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

2021 PROJECT PEER REVIEW
U.S. DEPARTMENT OF ENERGY
BIOENERGY TECHNOLOGIES OFFICE

Feedstock Technologies

Nichole Fitzgerald, Program Manager

March 8, 2021

Feedstock Technologies Overview

- The Team
- Program Goals
- Program Structure
- Budget
- Key Accomplishments
- Future Directions
- Reviewers

The Feedstocks Technologies Team

Nichole Fitzgerald
Program Manager

Mark Elless
Technology Manager

Chenlin Li
Technology Manager

Liz Burrows
Technology Manager

Art Wiselogel
ORISE Fellow

Bri Farber
AAAS Fellow

Clayton Rohman
Project Support

Alexander Jansen
Project Support

Richard Coaxum
Business Support

Program Goals

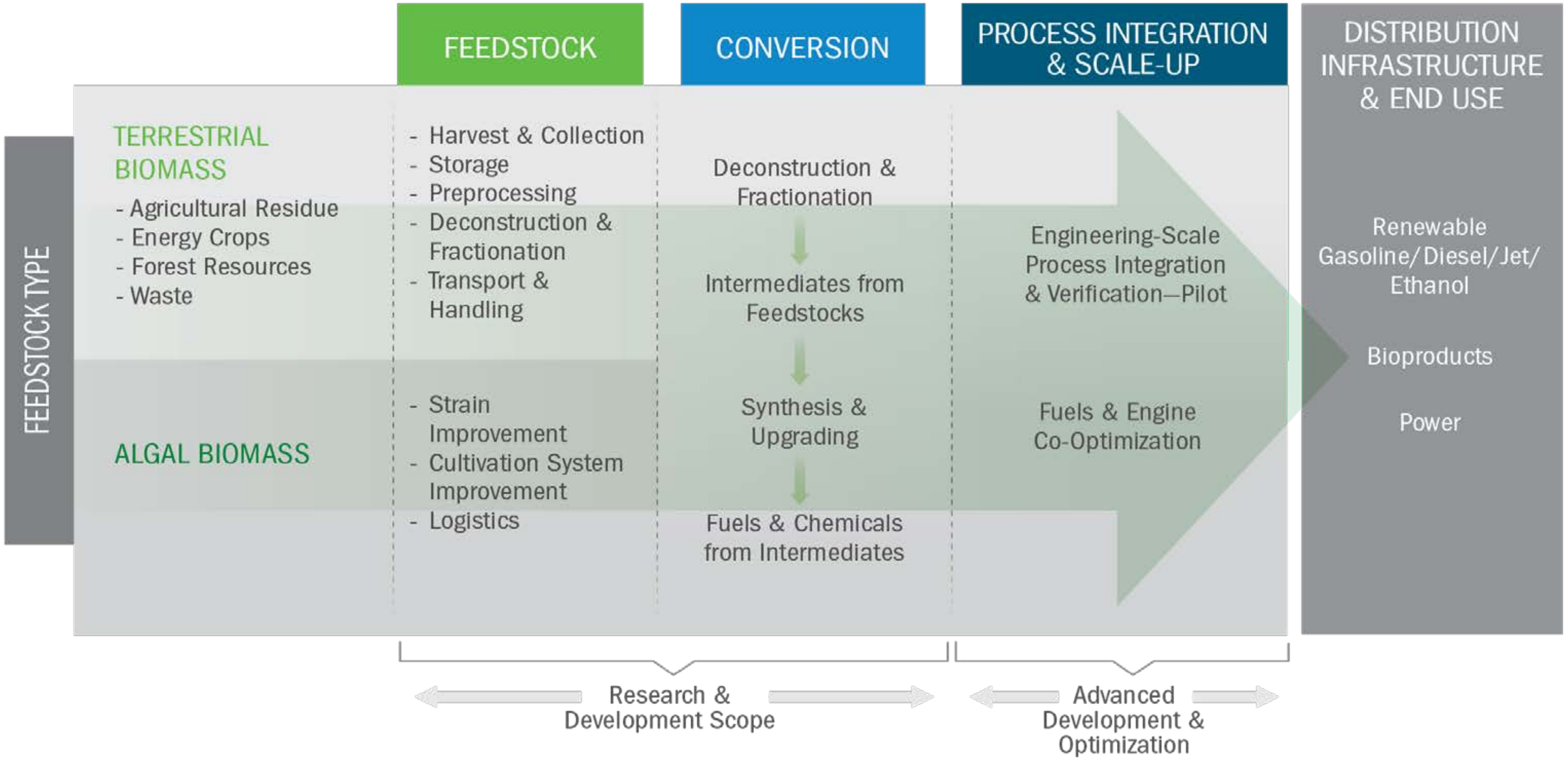
Strategic Goal: *Develop science-based strategies and technologies to **cost-effectively** transform renewable carbon sources into **high-quality**, **sustainable**, **conversion-ready**, and **energy-dense** feedstocks for biofuels, bioproducts, and biopower.*

Approaches:

- Defining requirements and specifications for high-quality, conversion-ready intermediates
- Developing fundamental understanding of the interactions between feedstock properties and conversion performance
- Identifying the key feedstock quality and performance factors affecting biorefineries
- Improving the efficiency of feedstock logistics operations

Cost-effective, high-quality, sustainable, and energy-dense feedstocks

Feedstocks Pathways



Focus Areas of Feedstock Technologies

Improve the Quality and Quantity of Renewable Carbon Feedstocks

Reduce Cost of Renewable Carbon Feedstocks

Strategies focus on improving the *efficiency* and *reliability* of harvesting/collection, storage, preprocessing, and transportation.

FT Goals FY 2021–FY 2030

By 2021, deliver feedstocks meeting the defined critical material attributes (CMAs) for the 2022 verification, supporting a modeled minimum fuel selling price of $3/GGE and a 60% reduction in GHG emissions relative to petroleum-derived fuels.

By 2022, identify the preprocessing system and critical processing parameters necessary to deliver the required critical material attributes for biochemical and thermochemical conversion at 90% operating effectiveness that meet a delivered cost of $86/dry ton. reliability.

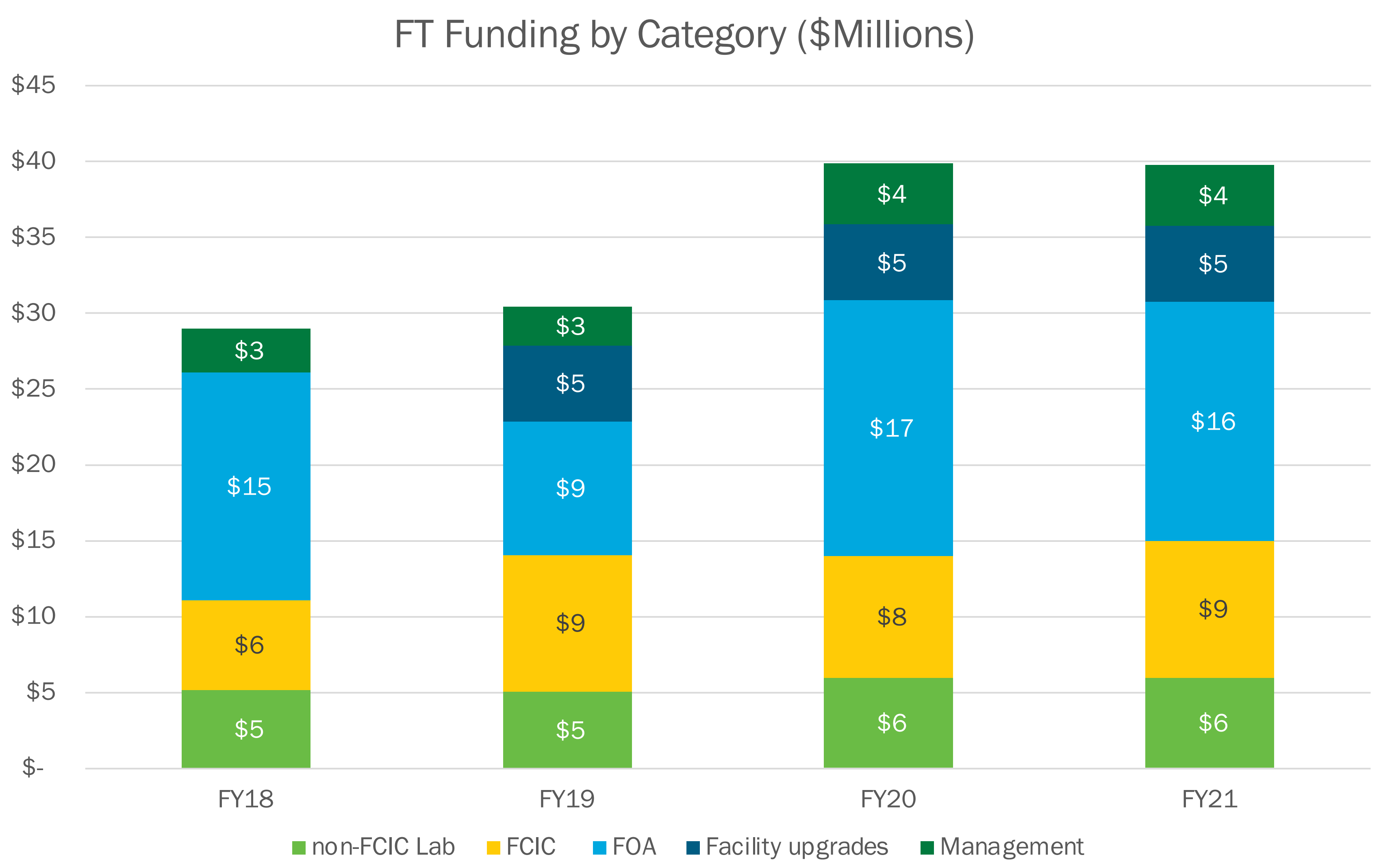
By 2025, verify coproduct technologies that utilize fractions of biomass derived from feedstock logistics and preprocessing to increase the total feedstock value by 10%.

By 2030, develop science-based strategies and technologies to cost-effectively transform carbon sources into sustainable, energy-dense, and conversion-ready feedstocks at 90% operating effectiveness that meet a delivered cost of $71/dry ton.

Program Structure

- **Feedstock Technologies R&D**
  - **Production & Supply**
    - **Supply Chain Analysis**: Assesses the potential availability and quality characteristics of a variety of biomass resources.
    - **Biomass Production**: Evaluates all the operations, associated costs, and sustainability issues related to site preparation, crop establishment, growth, and maintenance of terrestrial biomass crops.
  - **Feedstock Logistics**
    - **Harvest Collection & Storage**: Involves the cost-effective and sustainable removal of raw biomass and the methods and practices to cost-effectively store and preserve the quantity and quality until required for processing.
    - **Transportation & Handling**: Moving raw biomass to the preprocessing site *and* delivering preprocessed feedstocks to the throat of the reactor. Improving handling characteristics as well as minimizing fire risk.
    - **Preprocessing**: Transforming raw, field-run biomass into stable, standardized format feedstocks with characteristics that meet the required quality specifications of conversion facilities.

Budget


FT Funding by Category ($Millions)
$45
$40
$35
$30
$25
$20
$15
$10
$5
$-
FY18
FY19
FY20
FY21
$3
$15
$6
$5
$3
$5
$9
$9
$5
$4
$5
$17
$8
$6
$4
$5
$16
$9
$6
non-FCIC Lab
FCIC
FOA
Facility upgrades
Management

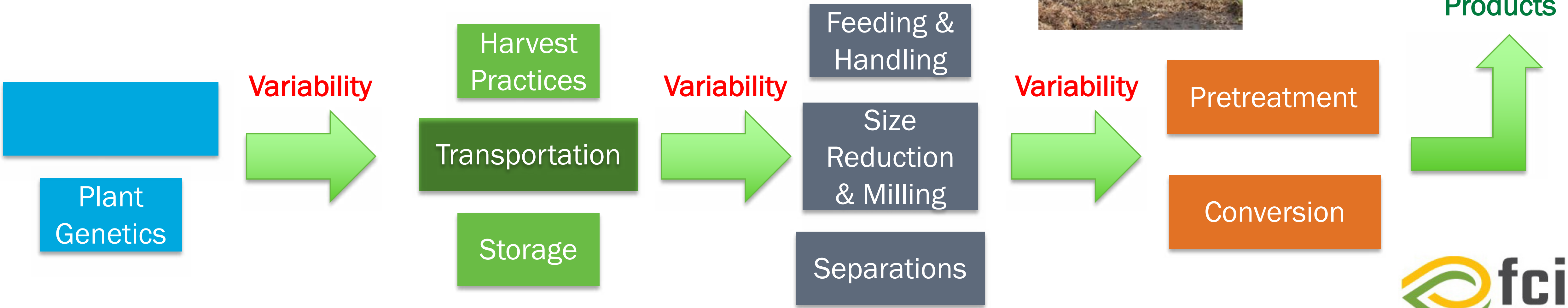
Feedstock-Conversion Interface Consortium

The Feedstock-Conversion Interface Consortium (FCIC) is led by DOE as a collaborative effort among 9 National Labs

Founding principles

- Biomass feedstock properties are **variable and different** from other commodities
- **Empirical** approaches to address these issues have been **unsuccessful**
- The biomass supply chain introduces **additional variability**: growth factors, during harvest/storage, during comminution, …

The FCIC seeks to systematically understand and mitigate this feedstock and process variability to reduce the risk for biorefineries



Feedstock-Conversion Interface Consortium

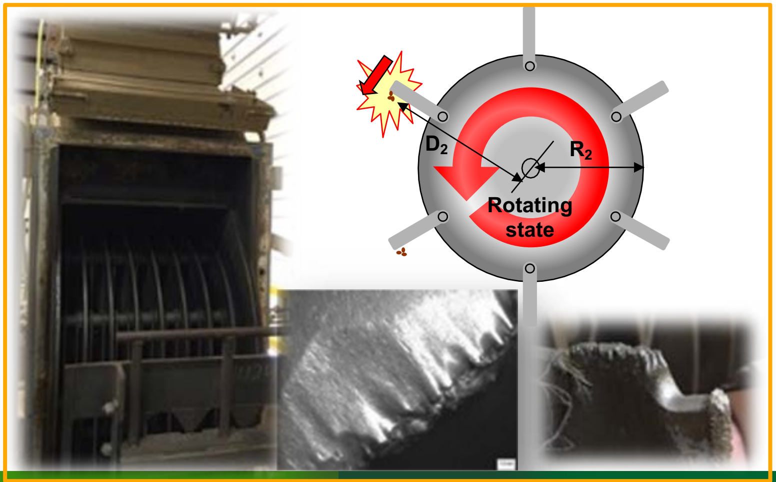
How are we reducing risk for biorefineries?

1) Through first-principles scientific understanding
2) Which leads to the development of industry ready and relevant tools
3) Which can result in energy/cost savings for operators ***AND*** Improved operational reliability

Hammer Mill

Blunt blades @ high speed
→ **Crushing**

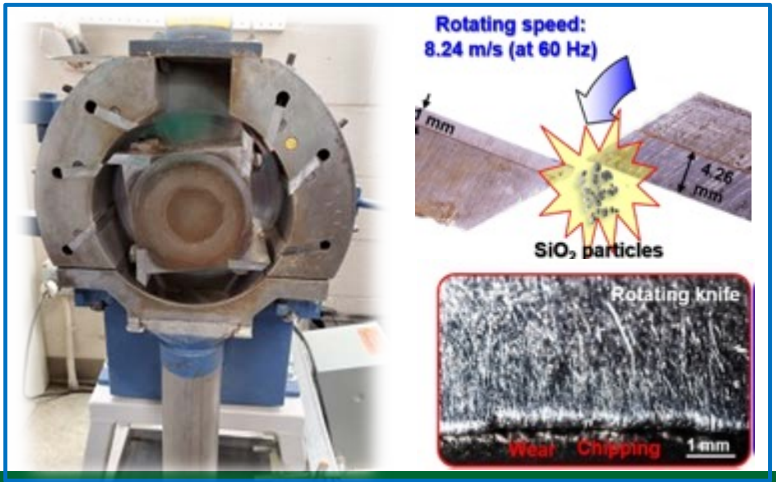
Erosive wear (dominant) + 2-body/3-body Abrasive wear (secondary)



Knife Mill

Sharp blades @ medium-high speed
→ **Cutting + Crushing**

2-body/3-body **Abrasive** wear + **Erosive** wear (both important, *depending on operation conditions*)



Crumbler® Rotary Shear

Sharp edges/corners @ low speed
→ **Cutting/Shearing**

2-body/3-body **Abrasive** wear (dominant) + chipping (secondary)
**Erosion negligible*

Feedstock-Conversion Interface Consortium

How are we reducing risk for biorefineries?

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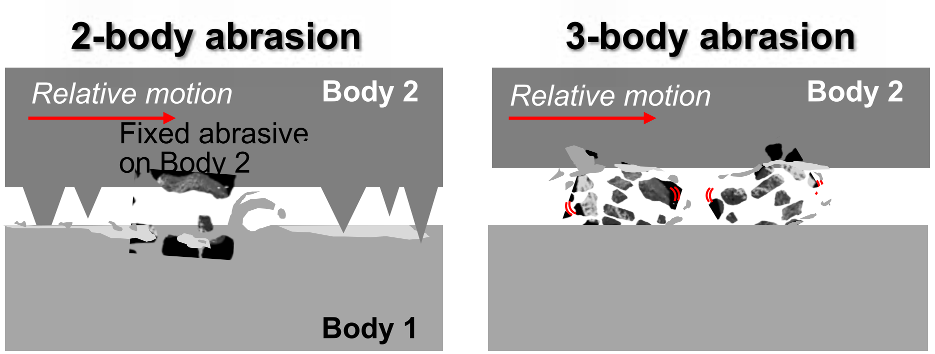
2-body/3-body Abrasive Wear

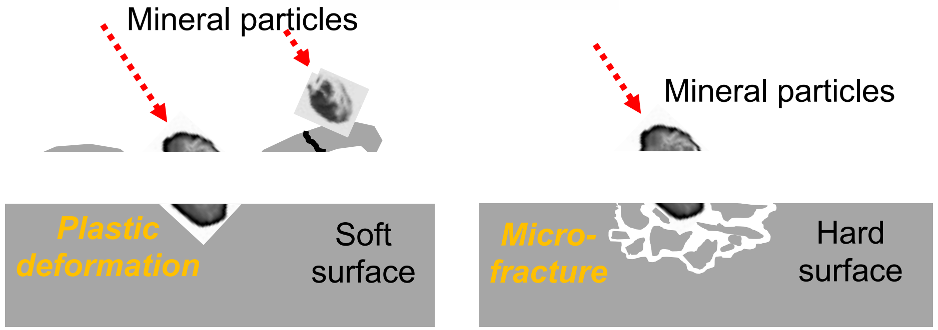


Manner of energy dissipation:
Groove plowing, cutting chips, grit fracture, heat

Critical tool material mechanical properties:
Hardness, yield strength, fracture toughness

Key processing parameters:
Abrasive grit shape/size, load, sliding speed/distance

Erosive Wear



Manner of energy dissipation:
Plastic deformation, micro-fracture, heat

Critical tool material mechanical properties:
Fracture toughness, hardness, fatigue ductility, yield strength

Key processing parameters:
Particle hardness, velocity, and size, impingement angle

Feedstock-Conversion Interface Consortium

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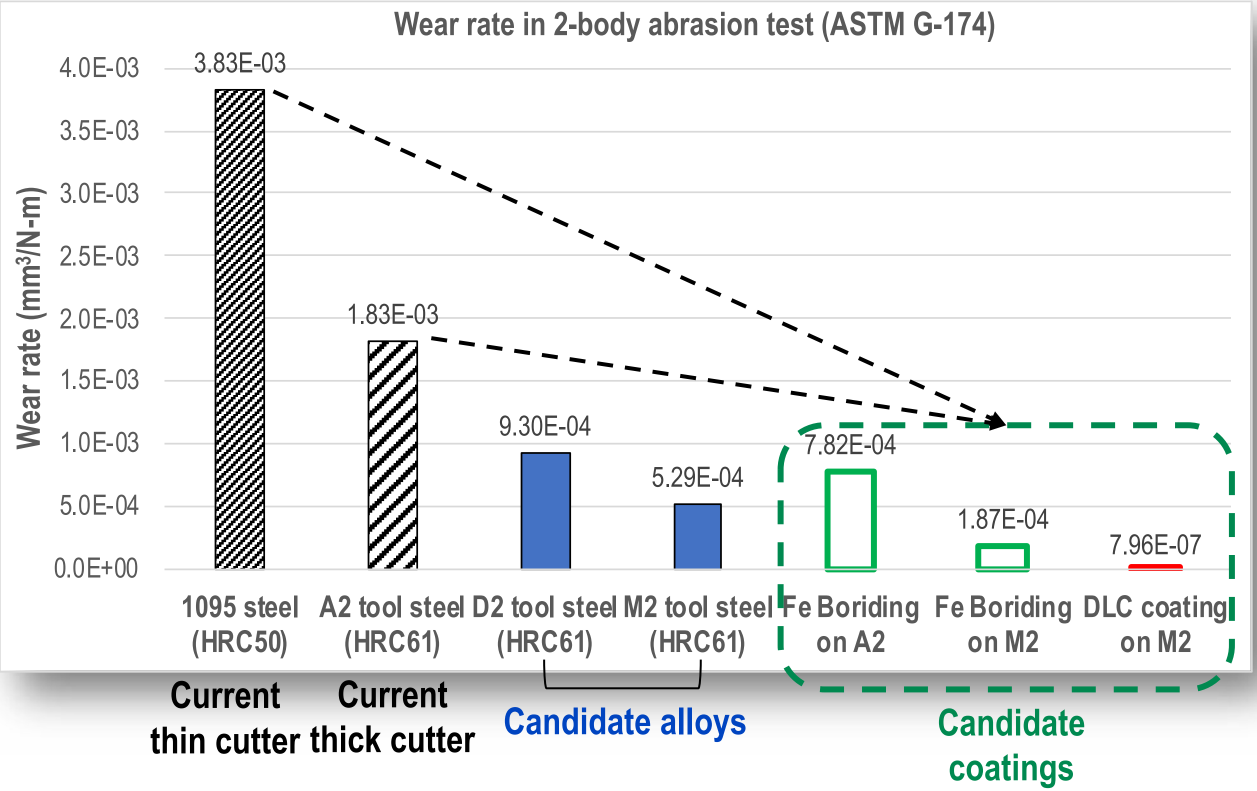


For thin cutter (1/16")		Wear rate ($x10^{-3}$ mm^3/Nm)	Potentially improved life	4.25"-dia. cutter cost*	Cutter cost factor
Current thin cutter (1095 steel)		3.83	Baseline	~$18	Baseline
Candidate coatings	Fe-borided A2	0.78	~5x	~$43	~2.4x
	Fe-borided M2	0.19	**~20x**	~$74	**~4.1x**
	DLC-coated M2	0.0008	**>4000x**	~$63	**~3.5x**

For thick cutter (3/16")		Wear rate ($x10^{-3}$ mm^3/Nm)	Potentially improved life	4.25"-dia. cutter cost*	Cutter cost factor
Current thick cutter (A2 tool steel)		1.83	Baseline	~$40	Baseline
Candidate alloys	Fe-borided A2	0.78	~2x	~$52	~1.3x
	Fe-borided M2	0.19	**~10x**	~$88	**~2.2x**
	DLC-coated M2	0.0008	**>2000x**	~$80	**~2x**

**Coating cost estimates based on batches of 100 parts*

Key Funding Announcements

Landscape Design for Sustainable Bioenergy Systems FOA

One project awarded ($9M), establish multi-disciplinary landscape design process, improve sustainability metrics, and assess logistics systems to deliver feedstocks to conversion facilities for bioenergy

Affordable and Sustainable Energy Crops (ASEC) FOA

Three projects awarded ($15M), using new varieties/cultivars of energy crops leading to increased availability, cost-effectiveness, and environmental sustainability of energy crop production systems

Bio-Restore: Biomass to Restore Natural Resources FOA

Three projects ($9M), will develop and employ new methods to quantify the environmental and economic benefits associated with growing energy crops on marginal and/or unproductive land with a focus on restoring water quality and soil health.

Biomass Component Variability and Feedstock Conversion Interface FOA

Seven projects ($8.6M), evaluate impact of biomass characteristics on feedstock performance in handling and conversion, design novel storage and handling approaches to control physical and chemical variability in biomass

Advanced Fractionation and Decontamination of Municipal Solid Waste for Improved Conversion Efficiency FOA

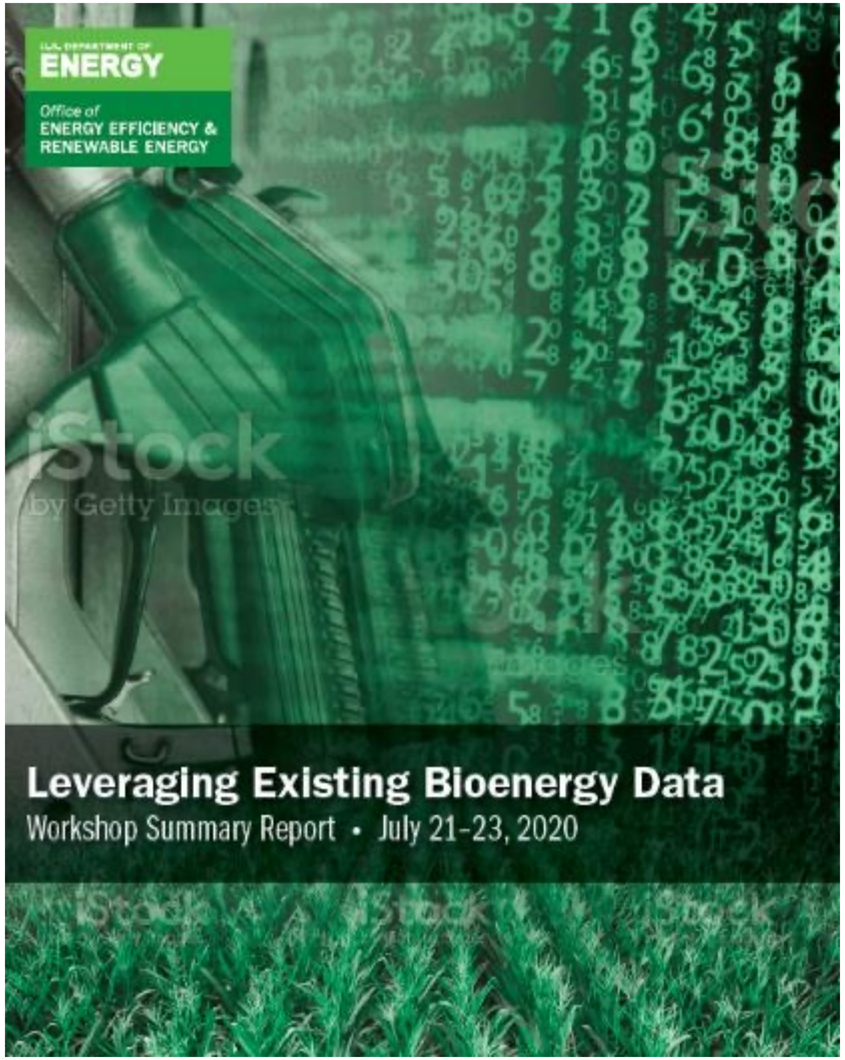
Four projects ($9M), develop advanced and techno-economically viable sorting and preprocessing methods tailored to MSW to address its known heterogeneity and variability, to produce high-purity, value-added feedstocks

Advancing the Bioeconomy: From Waste to Conversion-Ready Feedstock Feb 2020 Workshop

- **80 attendees**
- **MSW stream is currently undervalued**
  - Combustion or landfill are two major pathways
- **Participants agreed that advancements in the following areas are necessary:**
  - Better fractionation technologies to separate MSW stream into distinct components
  - Characterization of MSW, across multiple scales and using rapid/real-time analysis techniques
  - Specifications for feedstocks for various conversion technologies
- **Benefits and drawbacks of AI also needs further exploration**
- **Robust environmental impact modelling of waste utilization is needed**
- **Non-technical recommendations included**
  - Consumer & industry education
  - Regulation (e.g. landfill bans, carbon tax/credits)

Leveraging Existing Bioenergy Data Workshop July 2020

- **Goal: Discuss strategies for collecting and valorizing underused datasets and associated knowledge, with the objective of making this information public on existing databases**
- **189 total registrants**
- **Outcomes**
  - 49 existing, potentially acquirable datasets
  - More than 20 relevant established databases to house the bioenergy data
  - 31 data quality metrics with 94 suggested processes for confirming usefulness
  - 9 types of data owners and associated legal processes to acquire data
  - Multiple ideas for determining the monetary value of data
- **Report coming soon!**



Save the date! FY21 FT Workshop

- Virtual workshop
- Advancing Synergistic Waste Utilization as Biofuels Feedstocks: Preprocessing, Co-products, and Sustainability
- **April 14-15, 2021**; Register now!
- Featuring the following topic areas:
  - MSW preprocessing technologies to address feedstock quality challenges and meet specifications for conversion pathways and downstream integration;
  - Opportunities of co-product development to utilize low quality MSW fractions for valorization;
  - Sustainability impacts of MSW utilization via the analysis of environmental, economic, and social factors.

Introductions – FT Peer Review Panel

- Mr. Glenn Farris, AGCO (*Lead Reviewer*)
- Dr. John Cundiff, Virginia Polytechnic Institute and State University (retired)
- Dr. Sally Krigstin, University of Toronto
- Mr. Jason Martin, Poet-DSM Project Liberty
- Dr. Dana Mitchell, USDA Forest Service – Southern Research Station
- Dr. Jingxin Wang, West Virginia University






THANK YOU, REVIEWERS!

Introductions – FCIC Peer Review Panel

- Mark Penshorn, bb7 (Lead Reviewer)
- Kim Nelson, GranBio
- Paul Paxson, E3 Consulting
- Mike Tupy, Cargill
- Phil Weathers, Weathers Associates Consulting





THANK YOU, REVIEWERS!

Nichole Fitzgerald, PhD
Program Manager
Bioenergy Technologies Office
U.S. Department of Energy
Phone: (240) 562-1334
Email: Nichole.Fitzgerald@ee.doe.gov

www.linkedin.com/in/Nichole-fitzgerald

www.twitter.com/BioenergyKDF

www.bioenergykdf.net