DOE Bioenergy Technologies Office (BETO) 2015 Project Peer Review

Waste to Wisdom: Utilizing forest residues for the production of bioenergy and biobased products

March 23rd, 2015
Technology Area Review

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Humboldt State University

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Forest Residues

97 million dry tons @ $60/dry ton in 2012: Billion-Ton Update (2011)

Goal Statement

- **Goal**: to develop biomass conversion technologies and in-woods operational logistics that facilitate utilization of forest residues for the sustainable production of biofuels, bioenergy, and biobased products.

- **Expected Outcomes:** Positive environmental and economic impacts, and social benefits throughout the U.S., including…
  - Replacement of fossil fuels,
  - Reduction of greenhouse gas emissions,
  - Improvement of the economics of forest management activities,
  - New jobs in the forest and bioenergy sectors,
  - Promotion of economic development in rural areas.

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Quad Chart Overview

Timeline

- Official start date: 9/30/2013
  - Contracted and funds available in May 2014
- Official end date: 9/30/2016
- Percent complete: 30%

Barriers addressed

- Production of quality feedstocks
- Development of biomass conversion technologies
- Evaluation of environmental and economic benefits

Budget

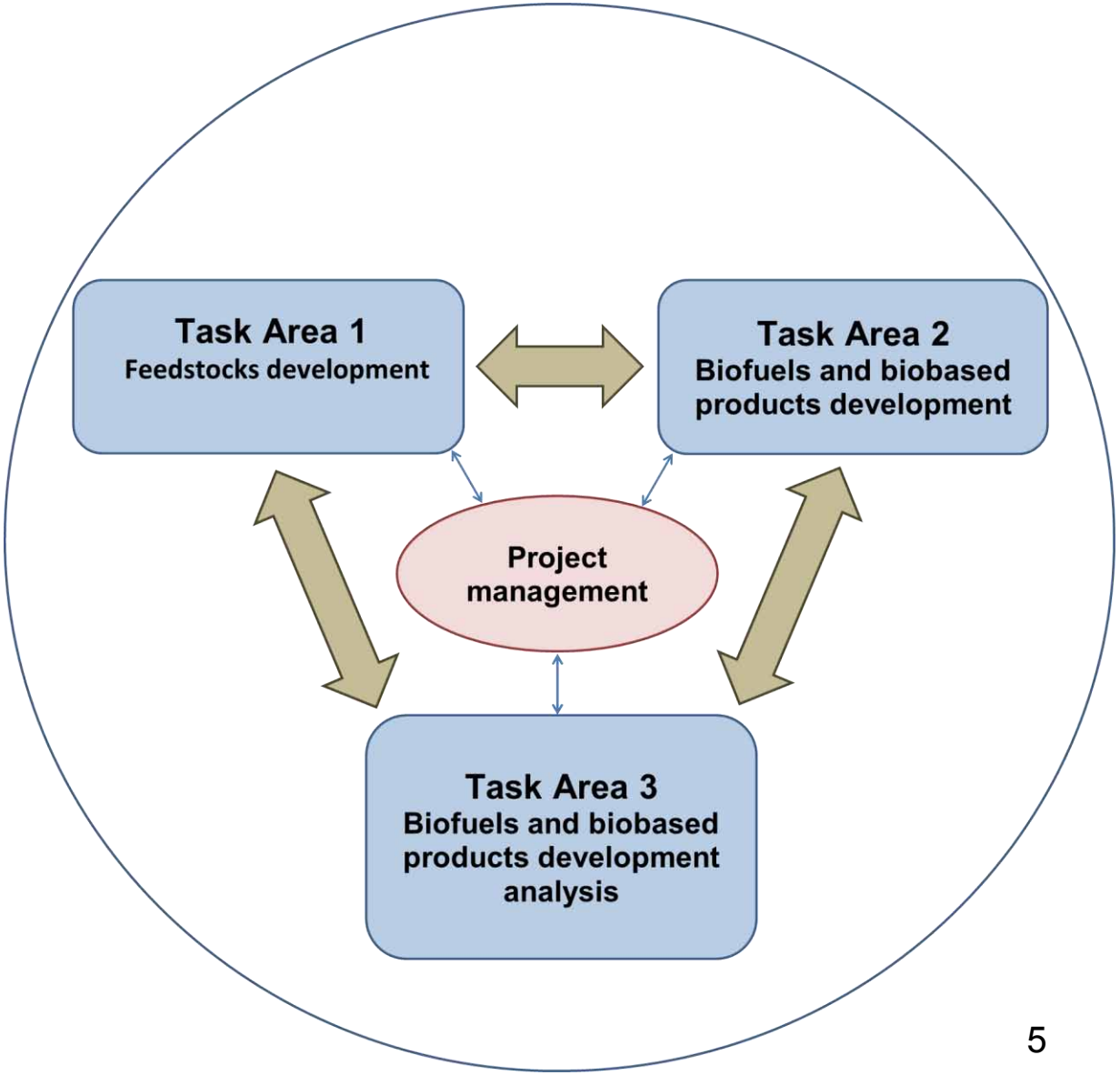
	Total Costs FY 14-FY15	FY 14 Costs	FY 15 Costs	Total Planned Funding (FY 14-Project End Date
DOE Funded	$553,289	$553.289	$2,138,900	$5,881,974
Project Cost Share	$265,444	$265,444	$571,211	$1,570,883

Partners

- Partners/Collaborators
  - DOE
  - USDA Forest Service
  - Land-Grant Universities
  - Forest Products Co.
  - Biomass Engineering Co.
- Project Management:
  - Humboldt State University

Project Management

DOE
Project Manager and Monitor



Partners (Principal Investigators - PI)

Task Area	Name	Institution	Invol.* (%)	Expertise
TA1	Han-Sup Han	Humboldt State Univ.	18	Forest Operations
	John Sessions	Oregon State Univ.	5	Transportation
	James Dooley	Forest Concepts Inc.	5	Forest Engineering
TA2	Arne Jacobson	Humboldt State Univ.	14	Env. Engineering
	Jonah Levine	Biochar Solutions Inc.	13	Biochar
	Aaron Norris	Norris Thermal Tech.	10	Torrefaction
	John Crouch	Pellet Fuels Institute	5	Pellet Equipment
TA3	Debbie Page-Dumroese	US Forest Service	4	Forest Soils
	Elaine Oneil	CORRIM	2	Life Cycle Analysis
	E.M. Bilek	US Forest Service	8	Forest Economics
	Richard Bergman	US Forest Service		Life Cycle Analysis
	Ivan Eastin	Univ. of Washington	12	Forest Marketing
	Craig Rawlings	For. Business Network	5	Public Outreach

*Partners involved in the project, expressed as % of project funding from DOE

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1 - Project Overview

- **History:** forest residues underutilized and wasted due to high collection and transportation costs and low market values
- **Context:** Converting forest residues into biochars, torrefied wood chips, and briquettes in a forest operations site
- **Objectives:**
  - **TA 1**: Production of quality feedstocks from forest residues and development of innovative biomass operations logistics
  - **TA 2**: Development of biomass conversion technologies (gasification, torrefaction, and briquette) that will be operated at a forest operations site
  - **TA 3**: Determining economic and environmental success of utilizing forest residues for production of biofuels, bioenergy, and biobased products

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1 - Project Overview (cont'd)

In-woods Biomass Conversion:

- ✓ Decrease transportation costs
- ✓ Increase product values
- ✓ Improve feedstock properties for energy production

Forest Residues

Biochars

Briquettes

Torrefied chips

2- Approach (Technical)

- ***Feedstocks Development (TA1):***
  - Sort and process forest residues to produce quality feedstocks
  - Compact forest residues into high-density bales
  - Develop logistics models integrating both in-woods biomass operations and conversion technologies
- ***Biofuels and Biobased Products Development (TA2):***
  - Evaluate the technical performance of three technologies (biochar, torrefaction, and densification systems) that are designed to run in a forest operations site
  - Building scale-up biomass conversion technologies from existing pilot systems that were proven to be functional
- ***Biofuels and Biobased Products Development Analysis (TA3):***
  - Evaluate the financial feasibilities of the technologies
  - Determine their economic and social impacts
  - Analyze the ecological sustainability of the processes

2 – Approach (Management)

Critical success factors:

- Collaboration between a wide range of researchers and companies
- Regular monitoring of project progress by three task coordinators
- Project accountants and coordinators provide administrative and technical supports such as instructions and templates for invoices and reports

Potential challenges:

- Meeting project end date with delayed funding
- Coordinating a large team with diverse research tasks

Project management structure:

- One PI overseeing each task area and coordinating with two task area team leaders with clearly defined responsibilities
- Management coordination through monthly project management conference calls with DOE project manager and monitor
- Annual research team meetings

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3 - Technical Accomplishments / Progress / Results

Task Area – 1, Feedstock Development

Progress meeting project objectives:

- Determined additional cost to sort and arrange residual woody biomass derived from timber harvest
- Characterized the quality of feedstock generated from sorted residues
- Tested the productivity and effectiveness of two different screening machines (Star and Deck)
- Improved design of baler to collect and densify forest residues
- Developing models to integrate the collection, processing, and transportation of material on a landscape level.

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

Task Area – 1, Feedstock Development

Most important technical accomplishments:

- Gained a greater insight into the methods and costs of sorting and arranging forest residues
- Produced high-quality feedstocks (size distribution, ash content, and bulk density) through comminution and screening for BCTs
- Established bale density target (25-30 lb/ft^3) and the baler design upgraded and ready for field testing
- Completed a mathematical model for landscape planning

Key milestones and status:

- Continuing field-based studies sorting, grinding/chipping, screening, and moisture content measurements
- Field trials of the baler planned for May-June 2015 in Arcata, California

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

Task Area – 2, Biofuels and Biobased Product Development

Biochar Machine

- Testing and data analysis completed
- Methods developed for time and motion studies
- Machine improvements currently under development

Torrefier

- Preliminary tests completed
- Machine being instrumented for field testing

Briquetter

- Preparation completed for April 2015 testing
- Mobile briquetter being sent to northern California for field testing

Remote Power Generation

- Biomass gasifier generator system selected as preferred remote power generation technology

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

Task Area – 2, Biofuels and Biobased Product Development

Most important technical accomplishments:

- Detailed biochar machine testing and data analysis completed
- Through these experiments, test protocol and data analysis methods have been developed

Key milestones and status:

- Field tests of all three biomass conversion technologies will be completed during summer 2015
- Performance data summaries will be distributed to the broader project team following data analysis

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

Task Area - 3, Biofuels and Biobased Product Development Analysis

Most important technical accomplishments:

- Financial model constructed with validation underway
- Methodology adapted for input-output analysis of overall economic impacts
- Three field sites established to test ecological sustainability of biochar application
- Website and a logo designed

Key milestones and status:

- Draft costing model of a forest-to-energy system will be completed
- Life cycle and chemical analysis of field site data will begin
- Stakeholder workshop will be conducted

4 - Project Relevance (to BETO MYPP)

This project aims to *"develop technologies to provide a reliable, affordable, and sustainable supply of terrestrial feedstocks to enable a nascent and growing bioenergy industry… and … develop commercially viable technologies to convert feedstocks into bioproducts and biopower."*

"Waste to Wisdom" - an integrated approach that will:

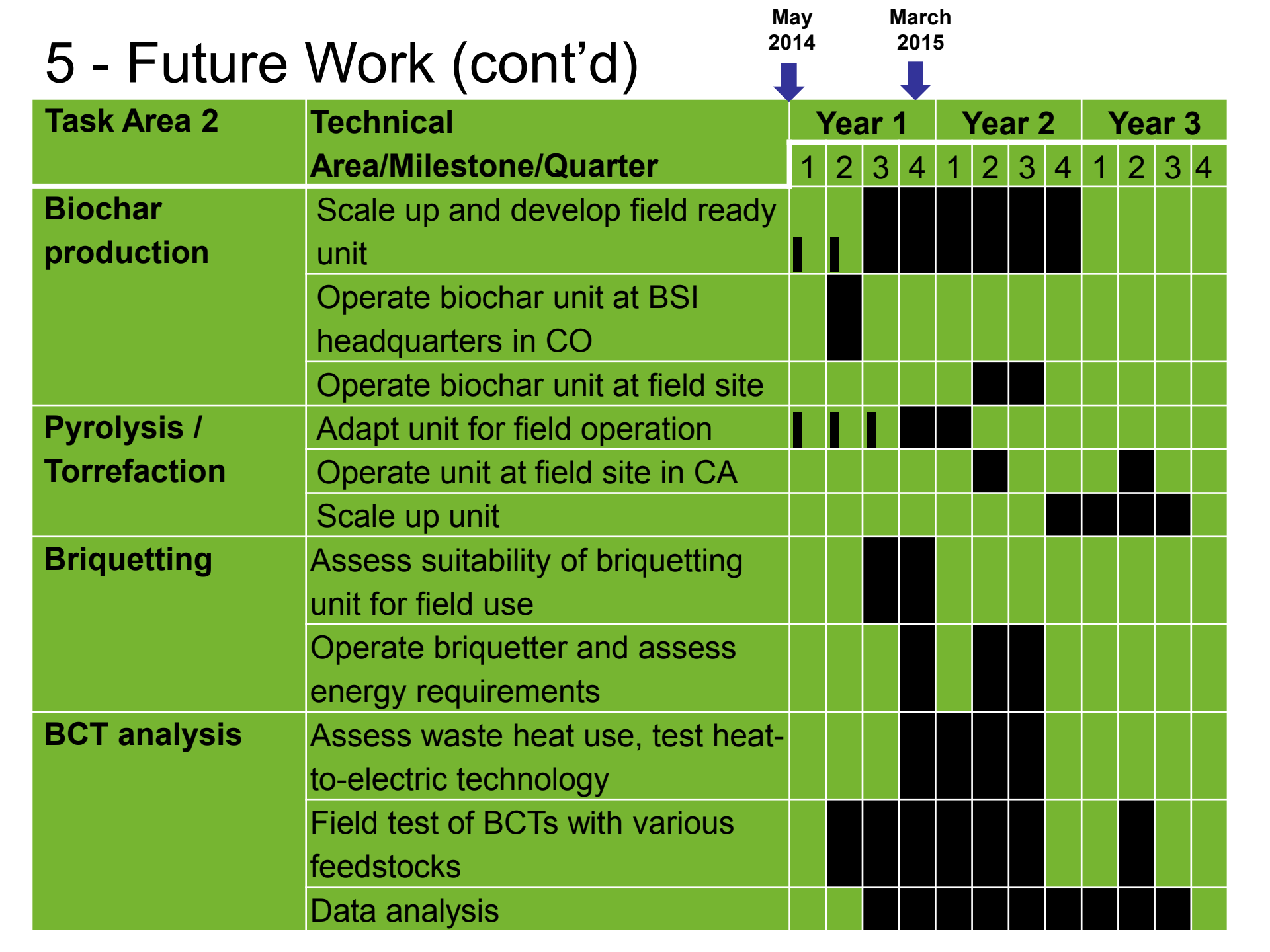
- Provide significant advancement in terrestrial feedstock supply and logistics that meet the MYPP target of $80/dry ton with low ash contents (<1%)
- Show how integrating BCTs into feedstock logistics can increase transportation efficiencies and improve longer-term feedstock storage in depots or biorefineries
- Provide products that reduce physical and chemical variability to ensure more reliable and efficient biofuels as a replacement for coal, compatible with existing infrastructure and reducing overall emissions
- Provide credible data and projections on current and future costs, social benefits, and environmental impacts, which will reduce uncertainty to developing biorefinery technologies

5 - Future Work

May 2014 March 2015

Task Area 1	Technical Area/Milestone/Quarter	Year 1				Year 2				Year 3			
		1	2	3	4	1	2	3	4	1	2	3	4
Biomass Collection & Processing	Sorting, arranging, comminution, and screening	■	■	■	■	■	■	■			■	■	
	Feedstock quality control experiments	■	■	■		■	■	■			■	■	
	Biomass operations integrated with BCTs	■	■	■			■	■	■	■	■	■	
Baler Technology	Productivity & cost analysis for forest residue types		■	■	■		■	■	■				
	Development of baling system logistics			■	■		■	■	■	■	■	■	
Transportation Analysis & Feedstock Scheduling	Biomass feedstock pathway development & analysis		■	■	■	■	■	■	■	■	■	■	
	Landscape scale feedstock scheduling model		■	■	■	■	■	■					
	Model validation & modification			■	■	■	■	■	■	■	■	■	

5 - Future Work (cont'd)



5 - Future Work (cont'd)

Task Area 3	Technical Area/Milestone/Quarter	Year 1				Year 2				Year 3			
		1	2	3	4	1	2	3	4	1	2	3	4
Economics & Marketing	Integrated engineering/costing models												
	Market assessment & strategic marketing plans												
	Economic impacts of biochar carbon sequestration												
Social Impacts	Social, envr. and economic evaluation												
	Avoided cost analysis												
Ecological sustainability	Field trial: Biochar application												
	Chemical analysis of soil samples												
	Seed germination, biochar application												
Life Cycle Analysis	LCI/LCA development												
	Spatial analysis and inventory assessment												
Project Outreach	Website development, technology transfer & marketing												
	Organize webinars, workshops and conferences												

Summary

- ✓ **Overview:** Utilization of forest residues for the sustainable production of biofuels, bioenergy, and biobased products
- ✓ **Approach:** Integration of new biomass conversion technologies with in-woods biomass operations
- ✓ **Technical Accomplishments/Progress/Results:** Significant progress made with production of quality feedstocks from forest residues; developed and tested pilot models of biomass conversion technologies and prepared them for a demonstration at a forest operation site; and analysis underway to evaluate economic, social and environmental benefits
- ✓ **Relevance:** Significant advancement in meeting the MYPP goals of sustainable supply of terrestrial feedstock and development of innovative biomass conversion technologies
- ✓ **Future work**: Continue working to meet the project timeline outlined in the Statement of Project Objectives (SOPO)

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Questions?

2- Approach (Technical)

Overall Approach:
Integration of new biomass conversion technologies (BCTs) with in-woods biomass operations: a solution to barriers.

Critical Success Factors:
- Built a team of PIs with proven knowledge and experience in each task
- Building scale-up biomass conversion technologies from existing pilot systems that were proven to be functional
- Excellent collaborations with private companies and forest landowners

Potential Challenges:
- Providing results that are relevant over a wide range of factors influencing conversion applications
- Finding markets that will accept the products from the BCTs at prices that will pay for the capital investments and operating costs.

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List of Abbreviations

- BCT – Biomass Conversion Technology
- BDT – Bone Dry Ton
- BETO – Bioenergy Technologies Office
- BSI - Biochar Solutions Inc.
- CORRIM - Consortium for Research on Renewable Industrial Materials
- DOE – U.S. Department of Energy
- LCA – Life Cycle Analysis
- LCI – Life Cycle Inventory
- MYPP – Multi-Year Program Plan
- PI – Principal Investigator
- SOPO – Statement of Project Objectives
- TA – Task Area

Additional Slides

Sorting & Moisture Content Study

- Study in progress
- 5 months of moisture samples collected and analyzed
- One full year of data (ending in July) will be collected

Piled arrangement

Teepee arrangement

Criss-cross arrangement

Scattered arrangement

Covered and uncovered

Screening to produce uniform feedstocks

- Objective – To evaluate fuel consumption, productivity, and the effectiveness of separating ground or chipped woody biomass using star and deck screeners.

Biochar Machine Testing Matrix

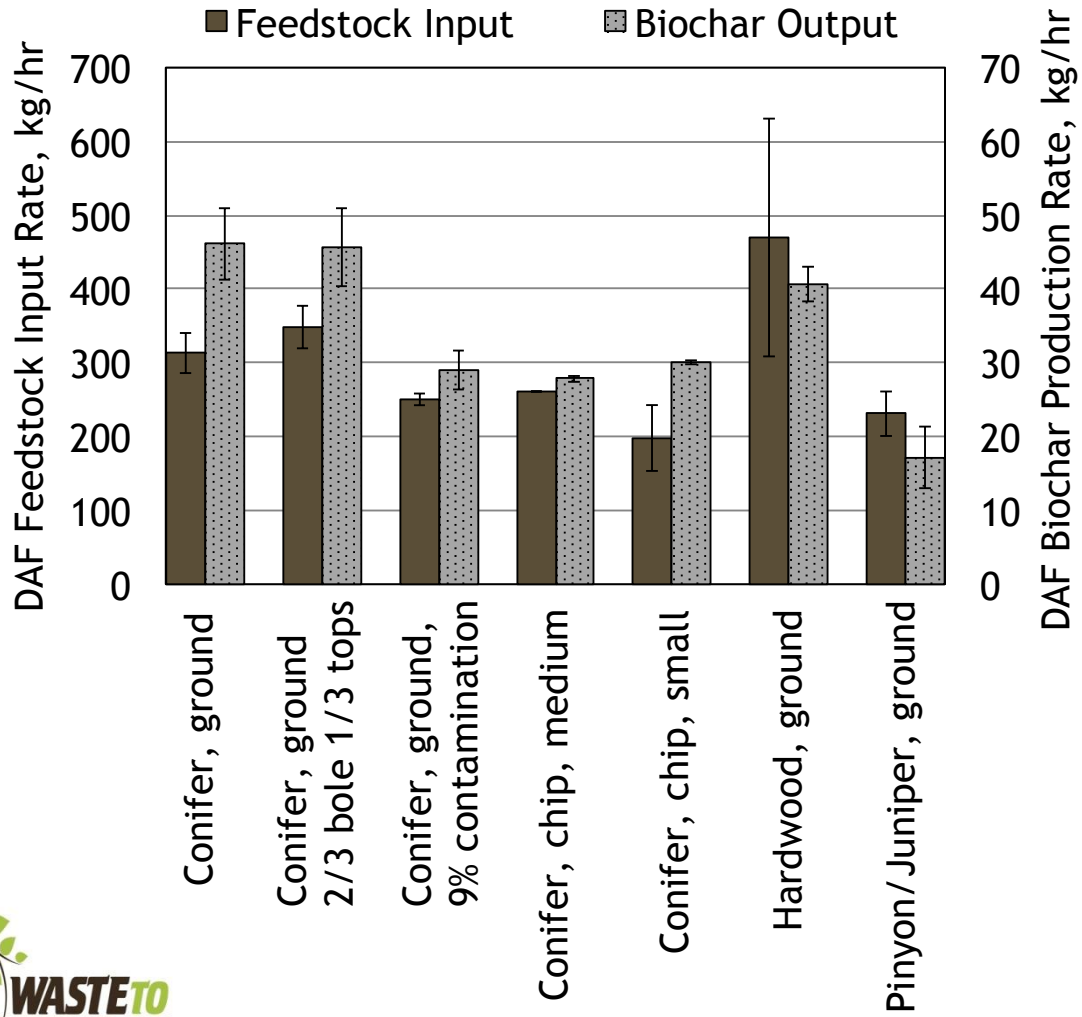
The biochar machine was tested in August 2014 in Pueblo CO to determine the effect of feedstock species and quality on operational parameters.

Species	Conifer		Conifer		Conifer		Conifer		Conifer		Hardwood		Juniper	
Comminution Method	Ground		Ground		Ground		Chip		Chip		Ground		Ground	
Contaminant	none		2/3 bole, 1/3 tops		9% soil		none		none		none		as received*	
Moisture Content	15%	19%	17%	15%	14%	16%	37%	25%	22%	20%	15%	16%	10%	10%
Ash Content	2%	2%	7%	2%	14%	14%	0.7%	0.1%	3%	3%	0.3%	1%	26%	21%
Particle Size (% mass) (<0.1”/0.1”-1”/>1”)	12/80/9		14/77/9		14/77/8		1/99/0		31/69/0		20/79/1		28/64/8	

* Contamination was not added, however the juniper feedstock was highly contaminated as received.

Feedstock Throughput and Yield

Feedstock input and biochar output rates on a dry, ash-free basis (DAF).



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Pathways to biomass conversion