DOE Bioenergy Technologies Office (BETO) 2023 Project Peer Review

FCIC Task 8 – Crosscutting Analyses

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

Steven Phillips and Erin Webb
PNNL and ORNL

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Project Overview

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

FCIC Task Organization

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

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

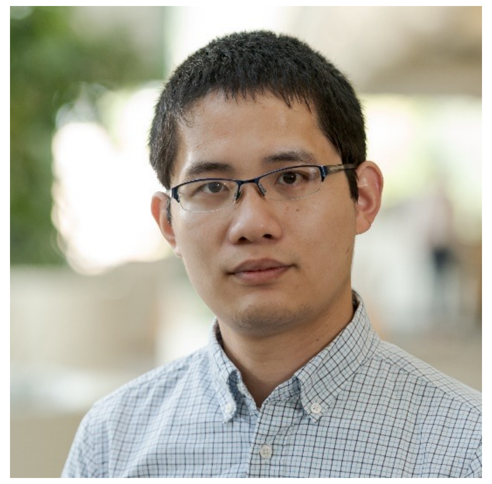
Task 9:Failure Mode & Effects Analysis (FMEA): Standardized approach for assessing attribute criticality

Crosscutting Analyses Team: Collaborating Across National Labs

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

Hao Cai

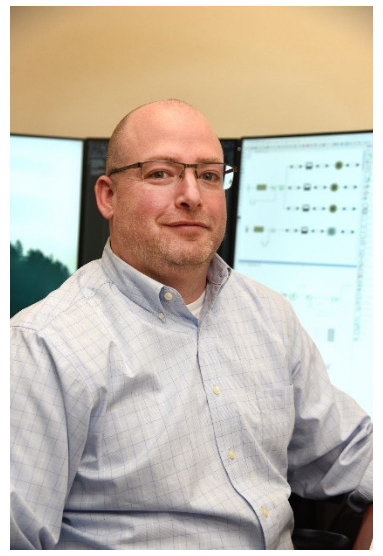


Longwen Ou

Sustainability

INL Idaho National Laboratory

David Thompson



Damon Hartley

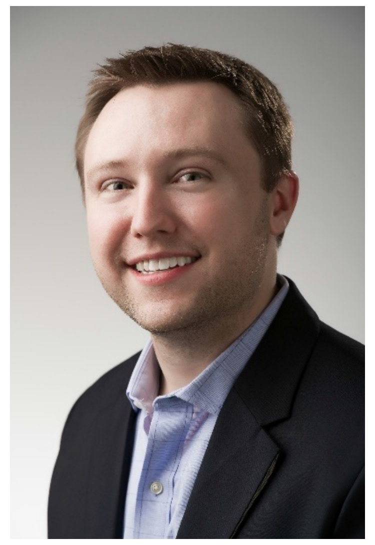
Preprocessing

Rachel Emerson

FMEA Criticality

NREL NATIONAL RENEWABLE ENERGY LABORATORY

Matthew Wiatrowski



Ryan Davis

Abhijit Dutta

Jacob Dempsey

Conversion

OAK RIDGE National Laboratory

Erin Webb

Robin Clark

Feedstock Supply

Pacific Northwest NATIONAL LABORATORY

Steven Phillips

Conversion

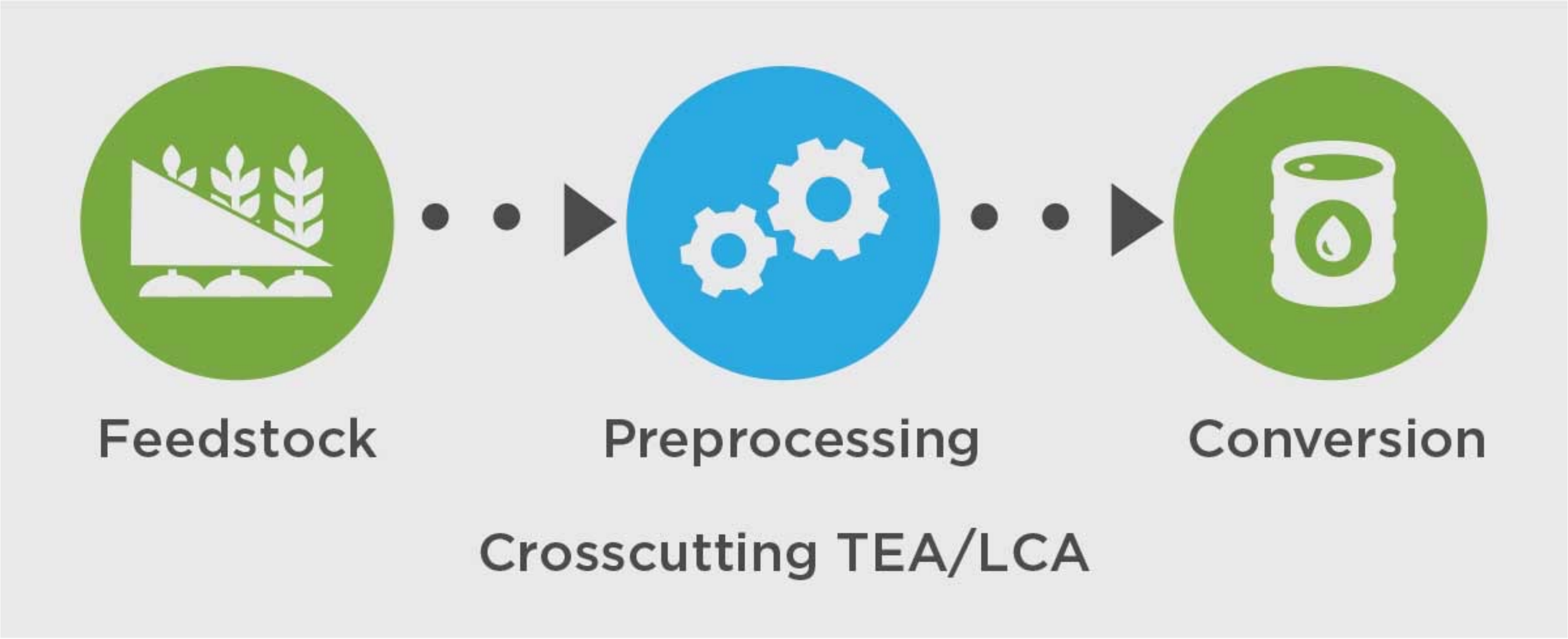
Crosscutting Analyses

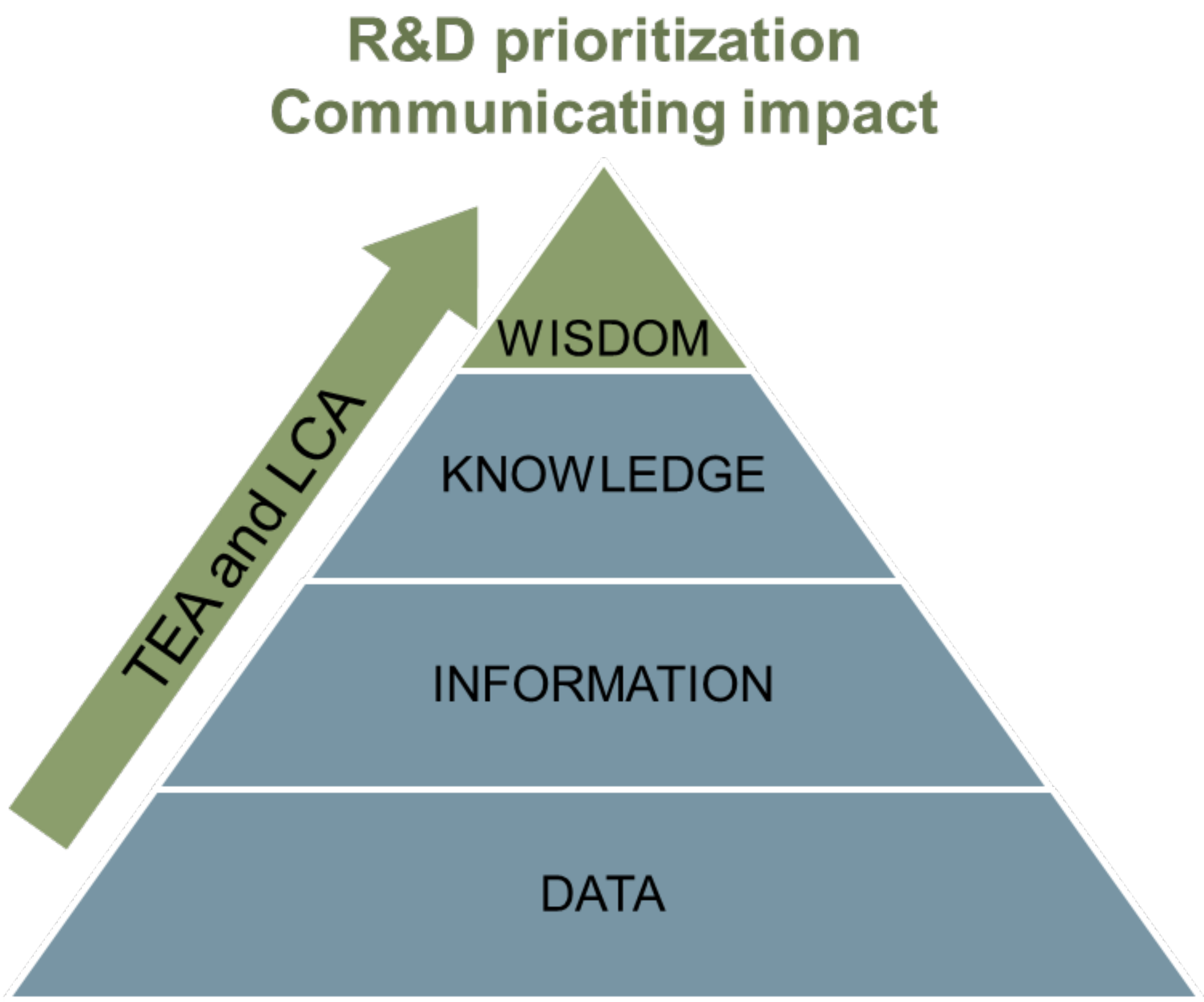
Objective: Quantify and communicate industrially relevant, system-level costs and environmental impacts for the discoveries and innovations of the FCIC.
***How does feedstock variability affect economics and sustainability metrics throughout the biomass-to-fuel value chain*?**

Impact: Quantifying operational costs of variability for feedstock suppliers, biorefinery engineers, equipment manufacturers, and owners/investors will guide improved system design and operation

Outcome: New knowledge on the costs and benefits of mitigating feedstock variability and quality is used by industrial stakeholders to inform their design and operating decisions early in the business cycle and beyond.

Bioenergy Value Chain



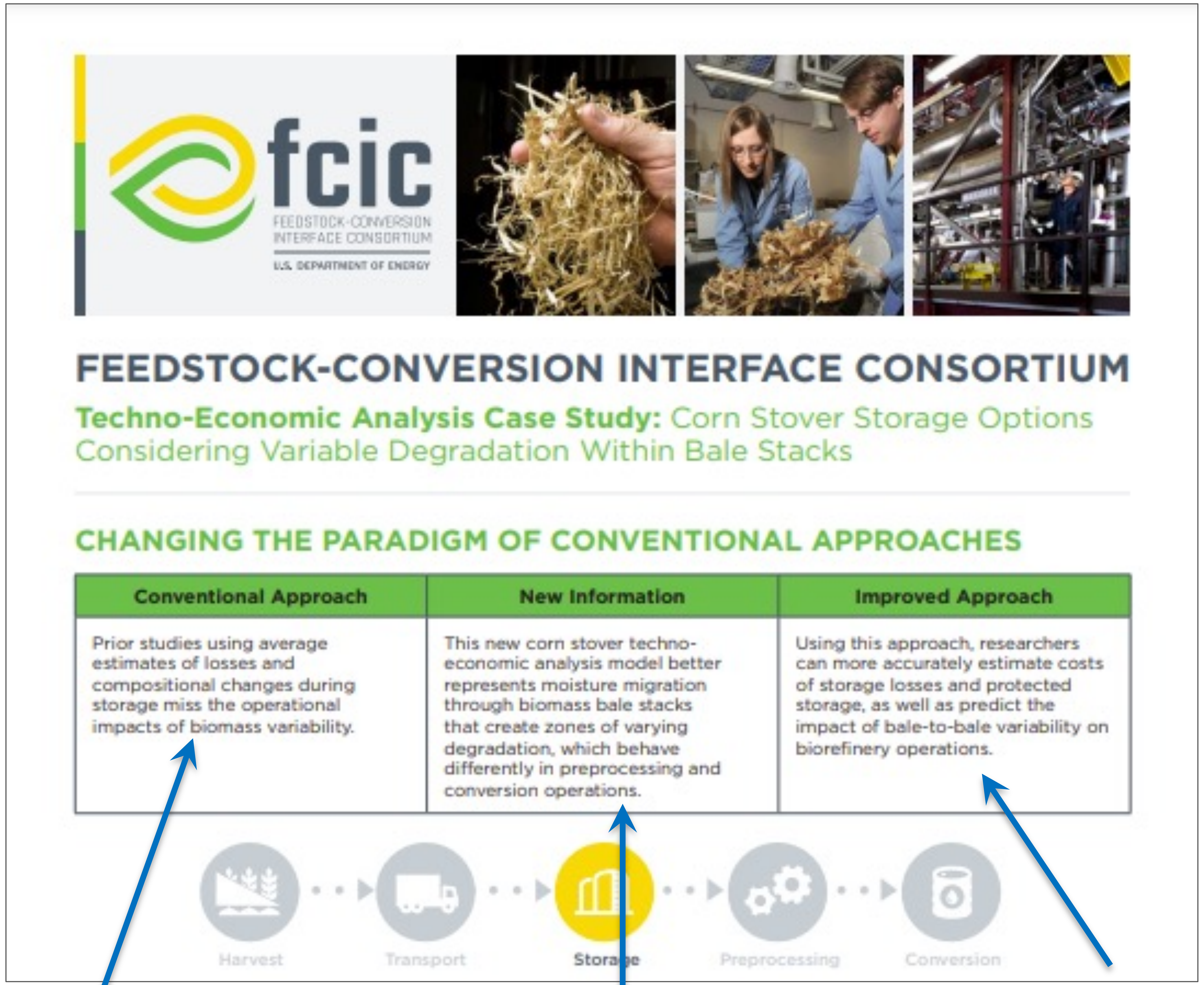


Integrating data and process information improves understanding of the impacts of feedstock variability on the biorefinery value chain leading to better-informed decisions.

Presentation Outline

- **Introduction**
- **Approach**
  - How our TEA and LCA studies differ from "typical" studies for a mature value chain
  - Collaborating with FCIC tasks to choose case studies and inform Design of Experiments to align with TEA/LCA data needs
- **Progress and Outcomes**
  - Review of completed case studies
  - Closer look at select representative studies
- **Impact**
  - Dissemination of insights gained to biorefinery stakeholders
  - Measuring the effectiveness of dissemination

Case study summary example (available online)



FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

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

CHANGING THE PARADIGM OF CONVENTIONAL APPROACHES

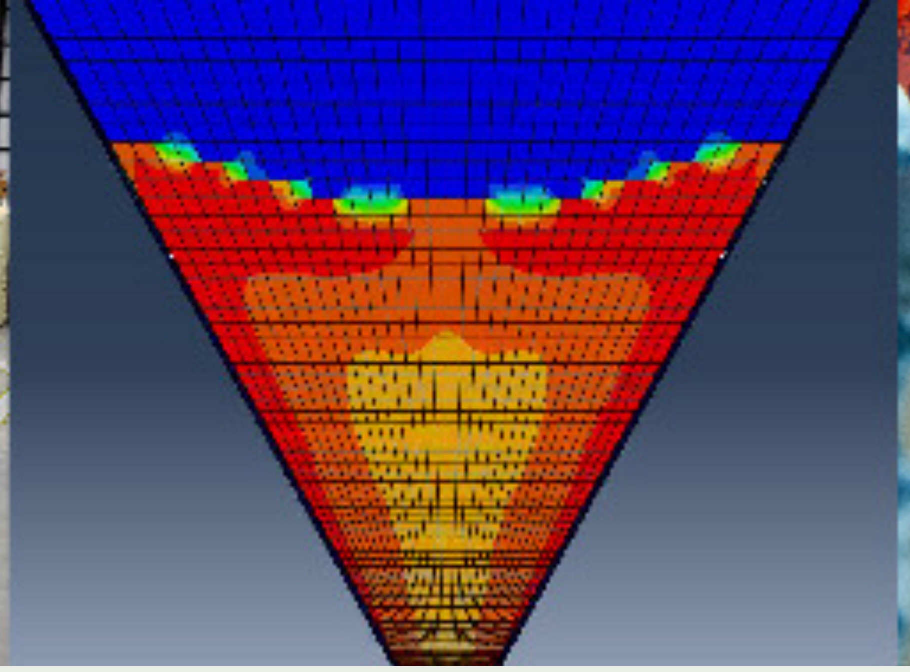
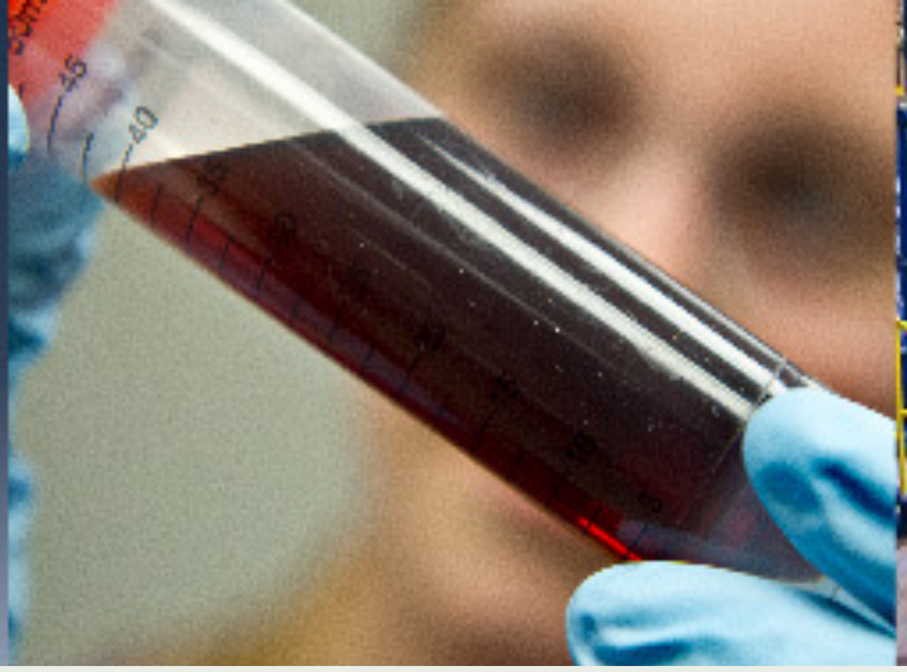
Conventional Approach	New Information	Improved Approach
Prior studies using average estimates of losses and compositional changes during storage miss the operational impacts of biomass variability.	This new corn stover techno-economic analysis model better represents moisture migration through biomass 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.

Describe conventional approach (baseline)

Quantify cost impacts of new FCIC knowledge

Suggest benefits of an improved approach



1 – Approach

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Technical Approach

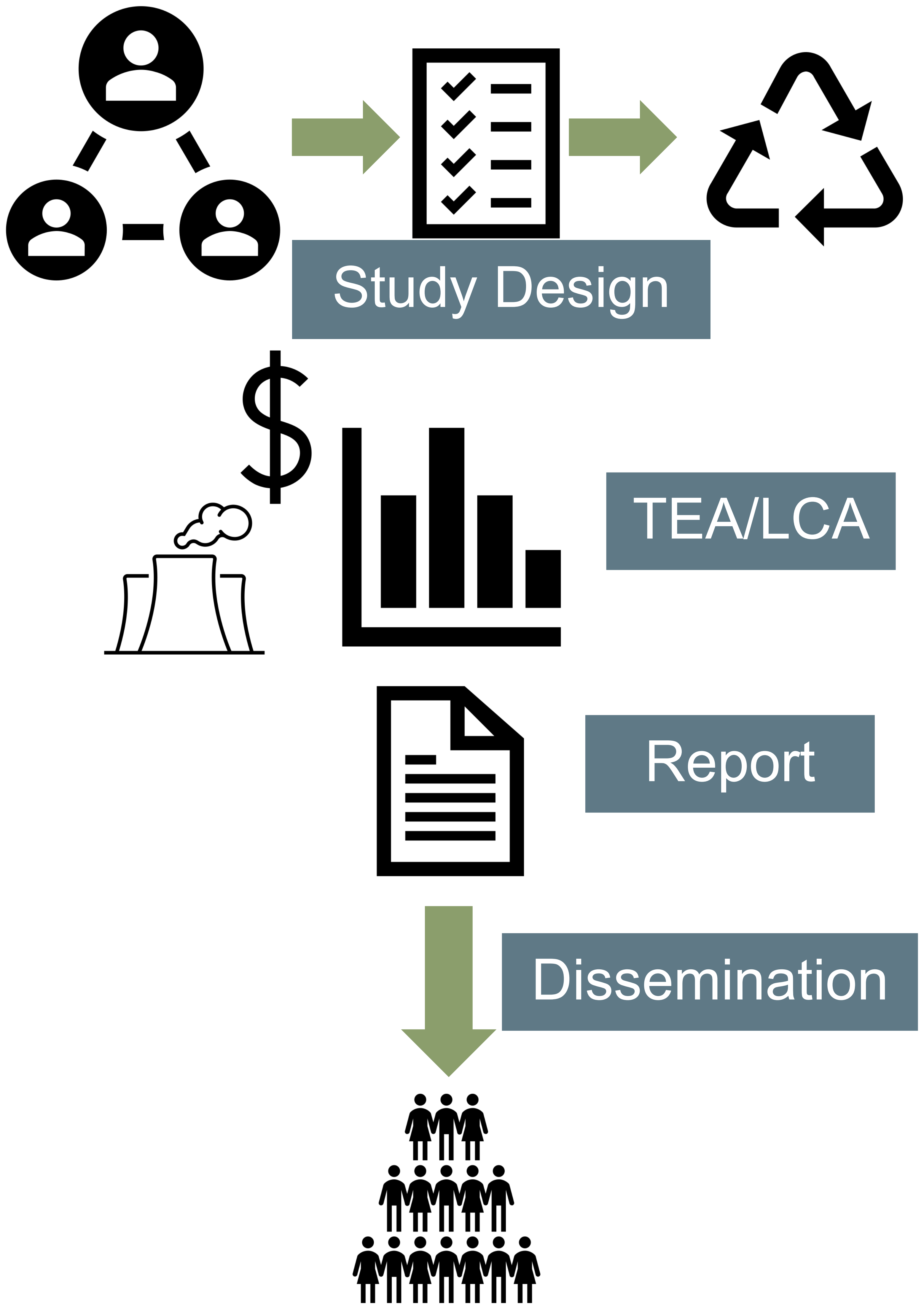
- **Collaborate with FCIC experimental tasks** to develop case studies of relevant unit operations **to estimate how variability in feedstock quality impacts the cost and sustainability** of these operations
- **Case studies are integrated to perform systems-level analyses** for biorefinery and feedstock supply chain
- For each case study, the **lessons learned are disseminated** through publications, presentations and summary sheets available through FCIC data hub or web site

Challenges

- **Obtaining process-relevant data and information** to model the impacts of feedstock quality on equipment-level dynamic operation
- **Costs for industrial-scale equipment and parts** are difficult to obtain to inform economics

Metrics

- **Case Studies Published and available** with OSTI number (*Number of downloads)*
- Case Study **2-page Summaries** on FCIC web site (*Number of hits)*
- **Presentations to Biorefinery Stakeholders** (# of presentations and articles)



2 – Progress and Outcomes

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Case Study Body of Work

Knowledge

fcic FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM U.S. DEPARTMENT OF ENERGY

	Feedstock	Preprocessing	Conversion
Corn Stover	Corn Stover Storage Options Considering Variable Degradation Within Bale Stacks TEA of corn stover anatomical fractionation by varying cut height	Value Proposition of Coatings or New Alloys on Hammer Wear Impact of anatomical fractionation of corn stover on hammer mill throughput and energy consumption	**Low-Temperature Conversion Performance Based on Isolated Anatomical Fractions of Corn Stover** Sugar/lignin fermentation dependence on CMAs imparted from upstream processing
Pine Residues	TEA of Anatomical Fractionation of Pine Residues at the Landing **Delivered Costs of Loblolly Pine from Thinning and Timber Operations** **Life-Cycle Analysis Case Study: Greenhouse Gas Emissions of Supply and Delivery of Loblolly Pine from Thinning and Timber Operations**	**Particle scale impacts on deconstruction energy of pine residues (wet vs. dry milling)** **Life-Cycle Analysis of wet milling versus dry milling of residues** Air classification of forest residue for tissue and ash separation efficiency TEA of Knife Wear using coatings and alloys Sensitivity analysis of air classification of forest residues for tissue and ash separation efficiency with regards to the air speed CPP, particle size CQA floor, fixed carbon CQA ceiling	A simplified integrated framework for predicting the economic impacts of feedstock variations in a catalytic fast pyrolysis conversion process Comparative techno-economic analysis of available feedstocks for high-temperature conversion: whole tree thinnings and mature pine residues Techno-economic assessment of air classified forestry residues as a feedstock for catalytic fast pyrolysis Life-Cycle Analysis Case Study: Greenhouse Gas Emissions of Biofuel Production via Catalytic Fast Pyrolysis of Loblolly Pine Feed-to-Fuel LCA for biofuels derived from air classified pine residues for varying levels of feedstock percent carbon CQA specification in HT conversion

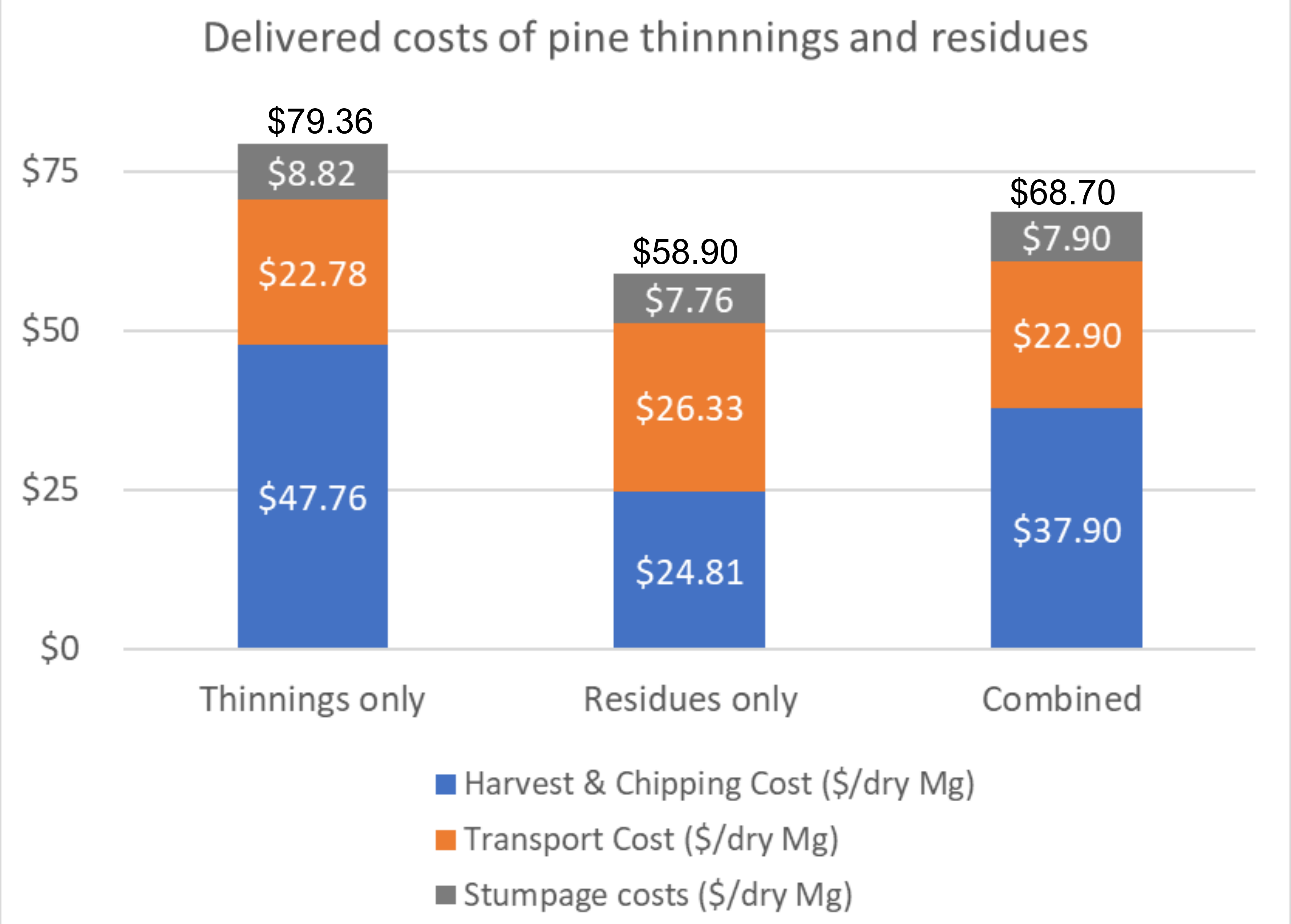
Bold case studies highlighted in subsequent slides

Techno-Economic Analysis Case Study: Delivered costs of higher quality pine by integrating thinning and timber operations

Changing the paradigm of conventional approaches

Conventional Approach	New Information	Improved Approach
Strategies to use woody biomass for biofuel and pellet markets typically focus on logging residues only.	There are opportunities to incorporate mid-rotation pine thinning operations to improve plantation health and provide higher-quality whole-tree biomass integrated with residue supplies.	Integrating whole tree biomass from pine plantation thinning operations offers the opportunity to increase the local feedstock supply and reduce biomass transport and associated GHG emissions.

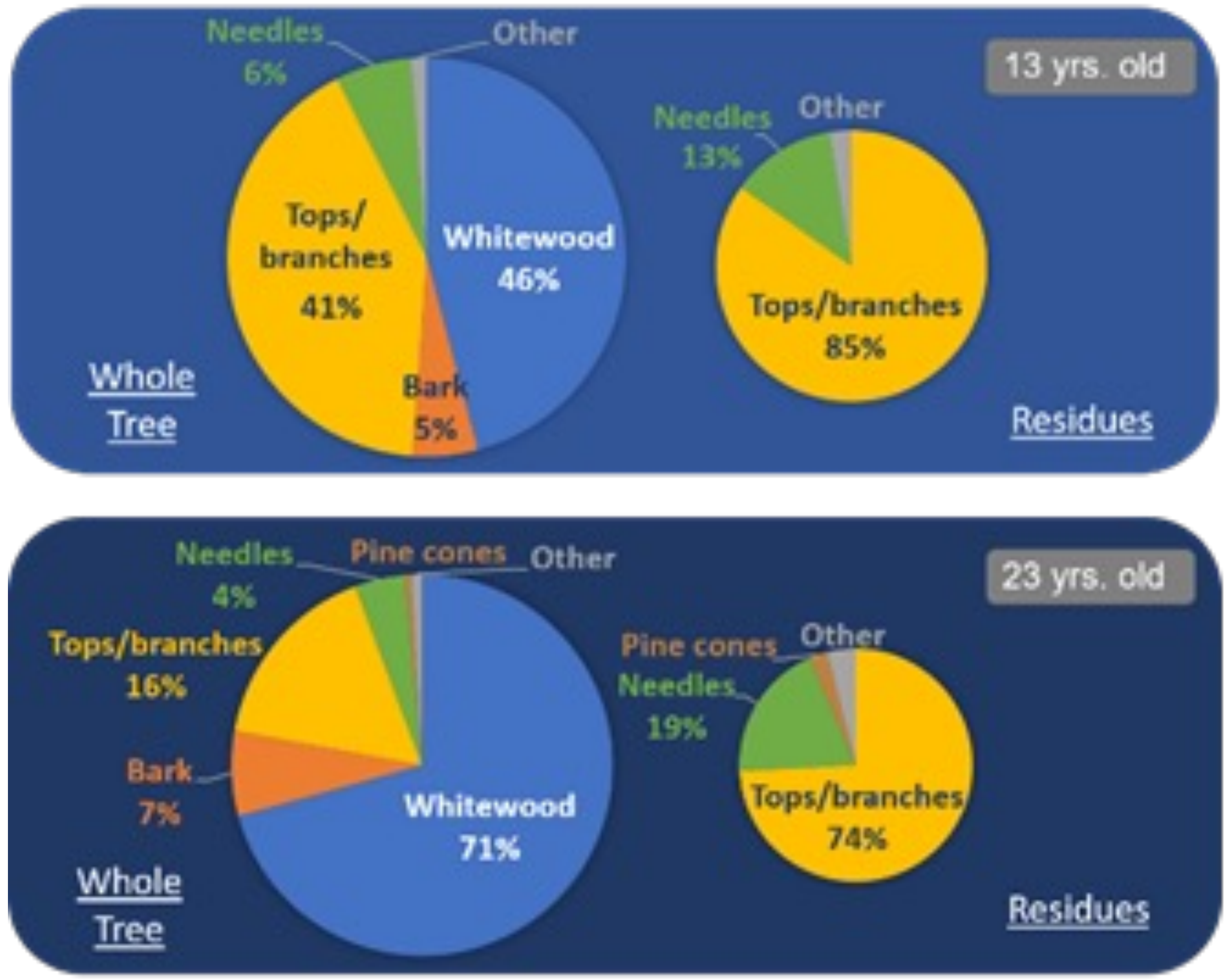
Mass fractions from FCIC Task 2, processed at INL, were used in assessing feedstock yields.



High Temperature Conversion

Knowledge

Comparative Techno-Economic Analysis of Available Feedstocks for High-Temperature Conversion: Whole Tree Thinnings and Mature Pine Residues

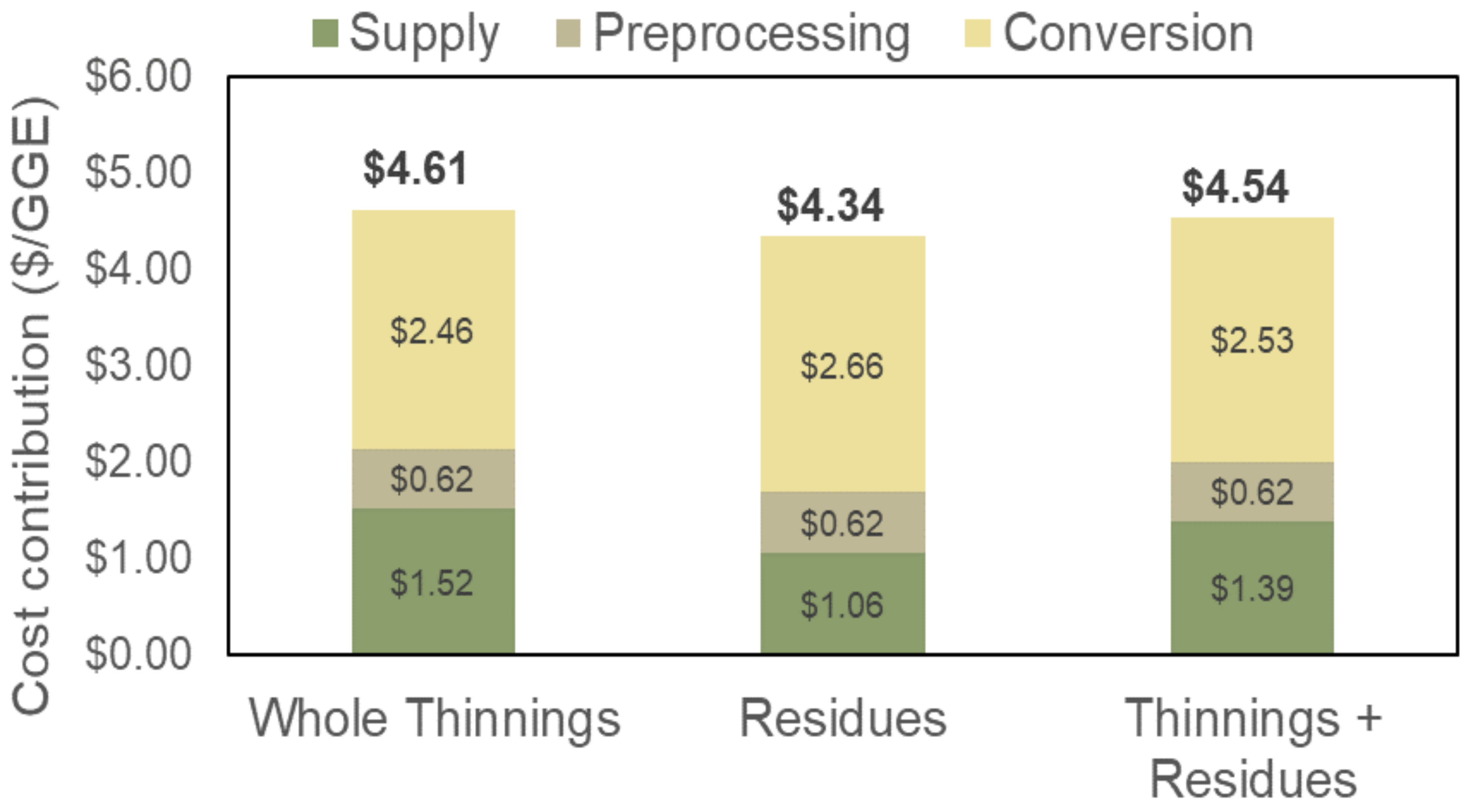


Changing the paradigm of conventional approaches

Conventional Approach	New Information	Improved Approach
Forestry residues from the commercial pine industry are seen as a leading feedstock option for high-temperature conversion due to their low cost and under-utilization.	Whole tree thinnings, felled at a younger age to encourage growth of surrounding trees, present an additional feedstock option for high-temperature conversion	Comparable supply chain costs for conversion of whole thinnings, residues, or a combination of the two show that whole tree thinnings are an economically viable feedstock option.

	Thinnings	Residues	Thinnings + Residues
Modeled CFP Fuel Carbon Yield	25.3%	26.4%	25.7%
Modeled Char Yield	14.6%	18.6%	16.1%

Comparable supply chain costs of each feedstock demonstrate the viability of using whole tree thinnings as an additional feedstock option. Compositional differences between different tree ages and anatomical fractions result in different yields through CFP conversion.



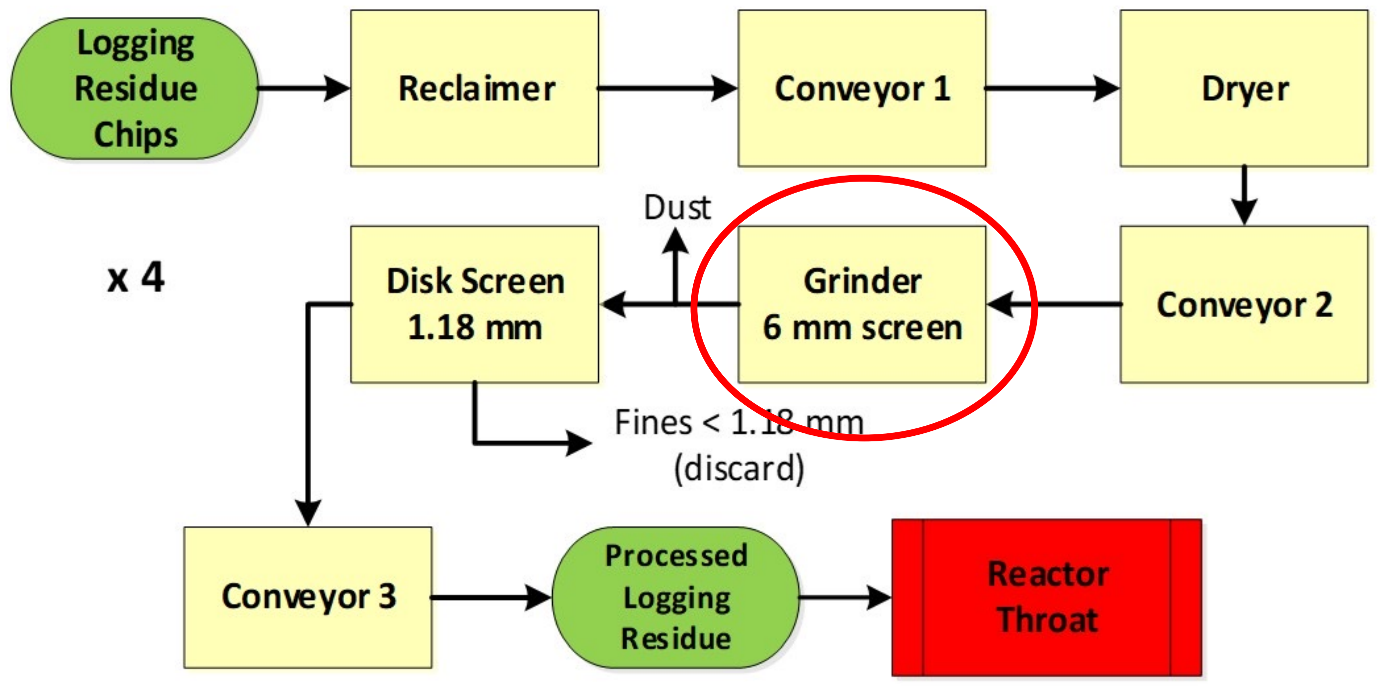
Preprocessing

Knowledge

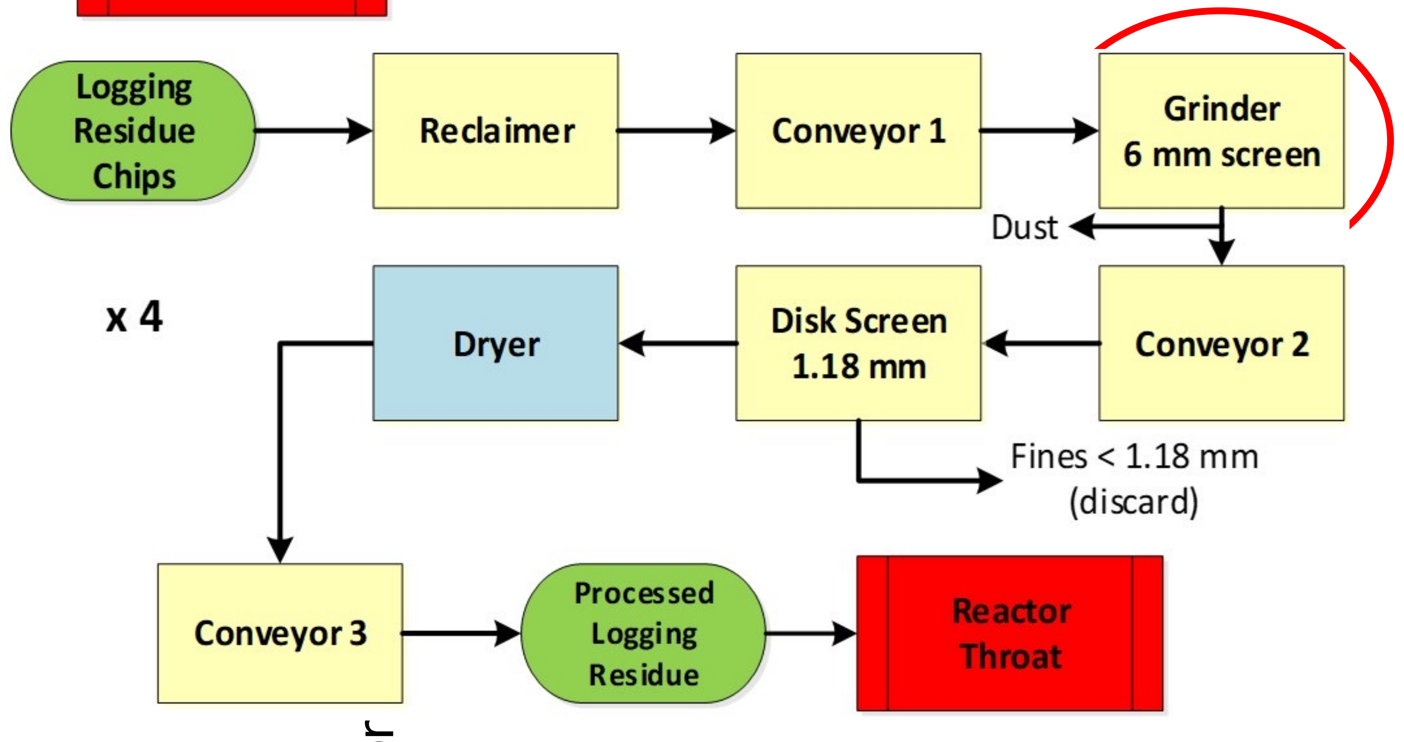
TECHNO-ECONOMIC ANALYSIS CASE STUDY: Benefits of wet-milling pine residues - cheaper feedstock and energy savings

CHANGING THE PARADIGM OF CONVENTIONAL APPROACHES

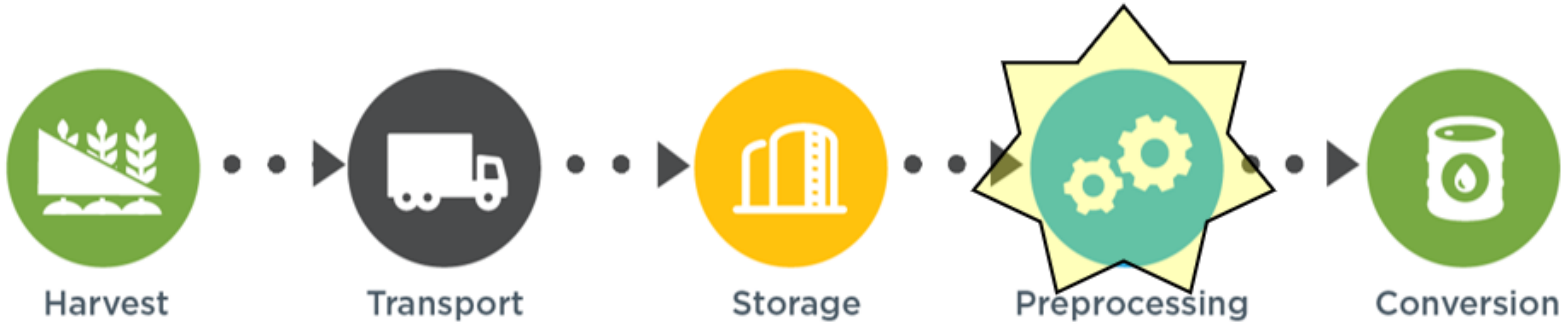
Conventional Approach	New Information	Improved Approach
Hammer milling in the pellet and feed industries is typically done on dry feedstock which leads to the generation of fines.	While smaller particles provide good heat and mass transfer properties for thermochemical conversion, at industry-scale fines cause feeding failures in catalytic fast pyrolysis (CFP) processes.	Grinding feedstock wet and then drying decreases the production of fines and yields more mass of feedstock that meet CFP specifications. Drying energy is also reduced compared to the conventional approach.



Dry milling

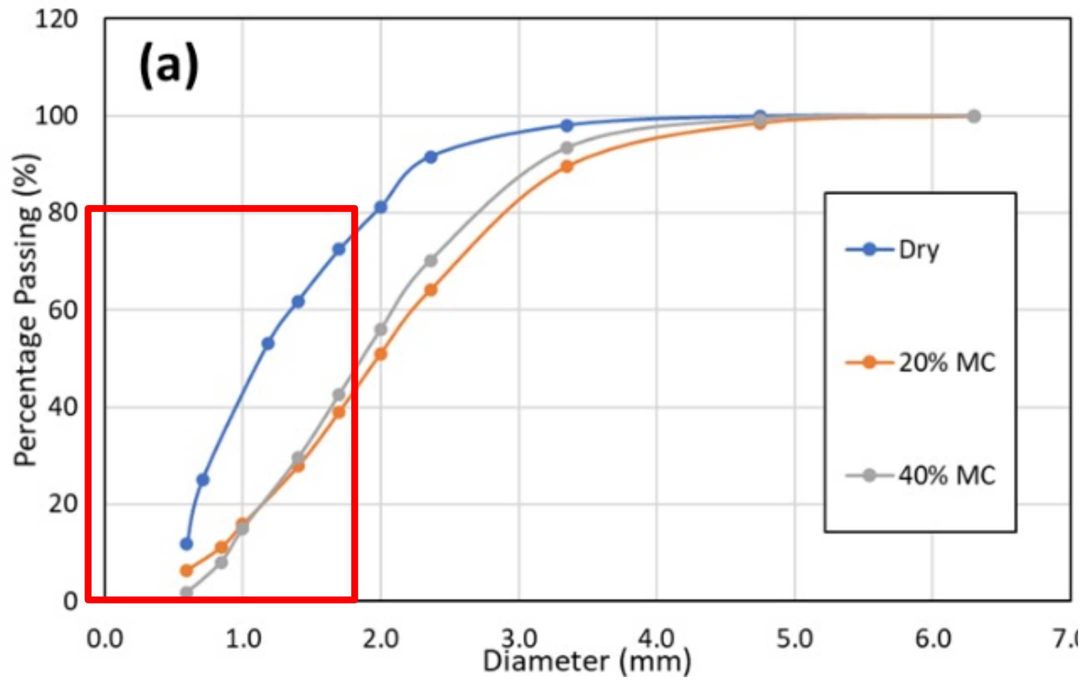


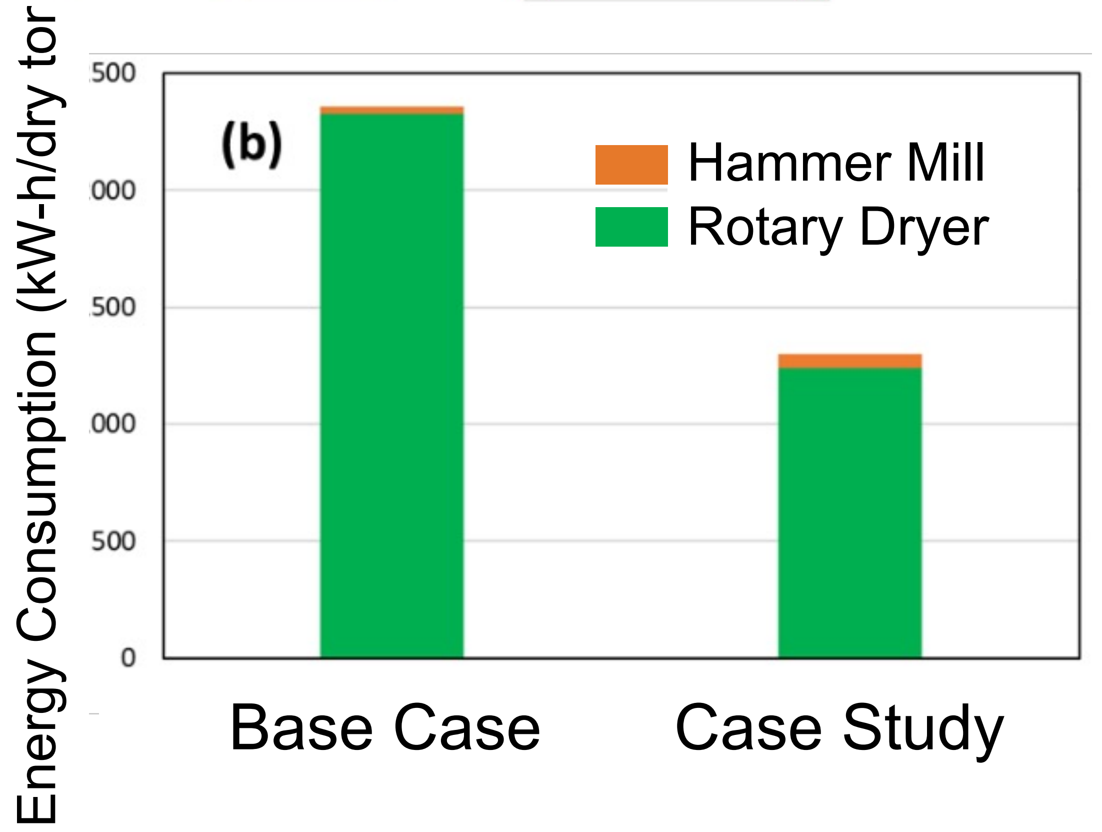
Wet milling



Schutte Buffalo Hammer Mill in the DOE Biomass Feedstock National User Facility (BFNUF) at Idaho National Laboratory

Fines passing through 1.88 mm screen are rejected:
Wet milling makes fewer fines

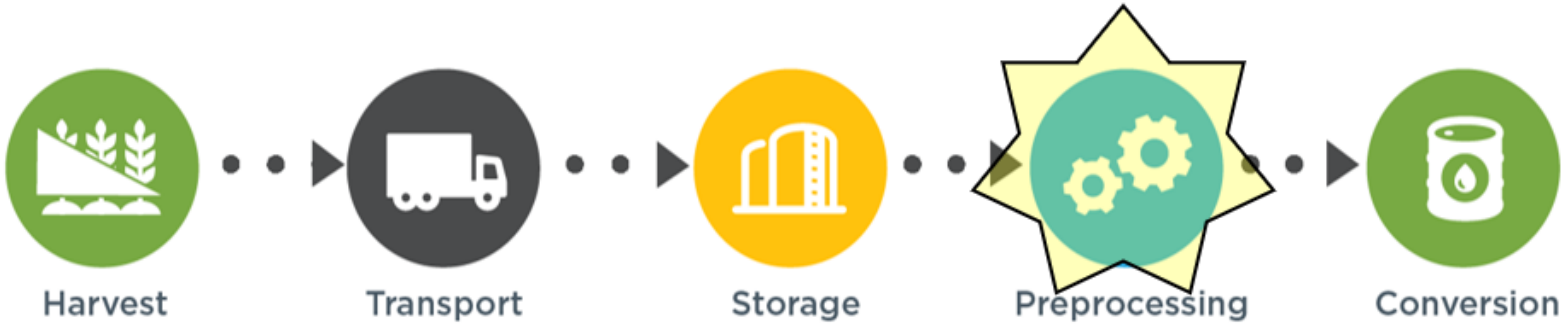




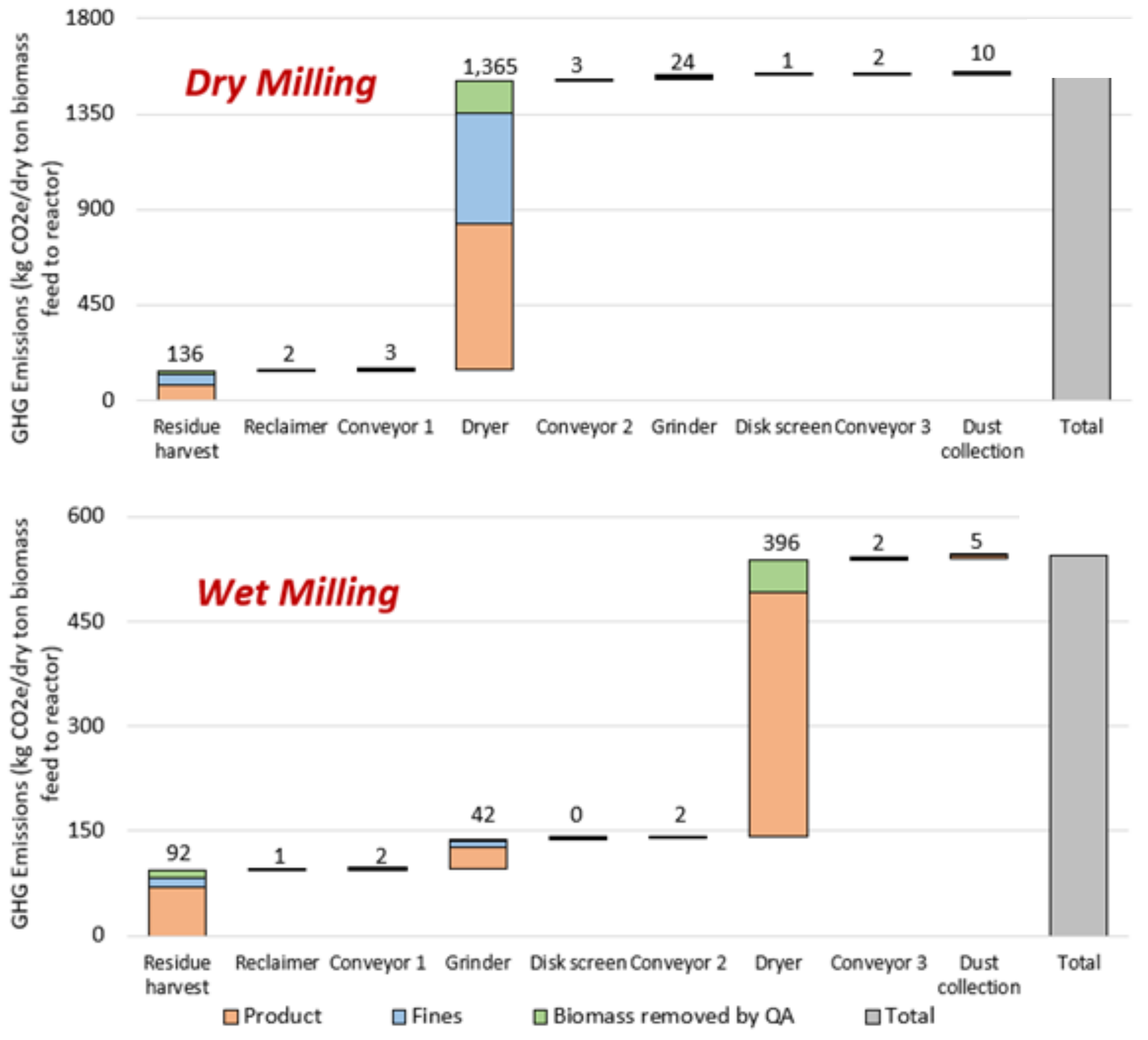
Sustainability

Knowledge

Life-Cycle Analysis Case Study: Greenhouse Gas Emission Impacts of Preprocessing with Wet Milling



GHG Emissions (kg CO_2-eq/ton biomass)



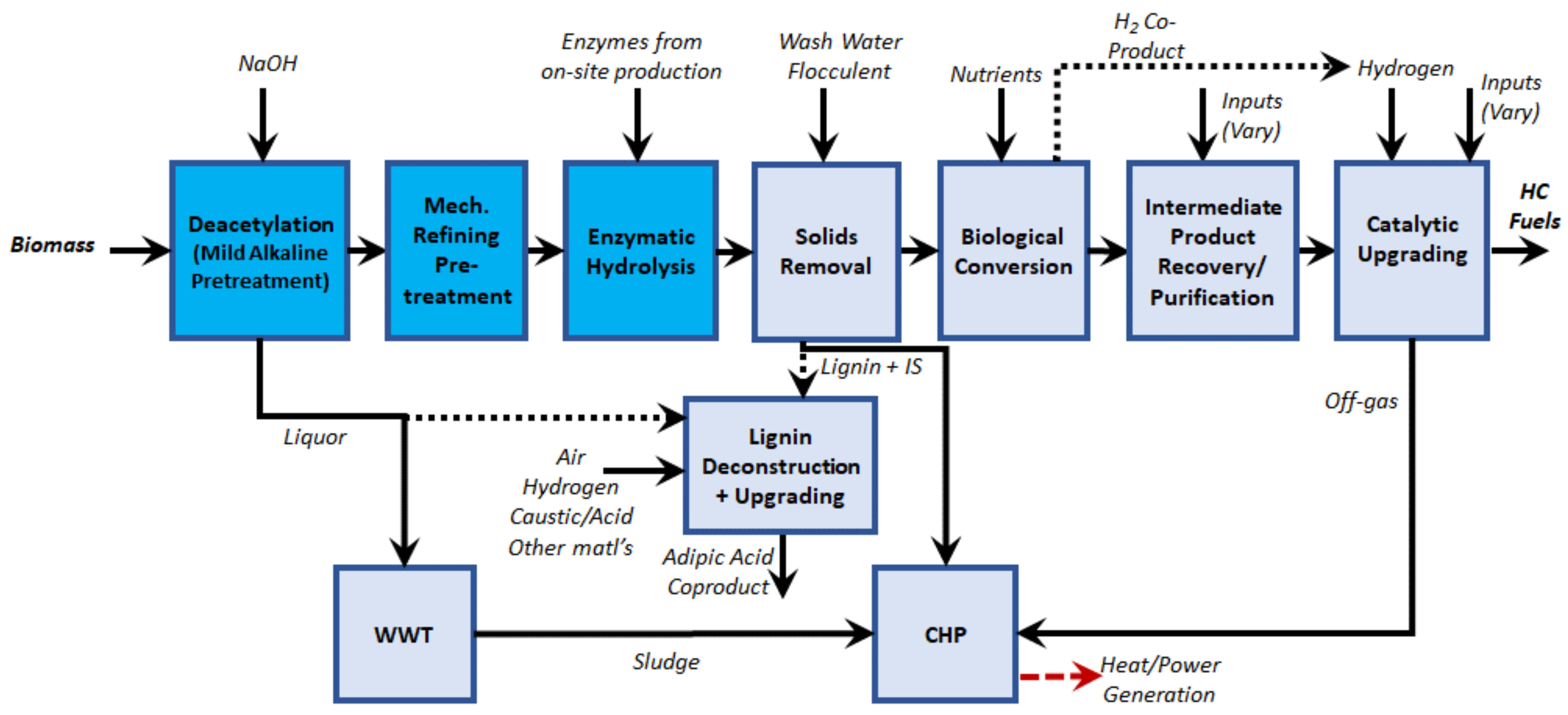
Low Temperature Conversion

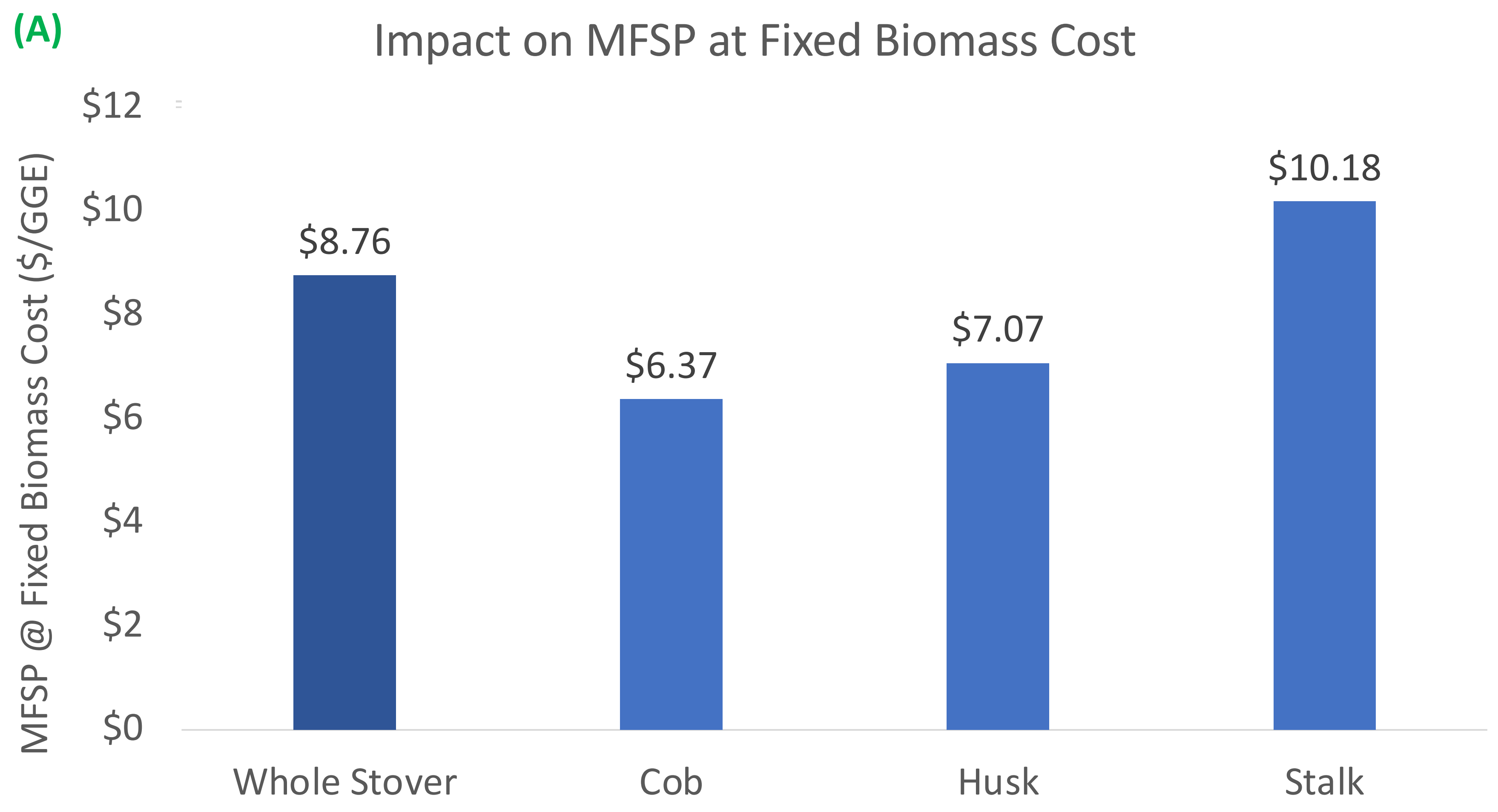
Knowledge

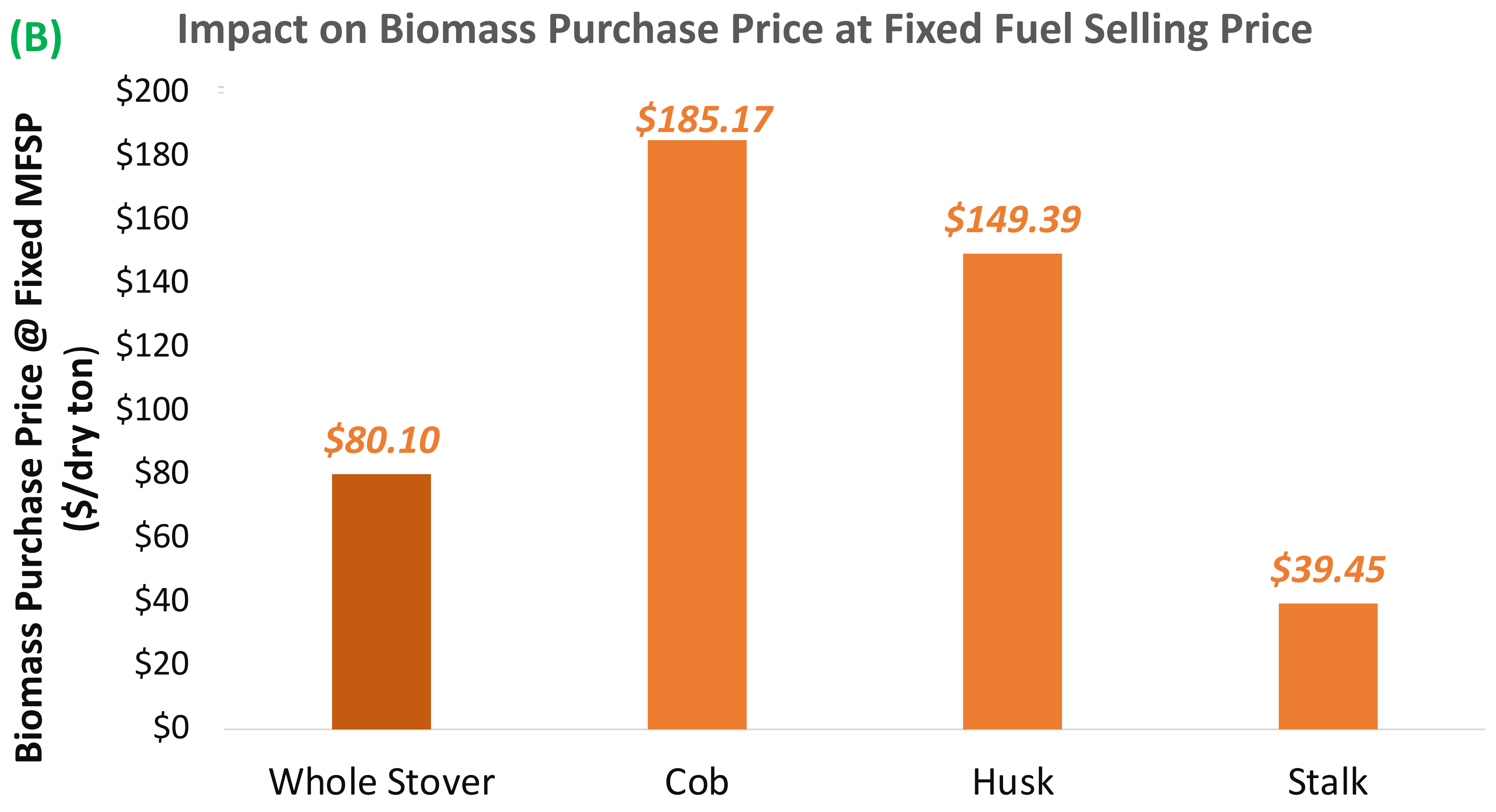
Techno-economic Case Study: Low-temperature conversion performance based on isolated anatomical fractions of corn stover

Changing the paradigm of conventional approaches

Conventional Approach	New Information	Improved Approach
Conventional approaches to biomass conversion assume processing whole stover biomass	R&D data on key conversion operations were run through TEA modeling across biomass fractions	New TEA highlights opportunities for improved economics by processing fractionated biomass







TEA results for (A) MFSP at fixed biomass feedstock cost ($80.10/dry ton) and (B) biomass feedstock price that can be accommodated at fixed fuel selling price (matching whole stover basis = $8.76/GGE)

3 – Impact

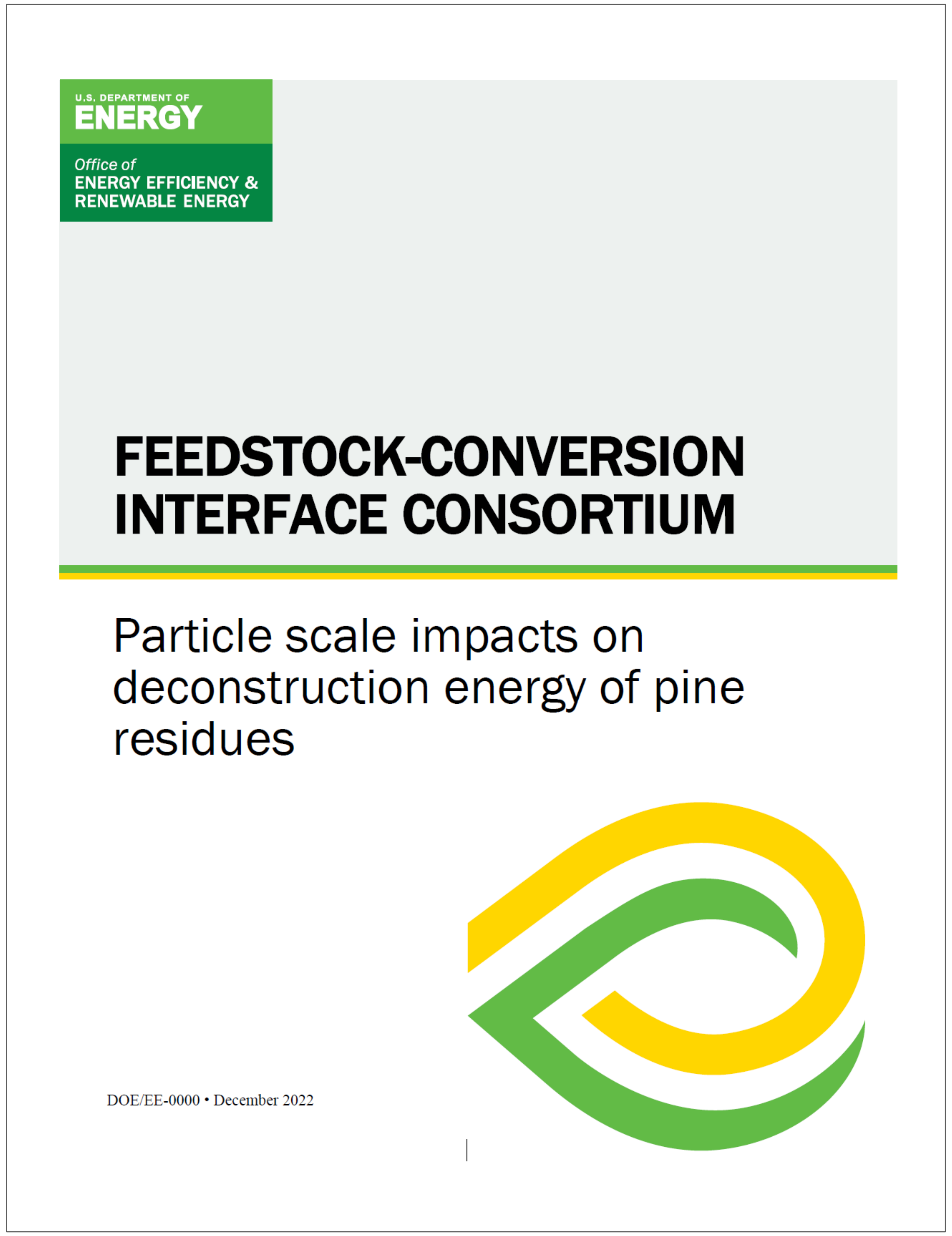
fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Disseminate Results

Knowledge

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

Completed Case Studies Published as Lab Reports



U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

Particle scale impacts on deconstruction energy of pine residues

DOE/EE-0000 • December 2022

Calls out new information and how it changes the paradigm

Report Reduced to 2-Page Summary

Case Study Summaries on FCIC Web Site

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.

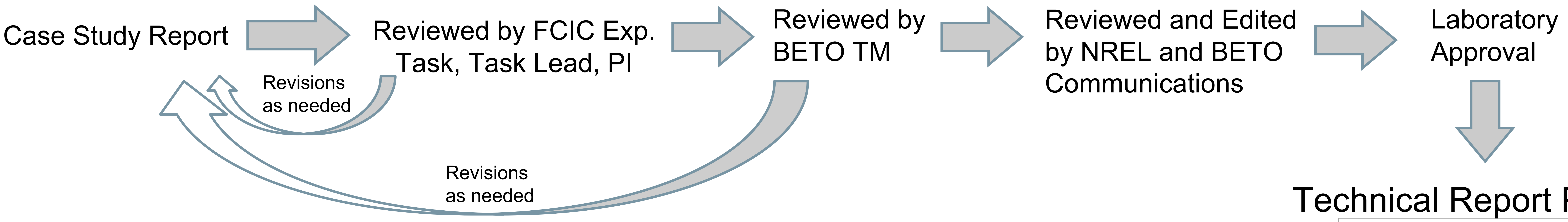
Moisture migration through biomass bale stacks creates zones of varying degradation that behave differently in preprocessing and conversion operations. In this study, Feedstock-Conversion Interface Consortium (FCIC) researchers developed a mathematical model of degradation zones within a corn stover bale stack based on moisture migration over the course of one year. This allows researchers to more accurately predict the variability of incoming feedstock streams due to changes during storage.

Below are the estimated costs of corn stover at a biorefinery gate by storage design, accounting for variable degradation within bale stacks. Cost reductions in preprocessing or conversion of approximately $1-$2/dry ton for tarped stover or $10/dry ton for covered storage would be necessary to justify the higher investment in storage protection.

Disseminate Case Studies

Knowledge

Tracking Progress Through Editing, Approvals, and Publishing with Internet Access



Technical Report Published

Uploaded to OSTI.GOV

OSTI.GOV U.S. Department of Energy Office of Scientific and Technical Information

Search 3+ million Department of Energy research results

Submit | Search Tools | Public Access | PID Services & Dev Tools | About | FAQs | News

OSTI.GOV / Technical Report: *Value proposition of coatings or new alloys on hammer wear*

Value proposition of coatings or new alloys on hammer wear

Full Record | Other Related Research

TECHNICAL REPORT:

View Technical Report

https://doi.org/10.2172/1905856

SAVE / SHARE:

Export Metadata

Save to My Library

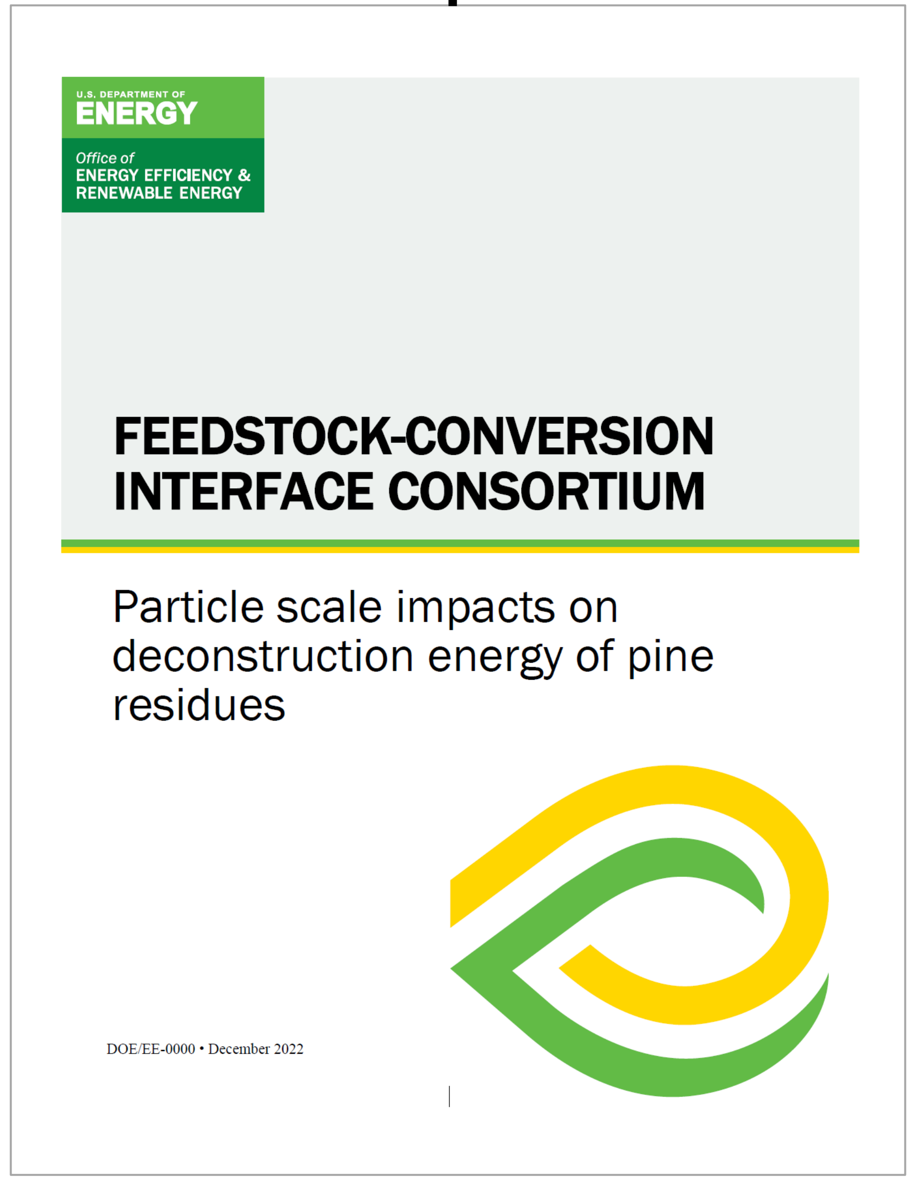
Abstract

The goal of this Case Study was to elucidate the value of improving of the life of parts that wear within a system in terms of the additional material cost that it takes to reach the level of improvement. We recognize that the failure limits and system performance are representative of a single system that may or may not exist in the real world, however, our goal of this project was not to provide an answer for a specific system or to provide a full understanding the economics of all potential systems. The analysis was performed using relative changes from the base alloy cost and considered relative improvements in part life in order to generalize the comparison without referencing specific alloys or coatings that might be employed. Ultimately, this work provides a first check of the potential for improving wear characteristics of grinder hammers to provide a meaningful and impactful benefit to biomass preprocessing and conversion systems. Key takeaways include: • Increasing the life of hammers by 3× provides a delivered feedstock cost benefit of approximately $2.25/dry ton assuming that the relative cost of the hammer material of construction is not increased. • The feasible area of relative hammer cost more »

Authors: Hartley, Damon S [1]; Griffel, L. Michael [1]; Thompson, David N [1]

+ Show Author Affiliations

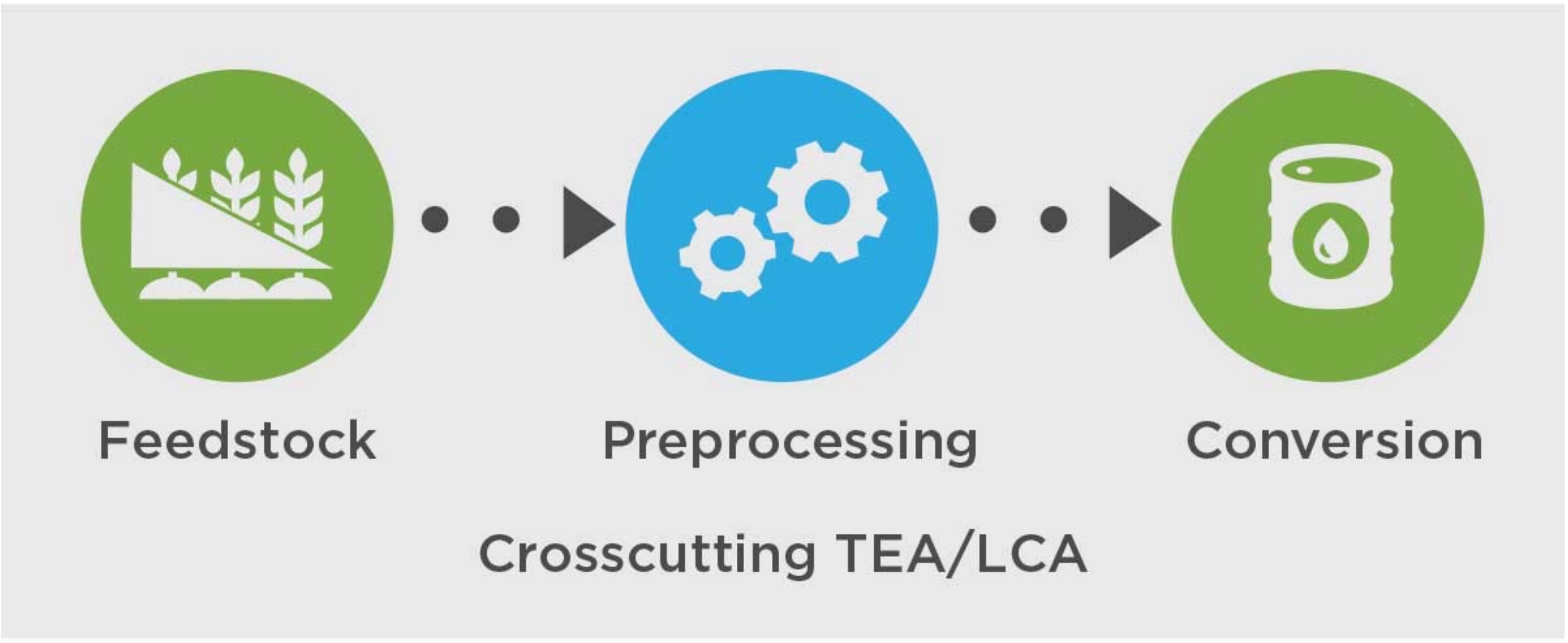
Publication Date: 2022-12-12



- Extensive review process used to achieve high-quality product
- Internet availability provides equitable access to reports
- Publishing studies allows citations in other studies
- OSTI report downloads helps tracks extent of dissemination and topic interest

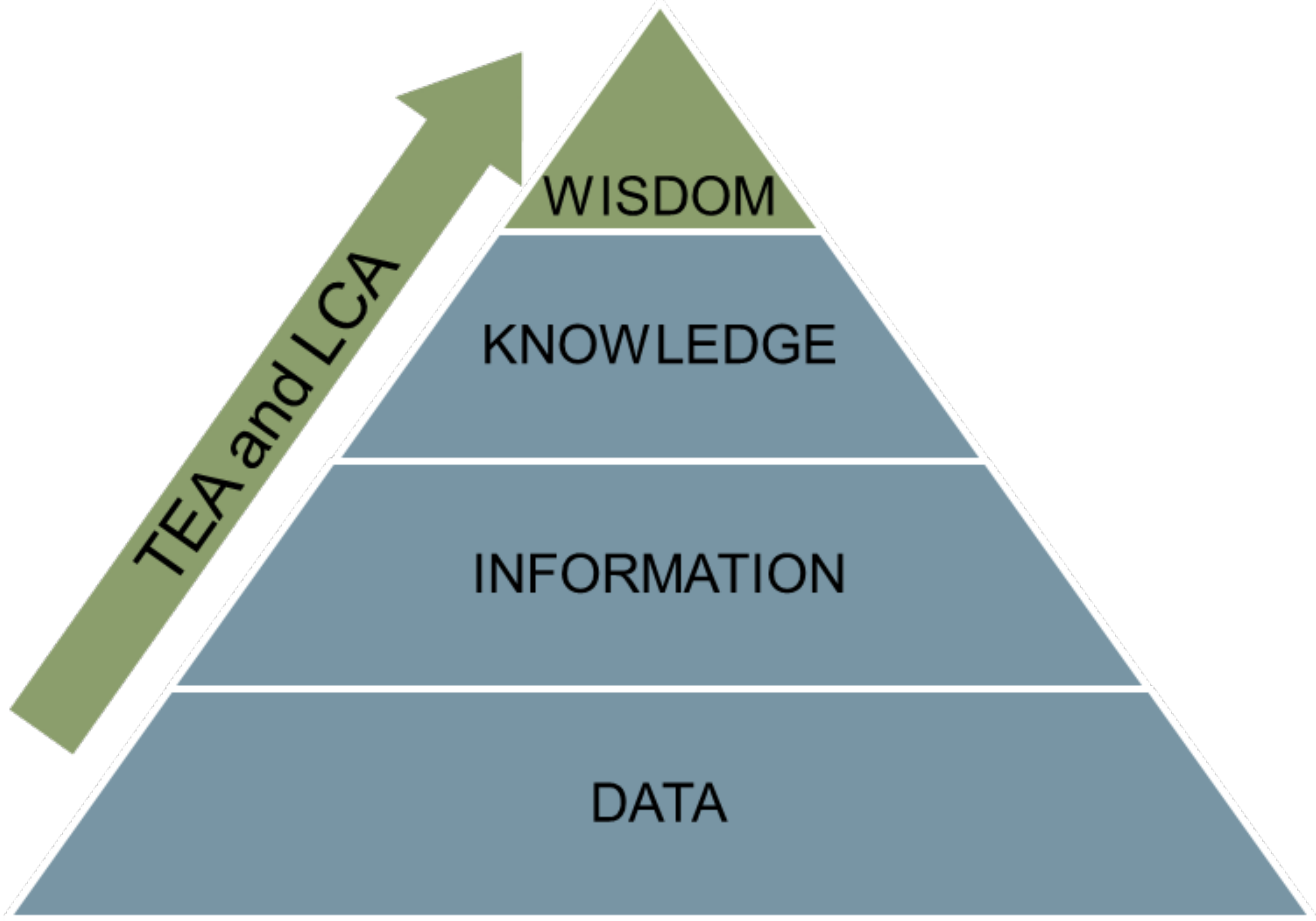
Summary

Bioenergy Value Chain

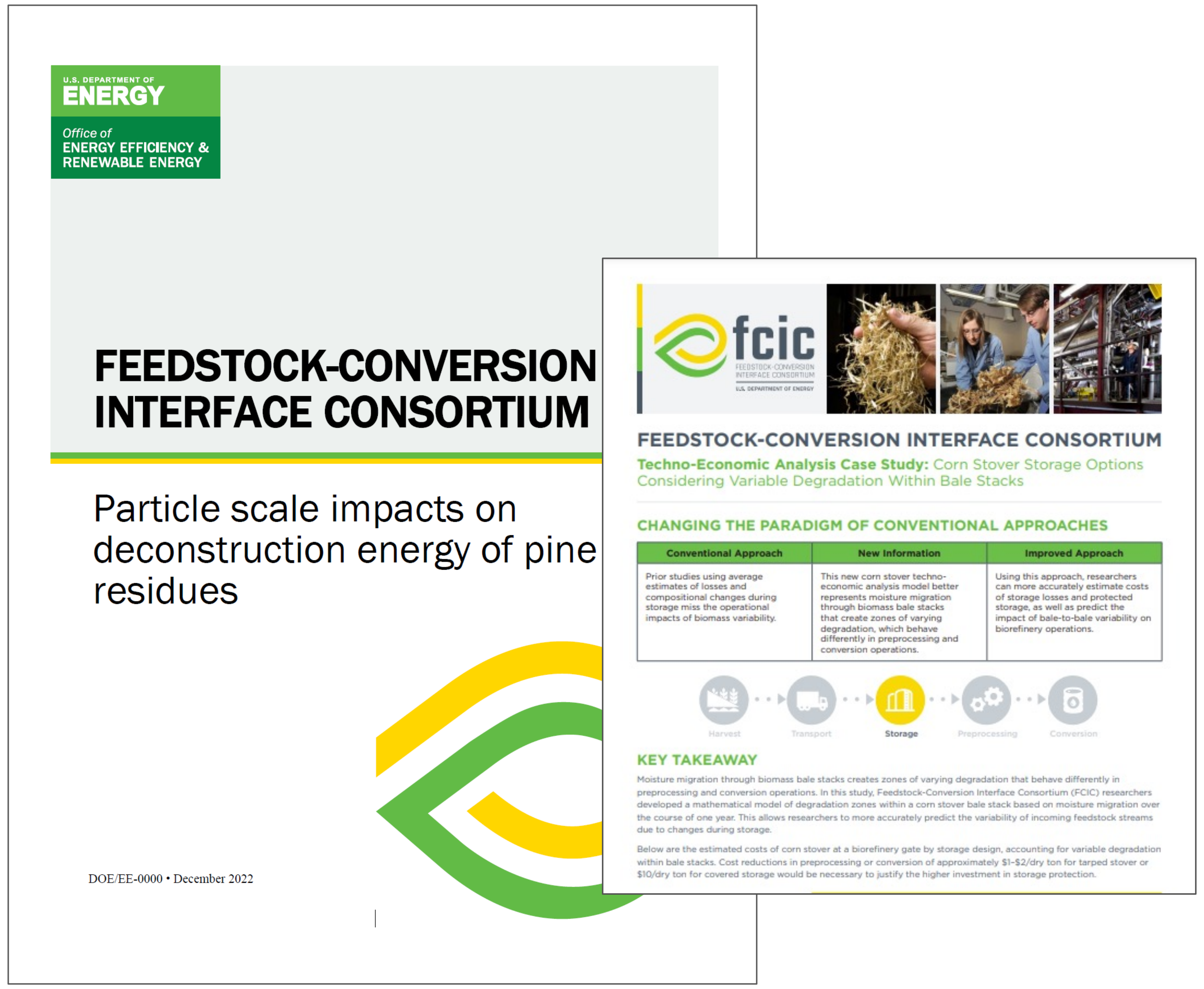


TEA and LCA case studies are selected and designed in collaboration with experimental Tasks to quantify economic and environmental impacts of FCIC R&D

R&D prioritization
Communicating impact



Each case study compares a new system design based on new FCIC knowledge with a baseline scenario to demonstrate the potential impact of an improved design.



Case study reports and summaries are carefully reviewed and designed to communicate findings to key stakeholders.

Quad Chart Overview

Timeline

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

	FY22 Costed	Total Award
DOE Funding	*(10/01/2021 – 9/30/2022)*	*$2,500K*
Project Cost Share *	NA	NA

TRL at Project Start:
TRL at Project End:

Project Goal

The goal of this project is to provide cost-benefit TEA and LCA focused on the impacts of feedstock variability and quality on yields, economics, and environmental sustainability to aid biorefinery engineers, equipment manufacturers and other stakeholders. This will be achieved by conducting feasibility studies of proposed equipment and process design modifications using FCIC-generated data and literature sources. The case studies will demonstrate the importance of systems-level analyses for biorefinery and feedstock supply chain design. Knowledge gained in Task 8 TEA and LCA can be implemented to achieve improved process designs, better economics, and more sustainable operations.

End of Project Milestone

Publish TEA/LCA lessons learned to guide biorefinery design. This will be achieved by publishing an article in a trade journal summarizing lessons learned in FCIC TEA/LCA case studies completed in FY22-24. The need for integrated feedstocks, preprocessing and conversion analyses to enable cost effective, reliable, and efficient biorefinery design will be highlighted.

Funding Mechanism

2021 Lab Call – FCIC Merit Review

Project Partners*

- NA

*Only fill out if applicable.

Additional Slides

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

1 – Management

Subtask	Lead(s)	Major Responsibilities
8.1 Feedstock Supply	E. Webb (ORNL), R. Clark (ORNL)	Evaluates how upstream changes to feedstock CMA specifications impact feedstock production, storage and transportation costs.
8.2 Preprocessing	D. Thompson (INL), D. Hartley (INL)	Evaluates changes in production costs and delivered feedstock costs as impacted by operational performance and compositional CQAs.
8.3 HT Conversion	M. Wiatrowski (NREL), S. Phillips (PNNL)	Evaluates how variability in feedstock material attributes such as mineral matter content, particle size distribution, and feedstock quality impacts HT process economics via product yields, process operability, and capital/operating expenditures.
8.4 LT Conversion	R. Davis (NREL), J. Dempsey (NREL)	Evaluates economic impacts on LT conversion yields and MFSPs, as well as solving for the increase or decrease in the "value" of a new feedstock attribute.
8.5 Sustainability	H. Cai (ANL) L. Ou (ANL)	Evaluates how variability in feedstock material attributes such as mineral matter content, particle size distribution, and feedstock quality (e.g., carbon content, moisture content, and ash content of various feedstock fractions) ultimately impacts supply chain sustainability.
8.6 QbD Implementation: Systematic Criticality Assessment Tool	R. Emerson (INL)	Apply Failure Mode and Effect Analysis (FMEA) to fit the unique needs of the FCIC objectives.

Completed Case Studies - page 1

Knowledge

Case Study Publishing Tracker

Case Study #	ID for Task 8 Tracking	Feedstock/Value Chain Area	Title	Technical Brief to BETO	2-Page Summary Sheet Status	Technical Report Goal/Completed	Technical report reviewers (1 lab + 1 FCIC review)	NREL and BETO Comms Approvals	Highlight Slide Status	DataHub Sheet Status
1	LT-S-1	Stover/Feedstock Supply	Corn Stover Storage Options Considering Variable Degradation Within Bale Stacks	4/16/2020	on FCIC web site	12/15/2022	Femi Oyedeji/Task 2 rep			published
2	LT-S-2	Stover/Feedstock Supply	TEA of corn stover anatomical fractionation by varying cut height	3/10/2022		12/15/2022	Femi Oyedeji/Task 2 rep			
3	LT-P-10	Stover/ Preprocessing	Value Proposition of Coatings or New Alloys on Hammer Wear		Prepared – needs editing	Hartley, D.S., D.N. Thompson and L.M. Griffel. 2022. “Value proposition of coatings or new alloys on hammer wear.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70097. https://doi.org/10.2172/1905856	Vicki Thompson, Steve Phillips			
4	LT-P-12	Stover/ Preprocessing	Impact of anatomical fractionation on hammer milling throughput and energy consumption at 3 moistures		Prepared – needs editing	Thompson, D.N. and D.S. Hartley. 2022. “Impact of anatomical fractionation of corn stover on hammer mill throughput and energy consumption.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70142. https://doi.org/10.2172/1905860	Vicki Thompson, Steve Phillips			
5	LT-P-7	Stover/ Preprocessing	Impact of moisture and grinder type on throughput and energy consumption of comminution of anatomically fractionated corn stover		Prepared, edited by EW and finalized FY22Q3	Thompson, D.N. and D.S. Hartley. 2022. “Impact of anatomical fractionation of corn stover on hammer mill throughput and energy consumption.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70142. https://doi.org/10.2172/1905860	Vicki Thompson, Steve Phillips			
6	LT-C-5	Stover/Conversion	Biomass deconstruction (DMR/EH) + fermentation performance based on isolated anatomical fractions	1/8/2021	BH Reviewed/EW editing	Report Complete - Needs final approval to publish	Jacob Dempsey, Ed Wolfrum, Steve Phillips			
7	LT-C-13	Stover/Conversion	Sugar/lignin fermentation dependence on CMAs imparted from upstream processing	3/31/2021	Prepared – needs editing	Considering for release on OSTI during FY23Q2				
8	LT-C-15	Stover/Conversion	Postponed – Impact of Stover Degradation on Conversion Performance	9/30/2021	On hold pending new data (if available) in FY23	On hold – conversion data reproducible but equivocal				
9	HT-S-1	Residue/Feedstock Supply	TEA of Anatomical Fractionation of Pine Residues at the Landing	3/10/2022		1/15/2023	Femi Oyedeji/Task 2 rep			
10	HT-S-5	Residue/Feedstock Supply	Delivered Costs of Loblolly Pine from Thinning and Timber Operations	4/7/2022	BH Reviewed/T8 editing	1/15/2023	Femi Oyedeji/Task 2 rep			

Completed Case Studies - page 2

Knowledge

fcic FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM U.S. DEPARTMENT OF ENERGY

Case Study Publishing Tracker

11	HT-P-5	Residue/Preprocessing	Particle Scale Impacts on Deconstruction Energy of Pine Residues (aka wet vs. dry milling)		BH Reviewed/T8 editing	Thompson, D.N. and D.S. Hartley. 2022. "Particle scale impacts on deconstruction energy of pine residues." Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70098. https://doi.org/10.2172/1905851	Jordan Klinger, Steve Phillips
12	HT-P-11	Residue/Preprocessing	Air Classification of Forest Residue for Tissue and Ash Separation Efficiency		BH Reviewed/T8 editing	Thompson, D.N. and D.S. Hartley. 2022. "Air classification of forest residue for tissue and ash separation efficiency." Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70171. https://doi.org/10.2172/1905857	
13	HT-C-1	Residue/Conversion	Prediction of Cost Impacts of Feedstock Material Attributes and Conversion Process Parameters in a Catalytic Fast Pyrolysis (CFP) Process Using Fitted Correlations from (a) Particle-Level Fast Pyrolysis Yield Model and (b) Detailed TEA Cost Model	12/31/2020	BH Reviewed/T8 editing	Published in BioFPR https://doi.org/10.1002/bbb.2319	
14	HT-C-7	Residue/Conversion	Comparative techno-economic analysis of available feedstocks for high-temperature conversion: whole tree thinnings and mature pine residues	3/31/2021		Reviews complete, final draft sent to publishing (pending publication)	Anne Starace Steve Phillips
15	HT-C-9	Residue/Conversion	Techno-economic assessment of air classified forestry residues as a feedstock for catalytic fast pyrolysis			Delay to expand with subtask 8.2 in FY23	
16	HT-LCA-8	Residue/Conversion	Life-Cycle Analysis Case Study: Greenhouse Gas Emissions of Supply and Delivery of Loblolly Pine from Thinning and Timber Operations		Prepared – needs editing	Draft	
18	HT-LCA-6	Residue/LCA	Life-Cycle Analysis of wet milling versus dry milling of residues		Prepared – needs editing	Ready to publish after resolving Cover Concern	Xinyu Liu Steve Phillips
19	HT-LCA-8	Residue/LCA	Life-Cycle Analysis Case Study: Greenhouse Gas Emissions of Biofuel Production via Catalytic Fast Pyrolysis of Loblolly Pine		Prepared – needs editing	Draft	
20	HT-P-8	Residue/Preprocessing	TEA of Knife Wear using coatings and alloys		In preparation	In preparation	
12 (expanded)	HT-P-11e	Residue/Preprocessing	Sensitivity analysis of air classification of forest residues for tissue and ash separation efficiency with regard to the air speed CPP, particle size CQA floor, fixed carbon CQA ceiling		On hold – pending expansion with conversion subtask (8.3)	Draft. OSTI release planned in FY23Q3	

2 – Case Study Approach Overview

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

Identify Process Areas Highly Impacted by Feedstock Variability

Design Experimental or Modeling Plans

Execute Experiments or Models and Produce Data

Publications

FCIC Web Site

FCIC or other BETO Researchers

Data/Results

Industrial Conferences

2-page Summary Sheets

Laboratory Report (with OSTI #)

Define Case Studies and Data Needs for Analyses

FCIC Analysts

Develop algorithms for predicting cost and environmental impacts of variable biomass qualities and processes

Techno-economic Analyses and Life Cycle Analyses for Case Study

Dissemination

The Case Study framework focuses TEA/LCA on small sections of the value chain that can be completed in relatively short time permitting more targeted, in-depth studies to be completed from across the value chain. Results dissemination critical!

Responses to Previous Reviewers' Comments

- Comment: "The presentation falls short of providing an overall recommendation for certain items studied. It wasn't clear what is the recommended approach to mildly or severely degraded corn stover from an LCA or TEA viewpoint according to the models."
- Response: "There was insufficient time allocated for the presentation to cover each case study adequately. Case studies were intentionally limited in scope to answer specific questions and provide insights that will inform new case studies with broader scopes. We attempt to consider impacts downstream, but there are still gaps in the available data that need to be filled. We are using the new insights gained to inform recommendations for the FCIC work in outyears. For example, the presentation stated that the cost of improved storage would add $0.30/gge to the MFSP. From other work by task 8.4 (biochemical conversion), it was estimated that a 2 percentage-points increase in carbohydrates content would be needed to compensate for the additional storage costs. Additional cost savings are anticipated in pre-processing, but this was not within the scope of this case study and is a knowledge gap. LCA of the corn stover value chain was not funded in FCIC."
- We provide the benefits and costs related to feedstock variability and mitigation studies. This information is useful to stakeholders by helping inform their decisions. We do not typically make explicit recommendations since the application of the studies will vary for different end users.

Responses to Previous Reviewers' Comments

FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM
U.S. DEPARTMENT OF ENERGY

- Comment: "The project has not researched and incorporated the capital and operating costs of the ARRA projects or validated their model against these projects. This should prove to be a worthwhile task"
- Response: "Unfortunately, the ARRA project cost information is not currently available to the national laboratories."
- Comment: "It was exciting to see the findings of each task translated to an actionable take-home message under the TEA task. This reviewer recommends incorporating the TEA take home message and Ishikawa relationship diagrams developed under Task 8 into each tasks Peer Review Presentations going forward, so that the industrial/operational relevance of their work and relationships between CMAs, CPPs, and CQAs are more clear."
- Response: "We have a lot of work ahead of us in this task to tie together all the case studies and develop insights into the next round of experimentation and case studies that would provide the most benefit to the biorefinery industry. Thank you for your suggestions."
- We have integrated case studies across the value chain to look at interactions between areas. Our summary sheets highlight the key takeaways as shown in this year's peer review presentation.

Publications

- Wiatrowski, Matthew R., Abhijit Dutta, M. Brennan Pecha, Meagan Crowley, Peter N. Ciesielski, and Daniel Carpenter. "A simplified integrated framework for predicting the economic impacts of feedstock variations in a catalytic fast pyrolysis conversion process." *Biofuels, Bioproducts and Biorefining* 16, no. 2 (2022): 403-412.
- Hartley, D.S., D.N. Thompson and L.M. Griffel. 2022. “Value proposition of coatings or new alloys on hammer wear.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70097. https://doi.org/10.2172/1905856
- Thompson, D.N. and D.S. Hartley. 2022. “Particle scale impacts on deconstruction energy of pine residues.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70098. https://doi.org/10.2172/1905851
- Thompson, D.N. and D.S. Hartley. 2022. “Air classification of forest residue for tissue and ash separation efficiency.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70171. https://doi.org/10.2172/1905857
- Thompson, D.N. and D.S. Hartley. 2022. “Impact of anatomical fractionation of corn stover on hammer mill throughput and energy consumption.” Technical Report, Idaho National Laboratory, Idaho Falls, ID. INL/RPT-22-70142. https://doi.org/10.2172/1905860.

Presentations

- Simulating the operational effect of particle scale impacts on deconstruction energy of pine residues. D.S. Hartley, D.N. Thompson, M. Wiatrowski, A. Dutta. *2021 Virtual AIChE Annual Meeting*, November 15-18, 2021. Paper 193e, Oral presentation.
- Crosscutting analyses in the Feedstock-Conversion Interface Consortium (FCIC). S.D. Phillips, E.G. Webb. *2021 Virtual AIChE Annual Meeting*, November 15-18, 2021. Paper 309d. (presented by D.N. Thompson for S.D. Phillips)
- R. Davis, I. McNamara, A. Bartling, “TEA Modeling to Quantify Economic Implications for Biorefinery Processing of Isolated Anatomical Fractions of Corn Stover.” Presented at the 2021 AICHE Annual Meeting, November 15, 2021 (virtual).