Improved Advanced Biomass Logistics
Utilizing Woody Feedstocks in the Northeast and Pacific Northwest

SUNY-ESF

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March 27, 2015
Technology Area Review
Goal Statement

• Principal goal is to lower the delivered cost of short rotation woody crops by optimizing a commercial-scale supply system:
  – $80 Dry Ton total cost to throat of conversion reactor
  – $50 Dry Ton for all cumulative logistic costs (excluding grower payments)

• Fits with terrestrial feedstock goals:
  – (1) reducing the delivered cost of sustainably produced feedstock
  – (2) preserving and improving the quality of harvested feedstock to meet the needs of biorefineries and other biomass users
Quad Chart Overview

Timeline

- Start: Anticipated Summer 2015
- End: Summer 2018

Barriers Addressed

- Ft-A. Feedstock Availability and Cost
- Ft-D. Sustainable Harvesting
- Ft-G. Feedstock Quality and Monitoring:
- Ft-H. Biomass Storage Systems:
- Ft-L. Biomass Material Handling and Transportation
- Ft-M. Overall Integration and Scale-Up

Budget

<table>
<thead>
<tr>
<th>DOE Funded</th>
<th>Total Planned Funding (FY 15-Project End Date)</th>
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<td>~$3.0 million</td>
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| Project Cost Share (Comp.)* | ~$936,000 |

*If there are multiple cost-share partners, separate rows should be used.

Partners

- SUNY ESF
- Case New Holland
- Greenwood Resources
- ORNL – WVU – INL (modeling)
- Applied Biorefinery Sciences
- Celtic Energy – ZeaChem – ReEnergy
1 - Project Overview

• Previous project (August 2010 to August 2014)
  – Primary focus was on harvester development for SRWC

• Previous Achievements
  – Increased harvester performance
  – Decreased costs by approximately one third
  – Achieved consistent quality from harvester (particularly chip sizes)
  – Improved methodology for tracking harvester performance
    • Better understanding of harvester performance
    • Identified logistics optimization factors including capacity & number of collection vehicles, haul distance, and harvest pattern

• Unsolved Issues
  – Harvesting system has not been optimized
  – Changes in feedstock quality through supply system
  – Relate specific crop and site conditions to harvester performance
    • Difficult to make specific recommendations for improving system
    • Can only evaluate inefficiencies in a general way
History - Harvesting Equipment in this Project

- New Holland FB-130 Coppice Header
- Designed to fit New Holland 9000 and Forage Cruiser series of forage harvesters
Factors affecting throughput

1. Ground Conditions
2. Vegetation Characteristics
   ✓ Shape and form
   ✓ Planting design
   ✓ Density of material
3. Mechanical limitations
   ✓ Horsepower
   ✓ Feed rates
   ✓ Flow into throat of harvester
4. Operator experience

(Eisenbies et al. 2014)
A variety of collection vehicles were tried during previous harvesting operations.
History Collection System Performance

“Out the Spout” to Storage

62-66% loss of efficiency overall

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Overall Efficiency:
- **62% decrease** from 70 down to 26 Mg hr⁻¹
- **66% decrease** from 77 down to 25 Mg hr⁻¹
2 – Approach (Technical)  Five Task Areas

1. **Harvesting Logistics of SRWC Systems**
   - Expanding the harvesting window (Engineering methods to remove leaves and snow)
   - Iterative process of modeling simulation and field trials to decrease costs
   - Improve data collection to integrate plot-level data with machine performance

2. **Transport and Storage** of SRWC feedstocks
   - Devise methods for tracking feedstock quality in a commercially realistic context
   - Integrating SRWC with existing forest-based biomass systems

3. **Pre-Processing and Blending** with other forest-based biomass to improve feedstock quality
   - Pre-processing methods such as HWE be used to increase feedstock value
   - Pre-processing and screening methods be used to stabilize feedstock quality

4. **Feedstock Characterization** throughout the supply chain
   - Baseline characterization of Willow and Poplar biomass crops
   - Devising high-throughput screening systems for SRWC feedstocks

5. **Logistic and Economic Modeling**
   - Develop advanced logistics and process simulation models and optimize planning and management of new and existing systems (Integrating Tasks 1-4)
2 – Approach (Management)

- **Critical Success Factors**
  - Achieve the $80 and $50 per dry ton costs to meet BETO goals
  - Improve system efficiency
  - Expand harvesting window
  - Developing and implementing system to affordably monitor quality (e.g. moisture content, ash content) in the field

- **Challenges**
  - Working in fields that did not implement recommended planting designs
  - Coordination of multiple independent players along supply chain
    - Coordinating harvesting trials
    - Tracking feedstock quality through supply chain
  - Engineering leaf and snow handling systems
  - Developing models and sampling protocols for measuring quality in the field

- **Structure**
  - Iterative: Model Simulation/Optimization & Harvest Planning ➔ Harvest Trials
  - Monthly phone calls and quarterly assessment of milestones using PMP
  - Annual meetings organized around harvests
  - Go/No-Go meeting midway through project
3– Relevance

**BETO Platform Goals and Objectives (MYPP)**
- Meet the $80 and $50 dry ton objectives
- Addresses important facets of terrestrial feedstock supply and logistics in the MYPP
  - Biomass production, Harvest and collection, Storage, Transport and Handling, Preprocessing, Quality Characterization and Assessment
- Addresses important facets of conventional logistic systems and moves SRWC in the direction of advanced logistics systems identified in the MYPP

**Applications for the emerging bioenergy industry**
- Working with private growers and end users to optimize the system to meet their needs in two regions.
  - 480 ha of shrub willow in NY
  - ~140 ha of hybrid poplar in Oregon
- Ensure that quality is maintained and/or identify quality challenges throughout supply chain to meet/preserve end user specifications
- Supply samples and quality data to INL feedstock library

**Advance the state of technology**
- Document and develop best practices for harvesting and establishment in conjunction with commercial growers and end users
- Developing and implementing system to affordably monitor quality (e.g. moisture content, ash content) in the field
Summary - Modeling Effort

IBSAL: Simulation & Harvest Plans ➔ Harvesting Trials
Summary - Modeling Effort

INL Example: Resource Availability for Woody Crops and Corn Stover
Site locating using a multi-objective decision model
- Suitability indices using a fuzzy-logic model
- Optimize feedstock mixes and logistics

Two-Stage modeling process
- Examine site suitability indices (economic, environmental, infrastructure, societal)
- Evaluate and entail the ranking of potential locations

WVU: Integrating Supply Chains at the Regional Scale
Summary – Couple conditions to performance

- In previous project, machine performance was assessed on a load basis (i.e. row or part of row with 8-12 tons of biomass)
- Now, we plan to evaluate machine performance relative to crop and field conditions at a much finer scale
  - Crop yield
  - Stemform
  - Soil conditions
  - Engine load
  - Fuel consumption

Distribution of engine load for New Holland Harvester in coppice hybrid poplar energy crops
Summary - Expand the harvesting window
Summary - Improve Harvesting Logistics (IBSAL)
Summary – Rapid Feedstock Assessment

Near Infrared Spectroscopy (NIR)
• Fast (20 seconds)
• Nondestructive
• Small sample requirements

Calibration required to compare lab/field NIR equipment

Most reliable calibrations
• Same species
• Same particle sizes

Quality Attributes
Moisture, Cellulose, HemiC, Lignin, Ash, and possibly “extractives”
Summary – Hot Water Extraction

Applied Biorefinery Sciences (ABS) Approach

- Hot-water based
- Incremental deconstruction
- Membrane technology
- Fermentation
- Product recovery

A means to improve feedstock quality while creating additional revenue streams
Ash content of blended pellets comprised of maple with willow, HWE willow, and HWE maple.
Summary - Relevance

• Develop advanced logistics and process simulation models to optimize planning and management of the new and existing systems (Integrating Tasks 1-4)
• Anticipate improved reliability and efficiency of a SRWC that will improve economics and advance these systems in two regions
• ReEnergy Holdings have signed contracts to purchase all the willow biomass from 1,200 acres in northern NY
• US Army has signed 20-yr power purchase agreement with ReEnergy
• ReEnergy is interested in increasing the proportion of willow in their feedstock supply
• Advanced Bioenergy Sciences is developing scale-up plans and pellet producers are interested in residual material
• Hybrid poplar biomass crops are being expanded to supply ZeaChem
Questions