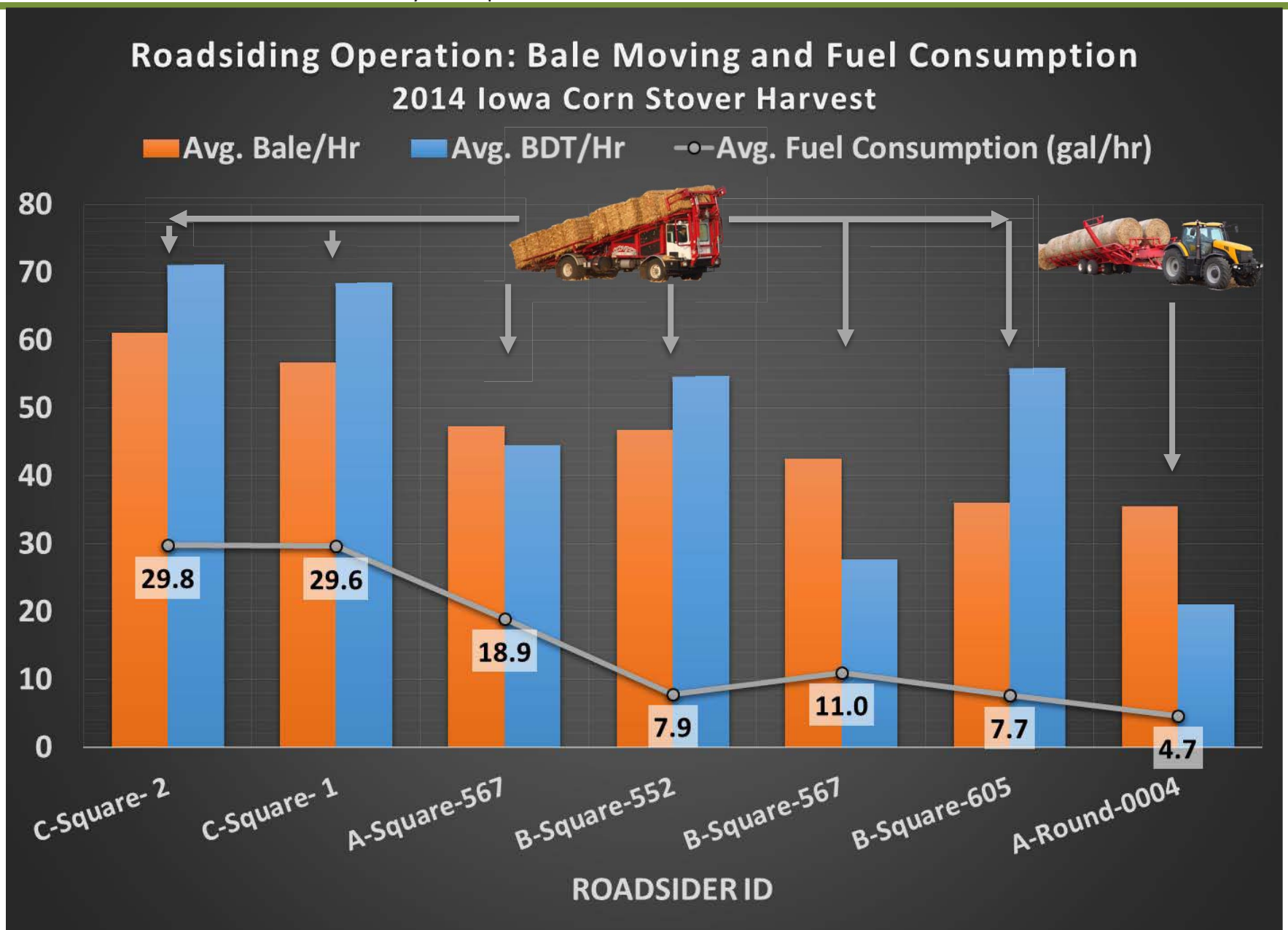

Comparison of Average Large Square Baling Costs
2014 Iowa Corn Stover Harvest
Labor
Equipment
Fuel
Supplies
Overhead
Average Baling Cost ($/Dry Ton)
$30
$25
$20
$15
$10
$5
$-
$26.25
$8.67
$1.04
$3.90
$8.46
$4.17
$18.72
$6.23
$0.99
$2.80
$6.06
$2.63
$19.22
$4.89
$1.00
$6.45
$5.29
$1.59
2014 IA Custom Rates
Crew A
Crew B
Crew C


Comparison of Average Large Square Bale Harvesting Costs
2014 Iowa Corn Stover Harvest (Baling + Bale Moving)
Labor
Equipment
Fuel
Supplies
Overhead
Average Harvesting Costs ($/Dry Ton)
$50
$45
$40
$35
$30
$25
$20
$15
$10
$5
$-
2014 IA Custom Rates
$38.37
$12.72
$1.04
$6.79
$12.14
$5.68
$23.58
$7.86
$0.99
$3.52
$7.86
$3.35
$25.47
$6.94
$1.00
$8.31
$7.11
$2.12
Crew A
Crew B
Crew C

Baling Operations: Bale Production and Fuel Consumption

2014 Iowa Corn Stover Harvest




Roadsiding Operation: Bale Moving and Fuel Consumption
2014 Iowa Corn Stover Harvest
Avg. Bale/Hr
Avg. BDT/Hr
Avg. Fuel Consumption (gal/hr)
80
70
60
50
40
30
20
10
0
29.8
29.6
18.9
7.9
11.0
7.7
4.7
C-Square- 2
C-Square- 1
A-Square-567
B-Square-552
B-Square-567
B-Square-605
A-Round-0004
ROADSIDER ID

2015 Harvest Plans - Vermeer

- Explore variables in ash content. Some preliminary tests in 2014 would reduce the impact of baler pickup height settings as top reason for high ash content.

- Bale density – reduce bale quantity, storage impact, machine maintenance impact, moisture content impact.

- Operator experience – limited research in 2014 lead us to believe experienced operators can substantially reduce harvest cost (bales/hour, baler uptime, reduced maintenance). Once identified, how can we assist new operators to reduce the learning curve?

Automated De-baler / Net Wrap Removal System

- Tested various methods for cutting the net wrap
  - Considered parameters such as: Dust generation, wear life, energy consumption and reliability.
  - Plan to integrate the net wrap cutting function with the bale deconstruction device.
- Investigated methods for removing net wrap once it has been cut
  - More than 30 tests have been conducted
  - Want to capture the net wrap without retaining excess feedstock
- Brainstormed more than 20 different methods for de-constructing a round bale
  - Focused on using the simplest/most reliable mechanism
  - Built several prototype components:

Net Removal Device

Shearing Mechanism

Overall System

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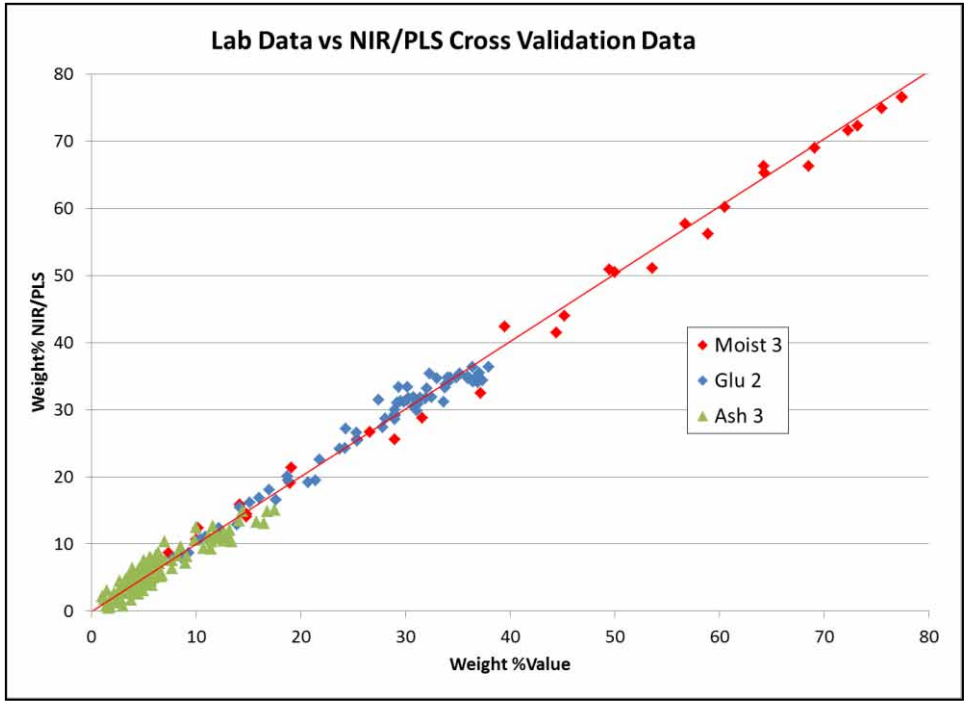
Bale Probe Design and Calibration

NIR/PLS Model	Moist 4	Glu 2	Ash 3
Cal. Range (%)	4 - 80	5 - 40	0.5 - 19
RMSECV (%)	2.4	1.5	1.3
Factors	2	3	5
R^2	0.989	0.969	0.850
N	33	68	162
Moist. Range (%)		4-80	4-80



- ASDI, INL and BHC have designed and calibrated a NIR Bale Probe accessory for the ASDI Field Spec.
- Prototype methods have been developed for the measurement of moisture, ash and glucan in corn stover.
- Recent method updates allow for analysis of samples with high moisture levels
- Glucan 4-60 %M and Ash 4-70 %M

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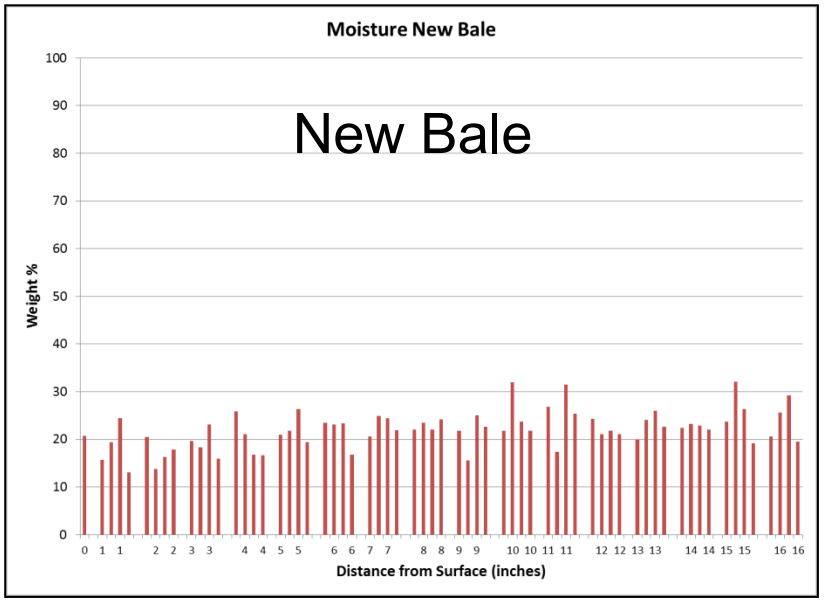
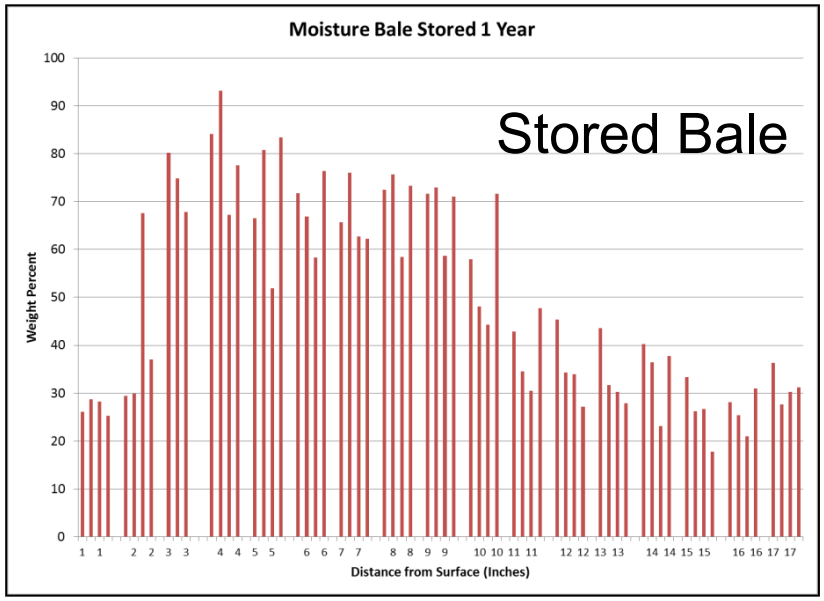
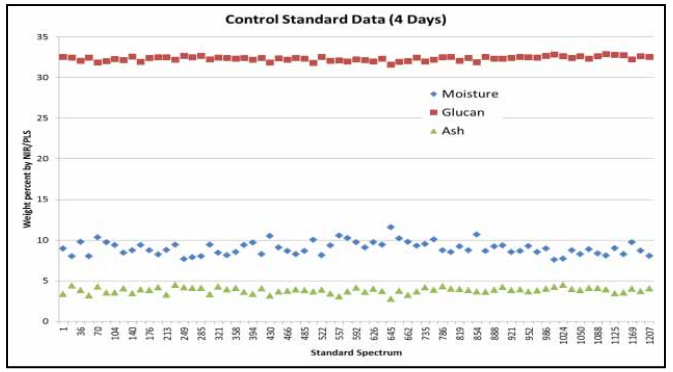
NIR Shakedown Tests Location 1





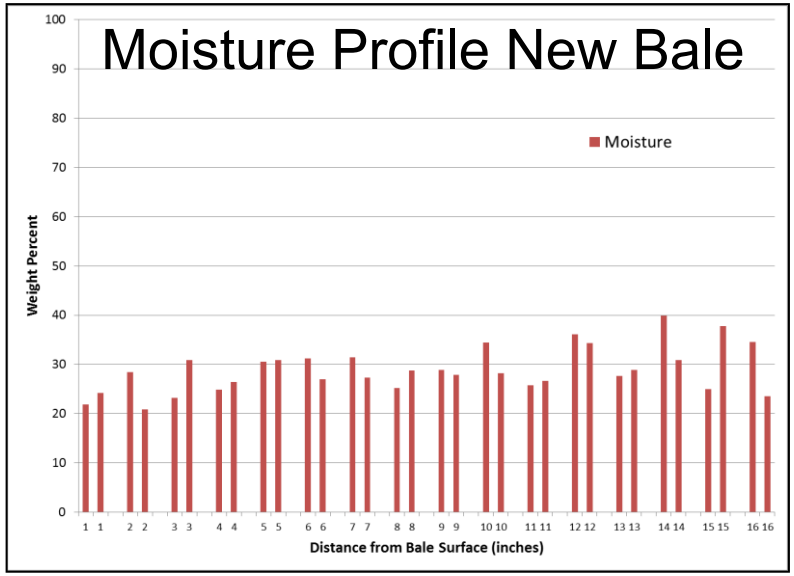
- Over 2100 spectra collected and analyzed
- 2 – 4 core samples collected per bale
- Scans at 1” increments from surface to center in hole
- Scans at 4 directions (Up,Right,Down,Left)
- QC sample scanned at set intervals
- Much higher variability seen in aged bales
  - May require more extensive sampling for accurate assessment

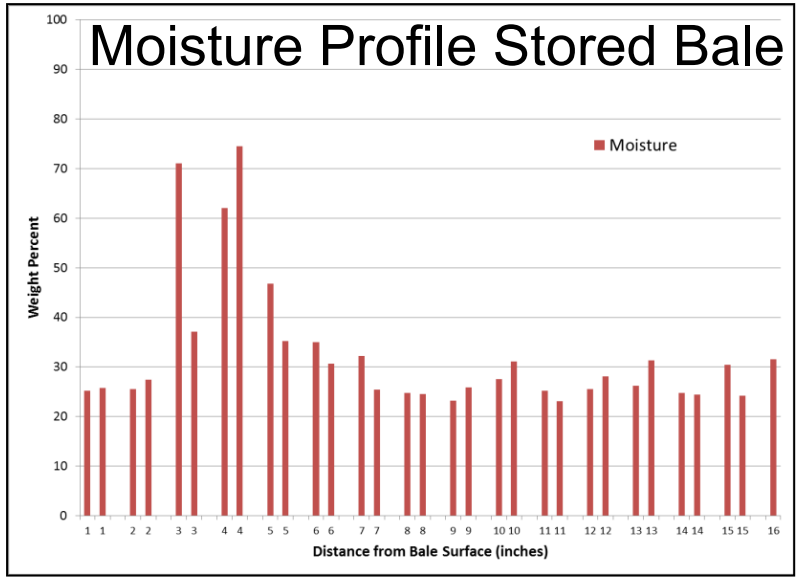


NIR Standard and control chart

BALES Biomass Alliance for Logistics Efficiency and Specifications

Streamlined Method Location 2



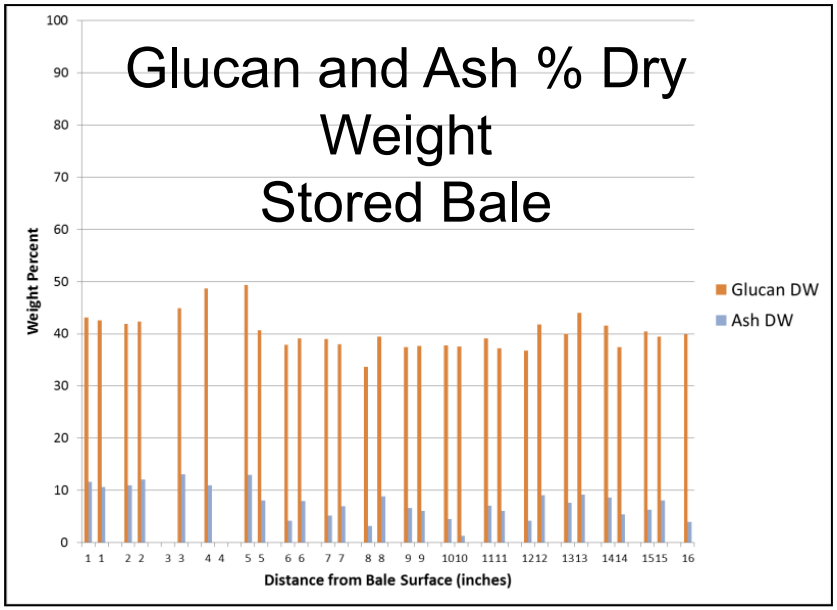


Updated Sampling Protocol:

- Scan at only 2 directions
- Calculate and report dry weight (DW) for glucan and ash
- Avg. Glu. DW: New 40.3%, stored 40.0%
- Avg. Ash DW: New 6.8%, Stored 7.6%
- 30 reading per core
- Sampling time 5-10 min. per hole

Future Plans:

- Expand and improve calibration
- Storage study with DAM project



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)

5 – Future Work

- Continued development and refinement of the NIR spectroscopy tools for rapid biomass analysis
- Development and Testing of new harvest and processing innovations
- Ongoing harvest demonstration and data collection activities
- Plan for 2015 fall agricultural residue harvests
- Process testing to meet biorefinery specs. (Summer, 2016)
- Continued team collaboration on sustainability issues.
- **Upcoming key milestones:**
  - Dual Drive Destringers and Automatic Destringer for Large Square Bales: Equipment Fabricated, Installed and Ready for Testing
  - 24-Bale Prototype Rack System for Round Bale Processing: Equipment Fabricated, Installed and Ready for Testing
  - Automated Round Bale Debaler/Net Wrap Removal System: Equipment Installed and Ready for Testing

Summary

1. **Approach**:
   - Broad approach for developing system and operation innovations for round and square bale based systems.
2. **Accomplishments**:
   - Initial prototypes developed for round and square bale systems
   - Demonstrated initial capability of NIR probe 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:**
   - Getting all prototype equipment and innovations fabricated and tested
   - Demonstrate feedstock cost reduction at the end users' specifications
   - Cultural changes and investment required to implement a new "system"
5. **Future Work:**
   - Process equipment fabrication & demonstration
   - Ongoing harvest demonstration and data collection activities, including innovations
   - Kelderman Pre-loader and Destacker
   - Continued development and demonstration of NIR bale probe
   - Continued collaboration and progress on sustainability issues

Additional Slides

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Cost Modeling Assumptions

Labor Rates							
Job Title	**Hourly Rate**	**Billability**					
Operator	$ 13.85	100%					
Crew Leader	$ 29.06	30.0%					
Operations Manager	$ 45.00	7.2%					
Overhead Expenses							
Overall Indirect Rate	50.0%						
Other Direct Costs							
Baling - Net Wrap ($/bale)	$ 0.035	$/L.F. @	4	wrap(s)	18.85	L.F./bale	
Baling - Twine ($/bale)	$ 0.004	$/L.F. @	1	wrap(s)	130	L.F./bale	
Grease - Square Bale ($/bale)	$ 0.008	based on	$ 4.00	/tube per	500	bales	
Grease - Round Bale ($/bale)	$ 0.005	based on	$ 4.00	/tube per	800	bales	
Diesel Fuel ($/gallon)	$ 3.60						
Equipment Costs							
Large Square Baler (3x4x8)	$ 2.07	$/bale					
Large Round Baler (5x6)	$ 1.16	$/bale					
Small Round Baler (4x5)	$ 1.16	$/bale					
Tractor Rental Rate ($/hp-hr)	$ 0.12	$ 27.44					
Stinger Stacker 6500	$ 2.09	$/bale					
Loader	$ 18.75	$/hr					
Pull-type round bale mover	$ 1.40	$/bale					