Biochemical & Thermochemical High Throughput Characterization of Feedstocks

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Biochemical &Thermochemical Conversion

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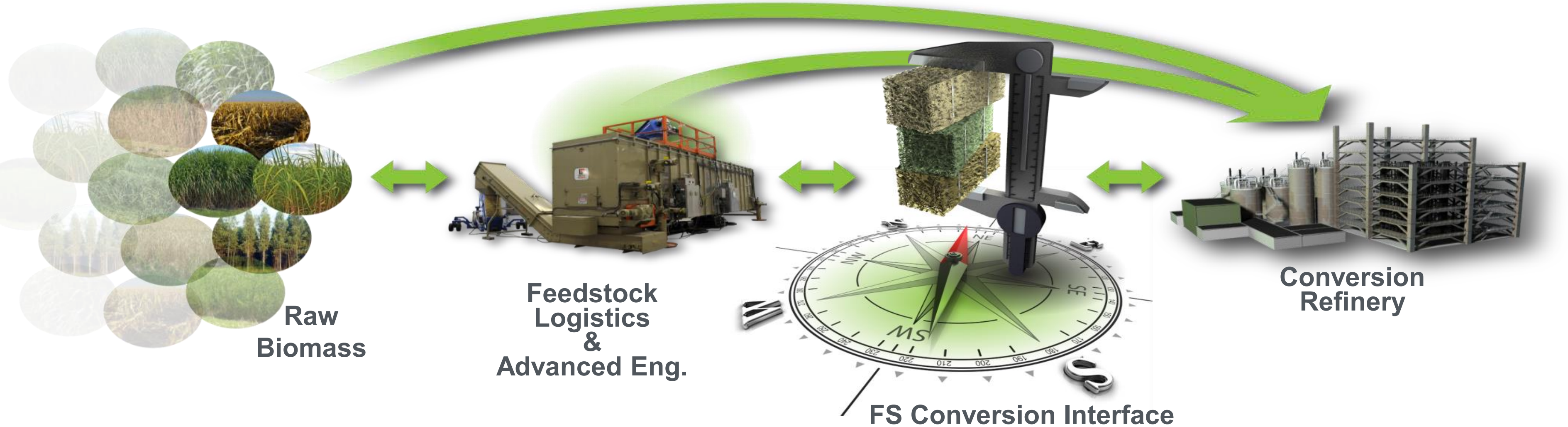
Goal Statement

Goal: Enable consistent high throughput characterization of large numbers of biomass samples

- Support BETO's 2017 goal of producing optimized dynamic blendstocks that meet cost, quality, & conversion targets
- Understand variability & bound specifications to allow blendstock formulation
- Support development of feedstock specifications/grades & quality control options for exchange-point valorization



Quad Chart Overview

Timeline

- Project start date: Nov. 2014
- Project end date: 2017
- Percent complete: 5%

Barriers

- Ft-G Feedstock Quality & Monitoring
- Ft-J Biomass Material Properties
- Bt-B Biomass Variability

Budget

	Total Costs FY 10 – 12*	FY 13 Costs‡	FY 14 Costs*	Total Planned Funding (FY 15)
2.2.1.303 Thermo	$715K	$433K	$227K	$250K
2.6.2.106 Bio	$369K	$1,106K	$215K	$285K

*Equipment budget

‡ Research/Equipment budget

Partners

- Idaho National Lab – TC Interface, BC Interface & BFNUF
- Eberbach Corporation – in-kind hardware support & robotics expertise
- BYUI – potential BYUI professor sabbatical

Project Overview

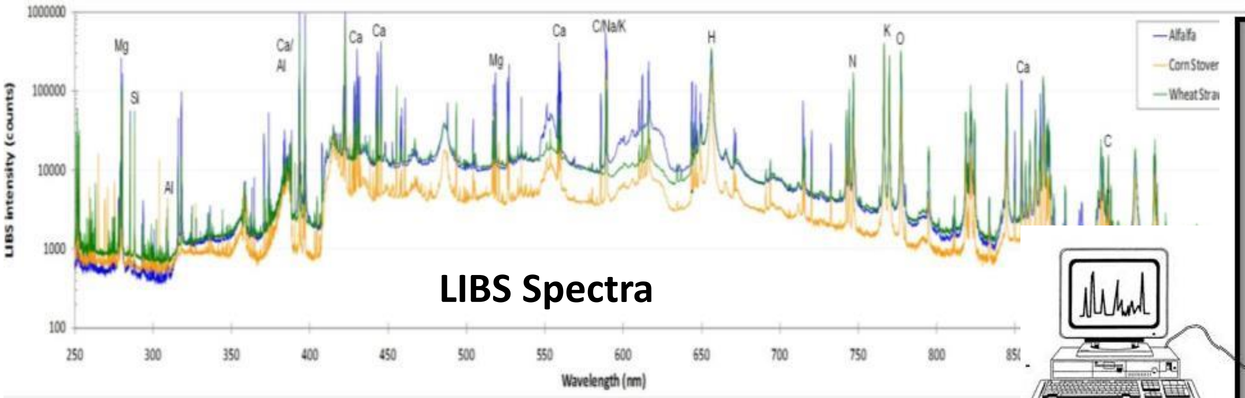
Context:

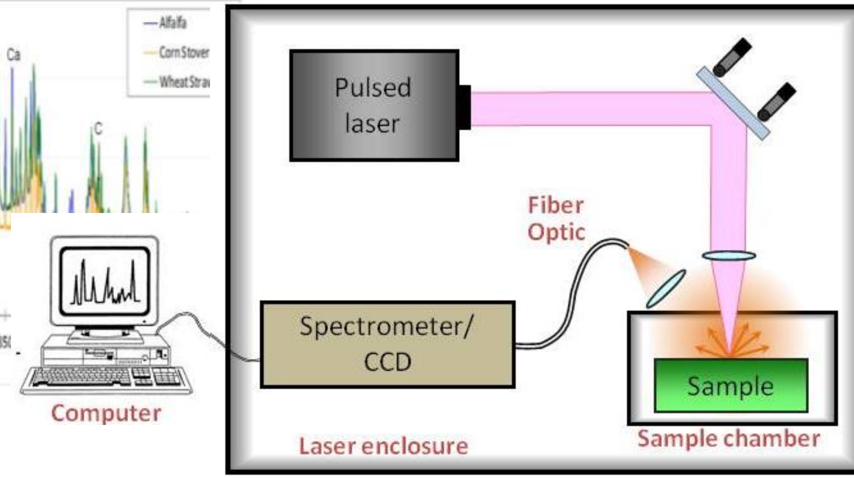
- Currently sample comminution & sample preparation must be performed on any sample requiring detailed characterization
- Major hurdle to rapid-screening methods & exchange-point quality control
  - E.g., preparation & transfer of ~450 samples for NIR compositional characterization; greater than 2000 samples characterized overall
    - 415 man hours (8 staff members) resulting in ~1 man hr/sample
- Impacts all aspects of research within the Feedstock Platform
  - FS Blending Strategies, Storage, Interface, Densification, Preprocessing, RFP, Analysis, BFNUF, SOT, FGIS approach

Project Objectives:

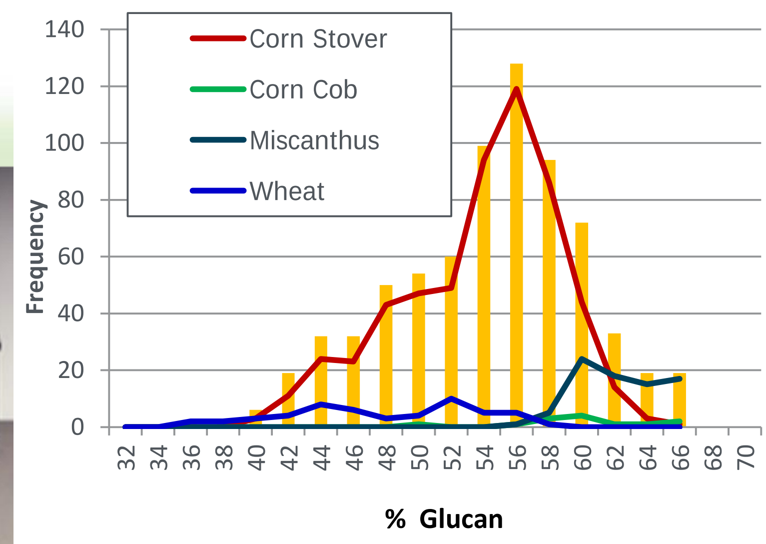
- Develop automated sample preparation methodology to reduce human interactions & increase sample throughput

2 – Technical Approach





- Automated sample preparation allows analysis of large sample numbers using rapid-screening techniques to optimize overall sample throughput
  - LIBS screening
  - NIR screening
  - Other conventional techniques



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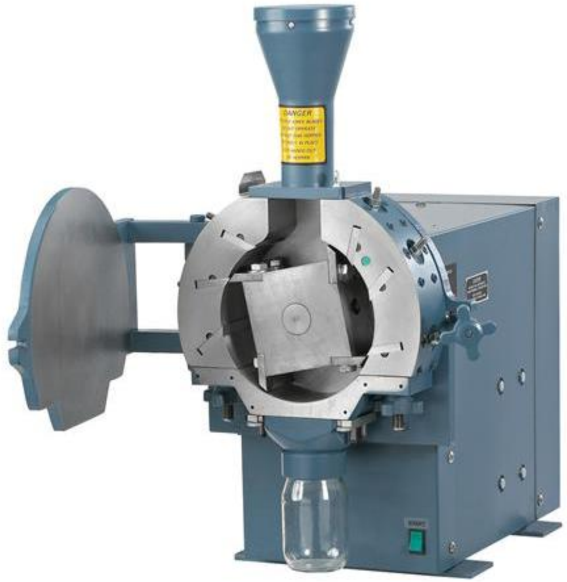
2 – Technical Approach

- **High throughput comminution based on Thomas Scientific Wiley Mill or consistent morphology**
- **Optimize comminution process**
  - Improve mill performance
  - Improve mill throughput cycle
- **Automate core processes**
  - Operator provides queuing system
  - Autonomous operation for input, grinding, collection & cleanup
- **Semi-Automated Sample tracking**
  - Linked to Bioenergy Feedstock Library



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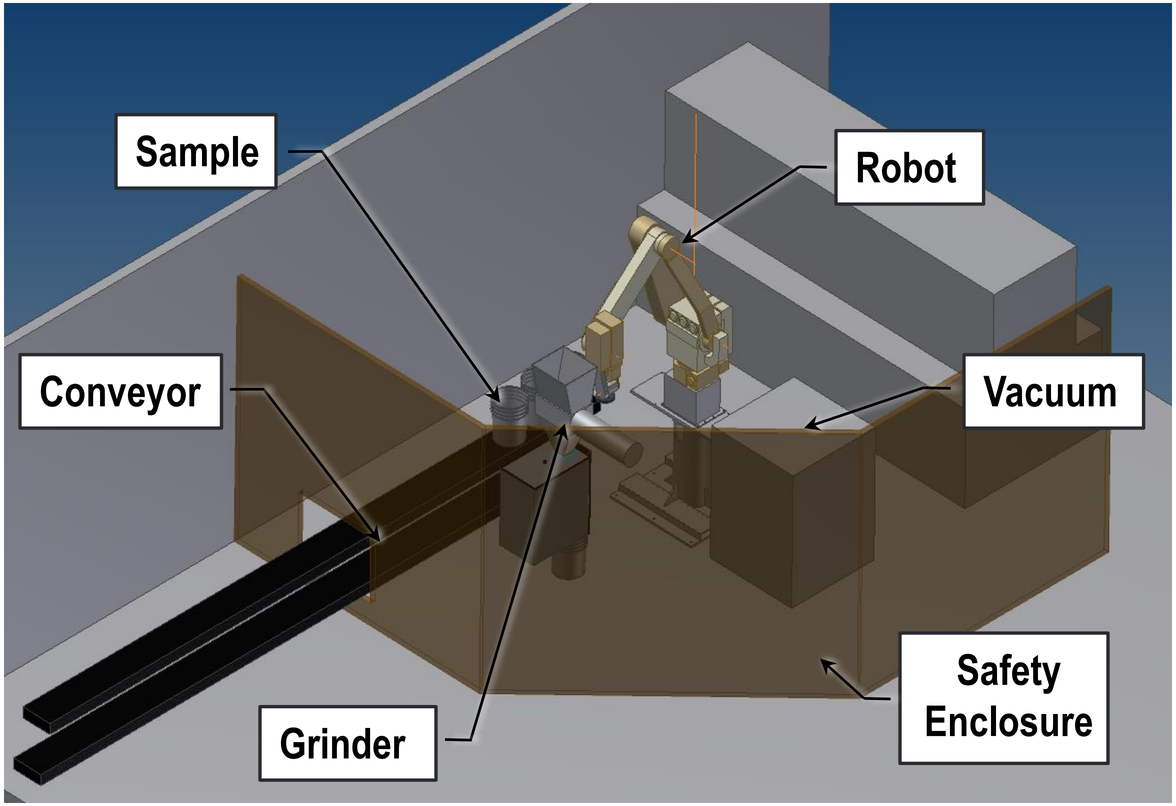
2 – Technical Approach

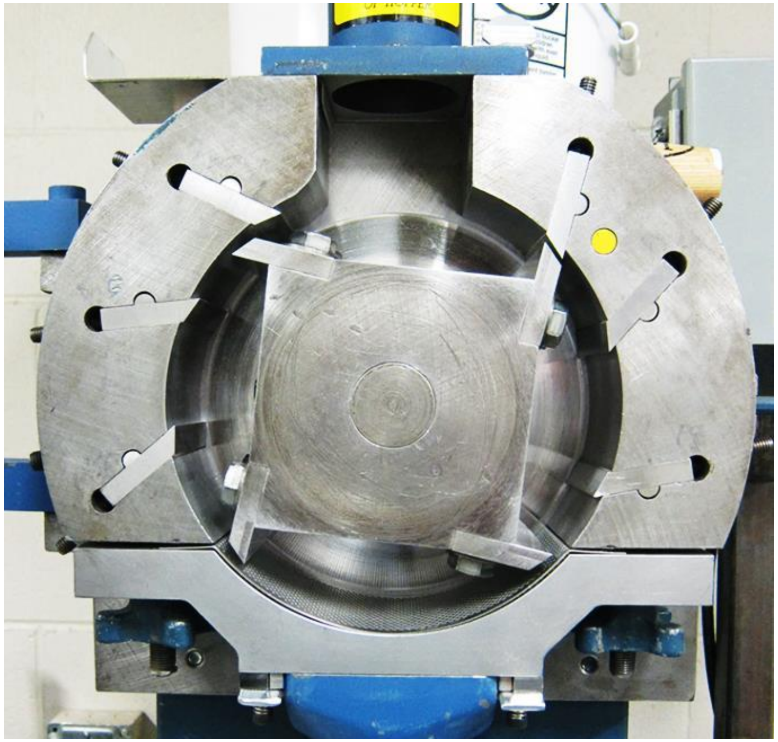


Process Flow

- Samples placed in conveyer queue
- Robot removes container from queue & introduces sample to inlet hopper
- Sample ground through mill
- Ground sample collected into bucket
- New sample is re-barcoded
- Robot places sample onto outlet conveyor
- Robot cleans mill to eliminate x-contamination

2 – Technical Approach

- Thomas Scientific Wiley Mill – mill box geometry & sieve critical to achieving correct particle morphology
- Automated system to feed & collect sample from mill – leveraging existing robotic system
- Mill will be monitored – system will control feed rate to ensure optimal mill performance
- Data collection & control feedback during milling process – grinding energy, temperature, etc.



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2 – Technical Approach

- PaR Systems Robotic Manipulator
  - 6-DOF Robotic Manipulator
  - 5 ft. Reach
  - 60 lb. Payload Capacity
  - Sealed (wash down capable)
- Leveraged from Yucca Mountain Project
  - Hardware leveraged value ~$500K
  - Development effort leveraged (software interface, control, etc.)
- Staff robotic expertise leveraged from extensive experience on Yucca Mountain project & commercial collaborator

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2 – Technical Approach

Top technical challenges:

- Consistent feeding of mill with sample materials that have different characteristics (i.e. woody vs. herbaceous)
- Wiley mill cooling – initially designed for low-volume grinding
- Cleaning & sample recovery
  - Some sample segregation occurs via electrostatic attraction of fines to grinder surfaces & outlet tube
  - Incomplete recovery of sample can impact analytical results

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2 – Management Approach

Success Factors

- Integration with Feedstock Conversion Interface projects & BFNUF is critical for project success
- Collaboration with Eberbach Corp. provides an opportunity to work directly with the grinder manufacturer
- Ability to generate large feedstock data set in a rapid manner will support all aspects of BETO Program
  - Exchange-point specifications

Approach

- Project execution has been divided into milestones based on development of subsystems & interaction of subsystems
- Leverages extensive experience with complex robotic systems

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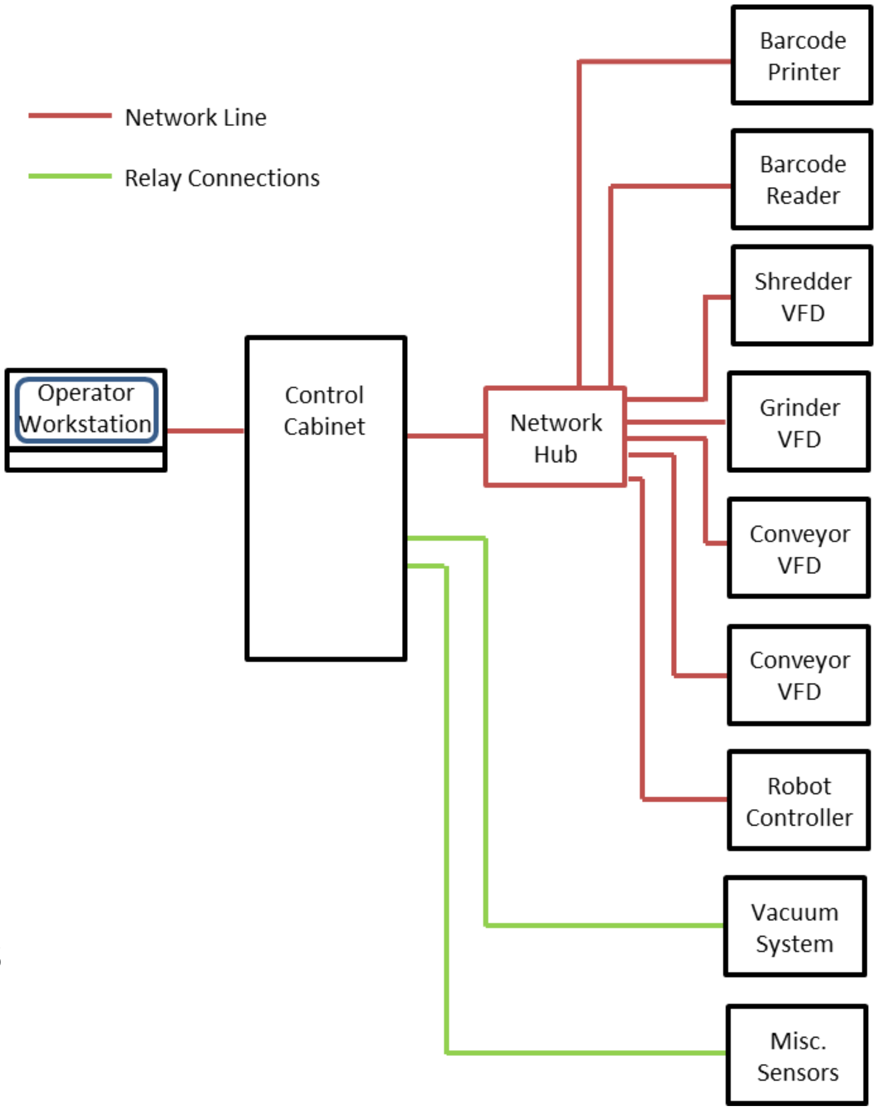
3 – Technical Progress

Project is in the early stages

- Equipment & software procurement completed
- Mill & PaR robot co-located in laboratory
- Development of operating procedures
- CAD models of project for planning purposes
- Electronic control hardware setup
- Software leveraged from previous projects



4 – Relevance

- **BETO MYPP Contributions**
  - Enables understanding of variability & bounding of specifications that will allow blendstock formulation through robust & timely data sets
  - Supports development of feedstock specifications/grades & quality control options
  - Supports BETO's 2017 goal of producing optimized dynamic blendstocks that meet cost, quality, & conversion targets
- **Impact**
  - Advances current state of technology for using of rapid-screening techniques
  - Provides robust & temporal data sets for practical dynamic blend options
- **Stakeholders**
  - **Researchers:** provides larger & more timely data sets
  - **Industry:** informs biomass end users on biomass strategy, dynamic blend options & fundamental to exchange-point characterization
  - **Policy Makers:** clear understanding of blend pathways to achieving sustainable energy options and valorization of feedstocks

5 – Future Work

- **Initial effort for the development of a fully automated sample analysis system to:**
  - Further improve both the consistency & efficiency of biomass sample analysis
  - Establish fundamental approach for exchange-point characterization
- **Development of functional robotic biomass grinding work cell to support the analysis of a large sample sets**
- **This work will focus on the challenges associated with:**
  - Feeding biomass materials of different characteristics in an even & consistent manner
  - Optimizing sample metrics for conventional & rapid screening techniques
  - Reducing ~ 1 hr/sample barrier

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Summary

- **Overview**
  - Sample comminution is a major hurdle to rapid-screening methods & exchange-point quality control
- **Approach**
  - Automated high throughput biomass processing enables substantial improvements over current methods while retaining current processing method benefits
- **Relevance**
  - Provides larger & more timely data sets for researchers & industry to better develop practical dynamic blend options
  - Foundation for "FGIS-like" exchange-point sample inspection
- **Future work**
  - This work is the initial effort in development of novel state-of-the-art high volume, high throughput comminution & analysis of biomass samples

Additional Slides

Acronyms

- BC – Biochemical
- BETO – Bioenergy Technology Office
- BFNUF – INL Biofuels National User Facility
- BYUI – Brigham Young University - Idaho
- CAD – Computer-aided design
- CoPI – Co - Principle Investigator
- DOF – Degrees of freedom
- FGIS – USDA, Federal Grain Inspection Service
- FY – Fiscal Year
- PaR – PaR Systems, Inc.
- RFP – Regional Feedstock Partnership
- SOT – State of Technology
- TC – Thermochemical
- VFD – Variable frequency drive