2013 DOE Bioenergy Technologies Office (BETO) Project Peer Review

1.3.1.2 Feedstock Preprocessing User Facility

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Technology Area Review: Feedstock Supply & Logistics

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Goal Statement

Provide “at scale” an innovative tool to use technology transfer capabilities to demonstrate BETO Fundamentals and Engineering discovery resulting in the conversion of raw biomass into stable, bulk flowable, quality-controlled material that can economically and sustainably be moved long distances (>50 miles) and stored long term (>1 year).

1.3.1.2 Quad Chart Overview

Timeline

- Project Task Start – FY09
- Project Task End – FY17

Barriers

- Ft-E Engineering Systems
- Ft-J Biomass Material Properties
- Ft-K Biomass Physical State Alteration

Budget

- Funding for FY11: $3.65M DOE
- Funding for FY12: $450K DOE
- Funding for FY13: $1.2M DOE
- Years the project has been funded, average annual funding: 4 years, avg. funding $2.73M/yr.

Partners

- Vermeer Manufacturing
- SEBS Feed & Supply
- Prairie Lands (Switchgrass, Corn Stover)
- Univ. of Oklahoma (Switchgrass, Sorghum)
- Auburn Univ. (Southern Pine)
- Grant 4-D Farms (Wheat Straw)
- MBI (Corn Stover)
- AOP (Corn Stover)
- POET (Corn Stover)

Project Overview

- Timeline:
  - FY09-FY11 – Design & Fabrication of the Process Demonstration Unit (PDU)
  - FY12 – DOE Project Demonstrations and Support
    - Scale-up of BETO funded fundamentals and engineering research (INL AOP, Interface Tasks, OBP funded research project, etc.)
    - Provide feedstock for BETO and industry research projects
  - FY13 – PDU User Facility Projects
    - "Initial Integrated Deployment Exercise" of PDU completed
    - Integration of Technology Transfer Plan through execution of cost shared utilization (CRADA) projects
    - Continue to Provide feedstock for BETO and industry research
  - FY14 – Execution of the PDU User Facility via cost sharing research funding and deployment of the PDU

Approach

- **Deployment of Fundamental Research at Scale:**

  The PDU provides an innovative solution to demonstration and deployment through validation of BETO fundamental, academic, and industry research at scale.

- **Focus** on
  - **Cost Reduction**: least cost performance (capacity (dry tons/hr) and efficiency (kWh/dry ton))
  - **Fundamental Process Advancement:** engineer feedstocks, densification, use of pneumatics for size control and product movement, particle size control
  - **Material Upgrading:** meeting industry specifications relative to: ash, particle size, sugars, etc.
  - **Material Performance:** flowability, mass and energy balance, blending characteristics, long term stability, etc.

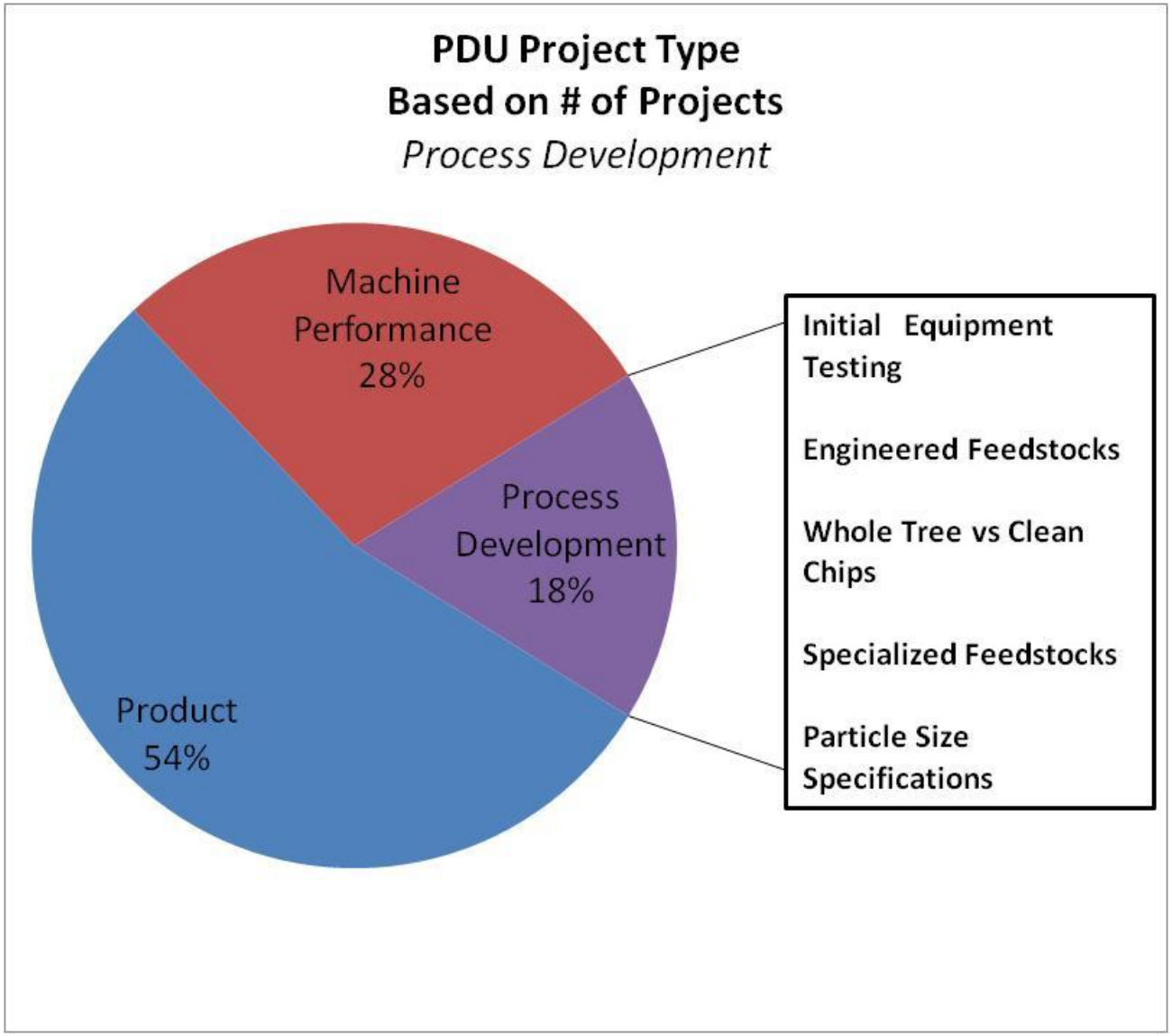
Technical Accomplishments/ Progress/Results

- Completed 96 Separate PDU Tests including:
  - 16 Separate Biomass Types * (Both Woody and Herbaceous)
  - 246 Tons of Biomass
  - Producing Pelletted and Ground or Chipped Product
  - Ground Product Size Ranging from 5/64-inches to 6-inches

- Technical Accomplishments Include:
  - Moisture Affect on Grinding
  - Moisture Affect on Particle Size
  - Single Stage vs Multi Stage Grinding to Produce Spec Particle Size
  - Screen Size vs Energy vs Particle Size
  - Effect of Rotary Drying on Particle Size
  - Optimization of Dryer Based on Moisture, Fan Speed, and Temperature Set Point
  - Ability to Remove Fines and Increase Capacity with Pneumatics
  - Successfully Produced Pellets with a broad range of feedstocks and combination of feedstocks
  - Achieved formulation of 4 blended biomass types in a densified product (corn stover, switchgrass, lodge pole pine, and eucalyptus)

*** Corn stover, switchgrass, straw, rice straw, prairie grass, reed canary grass, sorghum, miscanthus, arundo donax, pinion/juniper, lodge pole pine, ponderosa pine, southern pine, eucalyptus, hybrid poplar, and willow**

Technical Accomplishments/ Progress/Results (cont'd)



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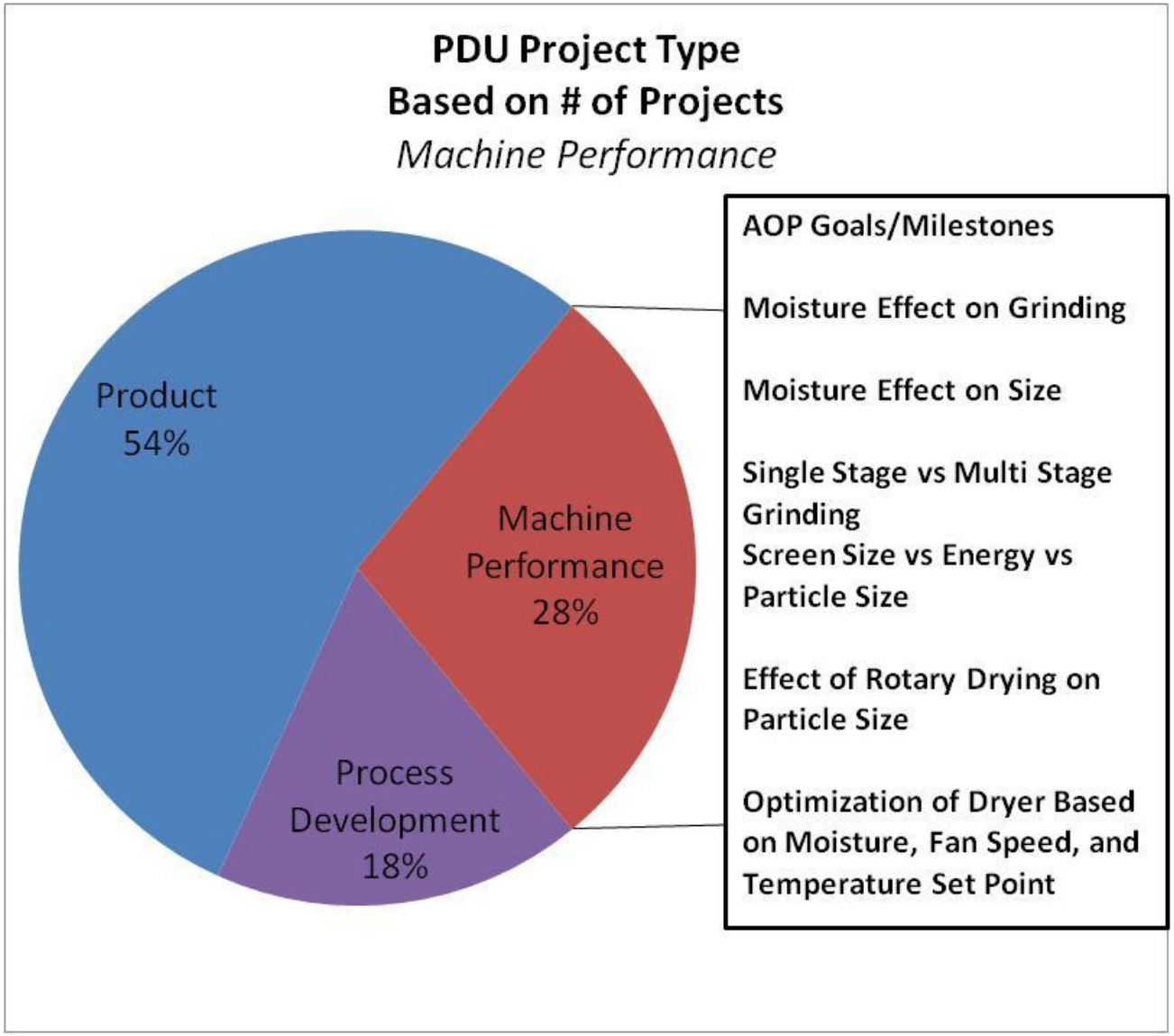

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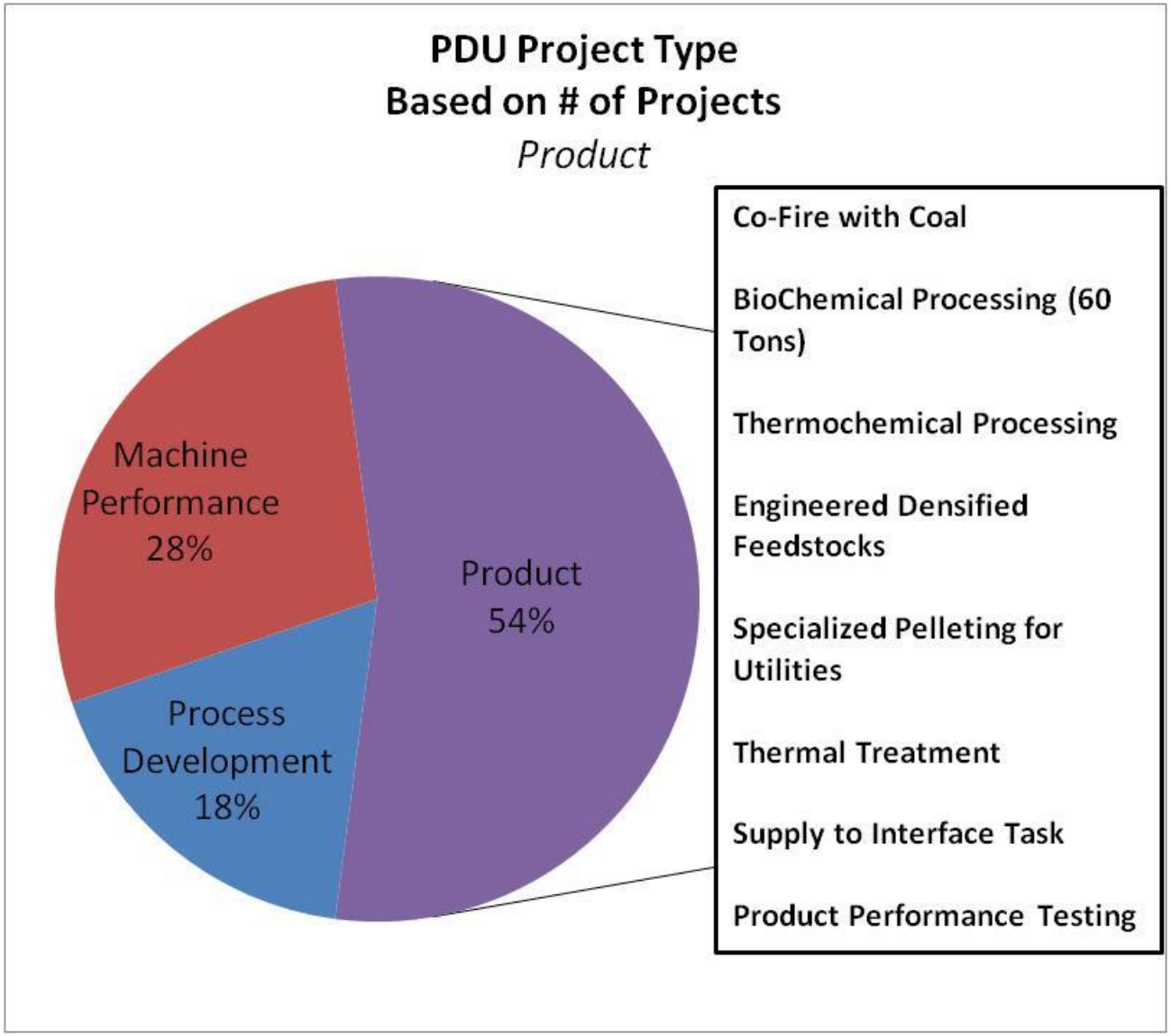


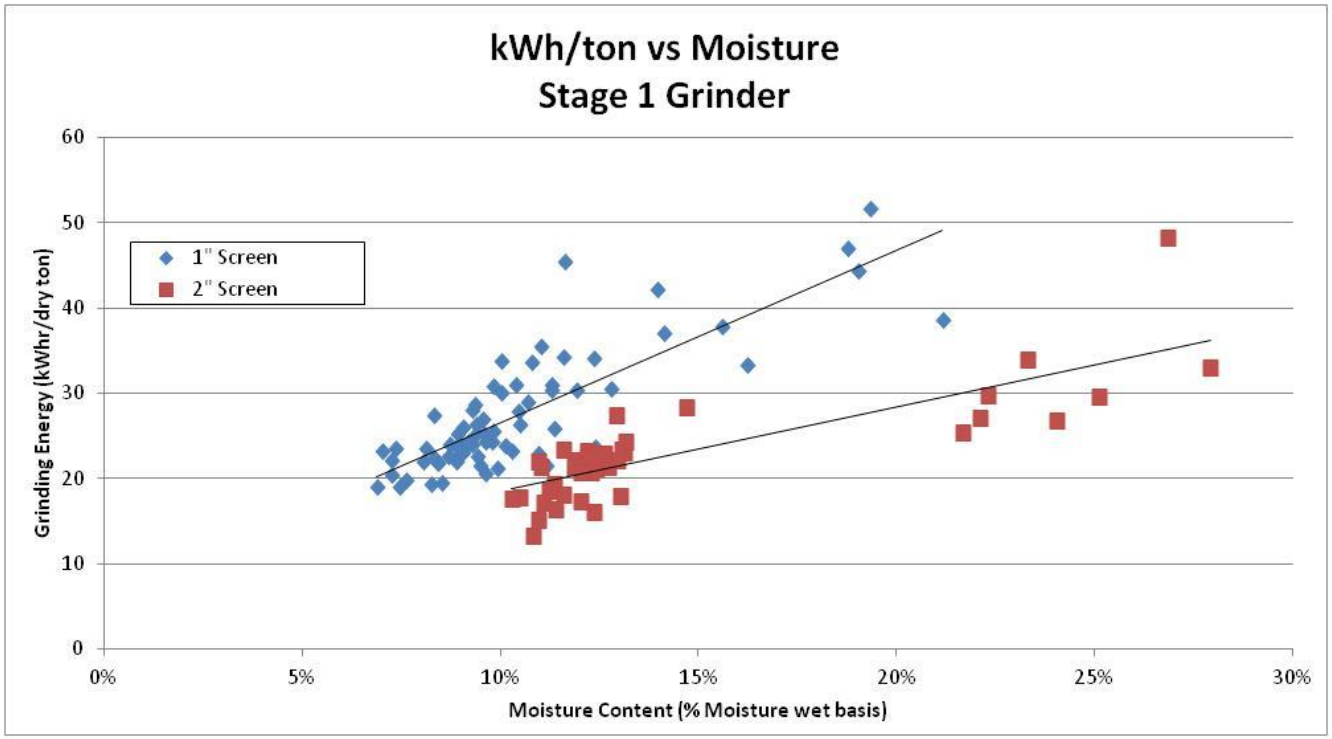
Technical Accomplishments/ Progress/Results (cont'd)

- Project Accomplishments to Date for PDU
  - **FY10** Production Cost Milestone achieved $37/dry ton
  - **FY11** Production Cost Milestone achieved $36.10/dry ton
    - Increased Capacity Using Pneumatic Transfer
  - **FY11** Densified Formulated Pellets (Corn Stover, Switchgrass, Pine, and Eucalyptus) (Densification Workshop Project)
  - **FY12** 25 Ton Production Cost Milestone achieved $35/dry ton
  - **FY12** MBI 30 Ton Run (CRADA)
    - (Restrictive Particle Size Requirements)
  - **FY12** Virent 30 Ton Run (CRADA)
    - (Began in FY12 ongoing)

Technical Accomplishments/ Progress/Results (cont'd)

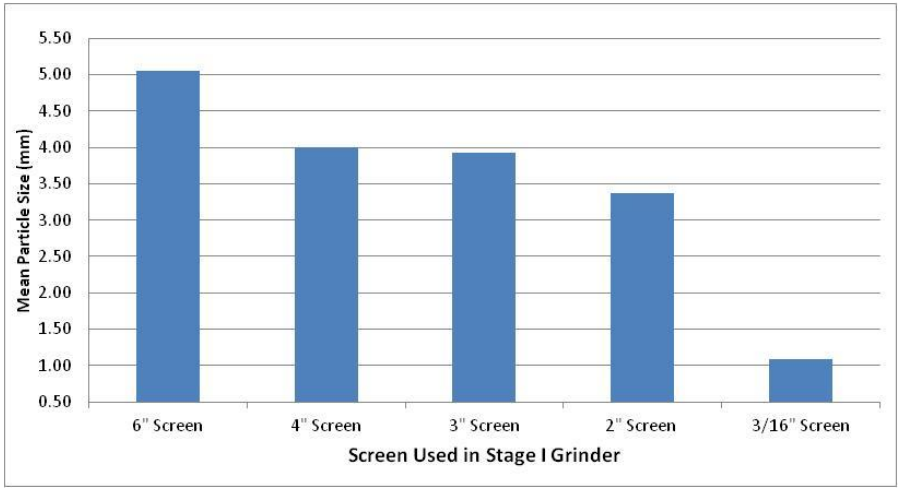
25 Ton $35/ton AOP Milestone :

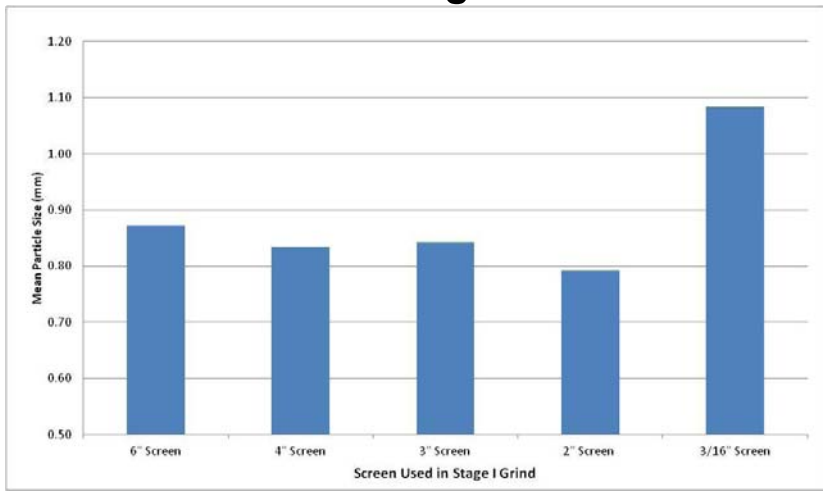
Moisture has a significant effect on grinding energy for corn stover. Two grinding tests are compared below. The moisture content for each bale was measured separately. The grinding energy was measured in kWhr/dry ton for each bale and plotted below. During a 25 ton grinding test (Red data point on the Figure) corn stover was ground with a 2 " screen. In a 30 ton grinding test (Blue data points) corn stover was ground with a 1" screen. Grinding energy is less with the 2" screen, but also the rate of effect is less with the two inch screen than the 1" screen.

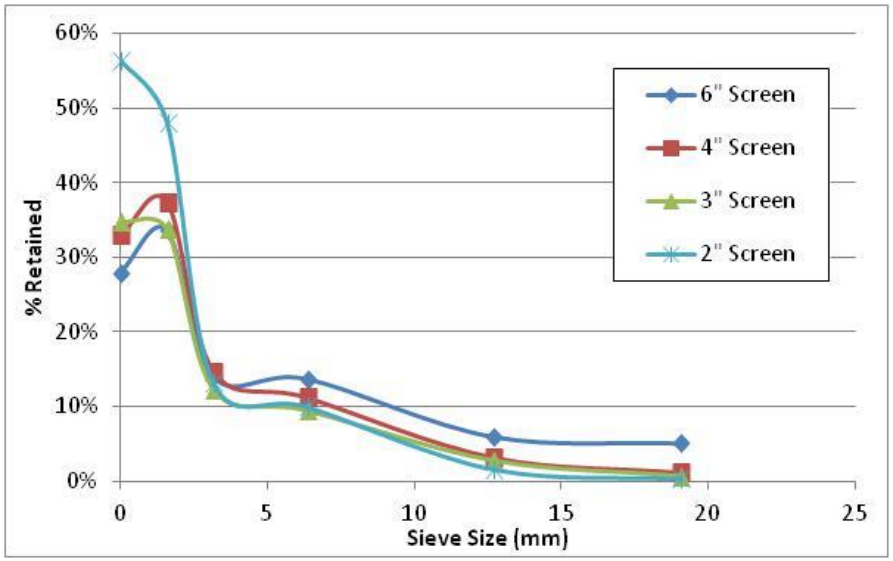


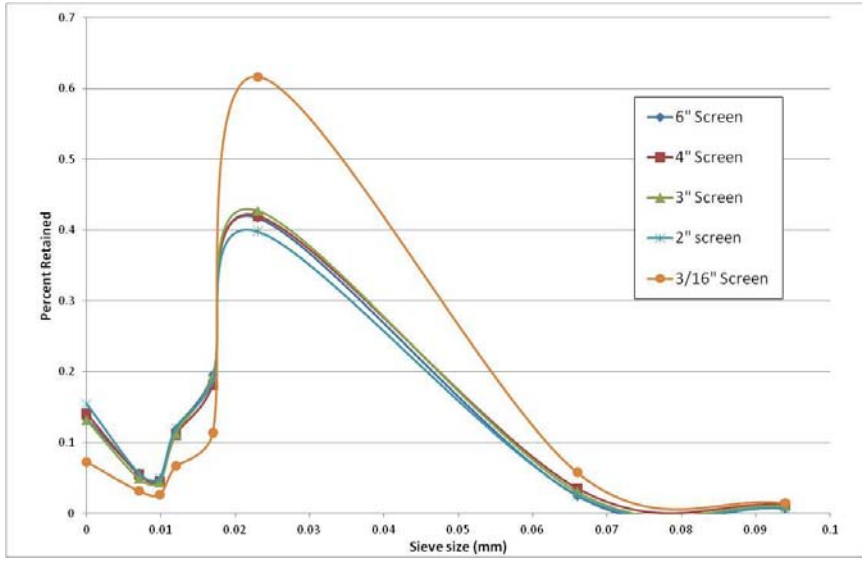
Technical Accomplishments/ Progress/Results (cont'd)

Single Stage Grind vs Two Stage Grind

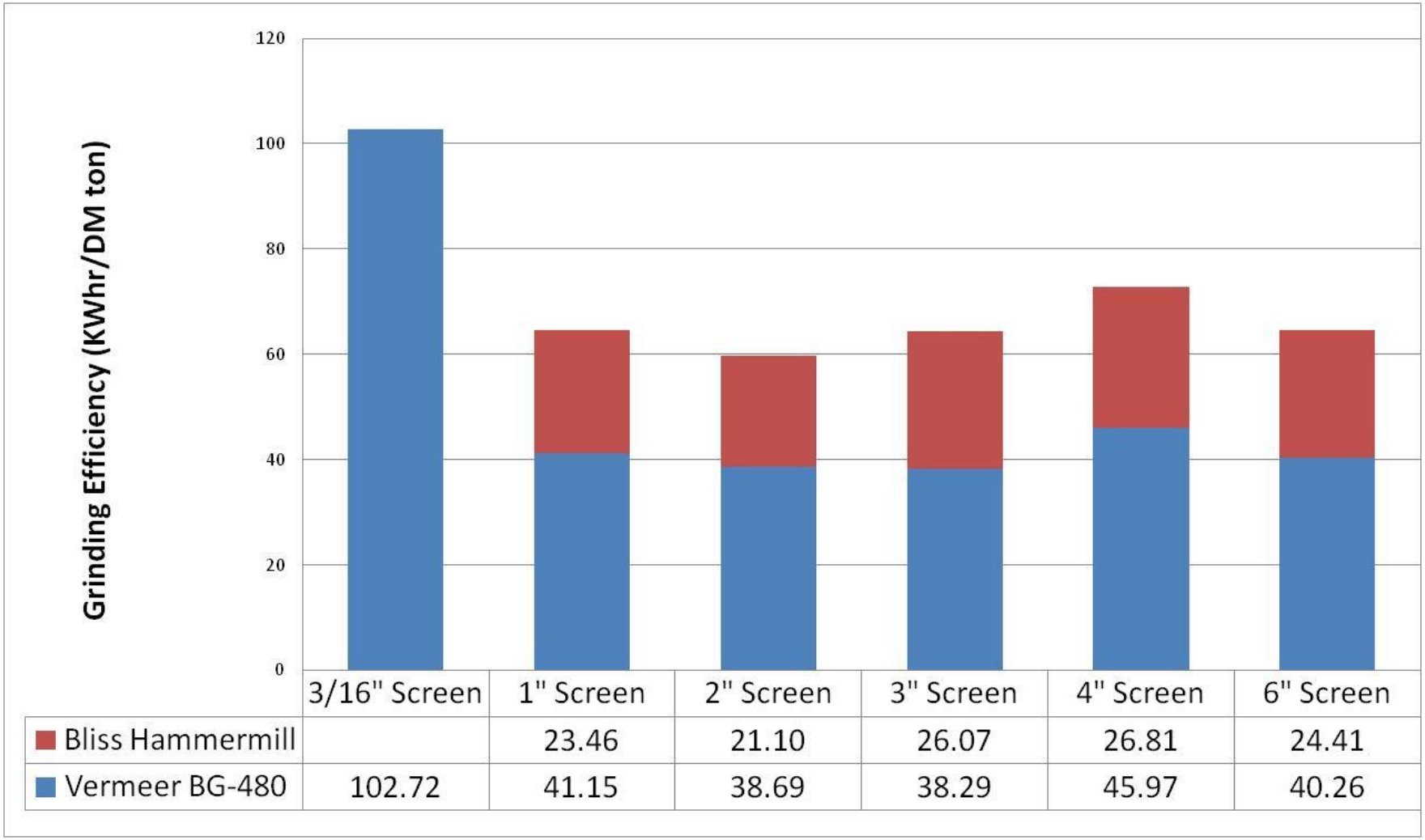








Technical Accomplishments/ Progress/Results (cont'd)



	3/16" Screen	1" Screen	2" Screen	3" Screen	4" Screen	6" Screen
Bliss Hammermill		23.46	21.10	26.07	26.81	24.41
Vermeer BG-480	102.72	41.15	38.69	38.29	45.97	40.26

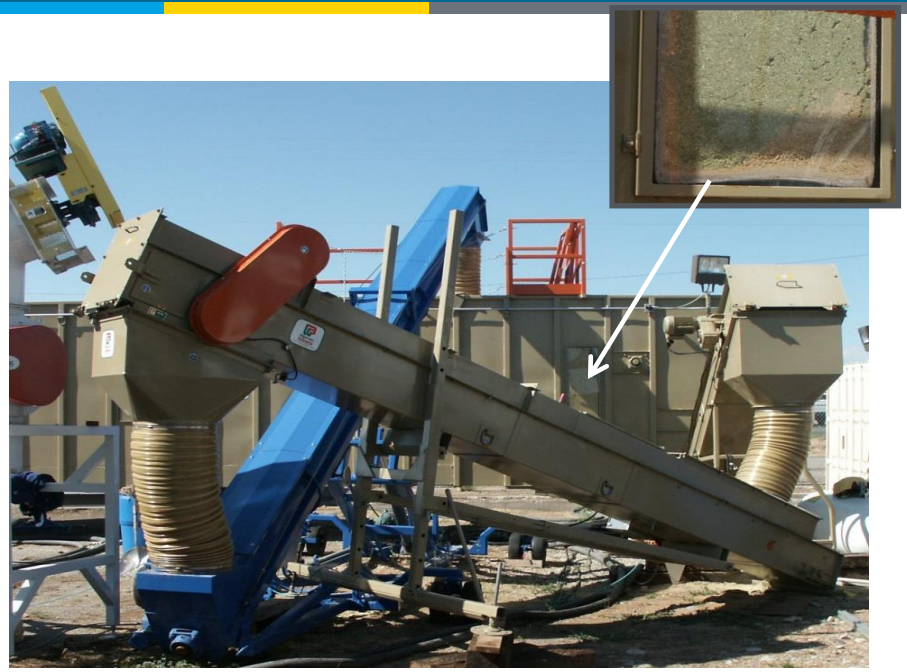
Technical Accomplishments/ Progress/Results (cont'd)

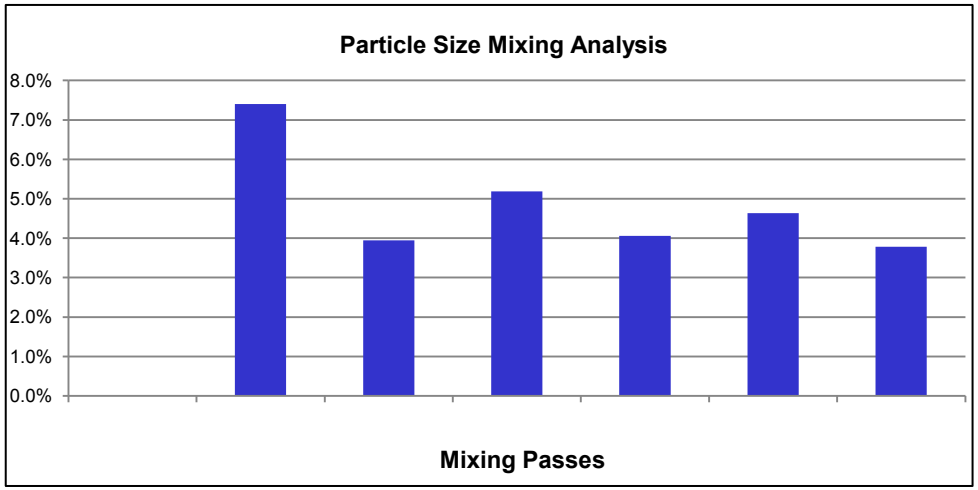
Engineered Feedstock

The Metering Bin's inflow is deposited in horizontal layers while the outflow is taken out in vertical slices. This feature provides the ability to perform batch blending of materials. Cycling the material thru the bin multiple times insures quality blending.

Initial testing was done with a 2 part mix of alfalfa and wheat straw, subsequent batches were done with a 4 part mix of pine, eucalyptus, corn stover and switchgrass.

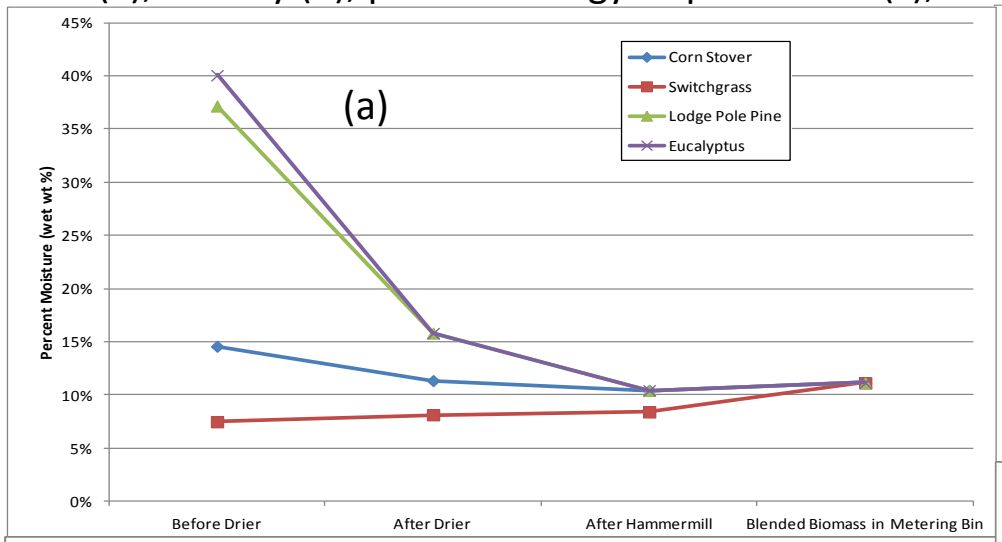
To insure adequate blending was taking place a particle size analysis was completed showing good blending occurred in as little as 2 cycles. A LIBS analysis was also preformed to verify blending.

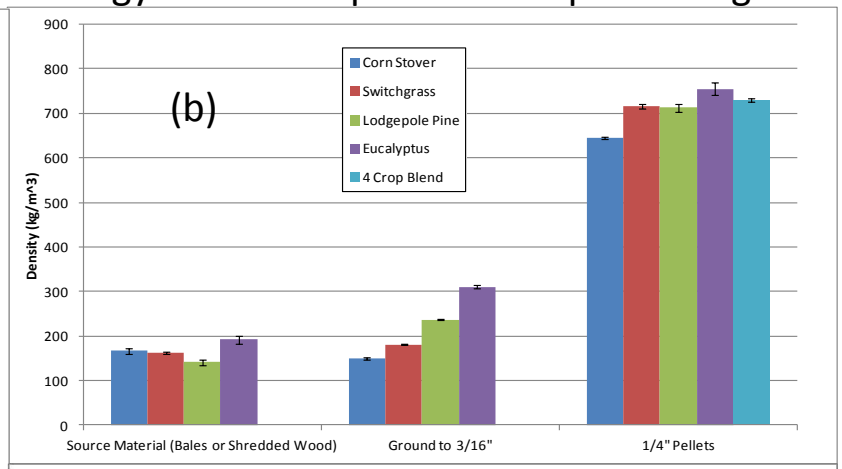


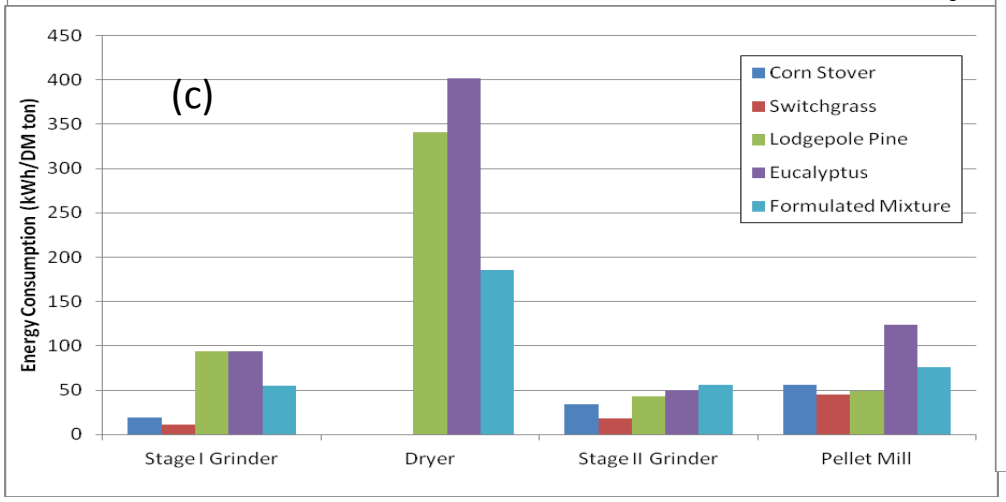


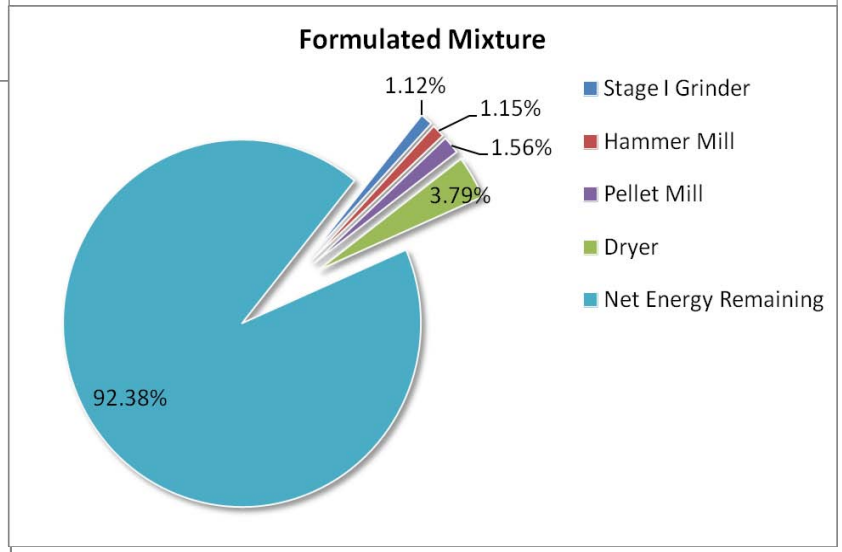
Technical Accomplishments/ Progress/Results (cont'd)

Four materials processed and blended in the PDU were analyzed at various stages for moisture (a), density (b), process energy requirements (c), and energy content of pellets after processing.









3 - Relevance

- Essential for demonstration of BETO technology targets
  - Integral to achieving DOE-OBP 2012 targets – demonstration of preprocessing performance and cost targets
  - During FY 2012 a 25 Ton machine performance test was conducted which demonstrated that the PDU was capable of meeting the $35/ton target
  - Source of Industrial Partnerships – CRADA, Work for Others, and DOE Funded Research
- Necessary to support scale-up of advanced preprocessing technologies
  - During FY2011 the PDU was used to demonstrate the ability to blend 4 feedstocks into a single densified product having improved quality characteristics (increased density, energy content, and durability
  - Both single stage and double stage grinding can be used to achieve particle size specifications.
- Necessary to supply feedstocks to BETO-funded conversion R&D projects
  - Supplied corn stover feedstock for NREL cellulosic ethanol demonstration
  - Supplied feedstock for benchmark validation of several DOE-OBP conversion projects
- Outlet for BETO-funded preprocessing technologies and INL capabilities (source of collaboration)
  - Provides opportunities for competitive projects (Several for FY12)

4 - Critical Success Factors

- Critical success factors
  - Users –
    - Fully booked operation
  - Deployment – critical mass of partners, projects, quantities of biomass
    - Both full PDU deployment or partial (single or multiple unit) deployment
  - Both onsite PDU use and Demonstration along with Offsite Deployment will Advance the State of Technology.
    - User Facility – Industry and research collaboration will work to overcome technology needs and challenges
    - Deployment – Successful deployment will overcome technical challenges and encourage additional deployment
- Potential Challenges
  - User Access & Collaboration
    - User Facility designation to enable/simply access by external users
    - BETO competitive solicitations provide opportunities for collaboration
  - Maintaining PDU State-of-the-Art Capabilities
    - As PDU components are deployed, replacement of that component with new state of technology must be accomplished
    - Insertion of advanced preprocessing technologies

Future Work

- FY13
  - Focus on size reduction/comminution projects
    - Hammermill hammer designs
    - Comparison of hammer, rotary shear and collision milling
    - Particle distribution control via…
  - Compression bagging
- FY14 -15
  - Meeting Industry Spec
    - Particle Size
    - Ash Reduction
  - Focus on moisture management
    - Size reduction of high moisture biomass
    - Drying
    - Densification of high moisture biomass
  - Preprocessing of MSW

Summary

1) Approach –
   1) Integrated Research
   2) Equipment Performance
   3) Process Discovery
   4) Material Performance and Upgrading

2) Technical accomplishments
   1)96 Tests
   2)246 Tons of Ground Biomass and Pellets
   3)Energy and Capacity
   4)Blending
   5)Drying
   6)Product Specification

3) Relevance
   1)Essential for BETO Demonstrations
   2)Support Scale-up
   3)Supply Feedstock
   4)Source for Collaboration

4) Critical Success factors and challenges
   1)User Facility
   2)PDU Deployment
   3)Advance the State of Technology
      1)Energy Improvement
      2)Industry Specs

5) Future Work
   1)Improved Efficiency / Capacity
   2)Comminution
   2) BETO Projects
   3) Deployment
   4) USDA CAP
   5) New Capability – Separation

6) Technology transfer
   1)Deployment
   2)New Capabilities

Publications, Presentations, and Commercialization

- PDU Publications.
  - "Drying, Grinding and Pelletization Studies on Raw and Formulated Biomass Feedstock's for Bioenergy Applications". Journal of Biobased Materials and Bioenergy
  - "Optimizing Hammermill Performance Through Screen Selection and Hammer Design". BioFuels
  - "Advanced Feedstocks for Advanced BioFuels: Transforming Biomass to Feedstocks". BioFuels
  - "Modifications to Fixed Cutter Grinders for Improved Capacity and Efficiency". ASABE
  - "Effect of Thermal Treating Corn Stover on Grinding Energy During Preprocessing". ASABE