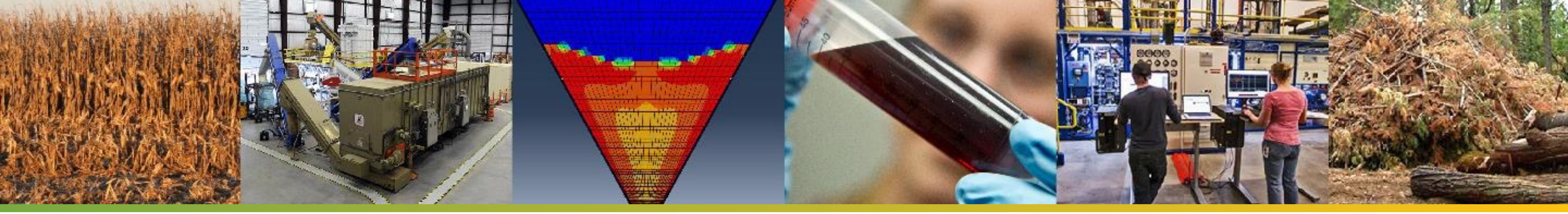

DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

FCIC Task X – Project Management and Consortium Overview

April 6, 2023
Feedstock-Conversion Interface Consortium (FCIC)

Edward J. Wolfrum, Ph.D.
Principal Investigator

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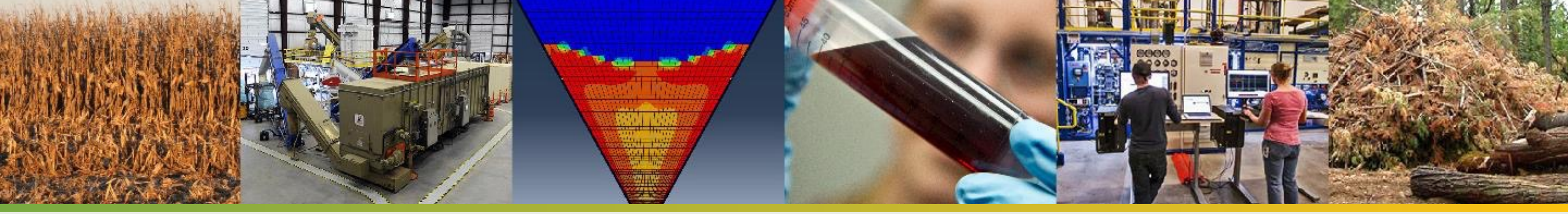
U.S. DEPARTMENT OF ENERGY



FCIC Overview

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1-slide guide to the FCIC

The Feedstock-Conversion Interface Consortium is led by DOE as a collaborative effort among researchers from 9 National Labs

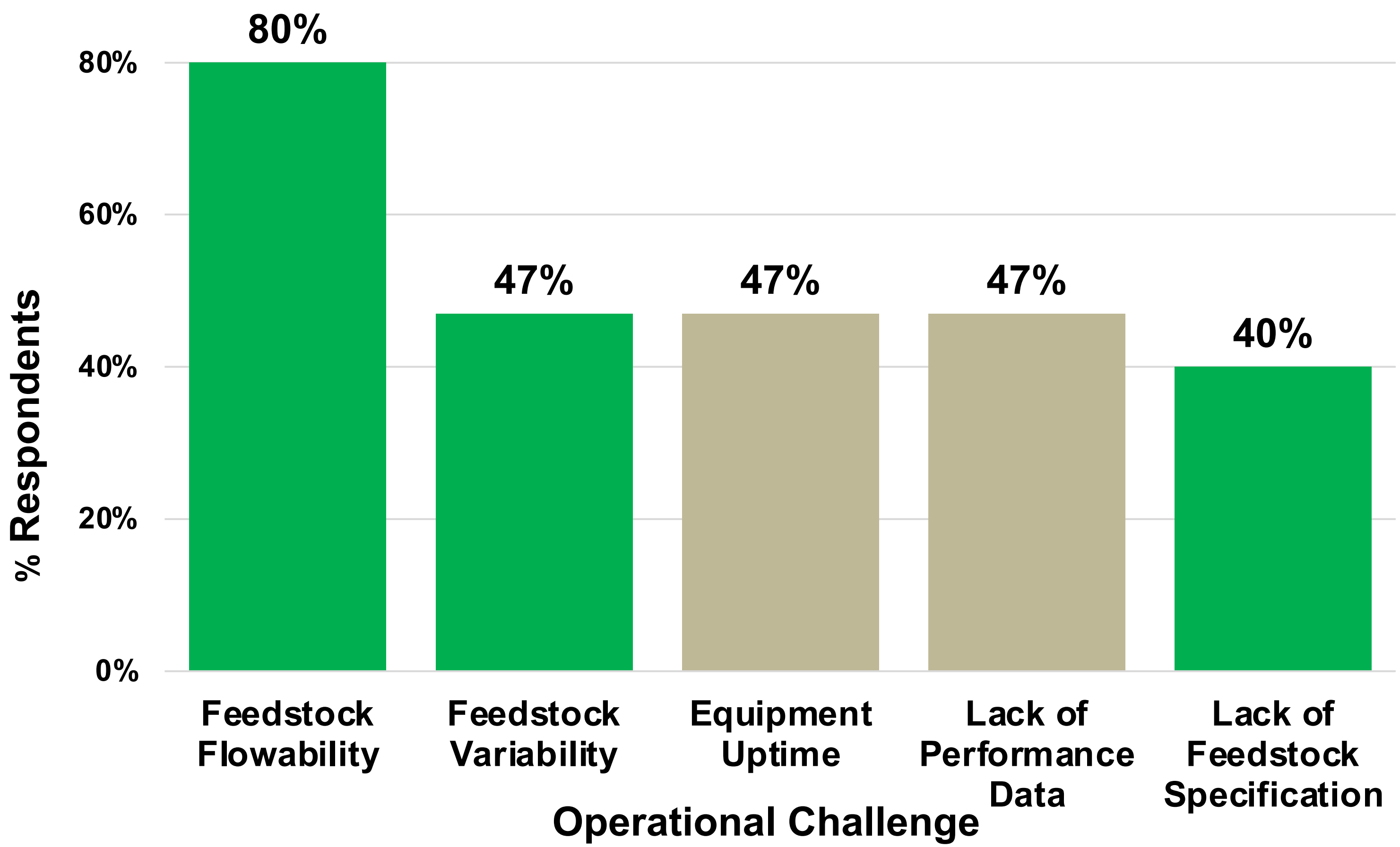
Key Ideas

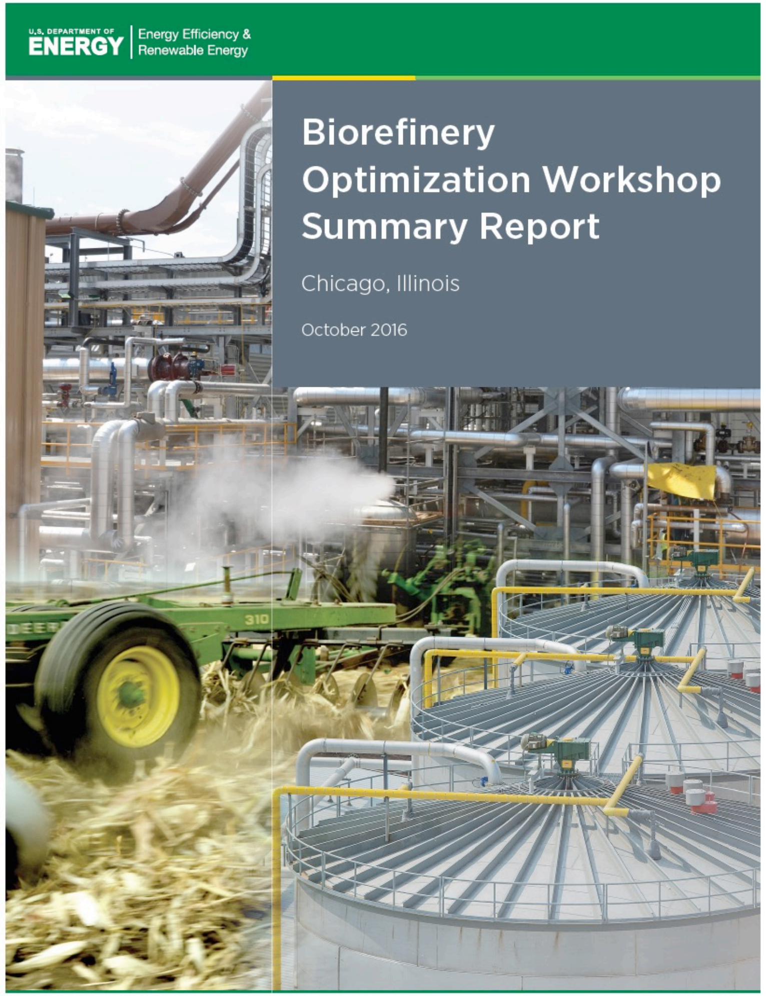
- Biomass feedstock properties are **variable** and **different** from other commodities
- **Empirical** approaches to address these issues have been **unsuccessful**

We are developing **first-principles** based knowledge and tools to **understand** and **mitigate** the effects of biomass feedstock and process **variability** on biorefineries

2016 Biorefinery Optimization Workshop

- Challenges, recommendations, and lessons learned from over 100 participants (industry, NL, academic)

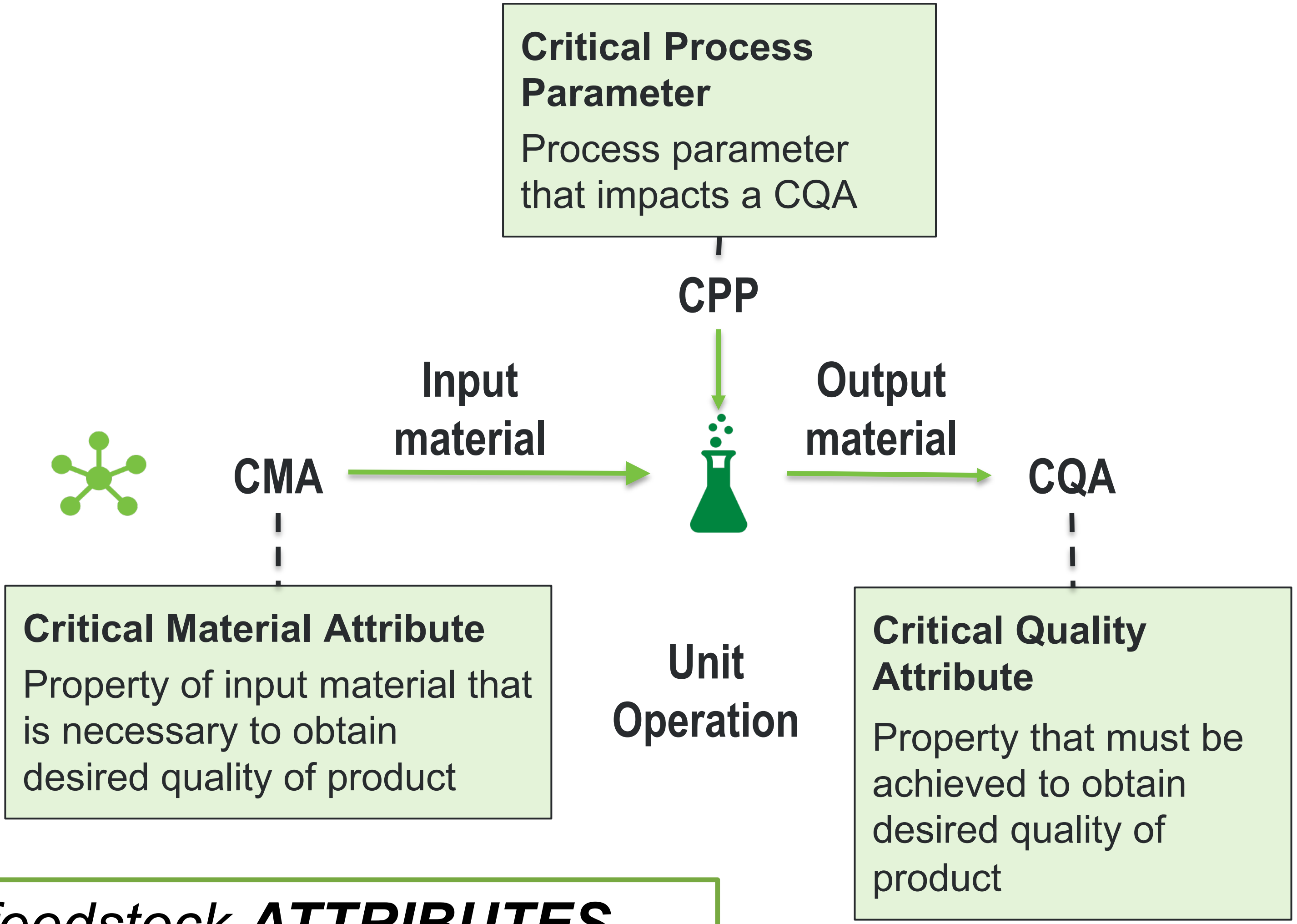




https://energy.gov/eere/bioenergy/downloads/biorefinery-optimization-workshop-summary-report

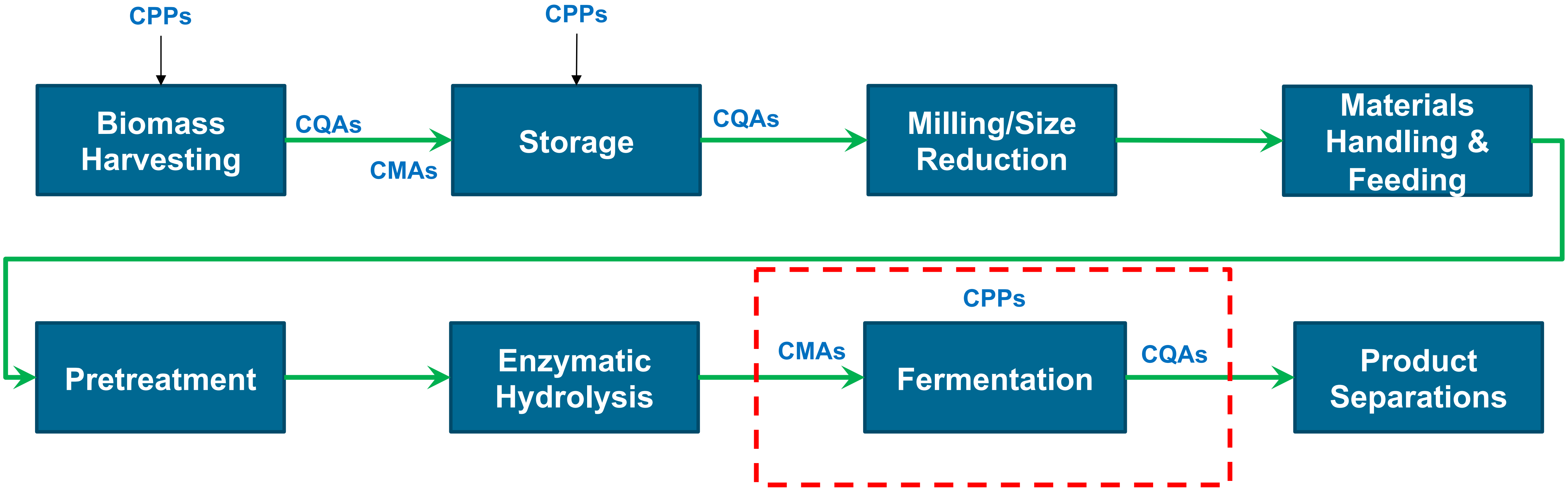
Quality by Design (QbD)

- Key operating concept and organizing principle
- Widely used in pharmaceutical manufacturing – FDA-endorsed
- Chemical processes are collections of <u>specific</u> unit operations
- Unit operations are discrete but connected



*Moving from feedstock **NAMES** to feedstock **ATTRIBUTES***

QbD for the Biomass Value Chain



CMAs:
Monomeric sugar content
Pretreatment byproducts
Inorganics (e.g. Na, K)

CPPs:
Temperature
Feeding strategy
Media composition

CQAs:
Product TRY
- Rate, titer, yield

Residual substrate
Byproducts

FCIC Task Organization

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Feedstock → **Preprocessing** → **Conversion**

Task 2: Feedstock Variability

Task 5: Preprocessing

Task 6: High-Temperature Conversion

Task 7: Low-Temperature Conversion

Task 1: Materials of Construction

Task 3: Materials Handling

Enabling Tasks

Task X: Project Management

Task 4: Data Integration

Task 8: TEA/LCA
Task 9: FMEA

Task X: Project Management: Provide scientific leadership and organizational project management

Task 1: Materials of Construction: Specify materials that do not wear, or break at unacceptable rates

Task 2: Feedstock Variability: Quantify & understand the sources of biomass resource and feedstock variability

Task 3: Materials Handling: Develop tools that enable continuous, steady, trouble free feed into reactors

Task 4: Data Integration: Ensure the data generated in the FCIC are curated and stored – FAIR guidelines

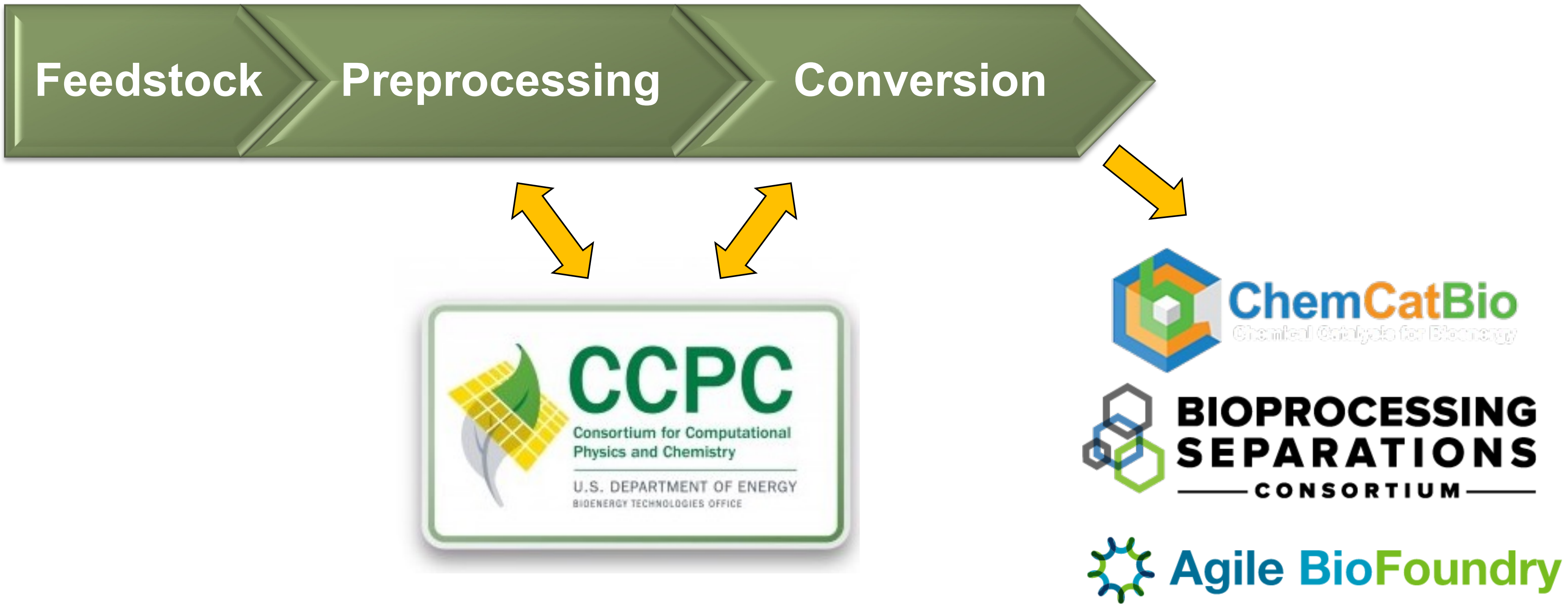
Task 5: Preprocessing: Enable well-defined and homogeneous feedstock from variable biomass resources

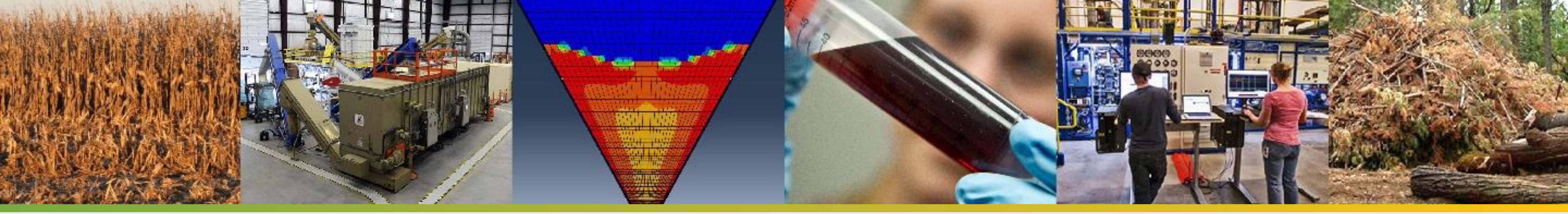
Task 6 & 7: Conversion (High- & Low-Temp Pathways): Produce intermediates for further processing

Task 8:Crosscutting Analyses TEA/LCA: Valuation of intermediate streams & quantify variability impact

Task 9:Failure Mode & Effects Analysis (FMEA): Standardized approach for assessing attribute criticality

FCIC Works in Preprocessing & 1st-stage Conversion





Individual Task Overviews

Task 2. Feedstock Variability

Objective

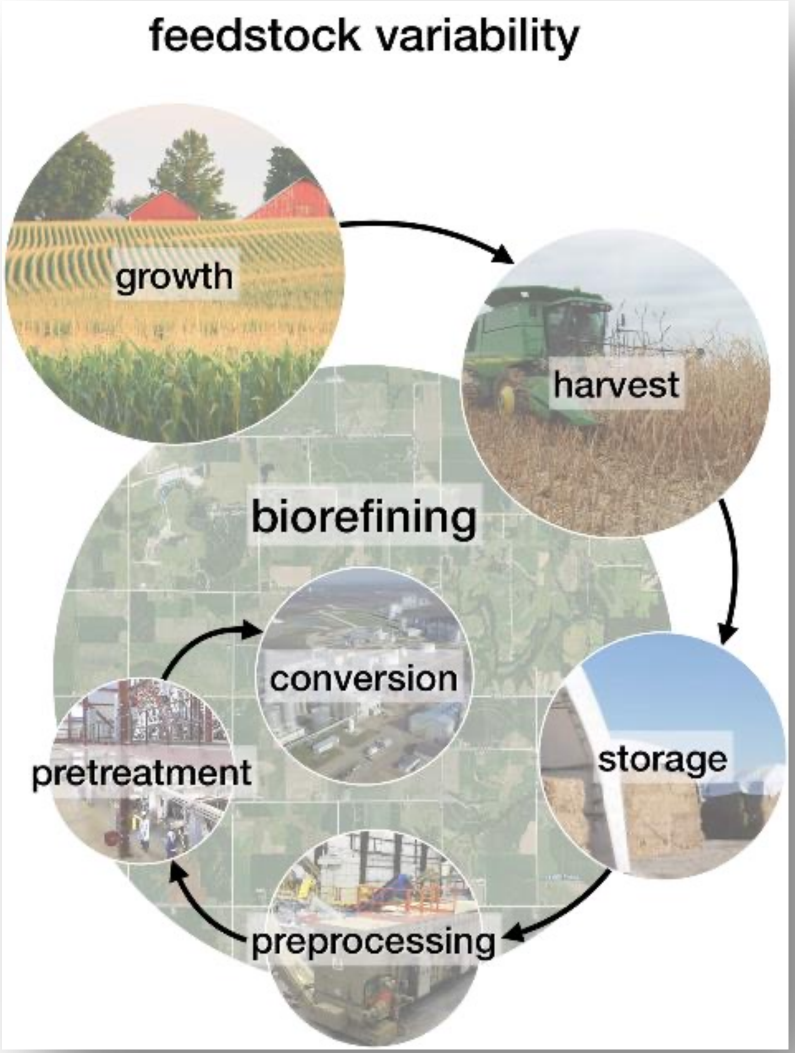
- Identify & quantify the initial distribution of feedstock CMAs and inform strategies to manage this variability

Impact

- Characterization tools and CMA variability data that inform 1) harvest and storage best practices, 2) feedstock quality, and 3) selection of processes that manage variability from the field through conversion
- Knowledge of the sources of intrinsic vs. process-derived variability
- Feedstock suppliers, process designers, and equipment manufacturers can benefit from this fundamental knowledge of drivers that are critical to de-risking the industry

Outcome

- Understanding key sources of biomass variability (e.g., growth conditions, harvest conditions, storage degradation) to identify and quantify CMA distributions that propagate across unit operations to inform cost-effective management of variability



Task 3. Material Handling

Objective

- Develop **first principles-based design tools** that enable continuous, steady, trouble-free bulk flow transport through processing train to reactor throat and enable applications of the developed tools to industry stakeholders.

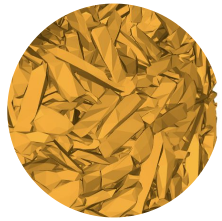
Impact

- Reliable working envelopes of CMAs and CPPs for CQAs of operation units, e.g., **design charts for consistent flow**. Validated design tools (design charts, open-source flow simulation codes) for equipment designers.
- QbD-based predictive design paradigms & tools for industry to effectively assist their design of feedstock processing & handling equipment.

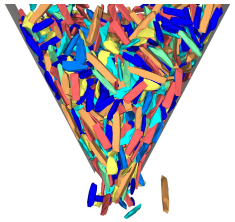
Outcomes

- **Open-source** feedstock flow simulation tools for multiple scales.
- Reliable feeding and handling solutions achieved through physics-based, experiment-informed & validated modeling tools and measurement.

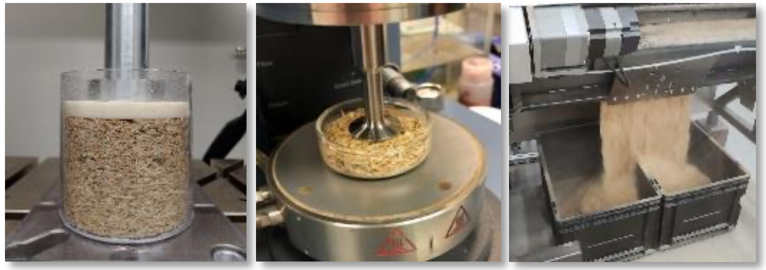
Chipped loblolly pine particles

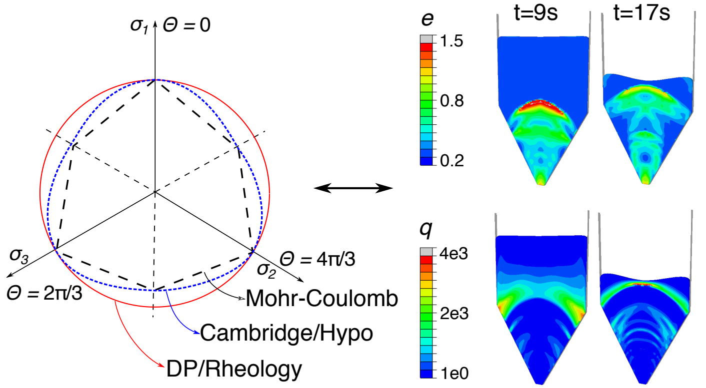


Polyhedral particles of arbitrary shapes



A v-shape hopper discharge simulation





Task 5. Preprocessing

Objective

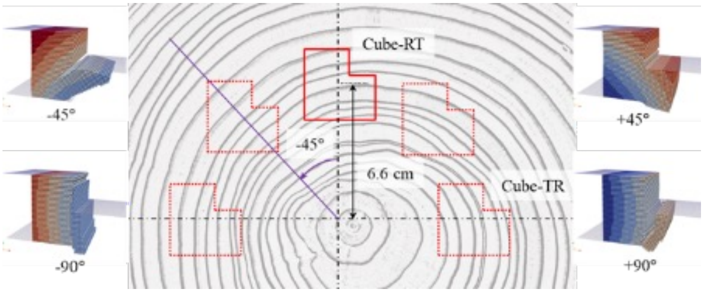
- Develop science-based design and operation principles informed by TEA/LCA that result in **predictable, reliable and scalable performance of preprocessing unit operations**.

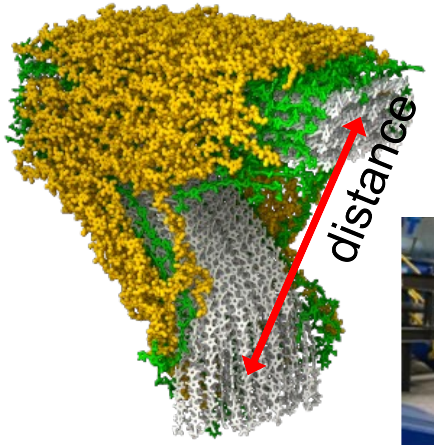
Impact

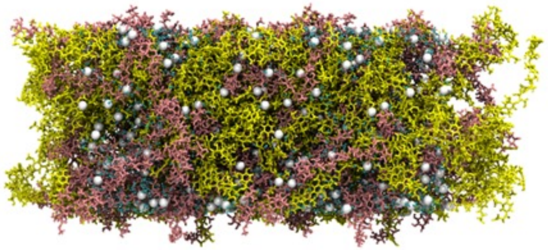
- This task provides knowledge and tools to industry stakeholders through fundamental studies of **comminution, fractionation, and deacetylation** that produce validated mechanistic models.

Outcomes

- A **first-principles-based set of modeling tools** that predict how material attributes of corn stover and pine residues and process parameters of milling, size classification and deacetylation unit operations interact to produce feedstocks with quality attributes required by downstream conversion.
- **Open-source strategy** for all model codes.







Task 6. High-Temperature Conversion

Objective

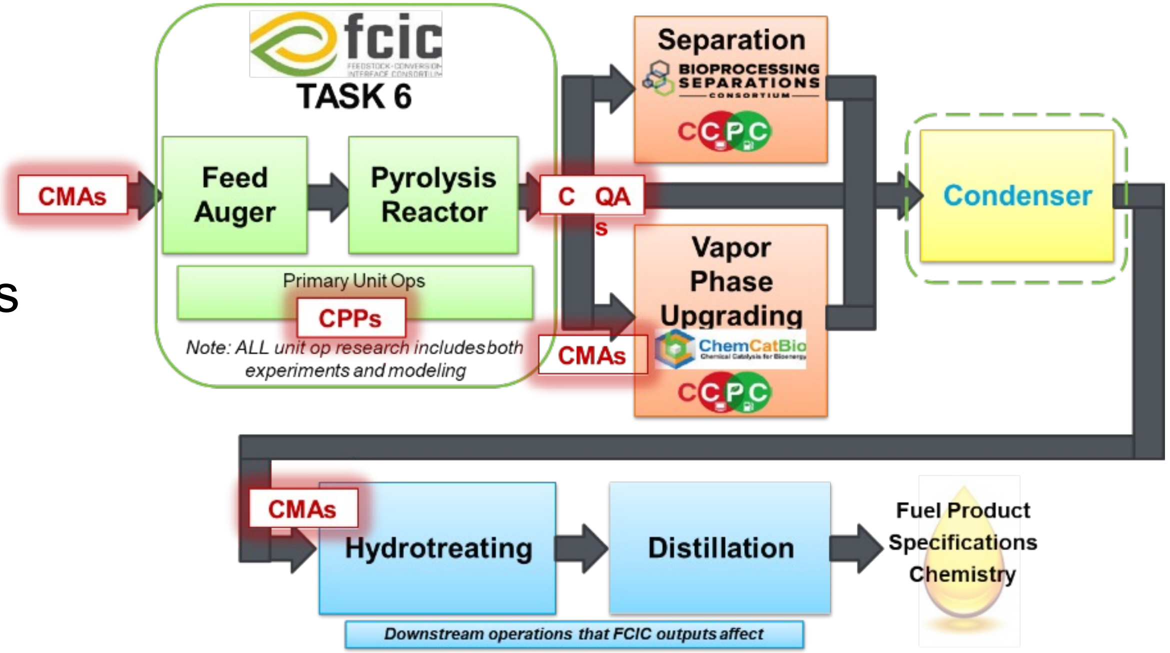
- Develop the science-based understanding required to **accurately predict the effects of variable feedstock** attributes (CMAs) and process parameters (CPPs) on **pyrolysis & gasification** product quality attributes (CQAs).

Impact

- The work from this task will allow biorefinery designers and operators will be able to design high-temperature unit operations/processes that are flexible and responsive to natural and market feedstock variability, while maximizing productivity.

Outcome

- A **validated, multiscale experimental and computational framework** allowing biorefinery designers/operators to maximize productivity and quality with variable incoming feedstock.



Task 7. Low-Temperature Conversion

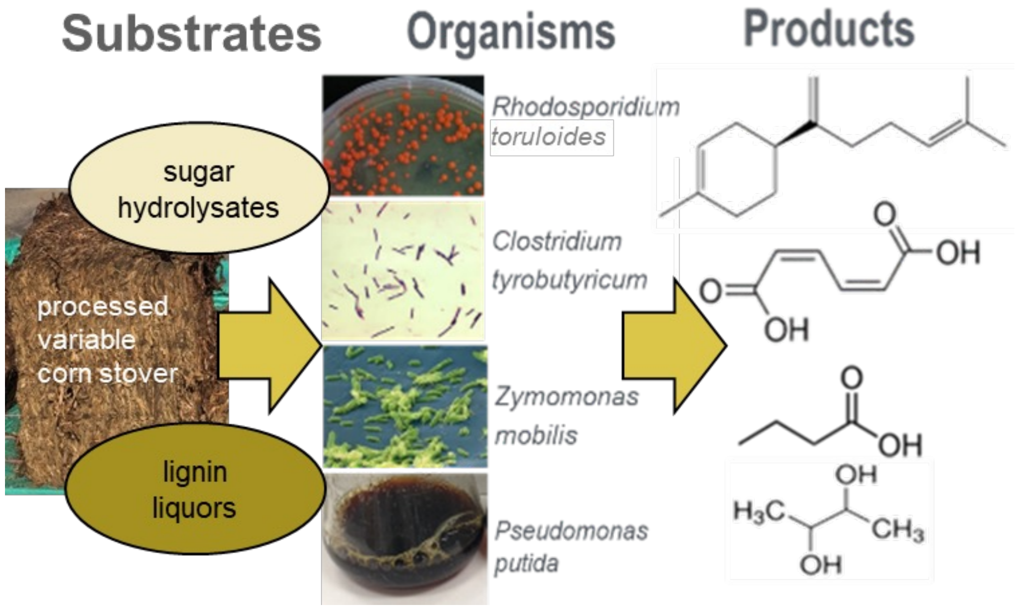
Objective: Manage the risks posed by biomass feedstock variability on low-temperature conversion processes (both sugar and lignin pathways) by evaluation of the impacts to train mitigation strategies.

Impact

- Knowledge and tools that sustain high-levels of production through **first-principles understanding** of materials attributes that negatively influence predictable performance (e.g., inhibitory effects) can be used to **guide process changes to minimize impacts**.

Outcome

- A **validated AI/ML framework** allowing stakeholders to minimize the impacts of feedstock and process variability on biological upgrading performance.



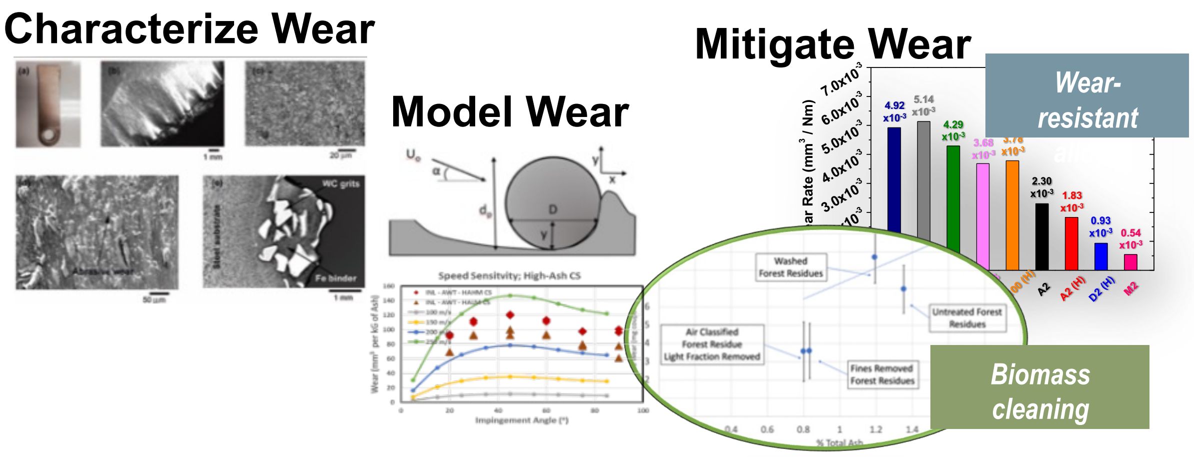
Task 1. Materials of Construction

Objectives

- Use a systematic quality-by-design approach with **integrated efforts of characterization, modeling, and testing** to gain fundamental understanding of the failure modes and wear mechanisms of biomass preprocessing equipment, develop analytical tools/models to predict wear and establish material property specifications.
- **Select and evaluate candidate mitigations** based on modeling and lab-scale testing
- Share the fundamentals and mitigations with the biomass industry.

Impact

- The knowledge and tools developed here will enable rapid design and selection of materials that resist wear and maintain structural integrity, resulting in sustainable performance and improved product quality.
- The science-based approach avoids the time and expense associated with trial-and-error methods.



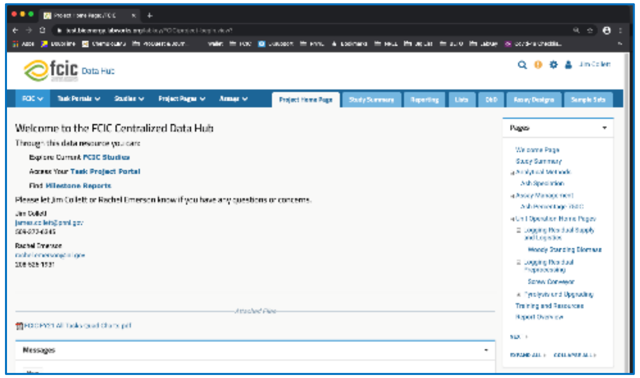
Outcome

- Develop **knowledge and tools to understand how to measure, predict, and mitigate wear**.

Task 4. Data Integration and Web Portal

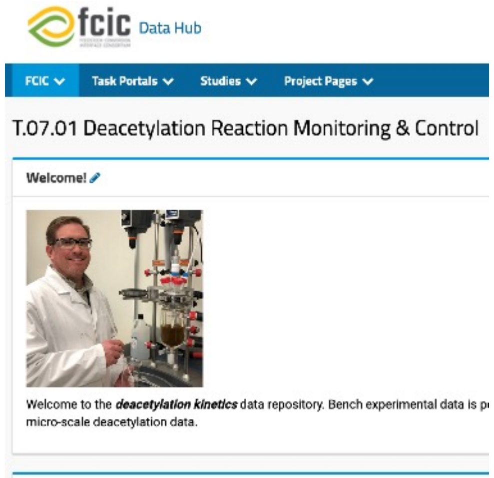
Objective

Build **database tools** for integrating CMAs, CPPs, CQAs and experimental data from across FCIC the within the LabKey Data Hub hosted on the AWS cloud. We are providing a collaborative computational environment for hypothesis development, experimental and modeling workflow management, integration of datasets and metadata, and deliverables sharing between FCIC subtasks and a portal for public access to FCIC results, data, and software.



Impact

This task provides the **necessary infrastructure** for FCIC researchers to store and integrate their experimental results according to FAIR guidelines and is enabling easier collaborations among tasks.



Outcomes

- A **web-based platform accessible to all FCIC researchers** and stakeholders to provide data and knowledge on the effects of feedstock variability.
- A means **to harmonize data across the FCIC**; and tools to facilitate sharing of Case Study results, including Case Study experimental datasets and cost analysis results.

Task 8. Crosscutting Analyses

Objective

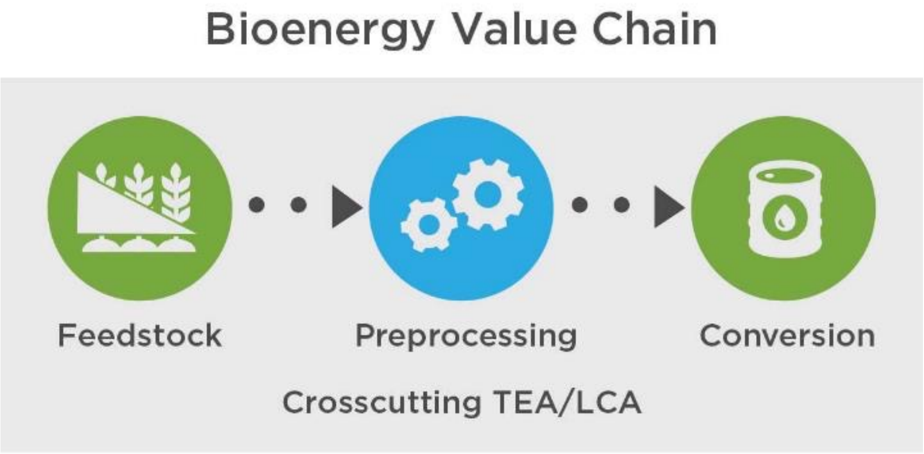
- **Quantify and communicate industrially relevant, system-level costs** and environmental impacts for the discoveries and innovations of the FCIC.

Impact

- This project provides cost-benefit TEA and LCA focused on **impacts of feedstock variability on yields, economics, and environmental sustainability** to aid biorefinery engineers and equipment manufacturers conducting feasibility studies of proposed equipment and process design modifications.

Outcomes

- The importance of systems-level analyses for biorefinery and feedstock supply chain design will be demonstrated.
- **Case study results** demonstrating the economic and environmental benefits of convergent feedstock-preprocessing-conversion design will be disseminated through publications and presentations targeting industrial stakeholders.



Task 9. FMEA Criticality Assessment Tools

Objective:
- Implement Quality-by-Design (QbD) by applying a systematic criticality assessment methodology to evaluate unit operations and systems.
- Develop framework to track and quantify the criticality of critical material attributes (CMAs), critical process parameters (CPPs), and critical quality attributes (CQAs).

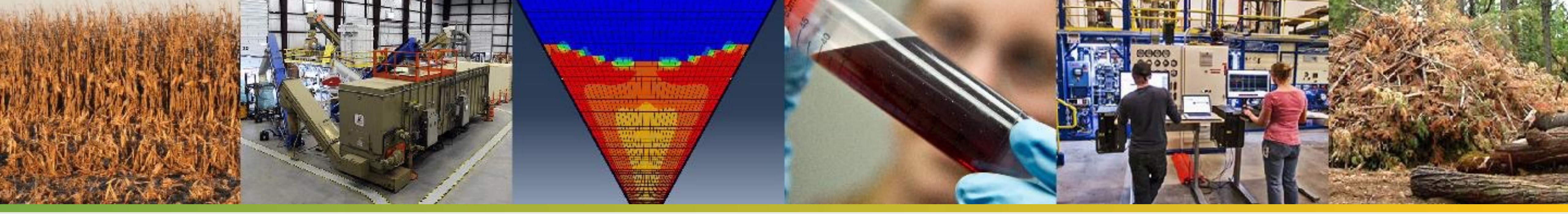
Impact:
- Development of a **systematic methodology** for biorefinery risk assessment using a QbD approach.
- Generation of FMEA database for risk assessment of future simulated system configurations.

Outcome:
- Provides **semi-quantitative criticality estimation** for quality attributes (CMAs, CPPs, CQAs) for a given unit operation or system.

Identify Failures
- Deviations from CQAs

Identify Causes
- CMA and CPP

Evaluate Risk
- Calculate risk priority number



Industry Outreach

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FCIC Industry Advisory Board (IAB) Members

Prof. Foster Agblevor (Utah State)
https://engineering.usu.edu/be/people/faculty/agblevor-foster

Mr. Brandon Emme (ICM)
https://www.linkedin.com/in/brandon-emme-6104ab67

Mr. Glenn Farris (Lee Enterprises)
https://www.linkedin.com/in/sgfarris/

Prof. Emily Heaton (U. Illinois)
https://cropsciences.illinois.edu/people/profile/heaton6

Mr. Brad Kelley (Gershman, Brickner & Bratton, GBB)
https://gbbinc.com/about/our-experts/bradley-kelley-bsme


Foster Agblevor


Brandon Emme


Emily Heaton

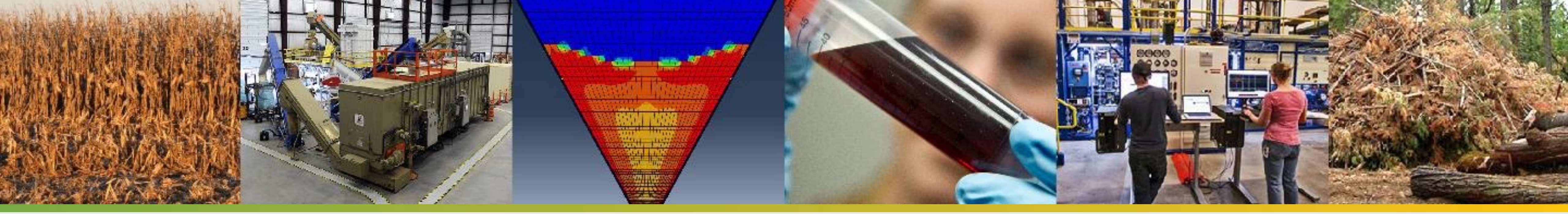

Glenn Farris


Brad Kelley

Task-Level Industry Outreach Activities

Some representative examples of FCIC Task-level industry outreach & interactions

Task	Industry Outreach & Interactions
X	Coordinating conference sessions (AIChE, International Biomass Conference)
1	Regularly engaging Comminution Equipment suppliers (e.g., Forest Concepts, Rawlings)
2	Publication series in Biomass Magazine https://biomassmagazine.com/articles/19639/feedstock-variability-causes-consequences-and-mitigation-of-biological-degradation
3	Publishing open-source modeling codes and design charts https://github.com/idaholab/LIGGGHTS-INL
4	Formation and Interaction with Data Stakeholder Advisory Team
6	Industry survey to ensure relevance; publishing open-source modeling codes
8	Publishing FCIC Case Studies



2023 FCIC CRADA Call

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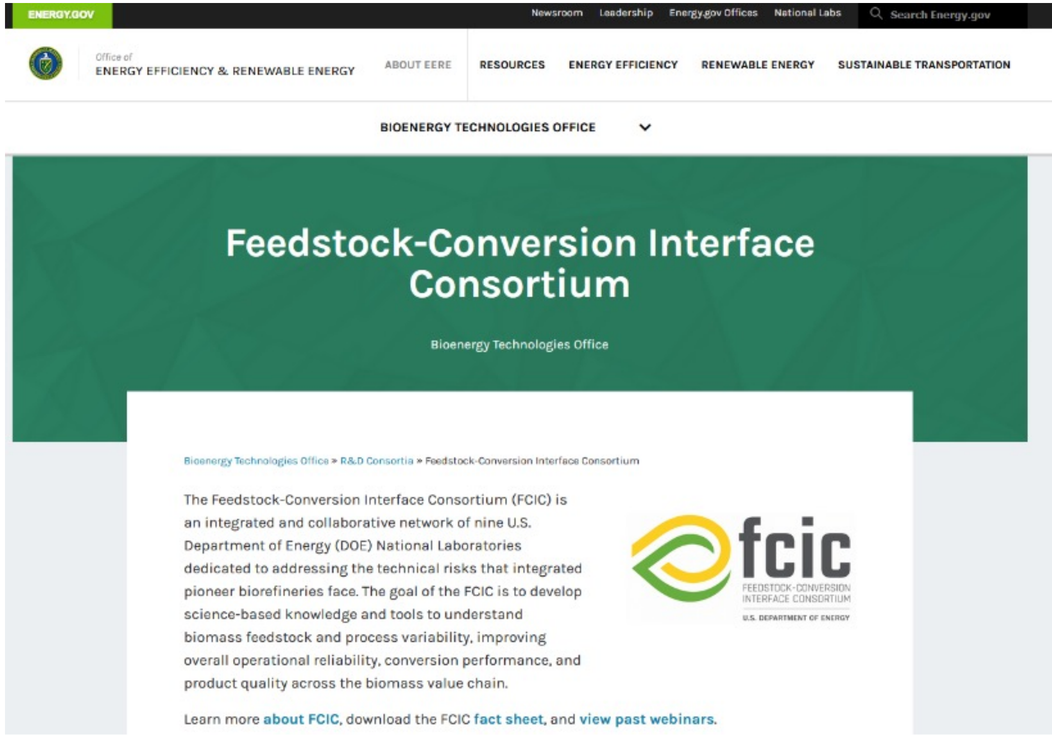
2023 FCIC CRADA Call

- The full CRADA Call is available at https://www.energy.gov/eere/bioenergy/fcic-cooperative-research-and-development-agreement-call
- The intent of this CRADA call is to **apply FCIC capabilities to real world problems** that the bioenergy and bioproduct industries are facing.
- To maximize the likelihood of near-term impact for industrial partners, the FCIC wants to **leverage existing capabilities** within the consortium as opposed to projects that require novel model or tool development.
- A full list of capabilities and tools can be found at: https://www.energy.gov/fcic



CRADA Call Timeline

Date	Event
Mar 14th	Informational Webinar
April 14th	Notice of Intent **Deadline**
April 21st	Applicant Presentation **Deadline**
May 5th	Proposal Submission **Deadline**
May/June	Project Proposal Review
June 30th	Announcement of Selections
October	Anticipated project kickoffs

Send a Notice of Intent

- A notice of intent is required by **April 14th**
  - Email FCIC@nrel.gov with the following information: Name, Organization, Email, and proposed National Lab Partner (if appliable).
  - You will receive a confirmation of receipt email within 1 working day.

- Prior to submitting a notice to propose a project, please read the terms of the Cooperative Research and Development Agreements (CRADA) at https://www.energy.gov/sites/default/files/2023-03/FCIC%20FY23%20CRADA-call-%20CRADA%20template.docx. This has been reviewed and approved by most participating DOE labs. This template will be used for all FCIC projects and is non-negotiable.

Previous CRADA Projects (2017 call)

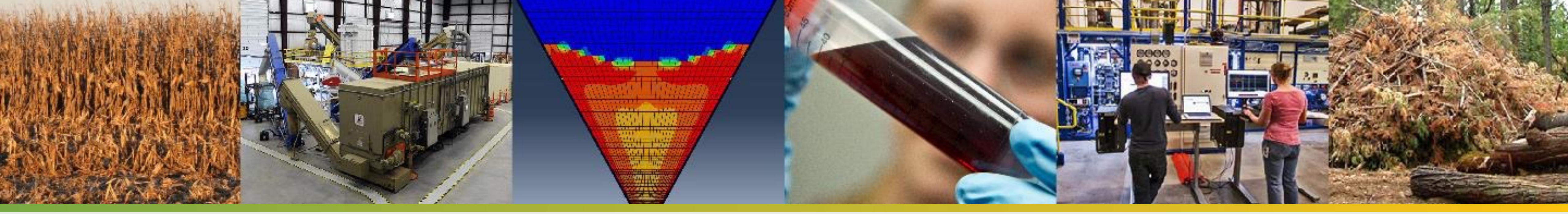
The Wonderful Company/Jenike/V-Grid/NREL/INL - Rational design of robust reactor feeding systems for heterogeneous cellulosic and agricultural wastes based on biomass quality characteristics

Fulcrum Bioenergy/INL - Moisture Management and Optimization in Municipal Solid Waste Feedstock through Mechanical Processing

Jenike & Johanson/LANL - "Smart" Transfer Chutes with In-line Acoustic Sensors for Bulk-Solids Handling Solutions

Forest Concepts/ORNL/INL - Investigating and addressing the wear issue of the rotary shear biomass comminution system

Idaho Forest Group/INL - Real time, Integrated Dynamic Control Optimization to Improve the Operational Reliability of a Biomass Dryer



Key FCIC Concepts

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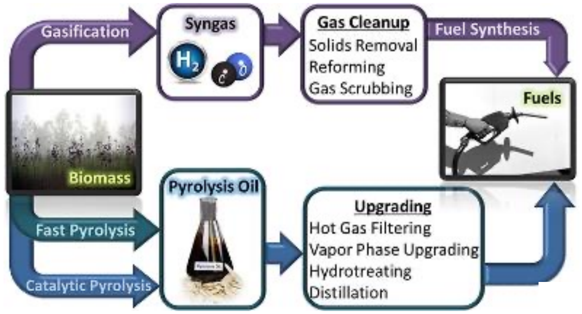
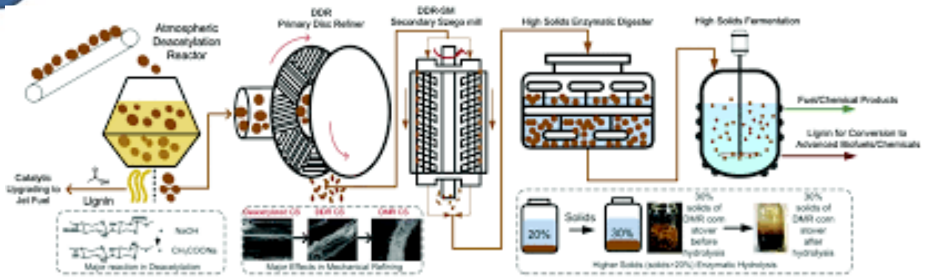
FCIC Key Concepts

Conversion Pathways

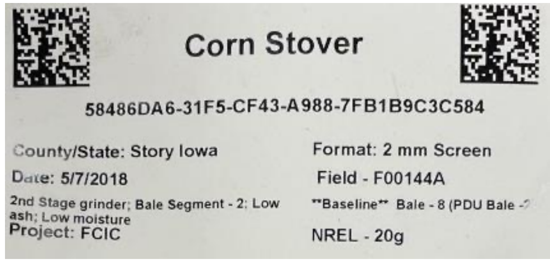
- High-Temperature Pathway
  - Pine residue & MSW feedstocks
  - Pyrolysis and Gasification
- Low-Temperature Pathway
  - Corn Stover & MSW feedstocks
  - Deacetylation & Mechanical Refining and Enzymatic Hydrolysis (DMR/EH)





Sample Tracking

- Using INL's Bioenergy Feedstock Library (BFL) to track samples
  - All samples get a unique ID
  - Parent/child relationships track samples across value chain



Feedstock Campaigns

- 13- vs. 23-year study (Pine)
- Anatomical fraction series (Pine & CS)
- Degradation series (CS)
- Drought series (CS)

Current FCIC Feedstock Portfolio

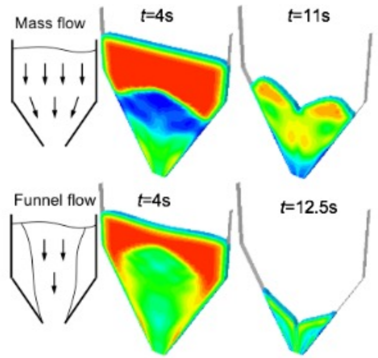
Corn Stover
- **Low-T conversion focus**
- Chemical, Physical, and Mechanical Differences among **anatomical fractions** substantial
- **Degradation** during storage showed big influence on conversion

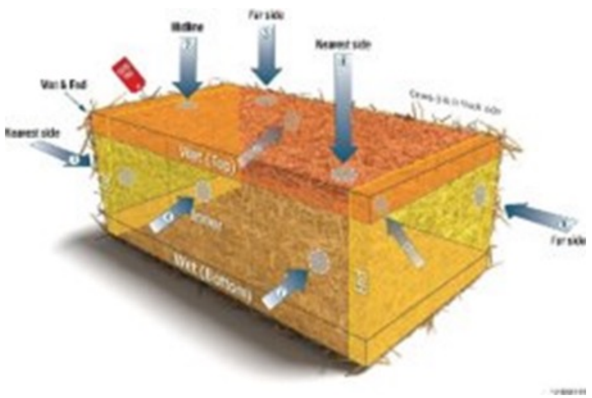
Pine Residues
- **High-T conversion focus** (pyrolysis & now gasification)
- **Anatomical fractions** are different
- Logging residues and tree thinnings differ in anatomical fraction distribution
- Changes/degradation during storage may be important (anecdotal)

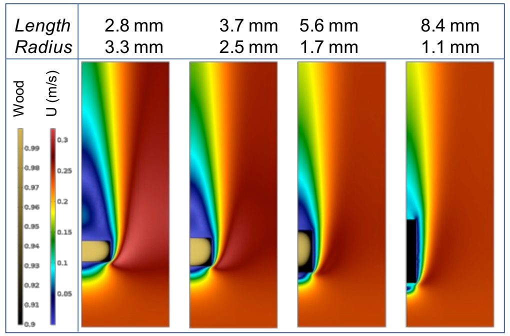
Landfill-bound MSW
- Currently looking at **post-MRF** streams
- **Paper-rich & plastic-rich** streams
- Some Low-T & High-T conversion data later this year

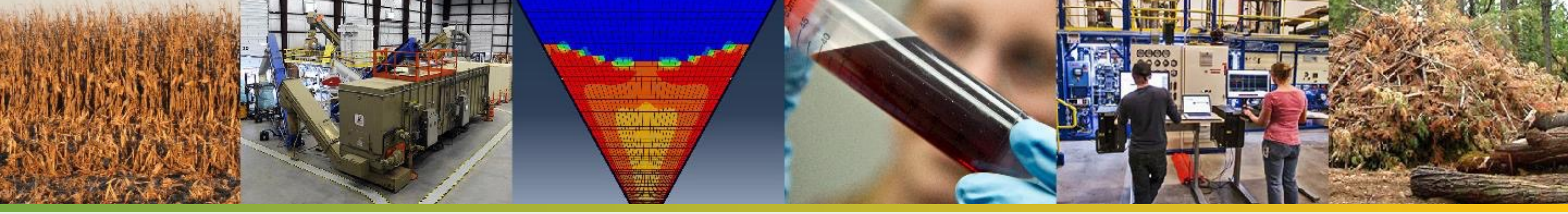
Summary

- **Feedstock Variability** across the Bioenergy Value Chain is a Risk to Biorefineries.
- **FCIC** Researchers are using elements of the **Quality-by-Design** approach to understand and mitigate the impacts of **feedstock variability** on bioenergy conversion processes.
- Deep **subject matter expertise**, detailed chemical, physical, and mechanical characterization, and robust and validated modeling is providing **knowledge and tools** to bioenergy stakeholders.









Project Overview

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

U.S. DEPARTMENT OF ENERGY

FCIC Project Management

Objective

- Provide **scientific direction** and **leadership** to the nine participating labs.
- Provide **project management** to ensure robust operational planning and execution.

Impact

- The FCIC supports the BETO portfolio by focusing on **feedstock variability across the bioenergy value chain.**
- **Effective project management** is essential for the success of the consortium

Outcomes

- **Successful Tasks,** each with different objectives but a common theme – feedstock variability.
- FCIC research successfully **complementing** existing **BETO-funded projects**

FCIC Project Management Team

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Amie Sluiter
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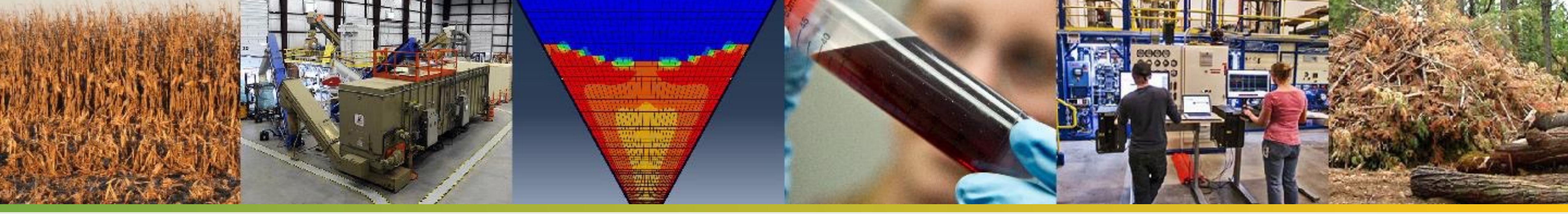


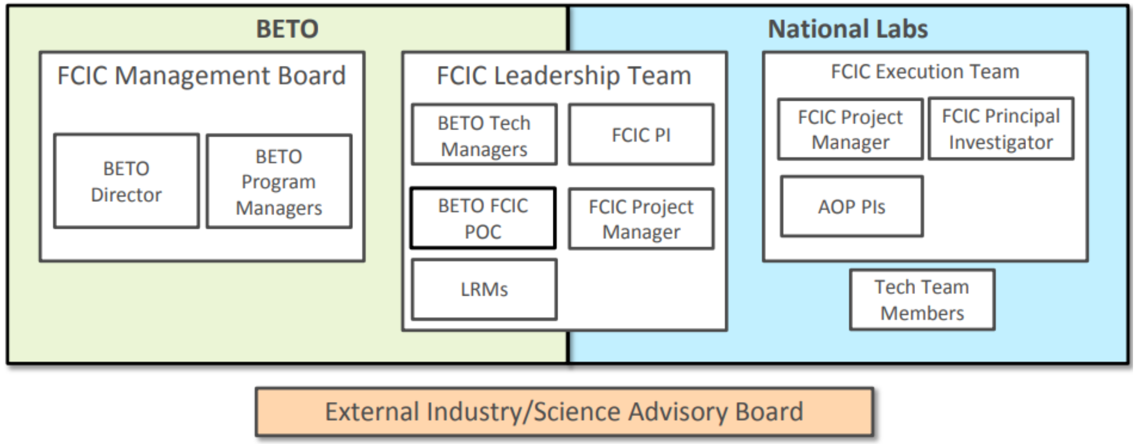
1 – Approach

1 – Approach

Technical Approach
- Emphasizing **collaboration** and ongoing **communication** among Consortium Stakeholders
- Implementing time-proven Project Management approaches

Challenges
- Coordination and communication among researchers across 9 Tasks and 9 National Laboratories
- Ensuring industrially relevant outcomes

Metrics
- Successful & timely completion of all FCIC milestones
- Positive feedback from BETO & Industry stakeholders



1 – Approach (2)

Risks/Mitigation

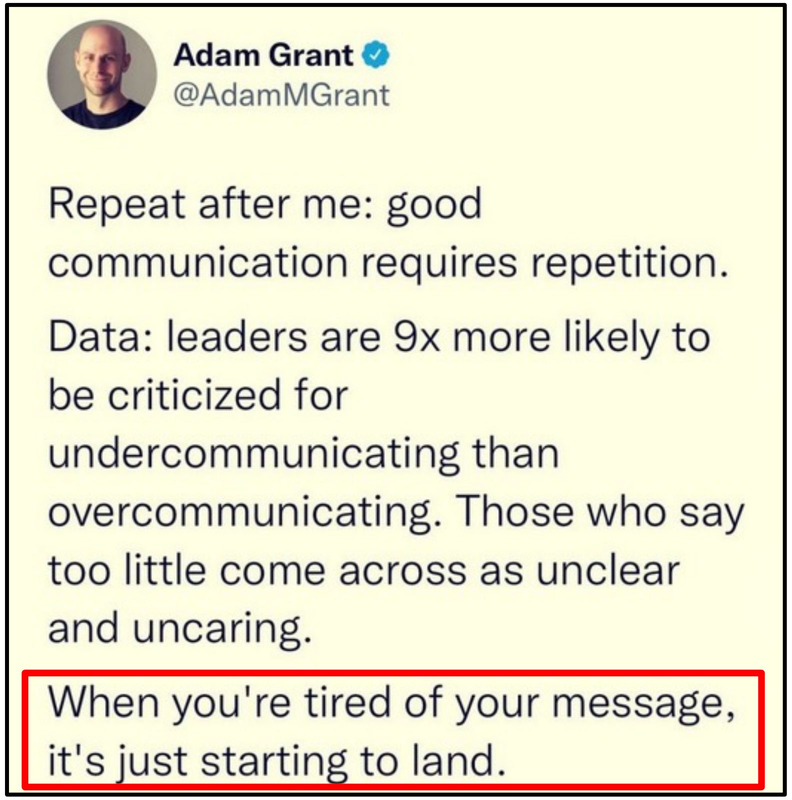
- Miscommunication among stakeholders (BETO, FCIC Task Leads, Lab LPMs, Industry)
  - Minimized by regular meetings among all stakeholders and frequent email exchanges
  - Material & data needs, sample tracking tools
- Research not industrially relevant
  - Regular communication with IAB members
  - Close collaboration with Stakeholders during Annual planning

Communication/Collaboration

- Biweekly meetings with **BETO TMs and Task Leads**
- Monthly meetings with **FCIC Leadership Team**
- Quarterly meetings with **FCIC IAB**
- Substantial Informal communication (calls & emails)

Diversity, Equity, Inclusion

- Multiple task- and lab-specific initiatives


Adam Grant
@AdamMGrant

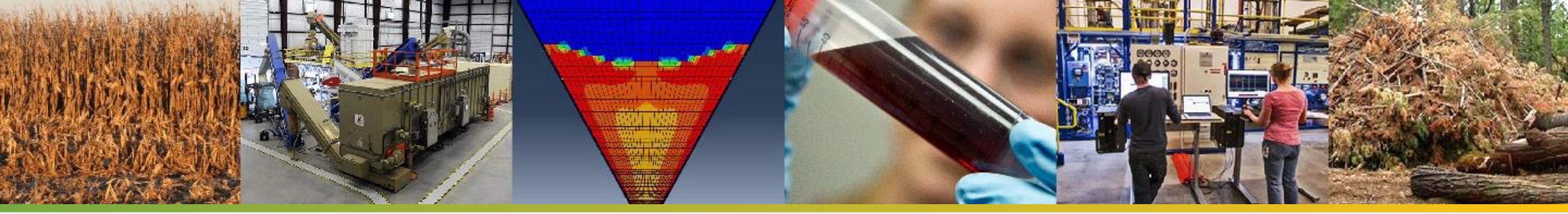
Repeat after me: good communication requires repetition.

Data: leaders are 9x more likely to be criticized for undercommunicating than overcommunicating. Those who say too little come across as unclear and uncaring.

When you're tired of your message, it's just starting to land.

FCIC DEI Plans

Task	FY23 DEI Plan
X	• Website- student and teacher resources link • INL rural school outreach program in Idaho • Establishing a long-term collaboration with a local MSI - Denver
1	Hands-on lesson plan to teach students about the strengthening of materials by addition of coatings or treatments
2	Outreach to small businesses and producers in underserved and rural communities
3	Production of a video highlighting women minority student-of-color interns
4	3-week lesson plan on waste-to-energy for Bioethics class at WA high school (serves a 60% Hispanic student population)
5	Webinar series to discuss roles/experiences through STEM education and accessibility, aimed at local INL underserved schools
7	Presentations focusing on MSI and farming communities



2 – Progress and Outcomes

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Overall Consortium Management

Effective Project Management

- Task Coordination
- Milestone Tracking
- Quarterly Reporting

Communications

- Regular Meetings (Task-level, Task 1-on-1's, Leadership Team, individual LPMs)

Business processes

- Annual Planning Process to generate integrated AOPs
- Annual Meetings (virtual in 20, 21, 22)
- Consortium-level preparation for peer review, merit review

CRADA Call pre-approved CRADA

- Lessons learned from 2017 call & similar calls from other Consortia - ABF/CCPC/ChemCatBio

Met	Lead Lab	Task	Milestone Name	
Y	INL	2	Task 2 FY23 Q1 (INL): Drought-stressed corn stover anatomical fractions.	Determine c quantitativel feedstock.
Y	INL	3	Task 3 FY23 Q1 (INL): Measure flowability of pine residue mixtures (up to 25-30% M.C).	Measure flo pine residue leads; LANL,
	PNNL	4	Task 4 FY23 Q1 (PNNL): Data Stakeholder Workshop	Inaugural an available Ca
Y	INL	5	Task 5 FY23 Q1 (INL): Calibrate and validate DEM knife mill model at pilot scale	Complete DE FY22 Q2 pilo (based on ef
Y	ORNL	6	Task 6 FY23 Q1 (ORNL): Compare chemical characterization of pyrolysis oils from pine anatomical fractions with model predictions	Validate pro pyrolysis oil variances be
Y	NREL	7	Task 7 FY23 Q1 (NREL): Compare MSW pretreatment/deconstruction approaches and generate lists of MAs to be experimentally assessed for criticality	Compare an yields and M

Y	ORNL	6	of pyrolysis oils from pine anatomical fractions with model predictions	pyrolysis oil chemical characterizat variances between model predictio
Y	NREL	7	Task 7 FY23 Q1 (NREL): Compare MSW pretreatment/deconstruction approaches and generate lists of MAs to be experimentally assessed for criticality	Compare and contrast pretreatmen yields and MA→CMA ranked orderi
Y	INL	8	Task 8 FY23 Q1 (INL): FMEA interview for MSW unit operation	Complete one FMEA interview with support further MSW process desig
	NREL	2	Task 2 FY23 Q2 (NREL): Public heuristics for variability from anatomical fractions.	Develop a public heuristics commu manage the range and sources of f
	INL	4	Task 4 FY23 Q2 (INL): Integration of FY22 Material Needs core FCIC datasets and metadata	Integration of FY22 Material Needs the Data Hub to enable linkage of c analysis and downloading by indust
	NREL	5	Task 5 FY23 Q2 (NREL): Demonstrate automatic particle segmentation in conveyer images	Demonstrate that EasyVision can a 80% accuracy compared with manu
	PNNL	6	Task 6 FY23 Q2 (PNNL): FP oils Characterization	Complete analytical characteristics common pyrolysis conditions (Main differences among the feedstock. P
	PNNL	8	Task 8 FY23 Q2 (PNNL): Case Study Publication	Publish at least 6 Case Studies on t published by FCIC laboratories, and
	ORNL	1	Task 1 FY23 GNG (ORNL): Identify wear mitigation	Identify at least one material or sur resistance compared with a commo

Overall Consortium Management (2)

Material Needs and Data Handoffs

- We coordinate and track material needs and data handoffs
- Gathered during yearly project planning & revisited monthly
- We are coordinating about 100 in FY21 & FY22 (In FY23 we have about 50)

Request ID	Status	Requestor			Material or Data	Provider			Due Date	(Notes)
		Lab	Contact	Task		Lab	Contact	Task		
FCIC20-066	Pending	NREL	Dave Sievers	7	6 samples @ 40 kg each degraded bale samples	INL	Amber Hoover	2	3/31/2020	INL has degraded bales from Iowa, stored inside
FCIC20-022	Pending	NREL	Abhijit Dutta	8.3	Feedstock composition & variability (includes ash, moisture, dimensions, aspect ratio, lignin etc.)	INL	Dave Thompson	8.2	3/31/2020	Limit information incorporation to parameters that have quantified or known impacts on downstream processes

Sample Tracking

- Using INL's Bioenergy Feedstock Library (BFL) to track samples
  - All samples get a unique ID - ***GUID***
  - Parent/child relationships track samples across FCIC Tasks at different laboratories
  - Still needs regular monitoring – Task 4 leading this

https://bioenergylibrary.inl.gov/Home/Home.aspx

Outreach Materials

FCIC Factsheet
https://www.energy.gov/eere/bioenergy/downloads/feedstock-conversion-interface-consortium-fact-sheet

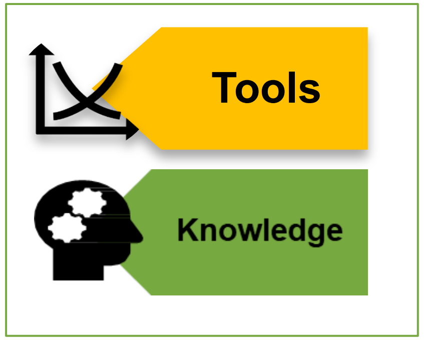
FCIC Website
http://energy.gov/fcic

FCIC 10-slide guide to Biofuels Digest
https://www.biofuelsdigest.com/bdigest/2022/02/27/de-risking-biorefinery-scale-up-and-startup-the-digests-2022-multi-slide-guide-to-fcic/

Annual Reviews
- Overview of the FCIC accomplishments in fiscal years 2020 & 2021 completed
- FY 2022 Annual review in progress

Technoeconomic Case Studies
- High-level summaries of TEA case studies and more detailed technical reports
- Associated datasets available for download

Tools and Knowledge Slides
- Consistent format for presenting FCIC achievements



Merit Review in Summer 2022 was Clear – FCIC needed to focus on some new areas

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Enhancing Impact of Key Results to Industry
Partnerships with industry are strongly encouraged. 1-year and 3-year outcomes must be clearly described.

Public Heuristics of Systems/Resources that Address Biomass Variability
1-year and 3-year outcomes must be clearly described. An area of interest and desired outcome for the consortium is to develop broad dissemination of system design heuristics. The development of storage, flow, and feeder systems that are compatible with the variability inherent to lignocellulosic feedstocks would have significant value. In this area, dissemination is strongly encouraged to include industrial partners and must include public dissemination in methods beyond academic journals.

Preprocessing Technologies/Processes to Improve Quality Downstream
1-year and 3-year outcomes must be clearly described. Proposals should explain what downstream verification will be used to validate these efforts. Proposals are encouraged to partner with existing AOPs or projects to leverage those projects and experimental workflows.

Inclusion of MSW as a Feedstock Source
1-year and 3-year outcomes must be clearly described. Proposals must explain how they have considered existing MSW supply chains and what downstream conversion processes are relevant. Proposals are encouraged to partner with existing AOPs or projects to leverage those projects and experimental workflows.

Enhancing the impact of FCIC results to industry…

- Continued engagement with FCIC **Industry Advisory Board**

- Continue maintaining **FCIC website (http://energy.gov/fcic)**
  - Added links to lab-hosted **GitHub repositories** with modeling code.
  - Major update later in FY23

- **Case Studies** being published

- Launching **Data Hub** later this year

- **Conferences**
  - AIChE Session (Nov 21 & 22)
  - ABLC Next (Oct 22)
  - Intl. Biomass Conference (Jan 22 & Feb 23)


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Techno-Economic Analysis Case Study: Corn Stover Storage Options Considering Variable Degradation Within Bale Stacks

CHANGING THE PARADIGM OF CONVENTIONAL APPROACHES

Conventional Approach	New Information	Improved Approach
Prior studies using average estimates of losses and compositional changes during storage miss the operational impacts of biomass variability.	This new corn stover techno-economic analysis model better represents moisture migration through biomass bale stacks that create zones of varying degradation, which behave differently in preprocessing and conversion operations.	Using this approach, researchers can more accurately estimate costs of storage losses and protected storage, as well as predict the impact of bale-to-bale variability on biorefinery operations.

Providing public system design heuristics …

- Task 2 is developing **data-supported guidelines** for industry stakeholders on how to identify and address feedstock variability at multiple points in the value chain

- Task 3 is providing the results of their advanced modeling work as **design charts** for industry stakeholders

- Task 5 is continuing its comminution modeling work and will supply **guidelines** based on this work to industry stakeholders

- Task 1 will provide **actionable guidance on selecting materials of construction** for biomass handling equipment based on its modeling and experimental work.

Emphasizing the downstream verification of preprocessing impacts…

- Developing and implementing rapid conversion screening tools for both the high- and low-temperature conversion pathways.

- **Low-Temperature Work Underway**
  - ~50g dry biomass samples
  - Batch deacetylation, PFI Mill mechanical refining, enzymatic hydrolysis with CTEC2/CTEC3 enzymes
  - Correlate EH results with optical fiber analysis – skip the time-consuming EH step

- **High-temperature work** – aligning/comparing existing methods currently used (py-GC/MS, small-scale pyrolysis)
  - What scales can provide useful, actionable data?

Valmet Fiber Image Analyzer

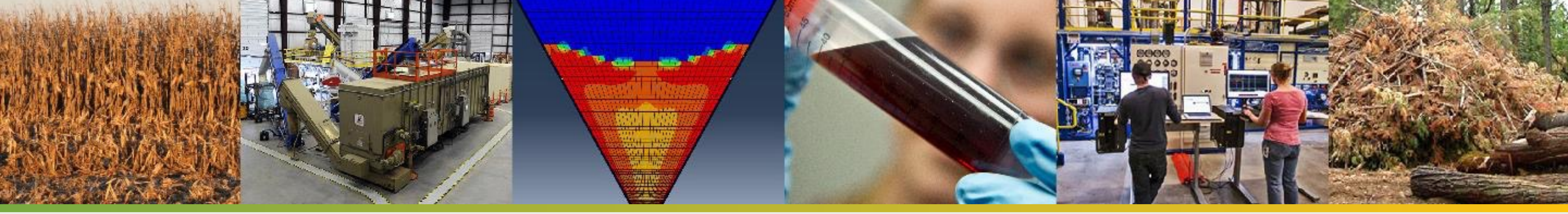
Incorporating MSW into the FCIC research portfolio…

- For the FCIC, MSW is defined as the post-recycling organic waste stream consisting primarily of non-recyclable plastic, paper, wood, and in some cases food waste that is currently sent to landfills

- INL acquired some representative post-MRF bales from Michigan (a bottle bill state) and is sorting these
  - Created plastics-rich and paper-rich streams using robotics system
  - Comminuted using Forest Concepts rotary shear
  - Distributed to FCIC Stakeholders

Incorporating MSW into the FCIC research portfolio… (2)

- MSW is defined as the post-recycling organic waste stream consisting primarily of non-recyclable plastic, paper, wood, and in some cases food waste that is currently sent to landfills – **Landfill-bound MSW**
- Task 2 are performing **multiscale characterization** on MSW materials.
- Task 5 is identifying **CMAs for MSW preprocessing**.
- Tasks 5, 6 & 7 are testing the **conversion performance of select MSW samples** in both high- and low-temperature conversion pathways.
- Task 1 is defining the **wear impacts of MSW characteristics** in select MSW processing systems.
- Task 3 will be examining **MSW flow characteristics** using a combined modeling/experimental approach.



3 – Impact

3 – Impact

- **Feedstock variability** remains a **key challenge** to the scale-up and commercialization of bioconversion technologies.
- FCIC researchers are addressing this key challenge with research **across the bioenergy value chain**
- The success of the FCIC depends on the **individual successes** of the **individual Tasks.**
- This Task is helps FCIC researchers succeed by coordinating the efforts of over **100 researchers across 9 National Laboratories and 9 different FCIC Tasks**.
- **Industry Advisory Board (IAB)** helps ensure industry relevance

Feedstock → **Preprocessing** → **Conversion**

Summary

Objective

- Provide **scientific direction** and **leadership** to the nine participating labs.
- Provide **project management** to ensure robust operational planning and execution.

Technical Approach

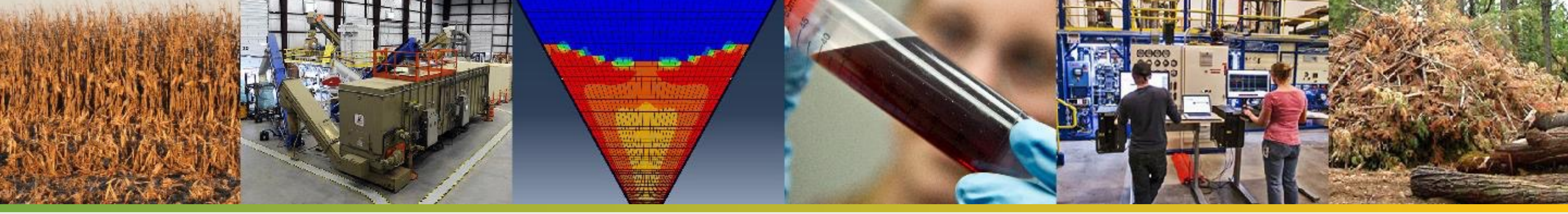
- Emphasizing **collaboration** and regular **communication** among Consortium Members
- Implementing time-proven **Project Management** approaches

Impact

- The FCIC supports the BETO portfolio by focusing on **feedstock variability across the bioenergy value chain**
- **Effective project management** is essential for the success of the consortium

Achievements

- **Successful Tasks,** each with different objectives but a common theme – feedstock variability.
- FCIC research successfully **complementing** existing **BETO-funded projects**
- Leading FCIC **Outreach** Activities



Additional Slides

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Quad Chart Overview

Timeline

- *October 1, 2021*
- *September 30, 2024*

	FY22 Costed	Total Award
DOE Funding	*$606K*	*$1.95MM*
Project Cost Share *	NA	NA

TRL at Project Start: N/A
TRL at Project End: N/A

Project Goal

Provide scientific direction and leadership to the FCIC and to ensure robust and timely operational planning and execution. The outcome of this task is a successful consortium, including scientific relevance, timely deliverables, and actively managed stakeholders.

End of Project Milestone

3-year capstone Report. Write a high-level progress report to capture progress across the consortium. Provide report to DOE and publish as a standing resource for the bioenergy community and to promote the consortium success.

Funding Mechanism

2021 Lab Call – FCIC Merit Review

Project Partners

- NA

Reviewer Comments/Responses

- **"The biggest gap is tasks demonstrating understanding of economic impact potential or delivery. TEAs are clearly being performed for prioritized cases, but some tasks did not report benefit of that understanding."**
  - The "Case Study" approach that Task 8 is taking has been very effective in articulating the economic impact potential of the projects. These Case Studies have required data generation from several sources, making them necessarily come after the experimental work. We are just now starting to publish these works publicly and should have our backlog of Case Studies cleared by the end of the fiscal year.
- **"The majority of research appears to be concentrated on corn stover and wood chips of a particular size…"**
  - The feedstocks we are currently investigating, corn stover and pine, have been chosen by BETO to allow us to develop tools that can be generalized to other feedstocks. After the 2022 Merit Review, we have added landfill-bound MSW to our portfolio of feedstocks.
- **"There has been good work on identifying CMAs and CPPs. Adding control limits will increase the value of this approach especially when studying the impact of feedstock variability…The process or model that causes BETO to name a particular attribute as a CMA should be well understood and verifiable by others…"**
  - This activity is ongoing, and the reviewer makes a very good point – the 'control limits' or 'permissible values' of a specific attribute depends on the overall process and the specific unit operation within that overall process. We believe the technical publications we have generated have been able to make this clear, as will the Case Studies as they are published this year. In addition, Task 9 is examining Failure Mode and Effect Analysis, which is a well-accepted procedure for establishing criticality.
- **"I would have like to have heard how risks are uncovered, tracked, and (where appropriate) provided with actionable tasks."**
  - The biggest risk the Project Management Task faces is miscommunication among the many members. Task X keeps track of all milestones, and we lead extensive communications among all stakeholders. This continues to be a challenge.

FCIC Historical Budgets

	FY21	FY22	FY23	FY24	FY22-24	
Task #:Name	$ 11,076	**$ 11,010**	**$ 11,185**	**$ 11,035**	**$ 33,230**	
Task 1: Materials of Construction	$ 472	$ 575	$ 575	$ 575	**$ 1,725**	
Task 2: Feedstock Variability	$ 1,885	$ 1,230	$ 1,230	$ 1,230	**$ 3,690**	
Task 3: Materials Handling	$ 1,879	$ 1,710	$ 1,710	$ 1,710	**$ 5,130**	
Task 4: Data Integration and Data Management	$ 489	$ 550	$ 550	$ 550	**$ 1,650**	
Task 5: Preprocessing	$ 1,660	$ 2,075	$ 2,075	$ 2,075	**$ 6,225**	
Task 6: High Temperature Conversion	$ 1,732	$ 1,750	$ 1,750	$ 1,750	**$ 5,250**	
Task 7: Low Temperature Conversion	$ 1,140	$ 1,070	$ 1,070	$ 1,070	**$ 3,210**	
Task 8: Crosscutting Analysis TEA/LCA	$ 1,099	$ 1,250	$ 1,250	$ 1,250	**$ 3,750**	
Task X: PI/PM	$ 650	$ 650	$ 825	$ 675	**$ 2,150**	2023 bud
Task 9: FMEA Criticality Assessment Tools	$ 70	$ 150	$ 150	$ 150	**$ 450**	FMEA wo