U.S. Department of Energy (DOE)
Bioenergy Technologies Office (BETO)
2019 Project Peer Review

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Next Generation Logistics Systems for Delivering Optimal Biomass Feedstocks to Biorefining Industries in the Southeastern US

March 6, 2019
Feedstock Supply & Logistics

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The University of Tennessee

Goal Statement

Goal

The project goal is to evaluate a state-of-the-art biomass merchandizing and processing system to identify sources of variation along the supply chain of multiple, high-impact biomass sources, and to develop practices to reduce biomass variability that lowers the cost of producing a hydrocarbon biofuel.

Outcome

The project will introduce new strategies to reduce dependence on a single biomass source, and provide innovative tools that allow the biofuels industry to benefit from efficiencies afforded by consistently high-quality feedstock.

Relevance

This biomass blend concept will allow biorefineries to utilize a much larger amount of biomass within their procurement radius (e.g. pine and herbaceous crops in the southeast U.S.), thereby enabling larger scale, and more economically feasible facilities to be constructed and operated.

Quad Chart Overview

Timeline

- Start date – 2/1/2016
- End date – 1/31/2020
- Percent Complete – 75%

Barriers

- FT-A. Feedstock Availability & Cost
- FT-E. Feedstock Quality & Monitoring
- FT-I. Feedstock Supply System Integration and Infrastructure

	FY 16 Costs	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 18 - FY 20)
DOE Funded	$294,866	$80,627	$726,037	$2,898,470
Cost Share	$73,139	$191,186	$825,824	$1,536,601

Partners: University of Tennessee, Auburn University, Genera Energy, Inc., ~~Herty Adv. Mat. Dev. Center (GSU)~~, Idaho National Laboratory, John Deere, North Carolina State University, Oak Ridge National Laboratory, PerkinElmer, Inc., Proton Power, Inc.

Objective

- Deliver high-quality feedstock blended from different biomass sources in the Southeast.

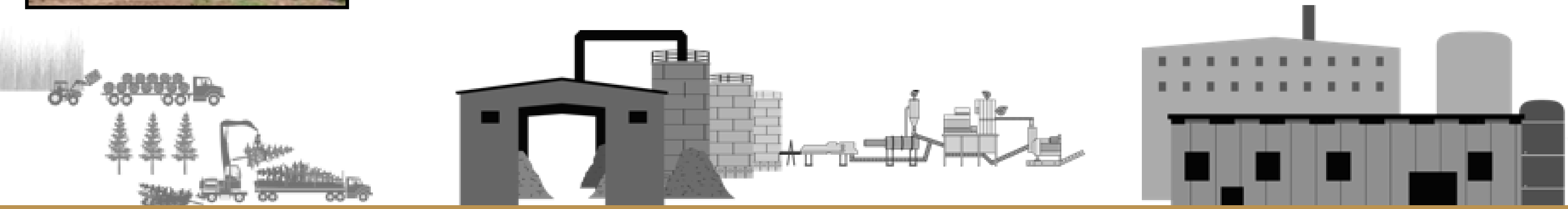
End of Project Goal

- Refine the depot system that receives both woody biomass and switchgrass through separate supply lines, then processes these biomass sources, and, where appropriate, produces blends of feedstocks engineered to meet specifications for specific biorefineries.

Project Overview




- Continuing Project with DOE BETO regarding improved logistics (Logistics for Enhanced-Attribute Feedstock - LEAF)
  - Builds on advances in two previous High Tonnage projects (Pine at AU; Switchgrass at Genera)
- Current opportunities:
  - Advanced merchandizing systems to maximize quality and reduce cost from southern pine biomass residue found in approximately 40 million acres of traditionally managed pine plantations (15 to 30 years old)
  - A more extensive forest product mix will add value to woody biomass and reward landowners across the U.S.
  - Dependence on single sources of biomass significantly constrains the scale of conversion facilities.
  - Information is needed to effectively utilize the inherent variability of biomass characteristics to optimize process behavior.



Management Approach

TASK 1:
Integrated Merchandising

Lead: Steve Taylor, AU
Tim McDonald
Tom Gallagher

TASK 2:
Quality Monitoring

Lead: Niki Labbé, UT
Peter Muller
Oladiran Fasina
Sam Weaver
Tim Young
Sushil Adhikari

TASK 3:
Formulated Feedstocks

Lead: Jaya Tumuluru, INL
Sam Jackson
Oladiran Fasina
Steve Taylor

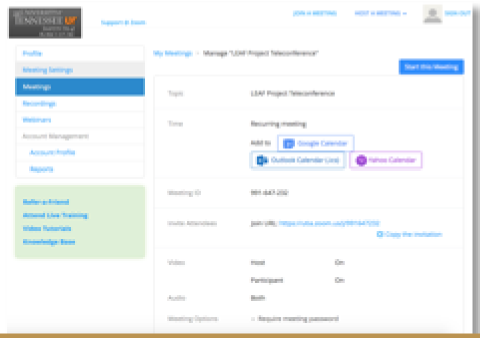
TASK 4:
System Evaluation

Lead: Steve Kelley, NCSU
Burt English, UT
Sunkyu Park
Yuan Yao
Edward Yu

Gantt Chart

Project Site

Monthly Calls



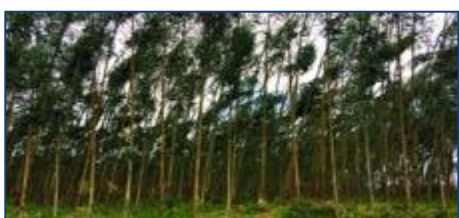
Technical Approach

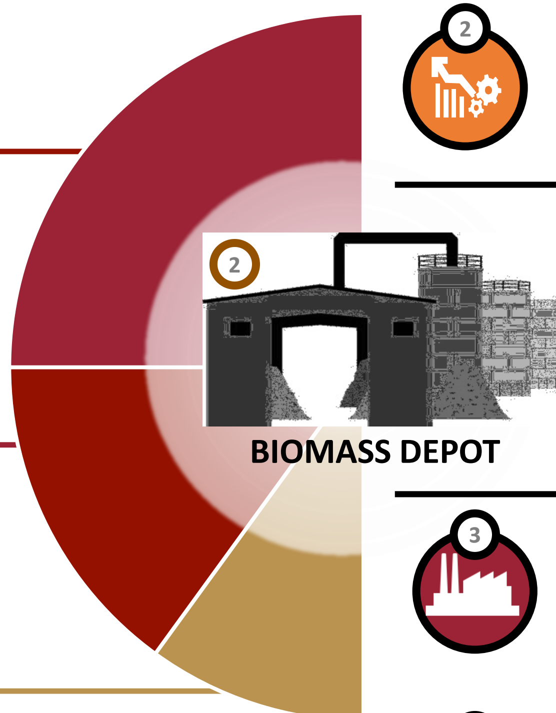
DIVERSE BIOMASS SOURCES

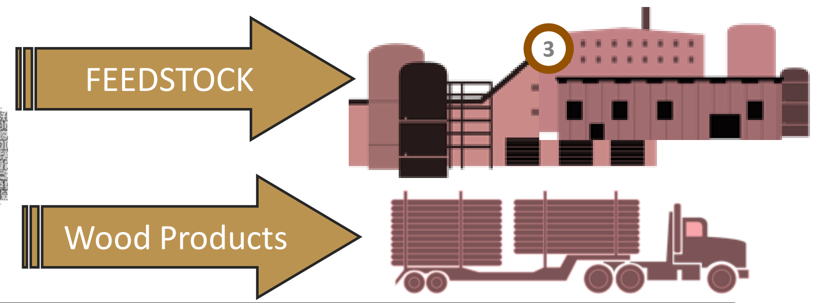
Pine Residue

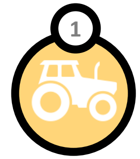
Herbaceous

Woody Crops









TASK 1: INTEGRATED MERCHANDISING
Demonstrate an integrated harvest, transport, and merchandizing system for maximizing value, quantity, and quality of biomass from southern pine forests.

TASK 2: QUALITY MONITORING
Introduce statistical process control methods that utilize biomass quality metrics obtained from novel, rugged spectroscopic sensor data to reduce feedstock cost, and improve quality.

TASK 3: FORMULATED FEEDSTOCKS
Explore the potential to formulate feedstock blends from diverse biomass inputs for improved processing performance at lower costs.

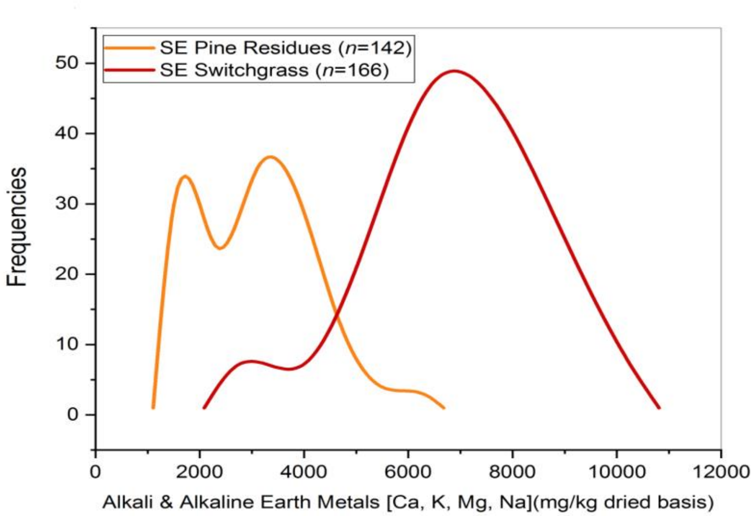
TASK 4: SYSTEM EVALUATION
Quantify the spatially specific economic and life-cycle gains afforded by the new system incorporating advanced methods and instrumentation to improve feedstock quality and consistency relative to the current supply system.

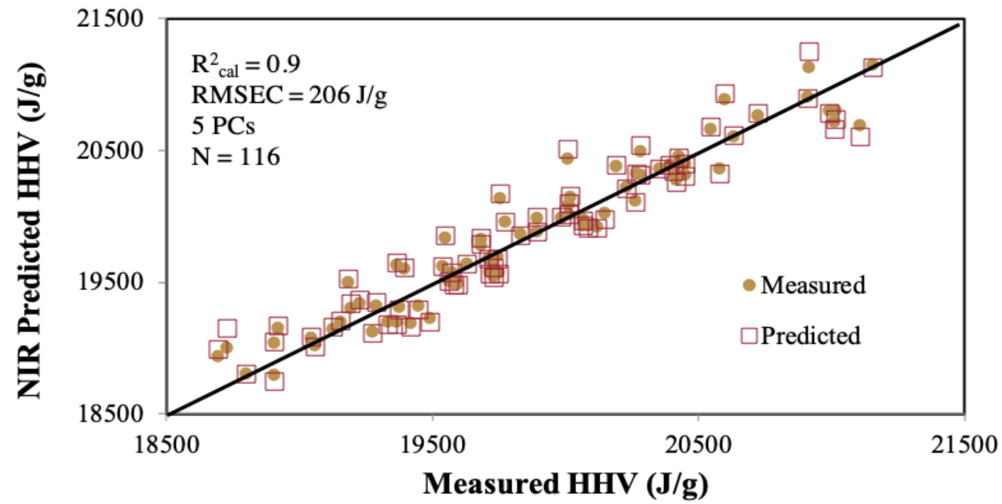
A New Biomass Source

- Significant payload increases with full-tree loads
  - "chip-n-saw" loads – 9,700 pounds of gained biomass
  - pulpwood loads – 8,000 pounds of gained biomass
  - 14% (green weight) of untrimmed load is gained biomass
- Additional axle weights are excessive for tandem axle trailers; tridem axle trailer in production
- John Deere processor throughput:
  - 88 tons per hour
  - 2.7 trees per minute
- Significant operator contribution to overall productivity
- Productivity data and simulation models are complete

	<Op1>	CV	<Op2>	CV
Fuel Consumption, gal/hr	7.36	1%	7.106	1%
Productivity, ft3/hr	2850	16%	2381	9%
Productivity, tons/hr	88.3	16%	73.8	9%
Productivity, logs/hr	250.1	6%	216.6	12%
Cycle Rate, trees/min	2.673	6%	2.39	14%
Volume Processed, ft3	156.3	13%	136.8	11%
# of Logs Processed	1791	23%	1509	12%
Mass Processed, tons	55.5	23%	46.79	12%

Feedstock Quality Control





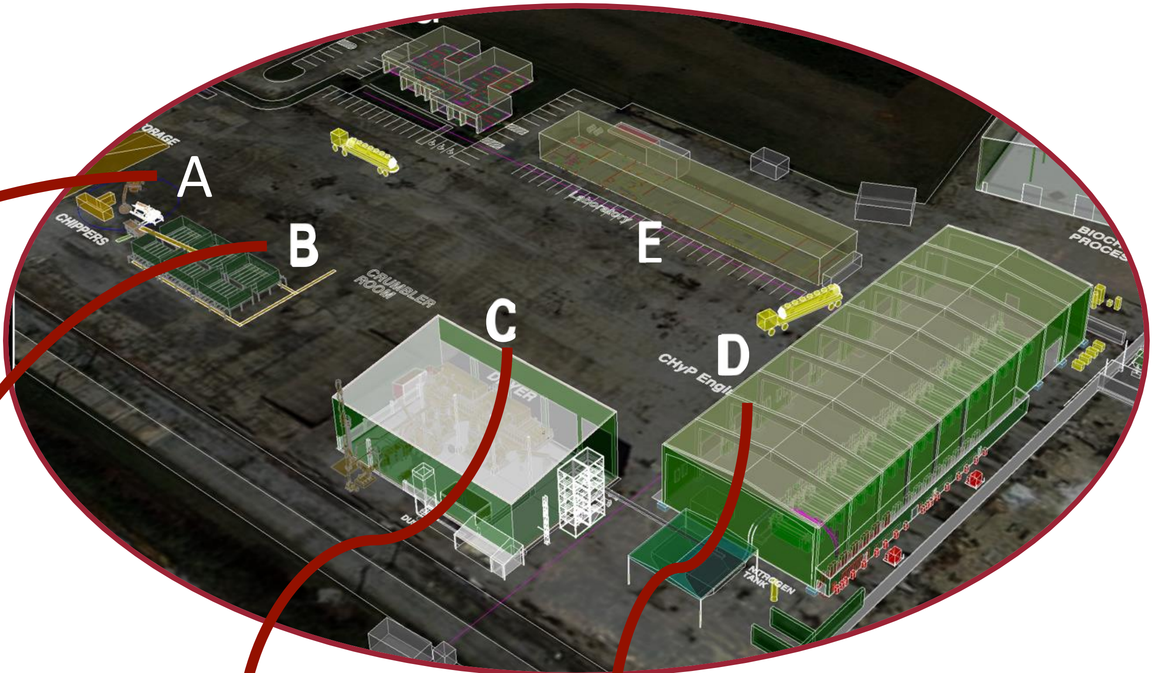
Robust NIR models constructed for biomass monitoring

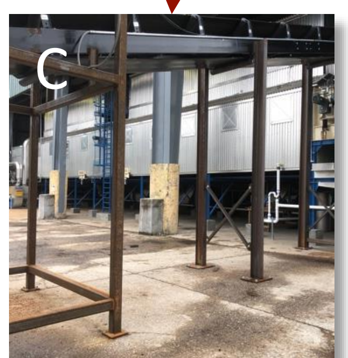
NIR Models (Lab)	Ash	AAEM (Ca-K-Mg-Na)	Individual Inorganics	High Heating Value
Single Biomass Switchgrass; Pine residues	√	√	√	
Blended Biomass Switchgrass & pine residues	√	√	√	√
Mixed Biomass Switchgrass, Pine residues, Pine wood, Hybrid poplar	√	√	√	√

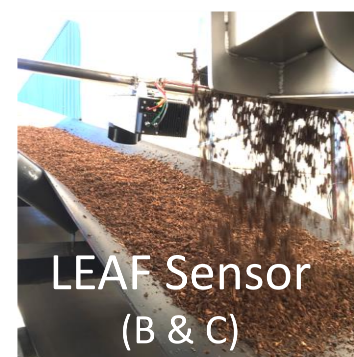
SPC: Essential Information

Location: Rockwood, TN
Platform: Thermochemical
Feedstock: Hardwood/Pine
Product: Green diesel / Biochar / other
Capacity: 7.5 MM GPY

Includes state-of-the-art depot operation for wood





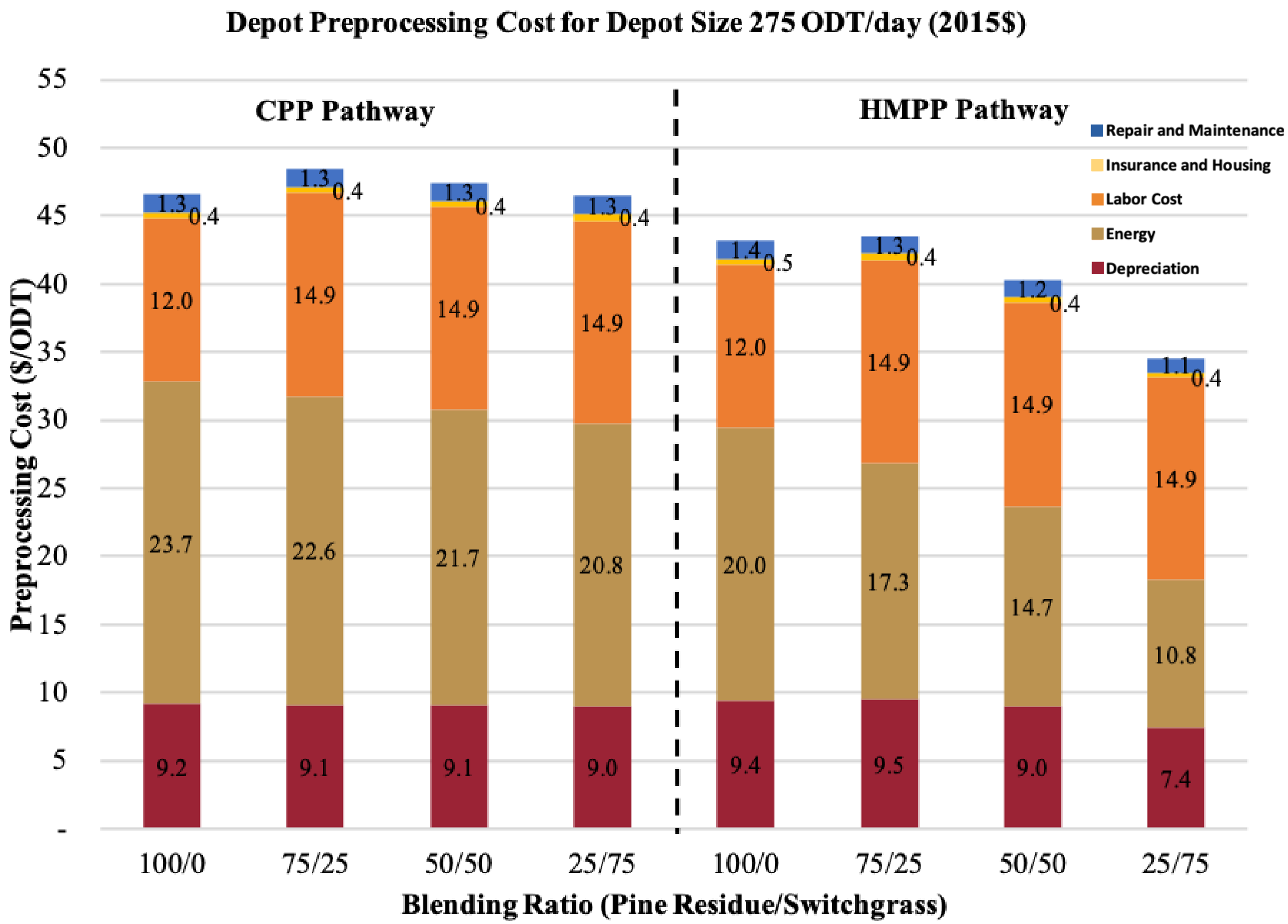


Assessing Depot Costs

- High-Moisture Pellet pathway offers cost savings over conventional method.
    - Low temp cross-flow dryer saves both energy cost and capital cost

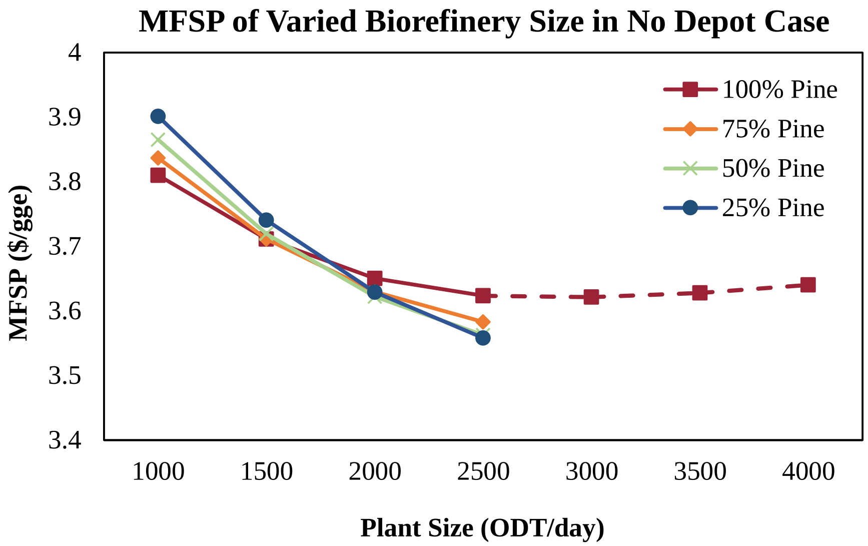
- Changing feedstock blending ratio from 100/0 to 75/25 increases depot costs
    - Additional equip't and labor

- Depot cost decreases for higher switchgrass formulations (energy saving in both drying and grinding)

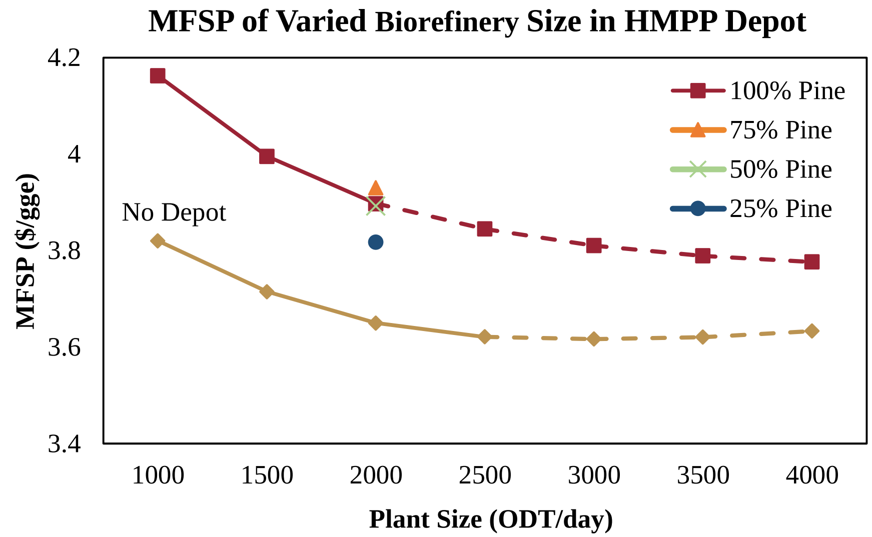


PROJECT RELEVANCE

- At 1000 ODT/day, 100% pine residue scenario has advantages over blending.
- Benefit of blending seen for larger depot.
  - Transportation cost saving
  - Low MC of switchgrass
- MFSP increases above 2500 ODT/day due to transportation costs (ca. $4/500 ODT).



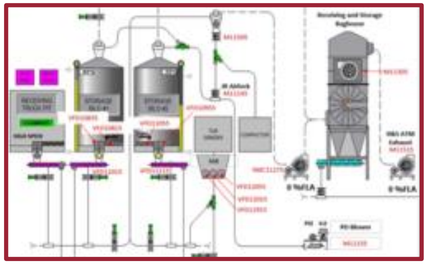
- The differential between no depot and HMPP depot decreases with plant size.
  - Lower transportation cost when plant size is expanded
  - MFSP continues decrease with scale.
- At 2000 ODT/day, increasing switchgrass can further decrease MFSP.



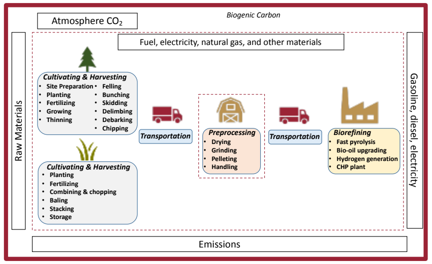
Future Work

Demonstrate full-tree transport and woody biomass merchandizing at field processing demo.

Conduct pilot-scale gasification of formulated blends of pine residue/switchgrass.



Extended processing campaigns to determine impact of sensors on process efficiency.



Refine technoeconomic analysis and finalize system life-cycle analysis with LEAF data.

Summary

Overview: This project addresses the potential for a depot system to be deployed in the Southern US to increase the quantity of biomass by blending switchgrass and pine, providing a consistently high-quality feedstock engineered for optimal performance in specific processes at an acceptable price point.

Approach: Achieving the vision requires technical and technological innovations in three distinct operations:

1. Whole-tree transport to a centralized biomass depot and merchandising for forest products and residual biomass to their best use, and improving quality.
2. Real-time access to biomass chemical composition with innovative online sensors (NIR) for advanced process monitoring capability.
3. High-moisture pelleting of blends formulated from multiple biomass sources.

Outcome: TEA and LCA based on advanced ASPEN models with LEAF data will provide strategic direction for further refinement and optimization of the Southern depot. Real-time access to information on feedstock properties will introduce new opportunity for increased understanding of the feedstock-conversion interface impact.

THANK YOU

UT AgRESEARCH
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THE UNIVERSITY OF TENNESSEE

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GEORGIA SOUTHERN UNIVERSITY

OAK RIDGE
National Laboratory

AUBURN
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Additional Slides

Criterion 1: Potential Impact of the Proposed Technology Relative to State-of-the-Art

Comment: Applicants did not demonstrate a full awareness of competing technologies for switchgrass logistics.
Response: While not directly in the proposal (primarily due to space/page limits), the partners in this project have researched, developed, and implemented more alternative logistics of switchgrass than anyone else in the country. Logistical systems including baling, chopping, densification, and others have been actively pursued, and extensive insights have been gained as a result of that experience.

Project partner University of Tennessee (UT) has been extensively researching the production and logistics of switchgrass since the late 1970's, first as a forage crop and more recently as a source of biomass for energy and products. Switchgrass logistics research began in earnest in the mid-2000's with the Sun Grant Initiative and early funding for modeling logistical systems. Further work and funding came via competitive grants from DOE and USDA, including two DOE BRDI grants and a more recent USDA Coordinated Agricultural Project grant. These projects have involved a variety of activities that have assessed in-field equipment logistics, movement of material, and challenges associated with meeting the needs of biomass users more efficiently. Other activities have developed knowledge and systems around traffic modeling, greenhouse gas impacts, and economic efficiencies. Research has focused on baling and forage harvesting switchgrass, working with partner Genera Energy. UT has also worked extensively with other project partners as well as national labs (Oak Ridge National Laboratory, National Renewable Energy Laboratory, and Idaho National Laboratory), universities and private companies.

Genera Energy began working with switchgrass logistics in 2008. GEI is the only company that has commercially applied many of the switchgrass logistical systems. Genera has harvested more than 75,000 tons of switchgrass since 2008. Initial logistics systems included various round baling, round bale aggregation, transport, and storage techniques. Round bale logistics included manual aggregation, round bale accumulators, various loading apparatus, and trucking configurations. Storage techniques included different site preparation, stacking, and covering techniques (including uncovered) as well as various storage period lengths. Large format square bale systems have also been implemented. Large square bale systems utilizing different bale densities, harvesting (single vs. multiple pass), self-propelled and pull-behind bale aggregators, and multiple trucking formats have been evaluated, as well. Storage techniques including various underlayment types, stacking and covering configurations have also been analyzed. Various lengths of storage, focusing on quality and other concerns have also been studied for large square bales. Forage harvesting is the third logistical system that Genera has implemented. Early work focused on logistics associated with a two-pass system (mower and then a self-propelled forage harvester) and the transport of the material to a receiving station. Later work was supported by a DOE High Tonnage Logistics Grant and expanded the work to include field-side and shipping location densification of the chopped material with a full trailer compaction unit. Additional work with chopped switchgrass has included ensiling of material and outdoor storage of piled switchgrass.

Criterion 2: Overall Scientific and Technical Merit

Comment: The proposal does not describe how the trailers are loaded, the expected bulk density of the load, how far the depot is from the harvest operation (5 mi haul, 10 mi, 20 mi), and how the trailers will be unloaded. Log trailers are unloaded with one motion of a frontend loader with large grapple and chip vans are unloaded with a truck dump. A number of technologies are available – the proposal should present some general idea how the system will work.

Response: For the proposed system the trailers will be loaded using knuckle-boom loaders at the landing, just as all logs are loaded today in southern pine tree length harvesting systems. Bulk density is a difficult term to quantify since the logs will be loaded onto a log trailer and quantifying volume is problematic. Payload is a more appropriate term on which to focus. The goal of the project is to obtain the full maximum legal payload for log trucks in the southern U.S. While there is some variation from state to state, the typical full payload is 50,000 lbs of logs. The recommended haul distance will be determined by the project's modeling and simulation team: however, the anticipated haul distance from the forest to the depot is relatively short (i.e. less than 25 miles).

The proposed work only involves transporting full trees (not chips), therefore log trailers will be used to transport the biomass. Once this type of system is implemented, we anticipate that the trailers will be unloaded with an overhead crane, which is used universally at wood products mills in the southeast U.S. Systems that transport full trees are in use in at least one pulp mill in Florida, and this mill uses a standard overhead crane. An example of a trailer that is being used to transport full trees is shown in Figure 2. Unloading these configurations is not difficult for the typical wood products mills in the southern U.S. that are equipped with overhead cranes shown in Figure 1.

Figure 1 - Typical crane used to unload tree length log trucks at wood products mills in the southern U.S.

Figure 2 - Log trailer transporting full trees to pulp mill in northern Florida.

Criterion 2: Overall Scientific and Technical Merit

Comment: There are several issues surrounding the issues of using pelletization to manage feedstock moisture: A) One reference was cited to support the claim that biomass (corn stover) can successfully be pelletized at moisture greater than 30%. Unfortunately, this reference is still under review and unavailable to the reviewer to substantiate this claim. This claim contradicts decades of pelleting and cubing research. B) No matter how energy is transferred to the biomass, a given amount of energy per unit mass is required to produce the latent heat of vaporization required to dry the biomass. Based on this, it is not clear how creating that heat by die friction reduces the "pelletization energy … by about 2 times". C) There is not an alternative approach to moisture management should the above method prove unsuccessful.

Response to (A): Prior research on pelleting has bounded the investigation to high density, high durability pellets that are designed long distance transportation. There is a quality tradeoff (density and durability) to high moisture pelleting. We believe that the tradeoff is manageable with significant advantages to logistics and feed handling even at lower density and durability.

According to the existing Pellet Fuel Institute (PFI) pellet standards, bulk density and durability, are normative specifications whereas according to the European Committee for Standardization (CEN) durability is a normative and bulk density is an informative specification (Tumuluru 2015). Pellets with durability values >96.5% and bulk density >640 kg/m3 are designated as super premium pellets based on PFI standards, whereas pellets with durability values >97.5% are designated as pellets with the highest grade.

Response to (B): In our studies we have seen that there is about 7% moisture reduction in pelleting during compression and extrusion through a constricted die hole and further cooling in a pellet cooler. The moisture loss during cooling process is about 2% and moisture loss during pelleting is about 5 % (w.b.). The main reason for moisture loss during high moisture pelleting is due to compression and extrusion which results in frictional heat in the die. During compression and extrusion the some of the surface moisture in the biomass is lost due to moisture flash-off (Tumuluru & Conner, 2015). Moisture flash-off is a common phenomenon when extruding high moisture foods (Shankar and Bandyopadhyay, 2004). The phenomenon of moisture flash off during high moisture pelleting was validated by measuring the expansion ratio of the pellets produced. The pellets produced at high moistures had higher diameters compared to the die diameters (Tumuluru et al., 2015). Higher expansion ratio resulted in lower bulk density (Tumuluru, 2015). Upon exiting the die, pellets are around 70 °C to 80 °C. Any remaining moisture within the material is drawn outward at these temperatures which, when combined with forced convection in a pellet cooler, evaporates moisture from the material.

Criterion 2: Overall Scientific and Technical Merit

Response to (B, cont'd): Our energy analysis indicated that total energy required for pelleting corn stover at optimized process conditions of feedstock moisture content, die speed and preheating temperature for a lab scale flat die pellet mill was about 110 kWhr/ton. Total evaporation energy calculated for 5 % moisture loss was about 68 kWhr/ton. Out of the total pelleting energy more than 50% is used to remove some of the moisture in the biomass. In the high moisture pelleting process, the pellet mill not only compresses and extrudes but also helps to drive some of the moisture from the biomass. Also, the steam conditioning step that is used in conventional pelleting process is avoided which actual takes additional energy of about 30-40 kWhr/ton. Our recent collaborative study with Bliss Industries on pelleting corn stover using their ring die pellet mill (1 ton/hr capacity) has indicated that it takes about 170-180 kWhr/ton to pellet corn stover at about 8-12% (w.b.) moisture content. The bulk density and durability of the pellets obtained were about 650 kg/m^3 and 99.3%.

Another reason for biomass pelleting at high moisture is due to reduction of glass transition temperature of the lignin at higher moisture content. Scanning electron microscope study on high moisture pellets indicated that lignin was observed in crosslinked state which suggests that lignin has reached its glass transition temperature during pelleting. Our initial studies using Dynamic Mechanical Analysis indicated the same fact where the glass transition temperature of lignin decreases with the moisture content.

Our recent studies on ammonia fiber explosion (AFEX) pretreated corn stover and municipal solid waste (MSW) at about 20 and 25% (w.b.) moisture content using Bliss ring die pilot scale pellet mill (1 ton/hr capacity) resulted in pelleting energies in the range of 100-130 kWhr/ton. A similar phenomenon for moisture loss was observed in the process. Pilot-scale, high-moisture pelleting studies have also shown that the bulk density of pellets decreased at higher feedstock moisture content, corroborating our lab-scale pelleting research. The bulk density of the MSW pellets produced at 24-25 % (w.b.) moisture content was about 544 kg/m^3 and pellet durability index was about 98.4%.

Our techno-economic analysis (TEA) analysis indicated that high moisture pelleting process helps to reduce the overall pellet production cost by about 30-40%. The main reason for reduction in pellet production cost is due to replacing the rotary dryer (which is typically used to dry the ground biomass fromn 30-10% (w.b.) in conventional pellet production process) with grain or a belt dryer to dry the high moisture pellets. The other advantages of replacing a rotary dryer with a belt or grain dryer are: 1) greater efficiency, 2) reduced fire hazard, 3) does not need high quality heat, 4) reduced volatile organic compound (VOC) emissions, 5) reduced particulate emissions, and 6) does not agglomerate high clay or sticky biomass.

Response to (C): If this method fails the alternative approach is to utilize forced air convective methods to manage biomass moisture.

GO/NO-GO REVIEW HIGHLIGHT (SEPT. 2016)

Comment: The reviewers offered thoughtful and constructive comments for for each of the Go/No-go decision criteria. Reviewers were unanimous in their opinion regarding the "Go" decision for criteria #1 through #7 (i.e., Tasks 1 and 2):

1. Completed design for prototype log trailer for transporting full trees
2. Completed economic analyses to document costs associated with re-purposing & multiple handling of wood residues for other mkts
3. Appropriate detection technology platform to provide high quality, accurate characterization of biomass feedstocks selected (the quality of the NIR sensor models (R2> 0.65))
4. Retrieved and integrated biorefinery existing data (air velocity, pressure, etc.) into statistical process control system
5. Completed initial process analysis, defining major sources of variation
6. Robust NIR models to predict biomass quality metrics from laboratory studies made available for process studies
7. Spectral sensor installed in merchandizing depot to monitor biomass

Their opinions were split between "Go" and "Not sure" from criteria 8 and 9. Below are the criteria that the reviewers regarded as the weakest segments of the review:

8. Switchgrass/pine blends prepared and characterized to meet target specifications, and to establish protocols to reduce variability.
9. Please comment on plans, as presented, for LCA. *[This is not a Go/No-go decision criterion.]*

For criterion 8 (Task 3), the main criticism was that reviewers were not able to understand what constitutes "success" for this criterion. Additionally, the goal was not very clearly defined. Nor was it clear how many blends would be explored during this work, or why. What are the desired target specifications for these blends? The strategy for creating blends that reduce variation in the physical and chemical characteristics of the feedstock entering a biorefinery was not convincingly presented. When adding the need for a dynamic capability for producing such blends in a biorefinery environment, this goal becomes even more unclear (though outside the scope of this project).

Criterion 9 (Task 4) was not used as a Go/No-go criterion, but some useful comments were provided by the reviewers: The project team appears very strong, the work is clearly important, and the preliminary work presented seems very encouraging. However, there were signs of inadequate communication and cooperation among all the partners, and the importance of this should be re-emphasized to the project leader in writing, even though it was communicated to him in the closing discussion. Another issue that was raised in the final discussion was a lack of distinction between what had been done in previous grant projects and what was being done in this new project. However, on additional review this is not as serious an issue as originally thought.

Go/No-Go Review Highlight (Sept. 2016)

Comment: The comments with regard to criterion 10 (*overall impressions of progress toward overall project goals and objectives, as you understand them*) were also not used for the Go/No-go decision. However, there were issues around communication among the project participants. It seemed clear that at least some of the project participants were not very well connected to the rest of the project activities, even within the same task.

In response, we've been working to improve this issue by:

- Introducing an additional monthly web discussion,
- Additional "specific issue" teleconferences, and
- Face to face conversations were scheduled to more tightly integrate the team.

PUBLICATIONS, PATENTS, PRESENTATIONS, AWARDS & COMMERCIALIZATION

Refereed Proceedings and Papers:

- Pan, P; McDonald, T; Fulton, J; Via, B; Hung, J. 2017. Simultaneous moisture content and mass flow measurements in wood chip flows using coupled dielectric and impact sensors. *Sensors*. doi:10.3390/s17010020.
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. 2017. Tracked Processors & Centralized Logging Depots: The Potential Future for Southeastern Logging. *International Journal of Forest Engineering*, (Publication in progress).
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. 2018. Differences in Total Stem Value when Merchandizing with a Tracked Processor Versus a Knuckle-boom Loader in Loblolly Pine. *Forest Res Eng Int J. 2(4):184-187. DOI:10.15406/freij.2018.02.00045.*
- Hess, J.R., A. Ray and T. Rials (Eds.). 2018. Advancements in Biomass Feedstock Preprocessing: Conversion Ready Feedstocks. Frontiers In Energy, Special Topic. (The special topic in this open-source journal compiles 23 original research articles.)
- Edmunds, C. W., Molina, E. A. R., Andre, N., Hamilton, C., Park, S., Fasina, O., … Labbe, N. 2018. Blended Feedstocks for Thermochemical Conversion: Biomass Characterization and Bio-Oil Production From Switchgrass-Pine Residues Blends. *Frontiers in Energy Research*, *6*(August), 16. https://doi.org/10.3389/fenrg.2018.00079.
- Ou, L., H. Kim, S. Kelley, S. Park. 2018. Impacts of feedstock properties on the process economics of fast pyrolysis biorefineries. *Biofuels, Bioproducts and Biorefining.* 12(3): 442-452. https://doi.org/10.1002/bbb.1860
- Young, T.M., O. Khaliukova, N. André, T.G. Rials, A. Petutschnigg, and C.-H. Chen. 2018. Detecting special-cause variation 'events' from process data signatures using control bands. Submitted to Quality Engineering.
- Zhang, H., T. Edward Yu, J.A. Larson, Burton C. English and S. Jackson, Economic Analysis of the Biofuel Supply Chains Utilizing Single versus Multiple Feedstocks. Manuscript prepared for the *International Journal of Energy Research.*

Non-refereed Proceedings and Papers:

- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. In Proceedings of Council on Forest Engineering annual meeting. Council on Forest Engineering. Morgantown, WV.
- T. McDonald, M. Smidt, J. Fulton. 2017. Big data in forestry. Presented at the 40th International Council on Forest Engineering meeting, 31 July - 2 August, 2017, Bangor, Maine. 5 pp. http://cofe.org/index.php/meetings/proceedings/153-2017-conference-proceedings
- Daniel, M.J., T. Gallagher, T. McDonald, D. Mitchell, and B. Via. (2018). Changing Times: How Technique & Technology Advancements Could Promote Woody Biomass Harvesting in the United States. In proceedings of Council of Forest Engineering (COFE) annual meeting.

Presentations at Professional Meetings:

- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. Council on Forest Engineering Annual Meeting, Vancouver, British Columbia, Quebec, Canada. September 19-22, 2016.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2016. Whole tree transportation system for timber processing depots. Short rotation woody crop conference. Ft. Pierce, FL, October 11-13.
- André, N., W. Edmunds, S. Jackson, N. Labbé, T. Young, and T. Rials. 2016. *Reducing the Cost of Consistent, High-Quality Feedstock from Biomass*. American Institute of Chemical Engineers Annual Meeting, San Francisco, CA; November 14-17.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2017. Whole tree transportation system for timber processing depots. Southeastern Society of American Foresters. Miramar Beach, FL, January 29-31.
- Rials, T.G. 2017. *Next Generation Logistics Systems for Delivering Optimal Biomass Feedstocks to Biorefining Industries in the Southeastern United States*. DOE-BETO Project Peer Review, March 6-9, Denver, CO.
- Lancaster, J., T. Gallagher, T. McDonald, and D. Mitchell. 2017. Whole tree transportation system for timber processing depots. Southern Region Council on Forest Engineering Meeting. Mobile, AL, March 7-9.
- Edmunds, C.W., N. André, T. Rials, N. Labbé. 2017. *Biomass formulation to control feedstock properties for thermochemical conversion*. Symposium on Biotechnology for Fuels and Chemicals. San Francisco, CA, May 1-4.
- Rials, T., N. Labbé, N. André, C. W. Edmunds. 2017. *Producing consistent, high-quality feedstock from mixed biomass sources*. Symposium on Biotechnology for Fuels and Chemicals. San Francisco, CA, May 1-4.
- Edmunds, C.W., C. Hamilton, T. Rials, N. Labbé. 2017. Thermochemical conversion of blended herbaceous and woody biomass feedstocks. American Institute of Chemical Engineers (AIChE) Annual Meeting. Minneapolis, MN, Oct. 29 – Nov. 3.
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- Marissa "Jo" Daniel, Tom Gallagher, Timothy McDonald, Dana Mitchell, and Brian Via. 2018. *Changing Times: Technique & Technology Advancements to Promote Woody Biomass Harvesting in the USA*. Council of Forest Engineering Conference Presentation, Williamsburg, VA, July 15-18.

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- Tom Gallagher. 2018. *Hot Loading Versus Set-Out Trucking*. Southeastern Forest Engineering Conference Presentation, Auburn, AL, September 5.
- Marissa "Jo" Daniel, Tom Gallagher, Timothy McDonald, Dana Mitchell, and Brian Via. 2018. *Tracked Processors & Centralized Logging Depots: The Potential Future for South-eastern Logging*. Southeastern Forest Engineering Conference Presentation, Auburn, AL, September 5.
- Tumuluru, J. S., Dee, M. and Scouten, D. 2018. *Effect of L/D ratio of the pellet die and moisture content on the quality of the pellets made from blends of southern yellow pine residue and switchgrass*. Thermal & Catalytic Sciences Symposium (TCS), Auburn, AL, Oct. 8-10.
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