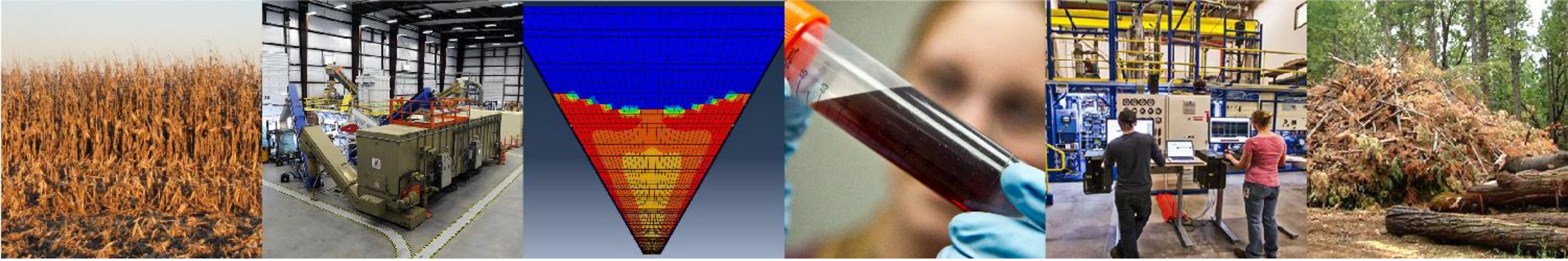
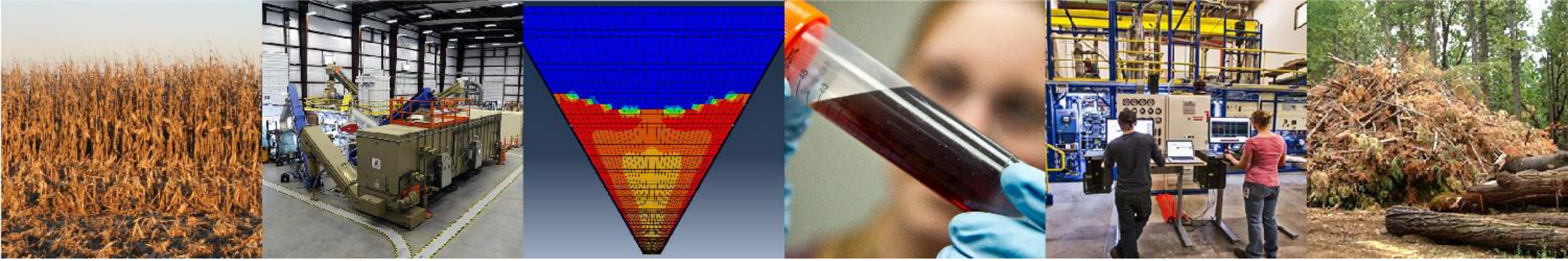


DOE Bioenergy Technologies Office (BETO) 2019 Project Peer Review

Industry Engagement & Project Management
WBS# 1.2.2.701-8

March 7, 2019

PI: Michael Resch, PhD



Goal of the Consortium

Identify and address the impacts of feedstock variability - chemical, physical, and mechanical – on biomass preprocessing and conversion equipment and system performance, to move towards 90% operational reliability.

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

Goal Statement

Project Goal: Manage and Coordinate 8 National Lab Consortia working together to leveraging core capabilities to address major issues plaguing the biofuels industry.

Outcome This project worked directly with BETO, FCIC leadership team and Industry Advisory Board to ensure a industry-relevant focus with strong potential for industry adoption of FCIC technologies, and manage the industry-collaborative R&D through Directed-Funding Opportunity.

Relevance By managing collaborative FCIC projects' R&D activities and focusing on IBR optimization issues we will address barriers to the growth and success of the biofuels industry.

Quad Chart Overview

Timeline
- Project Start Date: November 2017
- Project End Date : September 2018
- Percent Complete: 100%

	Total Costs Pre FY17**	FY 17 Costs	FY 18 Costs	Total Planned Funding (FY 19-Project End Date)
DOE Funded	N.A.	(See Below)	$784k	$0
Project Cost Share*	N.A.	N.A.	$0	$0

Partners:$345K (INL), $365k (NREL), $15K (LBNL), $15k (LANL), $15k (ORNL), $15K (PNNL), $7k (SNL), $7k (ANL)
2017 Forward Funded: $8M for Direct Funding Opportunity

Barriers addressed
Ct-A. Feedstock Variability, Ct-B. Reactor Feed Introduction, Ct-C. Efficient Preprocessing, Ct-D. Efficient Pretreatment, Ct-J. Process Integration , Ct-N. Materials Compatibility and Reactor Design and Optimization Integration, Ft-E. Feedstock Quality, Monitoring, Ft-G. Biomass Physical State Alteration Ft-I. Feedstock Suppy7 System Integration and Infrastructure, Ft-J. Operational Reliability, Im-A. Inadequate Supply Chain Infrastructure, It-B. Risk of First-of-a-Kind Technology, It-C. Technical Risk of Scaling

Objective
- Start-up, manage and coordinate the FCIC R&D project teams to ensure the collaborative synergies and facilitate the communications between BETO and National Labs.
- Enable and promote effective industry & science engagement to ensure the FCIC's focus on providing first principles science based solutions to industrially relevant issues

FY18 Project Goal
- Establish and coordinate the FCIC R&D activities so that the baseline activities and materials generated can be metricized and used as the benchmark to compare and establish future R&D performance objectives.
- Directed Funding Opportunity award selections

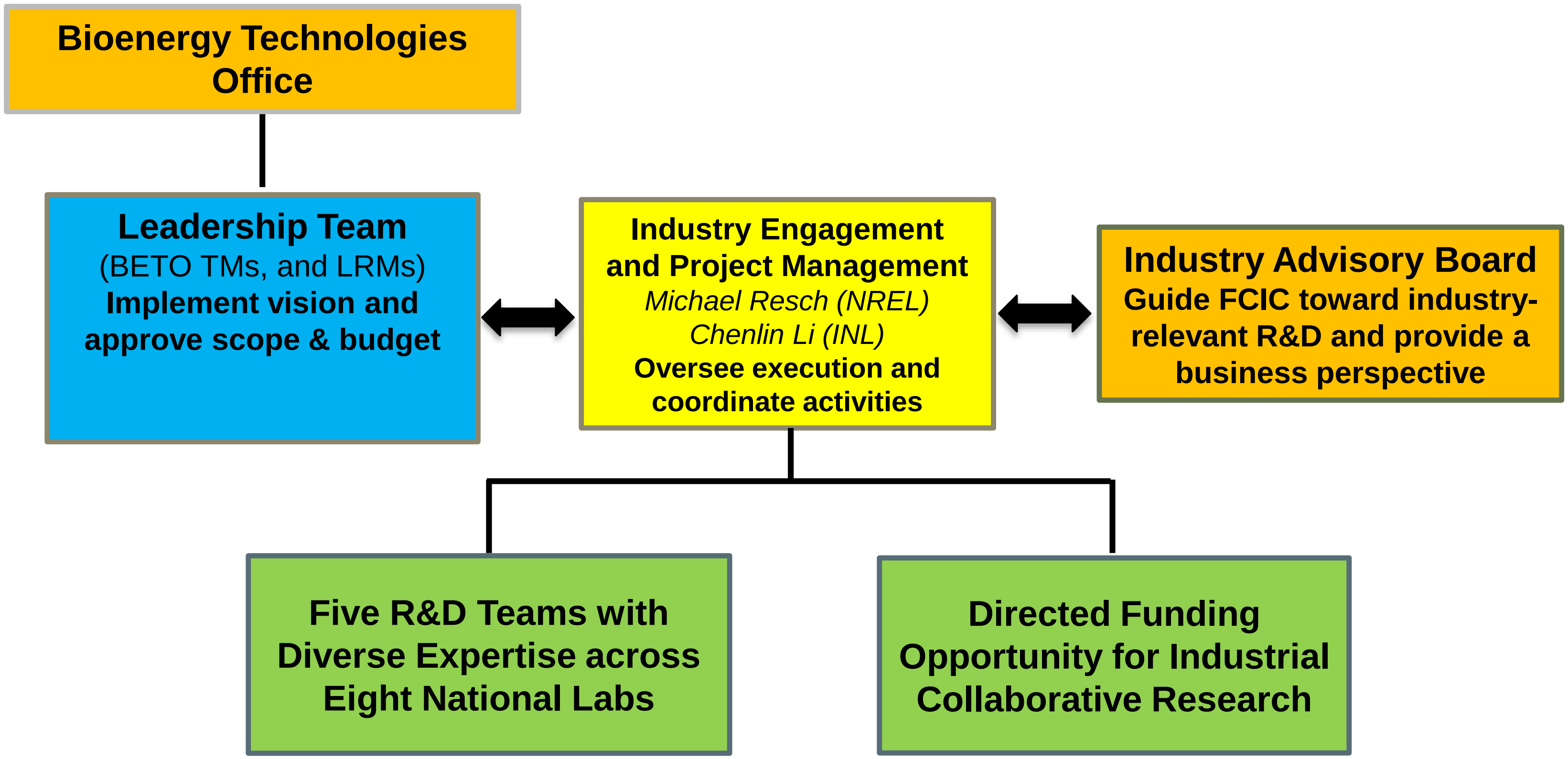
Project Overview

- **History**
  - Siloed research objectives across the BETO platforms and national labs (feedstock history, speciation, blending, densification, milling)
  - Metricized impacts of feedstock variability on integrated industry processes unknown

- **Relevance**
  - Coordinated research efforts to leverage national lab expertise and capabilities
  - Develop technologies stakeholders will utilize to improve the performance and operating reliability of biomass handling equipment and integrated biorefineries.

Approach – Management

Leadership Organization



Approach – Management


Chenlin Li (INL)


Kevin Kenney (INL)


Zia Abdullah (NREL)


Corinne Drennan (PNNL)


Katy Christiansen (LBNL)

Michael Resch (NREL)


Tim Theiss (ORNL)


Babetta Marrone (LANL)


Paul Bryan (SNL)

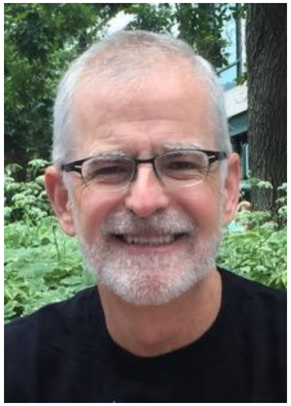

Meltum Urgun Demirtas (ANL)

Approach – Management

Ravi Chandran
(TRI)

William Crump
(Leidos)

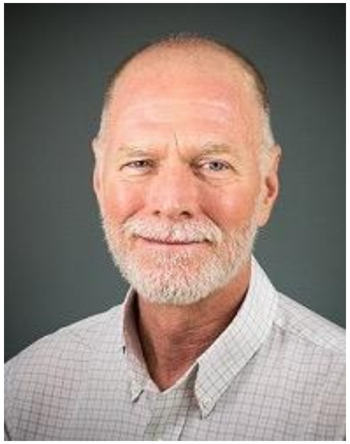
Brandon Emme
(ICM)



John Evans
(AB Biotek)

Glenn Farris
(AGCO)

Reddy Karri
(PSR)

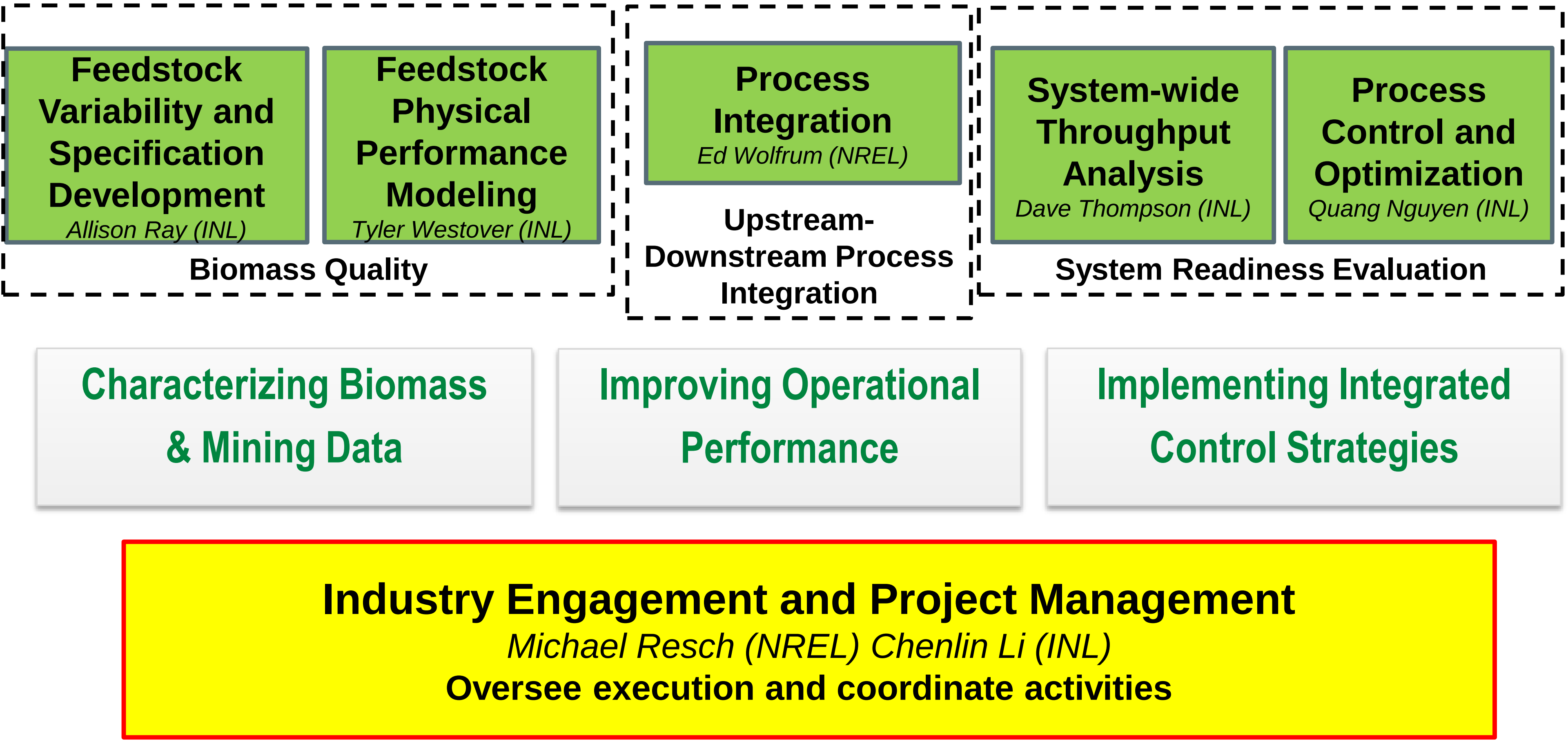


Steve Kelley
(NC State)

Tom Miles
(TR Miles Consulting)

Industry Advisory Board

Approach – Technical



Approach

Task 1 Industry Engagement

- Industry-relevant R&D portfolio with clear input from and handoffs to bioenergy industry stakeholders.
- Open communication between national labs and industry stakeholders.

Task 2 Industry Collaborative R&D

- Promote industry collaborative R&D through FCIC Directed Funding Opportunity (DFO).
- Web-based process tool and managing DFO submission, review, approval, award process and project execution.
- Establish FCIC communications channels

Task 3 Project Management

- Integration and coordination of activities to ensure hand off and deliverables will be provided to DOE in accordance with the approved work plan and budget.
- Coordinate Leadership Team comprised of representatives from DOE and national labs to establish vision, define strategy, approval directions and changes of R&D focus.

Approach - Technical

Challenges:

- Collaboration between National Lab and industrial partners unfamiliar working together
- Timely handoff of materials and data in order to meet milestones and deliverables
- Selecting Industry Advisory Board with diverse expertise and knowledge of past industrial problems
- Sensitivity around industry bottlenecks and formal communication
- Transferring FCIC results for industry adoption

Approach - Technical

Critical success factors:

- Close collaboration between National Labs with a collective understanding of roles, responsibilities and deliverables working towards the common FCIC goal.
- Active interaction with the Industry Advisory Board to review and contribute to FCIC AOPs and Directed-Funding Assistance Opportunity.
- Strong participation of industry stakeholders in FCIC Directed-Funding Opportunity program awarded projects.
- Tangible evidence of FCIC-developed scientific knowledge and technologies adopted by industry stakeholders.

3 – Accomplishments

Q1

- Assembled catalog of conversion equipment, and capabilities at participating FCIC National Laboratories, for inclusion on the public-facing FCIC website.
- Formation of Industry Advisory Board
- Kick-off meeting

Q2

- Respond adjust R&D based on IAB comments
- Launched FCIC website
- Formulated topics for FCIC Directed Funding Opportunity based on feedback from IAB, research needs and knowledge gaps.

Q3

- Reviewed and selected DFO National Lab/ Industry collaborative awards
- All-Hands workshop and Baseline Coordination

Q4

- Coordinated FCIC baseline results for use as benchmark and sample generation to establish future R&D performance objectives
- Planning of future work to leverage baseline results

3 – Accomplishments

Organization and Management

- Led weekly All-Hands calls, periodic technical presentations
- Successfully managed workflow and **integrated experimental design to leverage the capabilities and expertise at eight National Laboratories**
- Managed and coordinated the activities of various project teams to ensure the **collaborative synergies** and maintained **handoff** timelines across eight National Laboratories.
- Reviewed and coordinated 12 Quarterly Milestones and 24 Progress Reports throughout FY18 with a total budget of ~$15M
- Launched and executed the Direct Funding Opportunity (DFO) process including the announcement release, proposal review, selection of awards.

3 – Accomplishments

Key Feedback from Industry Advisory Board which led to FCIC scope

1. Design of Experiments: response or factors need to be identified. Define dataset to be collected from available resource (literature, library, etc.,) and experiments for statistical analysis and data mining.
2. Reactor probes and in-line instrumentation needed and implemented in an IBR
3. Current IBR problems and success are not available and should be made public. Ash speciation and effects on intermediates.
4. Bio-oil properties in relation to wear.
5. Use cost analysis as a metric for reliability and performance.
6. Embed researchers at industrial sites to acquire data and perform analysis and modeling.
7. Advise on grinder types vs feedstock type vs performance of feedstocks.

Directed Funding Opportunity

- $8 Million available for Industry/ National Lab Partnerships
  - 30% non-federal cost share required (in-kind &/or cash)
  - $500,000–$2,000,000 for each project for 12-22 months POP
  - Promoting industry/lab collaborative R&D for near term solutions
  - Contractual terms will be managed through a pre-established FCIC agreement
  - Call released Dec 20, 2017 and closed Jan 31, 2018
- Topics areas to address research gaps:

  1. Biomass Quality Evaluation and Optimization
  2. Biomass Preprocessing, Feed-Handling, and Conversion Process Integration
  3. System Readiness Evaluation through Techno-Economic Analysis and Process Control Development

Scoring Criteria

– Challenges, risk mitigation and research approach	40%
– Impact on FCIC goals and mission	40%
– Requested budget, milestones and key personnel	20%

DFO Review Process

- Jan 2018 Reviewers selected from industry, acadamia, consultants, thermochemistry and biochemistry, pretreatment and biomass experience
- Feb 2018 - 14 day Independent Review
- Feb 2018 In-person Review Panel Discussion
  - organize comments
  - Criteria review
  - Focus on Technical Merit
- March 2018 - Comments sent to applicants for response and clarification
- March 2018 - Responses sent to reviewers for consideration, finalization of comments, as appropriate.
- April 2018 - BETO discussions with FCIC Leads.
- April 2018 - BETO discussions with Program Director.

Directed Funding Opportunity

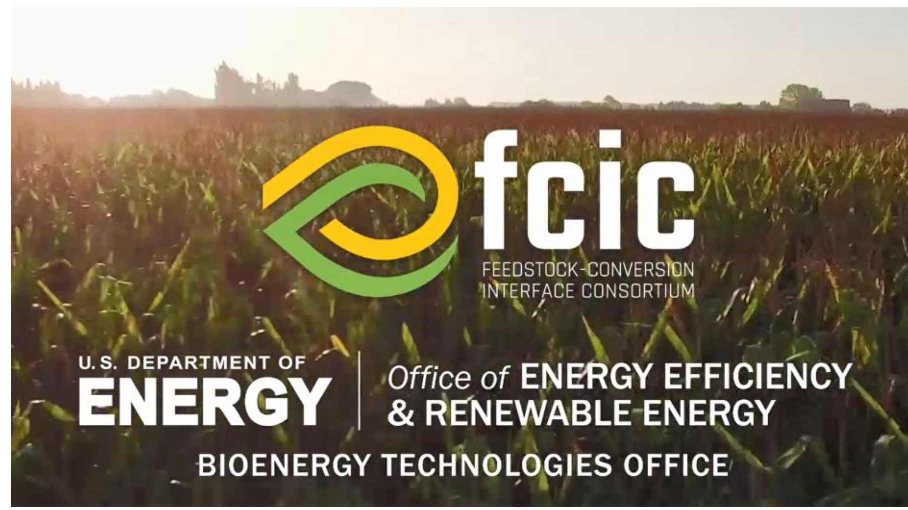
Project Title	Primary Institute (PI)	Partners	Poster #
Achieving High Operating Reliability for Continuous Feeding of Biomass into a High-Pressure Reactor	INL (John Aston)	Red Rocks Biofuels, Valmet, Forest Concepts ORNL, NREL	43
Moisture Management and Optimization in Municipal Solid Waste Feedstock through Mechanical Processing	Fulcrum (Mujinga Mwamufiya)	INL	41
Rational design of robust reactor feeding systems for heterogeneous cellulosic and agricultural wastes based on biomass quality characteristics	NREL (Daniel Carpenter)	Jenike & Johanson, The Wonderful Company, INL	45
"Smart" Transfer Chutes with In-Line Acoustic Sensors for Bulk-Solids Handling Solutions	LANL (Troy Semelsberger)	Jenike & Johanson	42
Real-Time, Integrated Dynamic Control Optimization to Improve the Operational Reliability of a Gasifier	INL (Roni Mohammad)	Sierra Energy, Energy Res. Co.	44
Investigating and addressing the wear issue of the rotary shear biomass comminution system	ORNL (Jun Qu)	Forest Concepts, ANL,	40

Communications Efforts

- Developed consistent communications and **outreach** by all FCIC labs
- FCIC website created and maintained
- An FCIC email distribution list to communicate FCIC announcements, news, and accomplishments.

- Three FCIC overview products
1. video overview
2. feature article
3. Multi-slide guide

- FCIC website was monitored with web analytics, which will guide future outreach campaigns



Video Overview: https://fcic.inl.gov/Page/fcic_aboutus

Website: www.fcic.inl.gov

Relevance

Stakeholder Relations

- Identified key industrial collaborative research projects to leverage national lab capabilities and funded competitive projects through Directed Funding Opportunity (DFO).
- Coordinated the FY18 R&D activities and communicated to Industry Advisory Board and stakeholders for feedback and guidance *via* two annual face to face meetings and written feedback.
- Drafted the '*FCIC primer*', with input from multiple researchers across FCIC pillars of an alphabetical glossary of terms and methods to enable more effective communication among diverse technical teams to facilitate R&D and expands upon the established, general glossary of terms used in the U.S. DOE EERE Bioenergy Technologies Program (https://www.energy.gov/eere/bioenergy/full-text-glossary) to include vocabulary specific to FCIC research areas

Relevance

How coordination of FCIC projects will lead to commercial viability of IBRs

- Bioenergy industry stakeholders will utilize the FCIC data and technologies to improve the performance and operating reliability of equipment and integrated biorefineries.
- Intellectual property will likely be generated in the projects, and licensing opportunities will be explored to transfer this to industry.
- Industry partnerships with biorefineries and equipment manufacturers will also be explored to share knowledge gained through this and other FCIC projects.
- Contributes to BETO goals by improving the knowledge of how variabilities in feedstocks impact IBR operational reliability (FY20-23 goals)

Lessons Learned

Organization and Management

Key Takeaways from team member survey (5/24 FCIC R&D Meeting)

1. "Rate value of your participation in this consortium." 1 (lowest) to 10 (highest)

N=	31
Average score	7.58
Stdev	1.84

2. "What would increase your value of participation in the FCIC?"
   - "Better and more timely communication among Labs and between BETO and Labs"
   - "Opportunities to leverage capabilities across labs"
3. "Rate the level of satisfaction you feel regarding your participation in the FCIC." 1 (lowest) to 10 (highest)

N=	33
Average score	7.92
Stdev	1.71

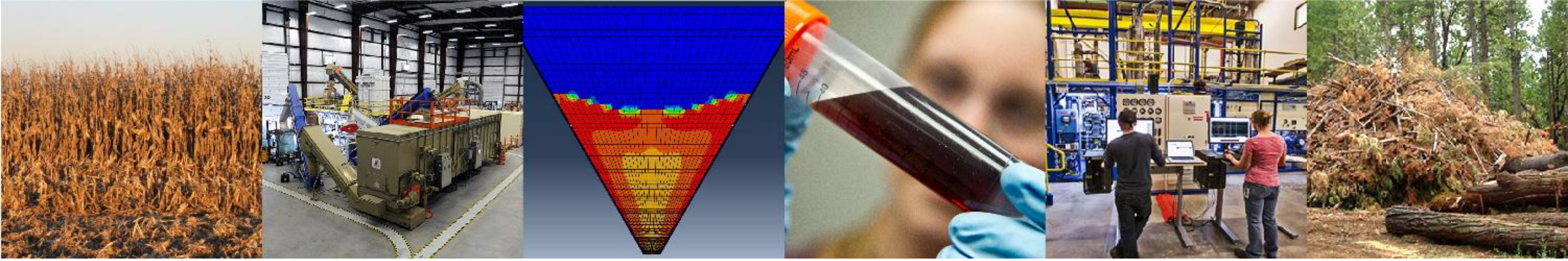
4. "What would increase your satisfaction in participating in the FCIC?"
   - "The FCIC often seems to feel like opportunities for inclusion are not valued. Many times it seems like the labs are competing rather than working together. The FCIC would benefit from a more inclusive and transparent approach to developing scopes of work."

Summary

1. **Overview** – Manage and Coordinate 8 National Lab Consortia working together to leveraging core capabilities to address major issues plaguing the biofuels industry.
2. **Approach** – NREL and INL serve as the two leading institutions, with 6 other FCIC labs' participation for effective project management.
3. **Technical Accomplishments/Progress/Results** – Achieved all FCIC deliverables, organized FCIC communications with IAB and industry stakeholders, reviewed and selected 7 DFO awards and delivered an annual report highlighting the FCIC FY18 Baseline results.
4. **Relevance** - This project worked directly with BETO, FCIC leadership team and IAB to ensure the industry-relevant focus with strong potential for industry adoption of FCIC accomplishments, and managed the industry-collaborative R&D through Directed-Funding Opportunity.
5. **Future Work** – Sun Setting –

Acknowledgments to the team

Photo of December 11th, 2017 all hands FCIC kick-off meeting held at NREL organized by IE&PM project.



Questions?

www.fcic.inl.gov

Michael.resch@nrel.gov

BIOECONOMY

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Presentations

1. Oral Presentation. Michael Resch. *Feedstock-Conversion Interface Consortium: Providing Innovative Solutions to Address Operational Challenges Faced by Biorefineries*. ABLC, (2018) Washington, D.C.
2. Oral Presentation. Michael Resch. *Feedstock-Conversion Interface Consortium: Providing Innovative Solutions to Address Operational Challenges Faced by Biorefineries*. SIMB – Symposium on Biotechnology for Fuels and Chemicals. (2018) May Clearwater, FL
3. Oral Presentation. Chenlin Li, Michael Resch. *Feedstock-Conversion Interface Consortium: Providing Innovative Solutions to Address Biomass Quality and Operational Challenges Faced by Biorefineries. 11th International Biomass Conference & Expo, April 16-18, 2018, Atlanta, GA.*

Related publications

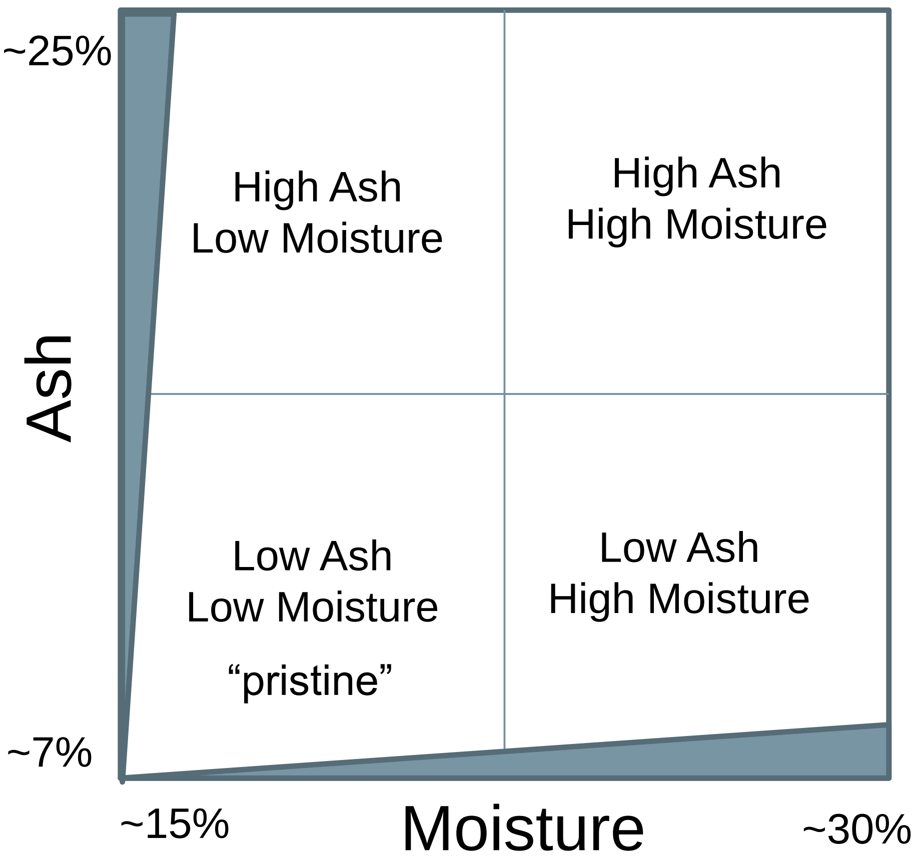
https://fcic.inl.gov/Page/fcic_publications_complete

Additional Information

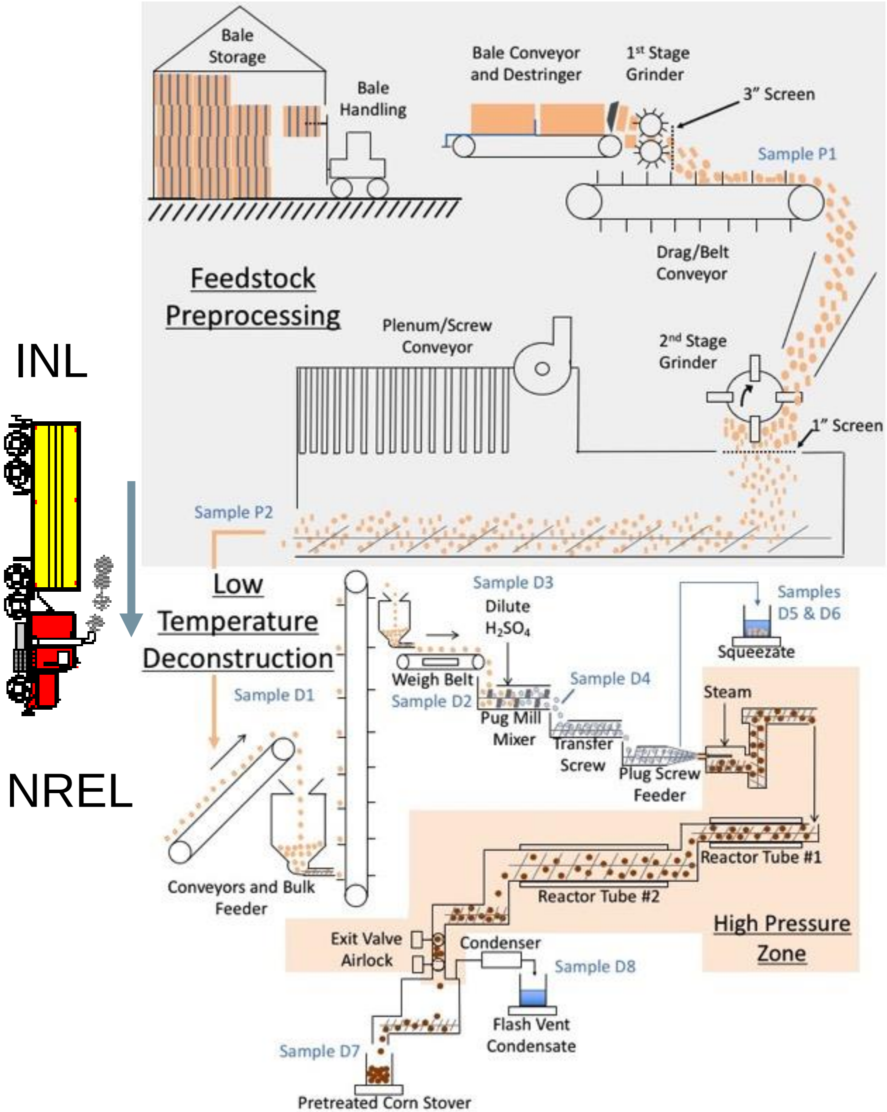
Corn Stover Feedstocks

Low Temperature Baseline Tests

- Secured ~34 bales for each of 4 conditions
- Mulit-pass harvest in IA 10/2018 adjacent to Project Liberty Plant
- Stored field-side, experienced rain events prior to final storage
- In storage at Iowa State, pending delivery to INL



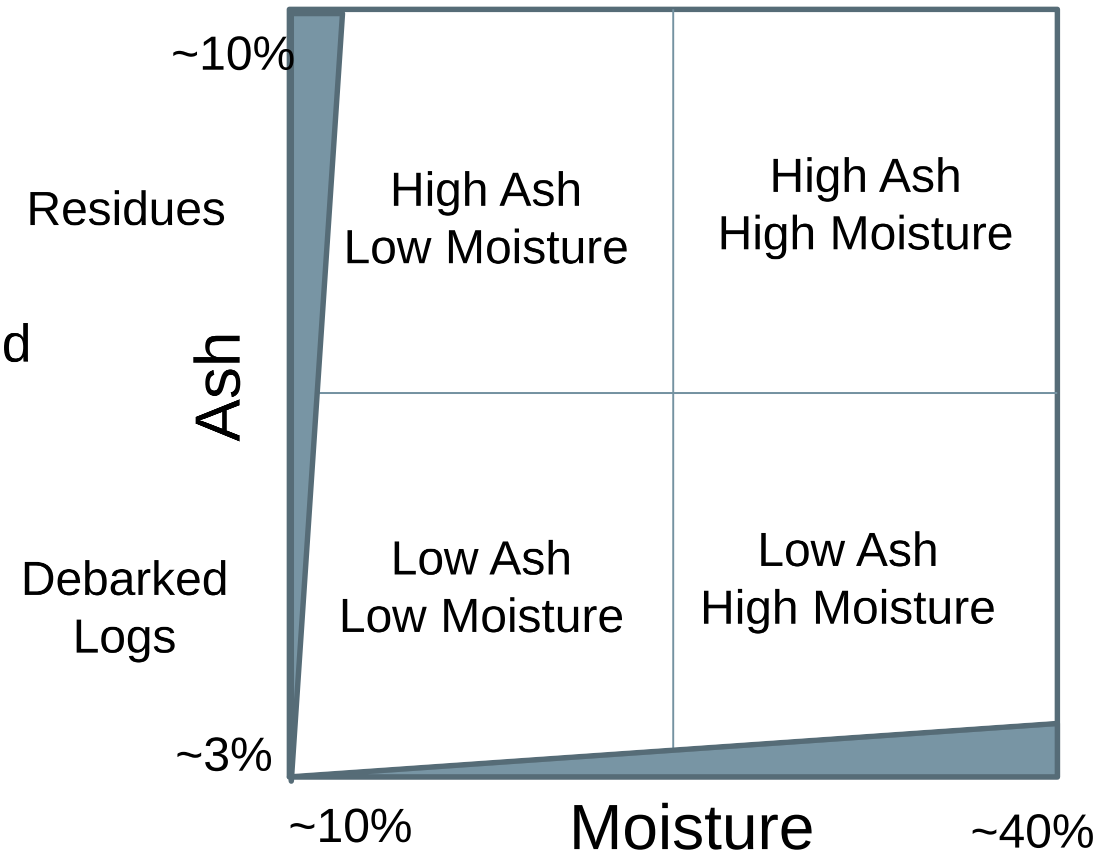
Low-Temperature Primary Deconstruction



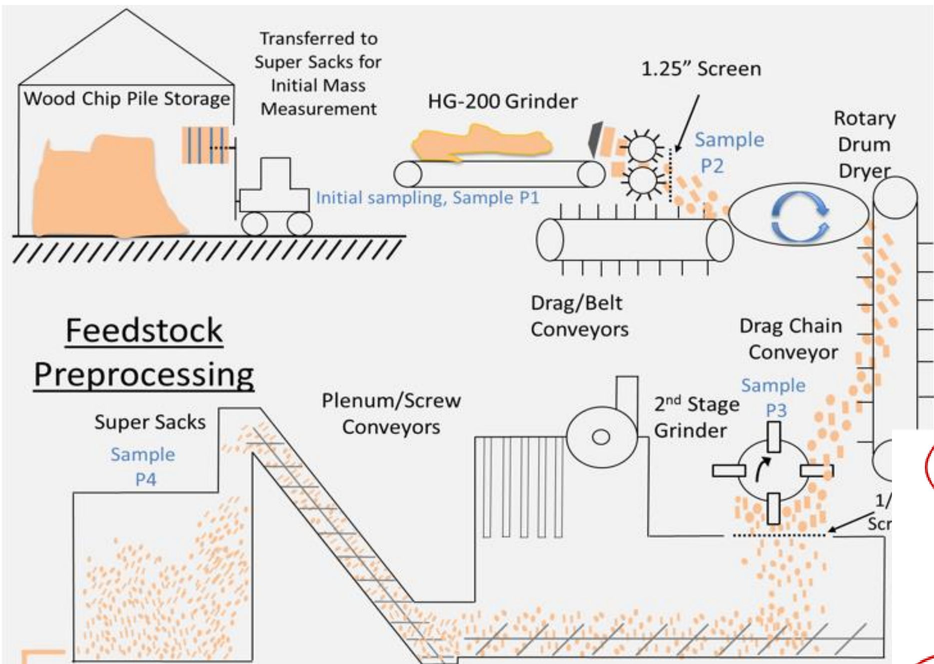
Pine Feedstocks

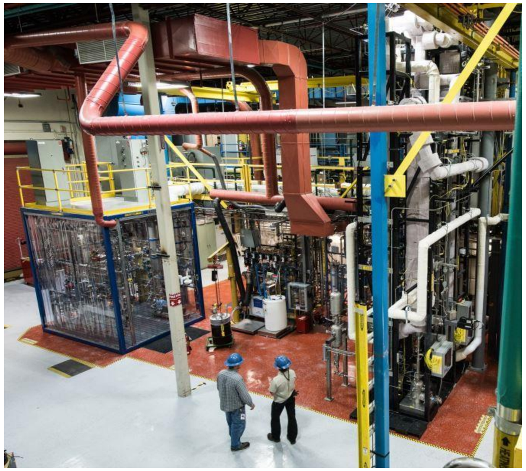
High Temperature Baseline Tests

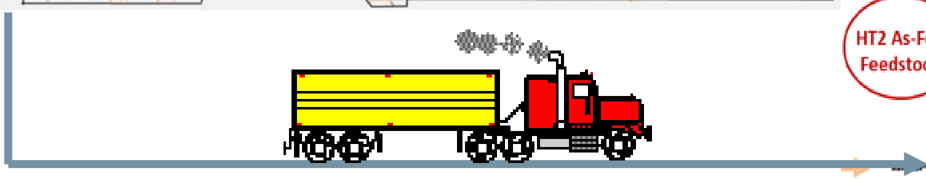
- 11-25 years of age from Georgia pine plantation
- Harvest equipment (Feller buncher, grapple skidder and disc chipper w/ or w/o flail chains).
- chipped to 2” nominal at the field then shipped to INL.



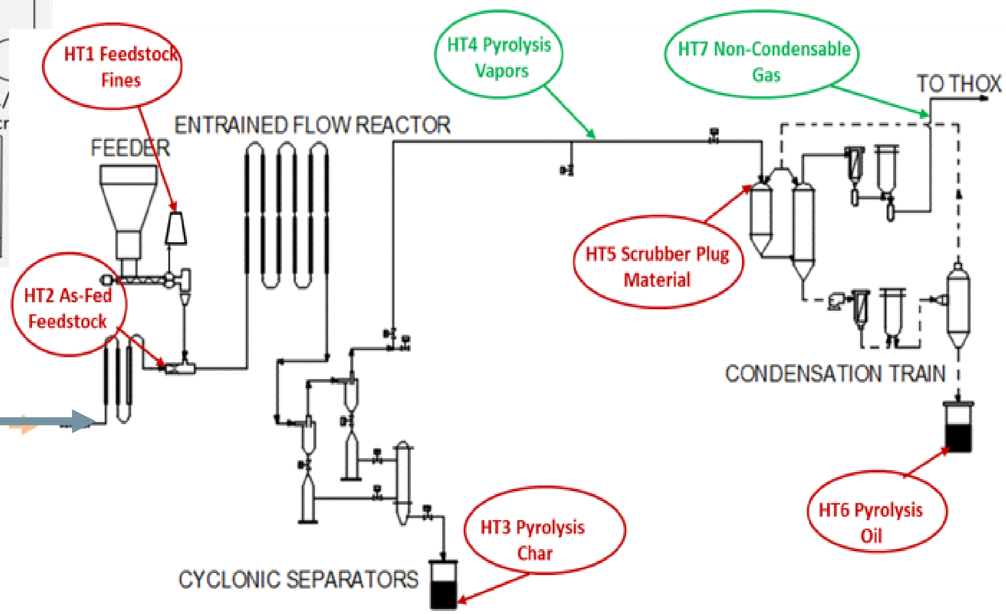
High-Temperature Primary Deconstruction

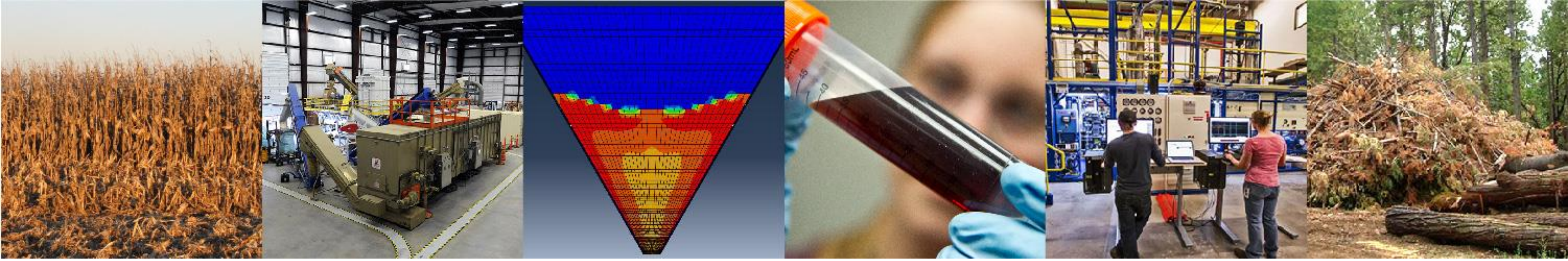






Ship to NREL





Feedstock Variability and Specification Development
Allison Ray (INL)

Feedstock Physical Performance Modeling
Tyler Westover (INL)

Biomass Quality

Process Integration
Ed Wolfrum (NREL)

Upstream-Downstream Process Integration

System-wide Throughput Analysis
Dave Thompson (INL)

Process Control and Optimization
Quang Nguyen (INL)

System Readiness Evaluation

Characterizing Biomass & Mining Data

Improving Operational Performance

Implementing Integrated Control Strategies

STA Investigators:
David N. Thompson, Damon Hartley (INL)
Jeongwoo Han (ANL)
Mary Biddy, Ryan Davis, Abhijit Dutta (NREL)
Erin Webb (ORNL)
Sue Jones (PNNL)

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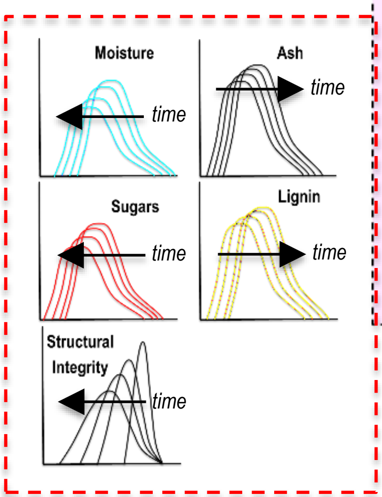
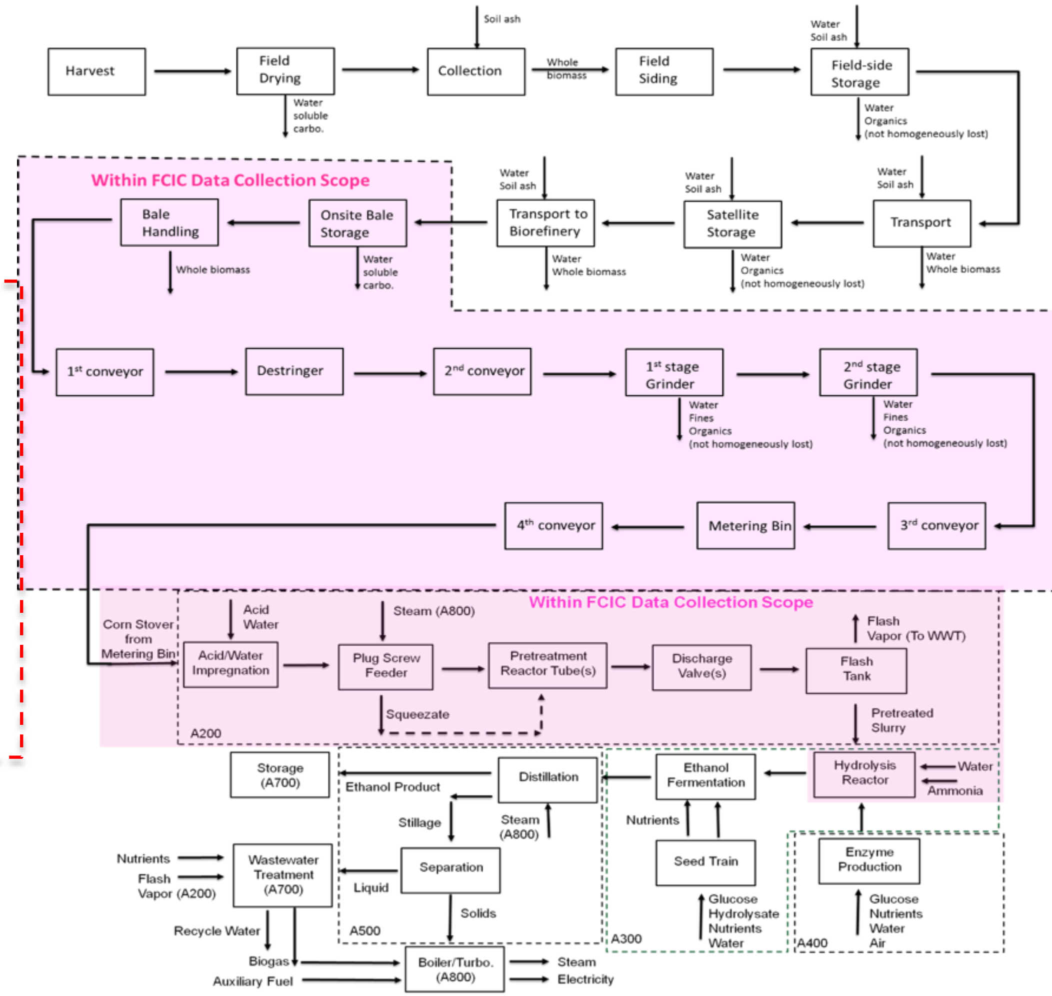
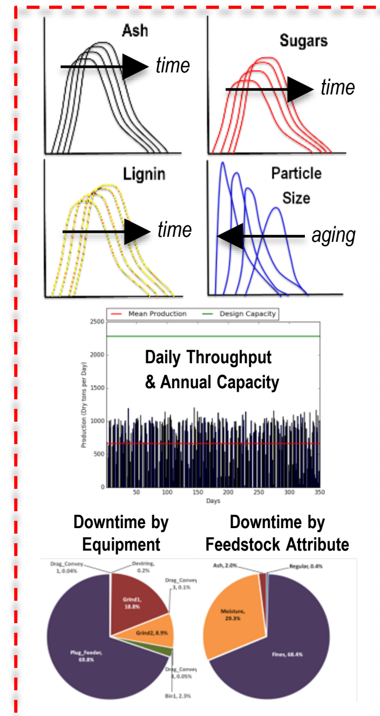
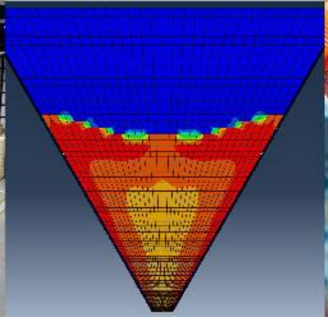
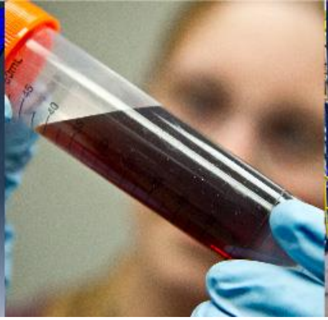
Discrete Event Simulations









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Allison Ray, Rachel Emerson, Amber Hoover, Jordan Klinger, Tyler Westover, Luke Williams, Magdalena Ramirez-Corredores (INL)
Deepti Tanjore (LBNL)
Troy Semelsberger (LANL)
Erin Webb (ORNL)
Bryon Donohoe, Nick Nagle, Ed Wolfrum (NREL)
Kenneth Sale (SNL)

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Feedstock Variability and Specification Development

Approach

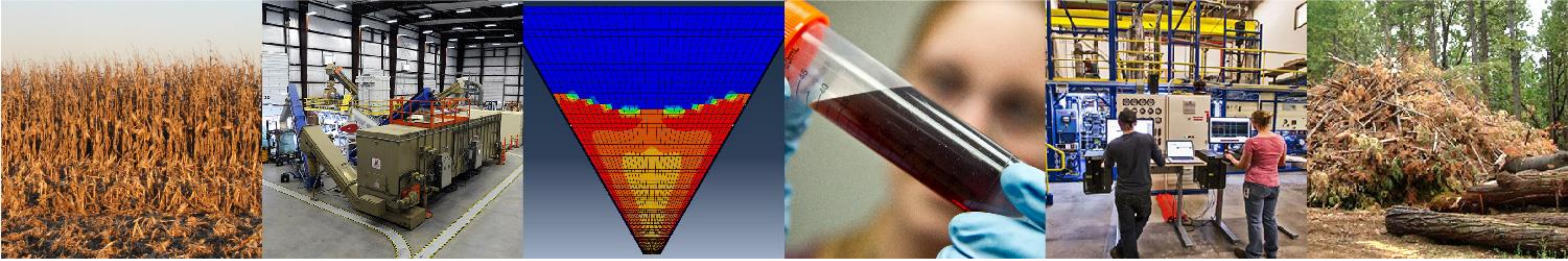
- Collect representative corn stover and pine residues for the 3 year project
- Quantify range and frequency variability
- Identify origins of variability

Sample Matrix (Corn Stover)

- Pristine
- High Ash
- High Moisture
- High Ash and Moisture
- Storage Effects

Sample Matrix (Pine Residues)

- Pristine Logs
- Residues
- Mixed
- Vary Particle Size Distribution



Biomass Quality

- Feedstock Variability and Specification Development
  Allison Ray (INL)
- **Feedstock Physical Performance Modeling**
  Tyler Westover (INL)

Upstream-Downstream Process Integration

- Process Integration
  Ed Wolfrum (NREL)

System Readiness Evaluation

- System-wide Throughput Analysis
  Dave Thompson (INL)
- Process Control and Optimization
  Quang Nguyen (INL)

Characterizing Biomass & Mining Data	Improving Operational Performance	Implementing Integrated Control Strategies

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Jonathan Stickel, Hariswaran Sitaraman (NREL)
George Fenske, Oyelayo Ajayi (ANL)
Carl Wassgren (Purdue University)
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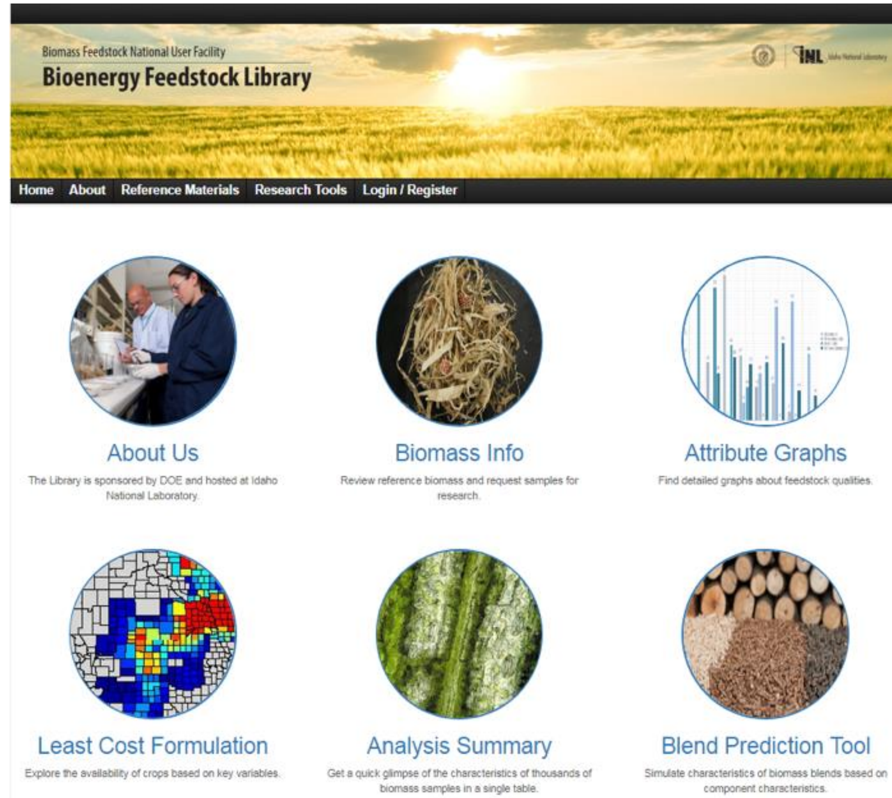
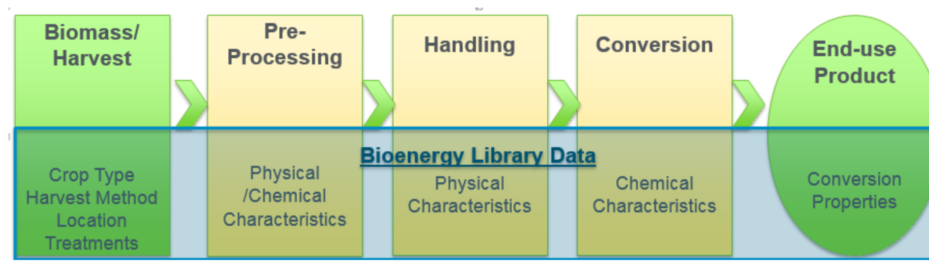
Data Acquisition and Analysis

- Harmonization of methods & vocabulary
- Collect existing analytical data for variability ranges/identify gaps
- Track the history and quality of representative FCIC biomass samples
- Machine learning component to identify correlations



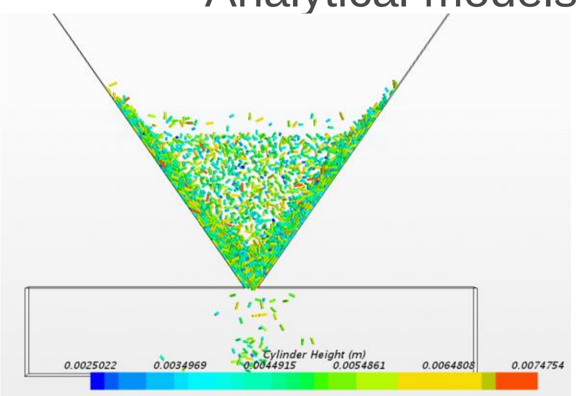


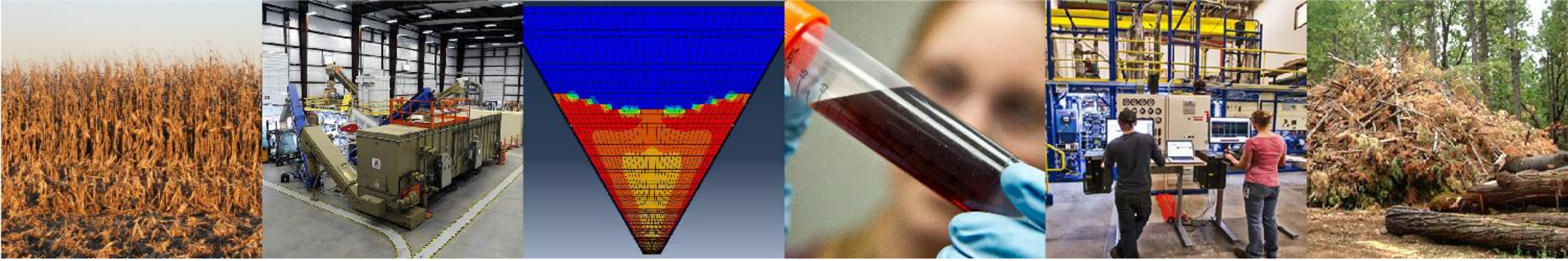
Feedstock performance modeling

Objective: Use mechanistic modeling to identify the causes of feed-handling failures and validate model driven design changes to lead to improved process and equipment performance

Technical Approach

- Particle models (discrete element method, DEM)
- Reduced-order continuum models (averages over many particles)
  - Plasticity/elasticity models for general flow & comminution
  - Comp. fluid dynamics (CFD) for specific cases
  - Analytical models for specific wear mechanisms





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Implementing Integrated Control Strategies

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Vicki Thompson, John Aston, Tyler Westover (INL)

Jim Kieser, Jim Parks (ORNL)

George Fenske (ANL)

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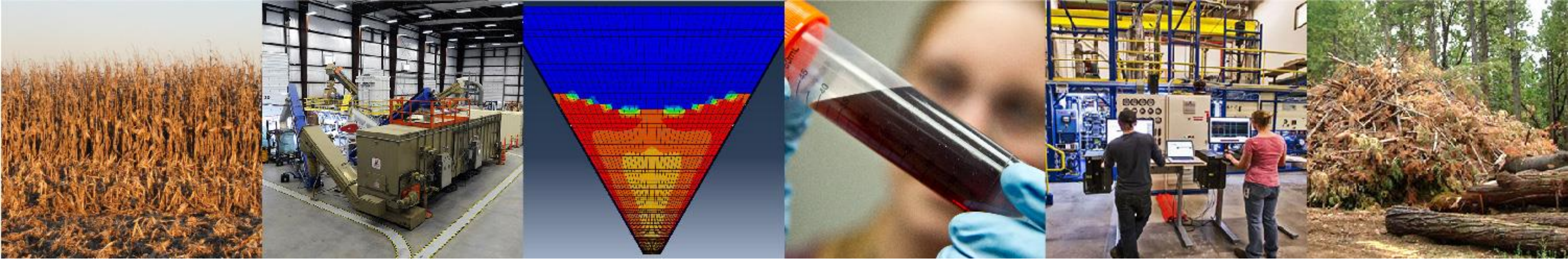
Process Integration

- **FY18 Major Goal is to Execute robust, industrially-relevant baseline testing** both low- and high-temperature conversion processes
- **Longer-Term Goal is to develop and demonstrate cost-effective mitigation strategies**
- Support other FCIC projects through experimental **validation**



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Process Control and Optimization
Quang Nguyen (INL)

System Readiness Evaluation

Characterizing Biomass & Mining Data

Improving Operational Performance

Implementing Integrated Control Strategies

INL: Quang Nguyen, Matthew Anderson, Robert Kinoshita, William Smith, Patrick Bonebright, and Neal Yancey

NREL: Richard Elander, Kristin Smith, Danny Carpenter, David Sievers, Katie Gaston, and Raymond Hasen

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

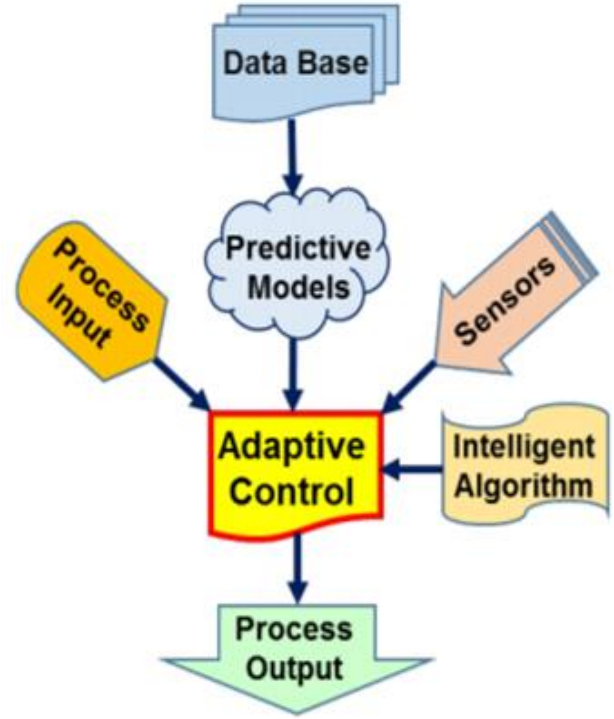
Project Objective

Goal:

- Verification and design control systems that increase the on stream **reliability** in industrially relevant conditions while **maintaining primary deconstruction conversion performance.**

Objectives:

- Test dynamic control systems that can adapt in real time to changing biomass composition and process conditions



Fulcrum BioEnergy, Inc.

Moisture Management and Optimization in Municipal Solid Waste Feedstock through Mechanical Processing

Project Details

Principal Investigator: Mujinga Mwamufiya

Lead Institution: Fulcrum BioEnergy, Inc.

Collaborating Institutions: Idaho National Laboratory ("INL")

Project Duration: 22 months

Topic Area: 2

Overview

Project Objectives

- Reduce MSW feedstock moisture content to < 10% (w.b.) by developing a material engineering solution (densified biomass pelleted product) with bulk density of 25-27 kg/m3 and durability of > 95%, at a 40% reduced preprocessing cost (compared to conventional methods).

Technical Approach

- Develop a material engineering solution, integrating fractional milling, high-moisture pelletizing and low-temperature drying techniques to produce MSW feedstock that meets the required biorefinery specifications.

Milestones/Outcomes

Milestone: Integrated demonstration of fractional milling, high moisture pelleting and low temperature drying to meeting the required specifications.

Output: Mathematical models to describe fractional milling, high moisture pelleting and low temperature drying. Defined process conditions and commercial scale cost for reducing MSW moisture content of MSW to below 10% (w.b.) at 40% reduction of preprocessing cost, optimized to achieve bulk density of 25-27 kg/m3 and durability of >95%.

Outcome: Identify viable options to optimize preprocessing systems for managing moisture efficiently in an MSW-to-renewable fuels process.

Impact

How does the project support the goals and mission of the FCIC?

- Advances the understanding of the physics and chemistry of biomass-derived feedstock.
- Develops and tests equipment and techniques to be integrated in preprocessing, feed and handling systems to further FCIC's 90% operational reliability goals.
- Develops process models which can be used to find that process conditions will optimize preprocessing and operating costs.

Achieving High Operating Reliability for Continuous Feeding of Biomass into a High-Pressure Reactor

Project Details

Principal Investigator: John E. Aston

Lead Institution: INL

Collaborating Institutions: **Red Rock Biofuels**; ORNL, NREL, Valmet, Forest Concepts

Project Duration: 22 months

Topic Area: 2

Overview

Project Objectives

- Improve operational reliability of continuously fed reactors via (1) More consistent comminution of variable woody feedstocks, and (2) Implementation of a 5-inch screw feeder designed to minimize plugging and lessen wear at the compression zone.
- Improve the scalability of data between national laboratory PDUs in the FCIC and industrial applications by using a 5-inch screw feeder.

Technical Approach

Use a parametric matrix to (1) study the comminution of characterized forest residues, mill residues, and rail road ties using Forest Concepts' rotary shear and traditional hammer milling, and (2) Evaluate the performance of these preprocessed materials in 4- and 5-inch screw fed plug reactors at high pressure so that (3) Transfer functions can be developed to scale such systems based on feedstock properties.

Milestones/Outcomes

- Deliver 8 tons each of preprocessed forest residues, mill residues, and railroad ties from Forest Concepts to INL in amounts sufficient to complete screw feed tests in INL's CPS. Month 9.
- Installation of 5-inch screw feeder and accompanying bins onto INL's CPS. Month 12.
- Complete parametric tests on preprocessed (both via hammer mill and via Forest Concepts Crumbler rotary shear) forest residues, mill residues, and railroad ties (rail road ties may be blended with forest or mill residues) using the 5-inch plug flow screw feed system at INL. Month 18.
- Deliver a data package to RRB that informs their screw feed size, feedstock specifications, and screw feeder material/treatment to maximize overall operational reliability. Month 22.

Impact

The integrated, hands-on research and data sharing between industry leaders and national laboratory researchers will help researchers identify fundamental research areas that help industry improve process and equipment design, and operating strategies to achieve design throughputs and conversion yields.

In addition, operating the 4-inch feeder at NREL and 5-inch feeder at INL will provide data for evaluating scalability of these feeders to relevant industrial scales. This would help the Low-Temperature Conversion Platform better evaluate the performance characteristics of the 4-inch feeders, and thus make the R&D results more relevant to industry as compared to using the existing systems at NREL and INL.

FCIC-18-15809

Rational design of robust reactor feeding systems for heterogeneous cellulosic and agricultural wastes based on biomass quality characteristics

Project Details

Principal Investigator:	Daniel Carpenter
Lead Institution:	NREL
Collaborating Institutions:	Wonderful Renewable Energy, Jenike & Johanson, INL
Project Duration:	22 months
Topic Area:	2

Overview

Project Objectives

- Develop a generalized **methodology** for designing robust biomass handling and high-temperature in-feed systems; determine the feedstock physical, chemical, and mechanical attributes driving these design decisions.
- Deliver an **engineering design package** for such a system to Wonderful Renewable Energy for conversion of almond waste products to syngas; validate the approach with forest residues.

Technical Approach

Use a detailed understanding of biomass characterization data to conduct iterative computational flow modeling and bench-scale preprocessing, solids flow, and feeder tests to design an integrated preprocessing, handling, and reactor in-feed system.

Milestones/Outcomes

- Detailed feedstock characterization – physical, mechanical, and chemical compositional data
- Preprocessing tests and feedstock re-analysis – optimization of grinding, drying, densification, and costs
- Bulk flow material testing, reactor feeder testing, and preliminary gasification tests to inform equipment specifications, computational modeling, TEA for overall process, and key feedstock drivers for these
- Deliver feed system engineering design package to Wonderful Renewable Energy
- End of Project: Deliver generalized methodology for solids handling design based on biomass properties

Impact

How does the project support the goals and mission of the FCIC?

To maximize biorefinery *process reliability*, we will derive and use the relationships between primary biomass attributes and performance in preprocessing, handling, and conversion for the rational design of solids handling systems. The methodology and design considerations established here will be validated with *pine forest residues* and may be broadly applicable to other biomass feedstocks. The experimental results and scaled system design, using an industrially-relevant waste stream (and associated quality and variability), will also add robustness to numerical bulk flow simulations and technoeconomic analysis being developed in the FCIC.

"Smart" Transfer Chutes with In-Line Acoustic Sensors for Bulk-Solids Handling Solutions

Project Details

Principal Investigator: Troy A. Semelsberger, Ph.D.

Lead Institution: Los Alamos National Laboratory

Collaborating Institutions: Jenike & Johanson

Project Duration: 22 months

Topic Area: 2 – Biomass Preprocessing, Feed-Handling, and Conversion Process Integration

Overview

Project Objectives

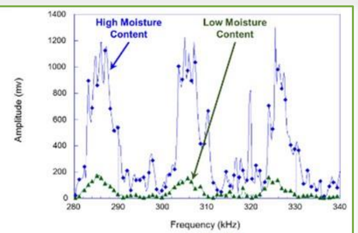
- **Project Objective:** Develop innovative solids handling equipment and unique in-line measurement sensors to greatly improve operational reliability, safety, throughput, and yield of biorefineries

Technical Approach

- Design and demonstrate "smart" transfer chute technology to discard problematic biomass material using novel in-line moisture sensor
- Design and demonstrate in-line acoustic sensor for "real-time" monitoring of plug-screw feeder erosion

Milestones/Outcomes

- Demonstrate the ability to measure moisture content of corn stover to within ±10%
- Demonstrate the ability to measure plug-screw feeder erosion to within ±10% of measured mass
- Field demonstrate "smart" transfer chute coupled with in-line acoustic moisture sensor



Impact

The three innovative technologies developed in this project will have a profound impact on integrated biorefineries by:

- ✓ Increasing IBR time-on-stream
- ✓ Offering advanced process control strategies
- ✓ Increasing product selectivity, conversion, and yields
- ✓ Increasing IBR plant operational safety
- ✓ Decreasing maintenance downtime & costs (i.e., failures)
- ✓ Active control of incoming feedstock quality

All innovations address priority challenges highlighted in the ADO and Biorefinery Optimization Workshops

Real-Time, Integrated Dynamic Control Optimization to Improve the Operational Reliability of a Gasifier

Project Details

Principal Investigator: Roni Mohammad, Ph.D.

Lead Institution: INL

Collaborating Institutions: Sierra Energy, Lehigh Univ., Energy Res. Co., VA Commonwealth U.

Project Duration: 22 months

Topic Area: 3

Overview

Project Objectives

Project Objective 1:Develop a new, real time integrated dynamic control optimization solution to ensure 90% operational reliability of a gasifier

Project Objective 2 :Demonstrate the improved operational reliability of our industrial partner's gasifier using proposed solution to 90% with 20% improved conversion yield for biomass with 5–30% level of moisture, a 5–15% level of ash content, and particle sizes between 1/4 and 2 inches

Technical Approach Develop integrated control optimization model by integrating FCIC adaptive control capability and other FCIC, industry resources (e.g., sensors, in-line instrumentation, predictive modeling of mechanical behavior of biomass particles, process development unit)

Outcomes

Milestone#1 : Complete collection of base process performance data from Sierra's gasification system : ***Outcome***: Identification of root causes of low operational reliability and conversion yield; needed additional control equipment and sensors

Milestone#2 : Complete developing real time, dynamic control optimization model by integrating FCIC adaptive control capability and other FCIC resources : ***Outcome***: Dynamic control-optimization model and algorithm to achieve improved operational reliability and conversion yield

Milestone#3 : Complete demonstration of proposed solution at Sierra's gasifier. ***Outcome***: Improved operational reliability of the gasifier feeding system to 90% under feedstock variations, and improved conversion yield by at least 20%

Impact

Benefit to FCIC

- Direct transfer of information and knowledge developed by FCIC researchers to industry
- Significantly improve operational reliability of our industrial partner's gasifier if this project is successful.
- New technology on real time, integrated dynamic control optimization to assist second-generation biofuel biorefineries
- Support bioeconomy by utilizing diverse waste materials

Future Objectives of FCIC

- Objective 1
  - Presently, 7 out of 10 new pioneer biorefineries fail to achieve continuous profitable operations and only 3 out of 10 succeed.
  - The goal of FCIC is to develop knowledge and tools which will help technology developers, so that, with improved design, and process specifications, they will be able to flip this paradigm, so that 7 out of 10 new pioneer biorefineries succeed, and only 3 out of 10 fail.
- Objective 2
  - Develop a framework through which technology developers will be able to assess the quality and value of various streams in their processes for the purpose of using that valuation to make decisions to achieve Objective 1.

What is Different as Compared to FY18?

- The objectives are different. We will develop tool to enable technology developers to design and build biorefineries and processes so the 7 out of 10 succeed to achieve continuous operations
- In FY18 the goal was to focus only on process reliability. The focus now will also be on predictability, scalability, and development of methodology for stream valuation
- FCIC now has a framework which will focus the deliverables of the AOP tasks to achieve the objectives