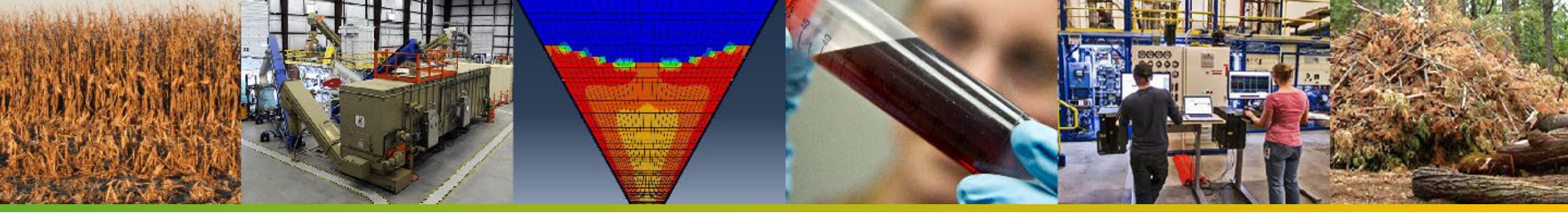


# *DOE Bioenergy Technologies Office (BETO) 2021 Project Peer Review*

## *Task X- Project Management*

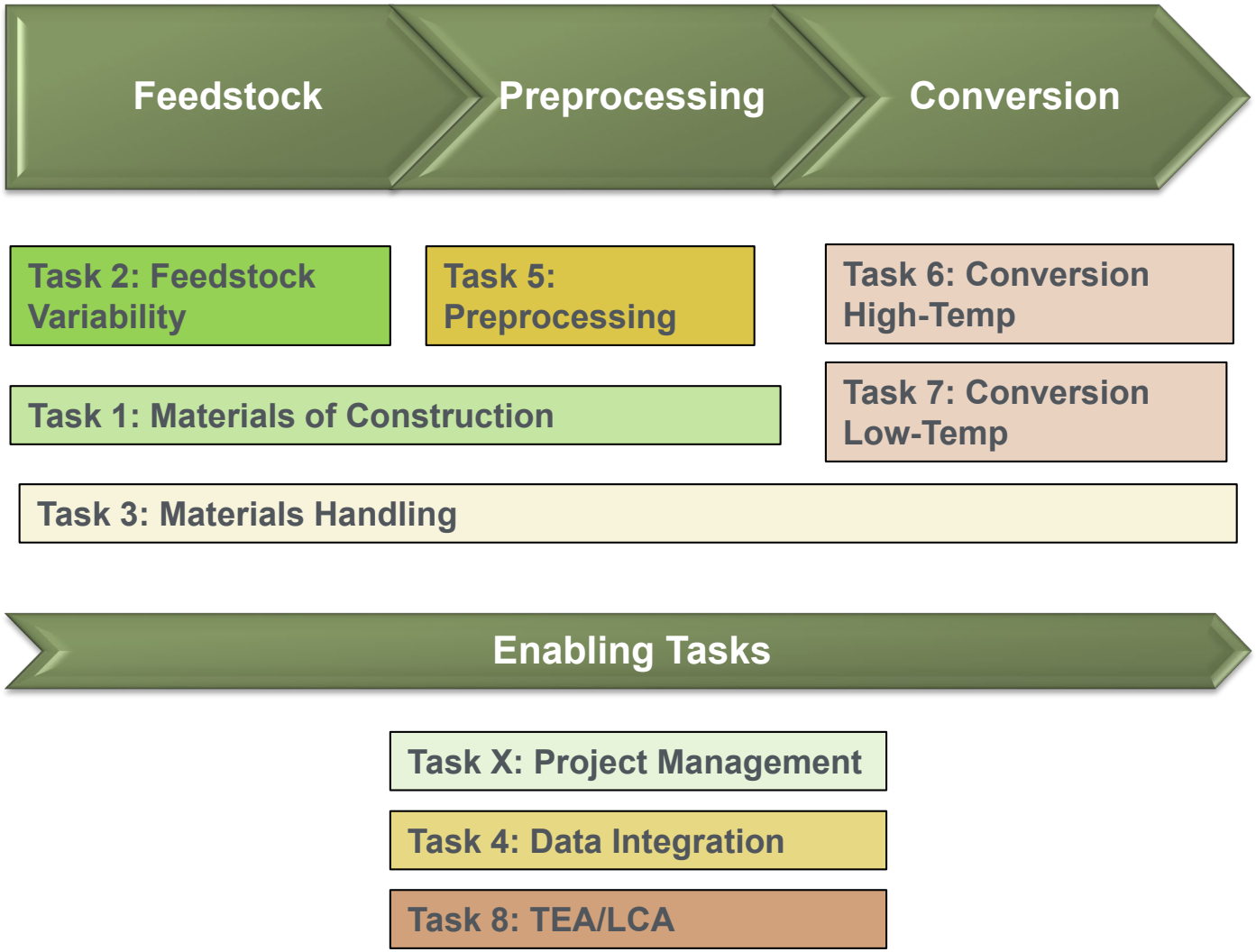
**March 15, 2021**
**Feedstock Conversion Interface Consortium**

**Amie Sluiter**
**National Renewable Energy Laboratory**

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

This presentation does not contain any proprietary, confidential, or otherwise restricted information

# FCIC Task Organization




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

**Task 1: Materials of Construction:** Specify materials that do not corrode, 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

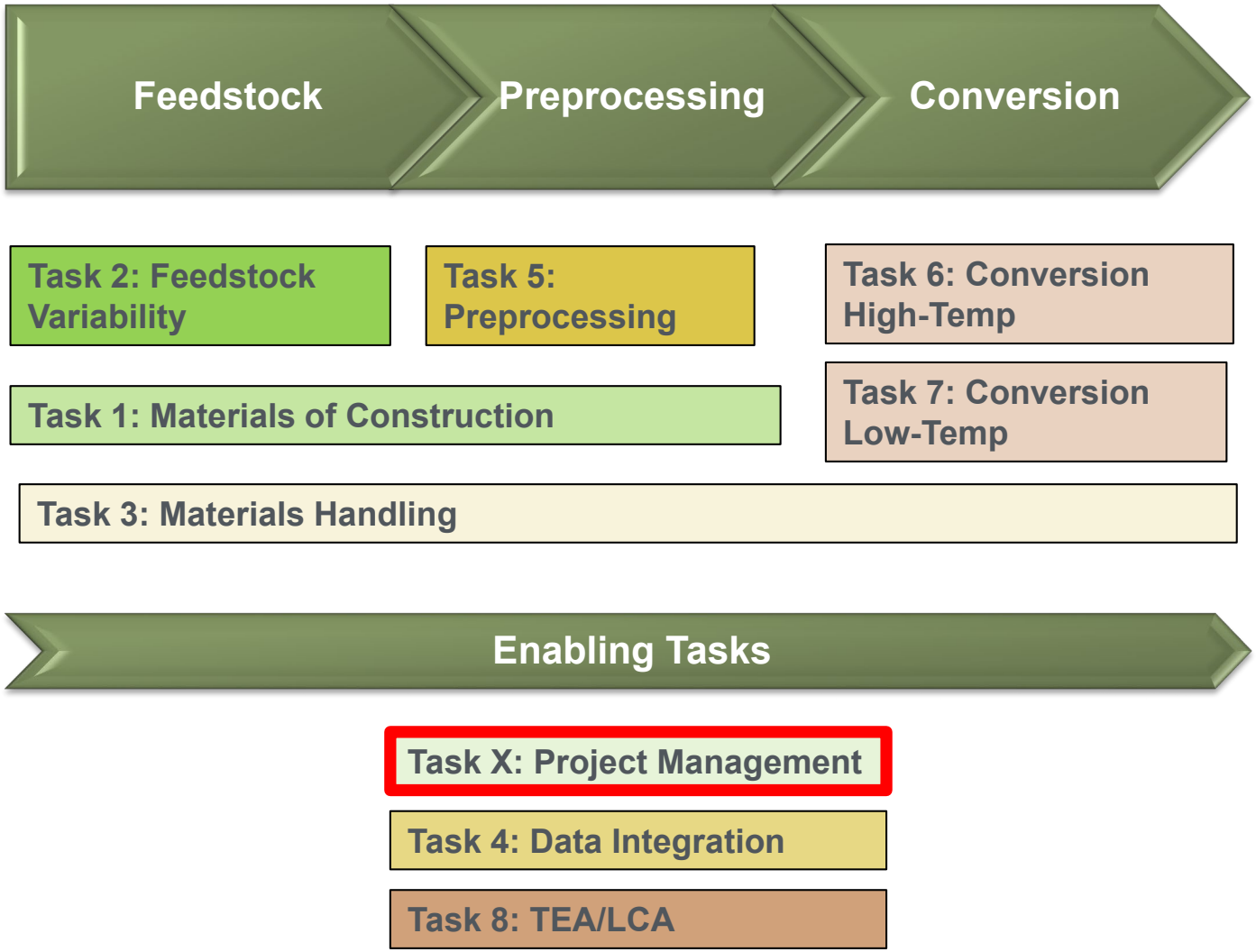
**Task 4: Data Integration:** Ensure the data generated in the FCIC are curated and stored – FAIR guidelines

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

**Task 6 & 7: Conversion (High- & Low-Temp Pathways):** Produce homogeneous intermediates to convert into market-ready products

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

# FCIC Task Organization




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

**Task 1: Materials of Construction:** Specify materials that do not corrode, 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 homogeneous intermediates to convert into market-ready products

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

# Task X- History- Consortium Refocus

- The FCIC was refocused and presented at the 2019 peer review
  - Move to Quality by Design and first principles-based science
  - Focus on variability effects and TEA
  - Steering committee recognized a need for established PI and PM leadership, based on the maturity process of other BETO consortia

- This task was charged with implementing the refocus

# Project Overview

- **Objective:** The purpose of the PI/PM task is to provide **scientific direction and leadership** to the nine participating labs and provide **project management** to ensure robust operational planning and execution.

- **Current limitations:** Large multi-lab consortia require leadership and coordination, as proven by the sustained accomplishments of other BETO consortia. Facilitated communication and organization between labs and process-specific projects results in cohesive outputs and minimizes duplicative work.

- **Relevance:** Ensuring industrially relevant successful outcomes requires actively monitoring and managing the science, engaging stakeholders and promoting accomplishments.

- **Risks:** Maintaining industrially relevant research requires monitoring and course correction. Stakeholder management, poorly handled, can result in ineffective collaboration across laboratories, leading to suboptimal performance.

# 1 – Management

- We are responsible for giving the consortium direction and coherence so that it is a focused research effort and not discreet unconnected projects
- Directly engaging our **DOE/BETO sponsors** to ensure that we **meet their expectations**
- Directly engaging with the **Industrial Advisory Board** (IAB) to ensure we understand the **needs of the industry**
- Directly engaging with **researchers** within the FCIC who are world experts in their field to ensure that we are staying on the **cutting edge of science**
- From these interactions we ensure we are enabling the industry with sound science

| Subtask | Lead | Major Responsibilities |
|---|---|---|
| **Principal Investigator (PI)** | Ed Wolfrum | Provides oversight and guidance of technical work |
| **Project Manger (PM)** | Amie Sluiter | Provides organizational support to consortium |
| **QbD Systematic Criticality Assessment** | Rachel Emerson | Perform a two-step failure mode and effect analysis (FMEA) |

# 1 – Management

## Communication strategy:

- **Engage external stakeholders**
  - Website www.energy.gov/eere/bioenergy/feedstock-conversion-interface-consortium
- **Engage the Industrial Advisory Board (IAB)**
  - Quarterly meetings
  - Direct involvement in outyear plans
- **Direct Funding Opportunity (DFO) industry partners**
- **DOE sponsor engagement**
  - Regular meetings and updates
  - Milestones, reports, presentations
- **Internal stakeholder engagement**
  - Meetings, bi-weekly to annual
  - Written communication
  - Informal calls

# 1 – Management

## Risks

- **Scientific risks**
  - Research direction, relevance, scope
    - Identified through reports and discussions with stakeholders
    - Mitigated with research course corrections
- **Project Management risks**
  - Operational issues and communication problems
    - Identified through active communication and deliverable monitoring
    - Mitigated through thoughtful planning and communication
- Both approaches allow for frequent course correction

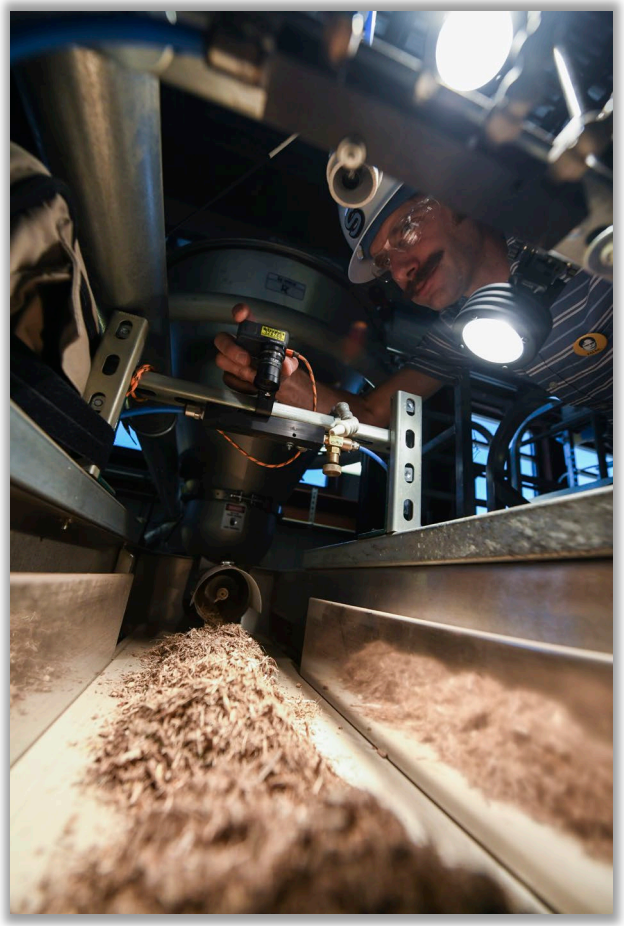


Photo credit Dennis Schroeder, NREL

# 2 – Approach

- Provide technical oversight and organizational support.
- Facilitate consistent consortium output with genuine industrial relevance.
- Allow researchers to focus on science.
- Leverage learnings from other BETO consortia.

## Technical

**Provide oversight & guidance of technical work**

- Coordinate tasks for unified vision & impactful deliverables
- Align work to ensure industrial relevance
- Form a Quality by Design (QbD) subject matter expert team
- Perform a two-step **F**ailure **M**ode and **E**ffects **A**nalysis
- Implement and oversee QbD systematically and centrally, with future potential

## Management

**Provide organizational support**

- Central contact for information and organization
- PM best practices
  - Develop Annual Operating Plans
  - Project Management Plan
  - Communication Plan
- Manage business processes and expectations
- Provide financial oversight and recommendations
- Facilitate data & materials transfer

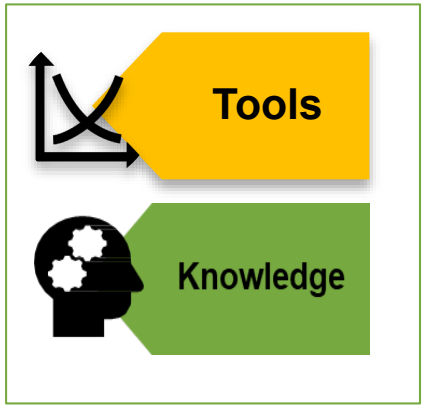
# 2 – Approach

Science | Organization | Communication

## Challenges:

- Coordinating work among nine National Labs
- Establishing and maintaining legal agreements among labs and external partners (intellectual property agreements, non-disclosure agreements, Cooperative Research and Development Agreements (CRADA), etc.)
- Soliciting actionable industrial feedback

**Metrics:** The outcome of this task is a consortium demonstrating scientific relevance, timely deliverables, and actively managed stakeholders




Organization of tasks and accomplishments for accessibility and digestibility

# 3 – Impact

## Impact

### Technical

- Industry is heard and proactively engaged
- Real-world applicability
- Feedstock and processes connected across the value chain
- Tasks contribute to a unified vision
- Common QbD framework and language

### Management

- Deliverables are timely and complete
- Milestones are SMART (specific, measurable, attainable, relevant, time-bound)
- Risks are identified and mitigated in advance
- Communication plan ensures stakeholder engagement
- Accomplishments and tools are publicly available and promoted
- Agreements and legal requirements are executed

## Dissemination

- Website
- Public webinars
- Annual Review of Research report
- Industrial Advisory Board engagement

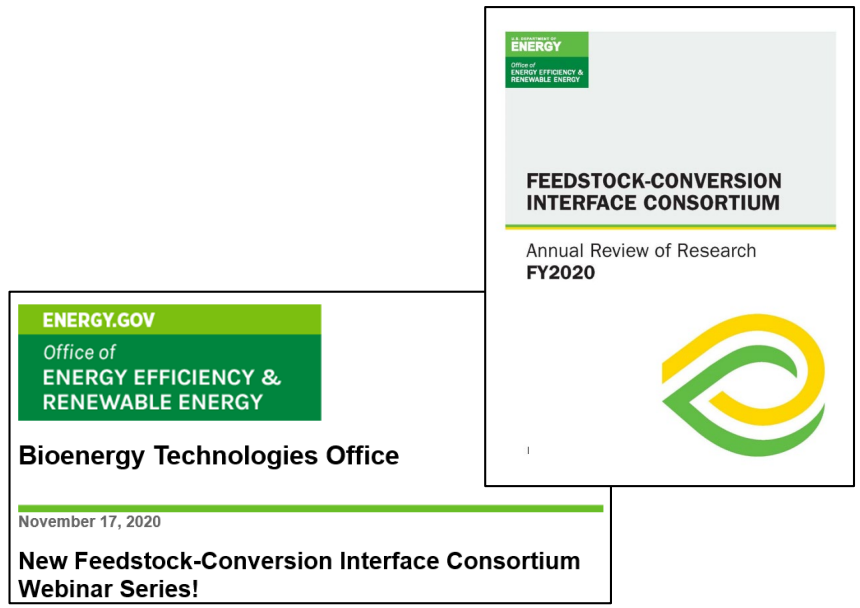



Photo credits Pat Corkery and Howard Brown, NREL

# 3 – Impact

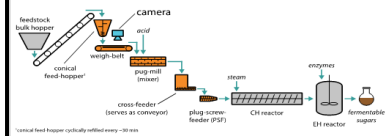
## Tools and Knowledge Slides

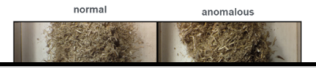
- Accomplishments are easy to find and understand
- Together make a book of information for industry
- Tools
  - Description
  - Value
  - Customers and outreach plan
- Knowledge
  - Current knowledge gap
  - Achievement
  - Relevance

### Real-Time Feedstock Image Analysis Model

Tools

**Automated machine vision technique and models to detect and quantify corn stover feedstock particle quality in real-time and enable automatic decisions that can be made by advanced processing controls**




**Description**
- Utilized a 26,000 image dataset from a continuous weigh belt feeder to a corn stover pretreatment reactor using inexpensive digital cameras
- Neural Network (NN) and Pixel Matrix Feature Parameterization (PMFP) approaches developed

**Value of new tool**
- NN models predicted anomalies (feed interruption, coarse-particle segregation) even when camera lens obscured by dust (97% true positive/3% false negative).
- PMFP method indicated significant textural features related to surface roughness, shade variations, and particle size distribution variation
- NN and PMFP approaches are complementary and can describe why feedstock images are classified a certain way

**Potential Customers & Outreach Plan**
- Broad applicability to other unit operations where continuous feeding images can be gathered (FCIC 2.4, 3.5, 5.1, and 5.2)

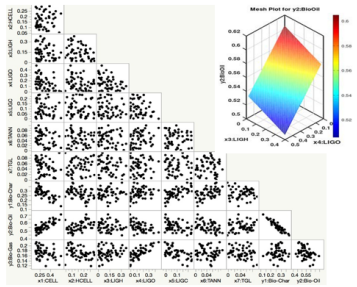
…boration on color channel model for predicting self-heating of …d on photographic images.

*Task 5 – Preprocessing*

### Assessing the sensitivity of pyrolysis products to feedstock composition

Knowledge

**Global sensitivity analysis determined that the yield of bio-oil is correlated to oxygen-rich lignin**

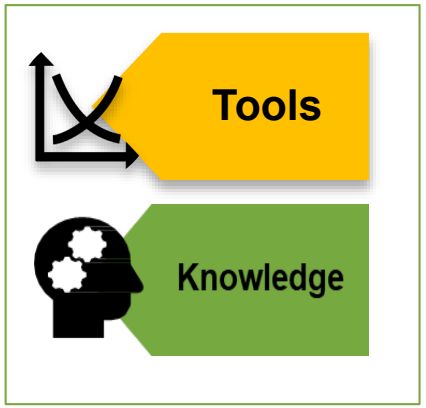


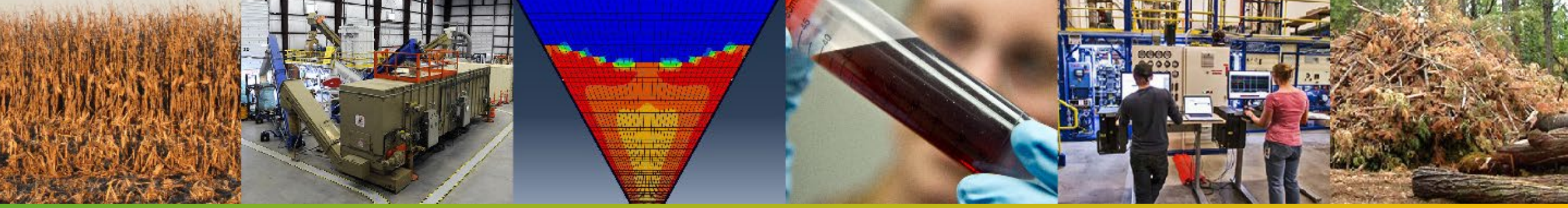
**Current Knowledge Gap**
- Lignocellulosic biomass is primarily composed of polysaccharidic cellulose, hemicellulose and polyaromatic lignin. However, the influence of these compositions on pyrolysis products is not well understood.
- Detailed pyrolysis kinetics mechanism is missing

**Achievement**
- Implemented and Validated a detailed pyrolysis kinetics mechanism
- Sensitivity of pyrolysis products to feedstock compositions was investigated by performing a simulation campaign based on statistical design of experiments principles utilizing MFiX-Nodeworks toolset

**Relevance**
- The complex influence of biomass compositions on pyrolysis products is understood and explained
- The insight gained from this study can be utilized in re-allocating adequate resources to reduce the uncertainties associated with the reaction kinetics of the most influential species

*Task 6 – High Temperature Conversion*





# *4 – Progress and Outcomes*

fcic
FEEDSTOCK-CONVERSION
INTERFACE CONSORTIUM

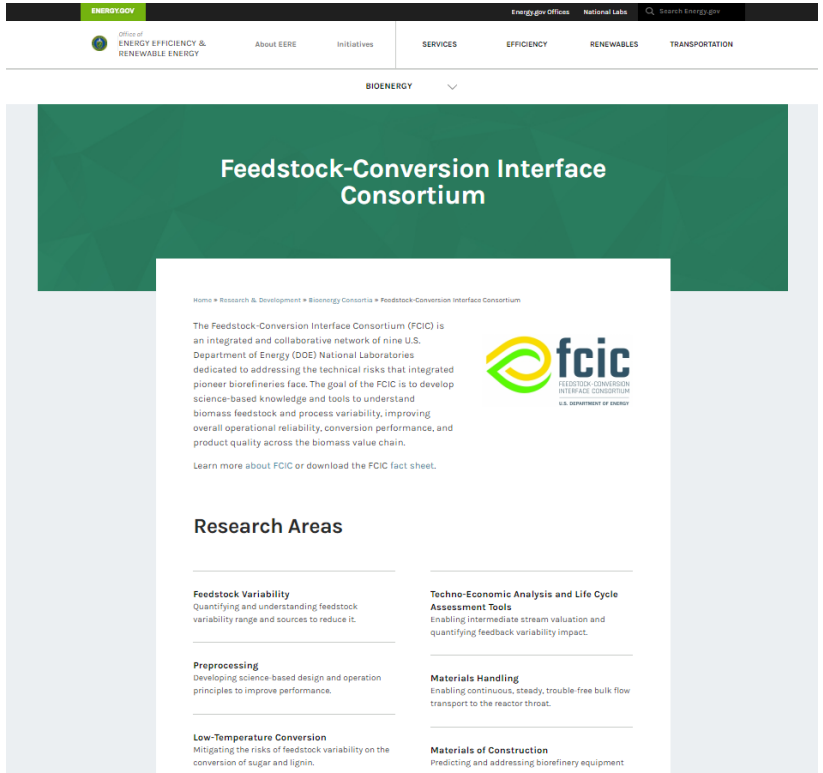
# Task X- External Engagement

## New FCIC Website

https://www.energy.gov/eere/bioenergy/feedstock-conversion-interface-consortium

Provides an external communication tool, allows interested parties to engage with us, and will provide a platform for future external solicitations.

- User-friendly navigation
- Downloadable fact and introduction sheet
- Description of research areas, leadership staff, and partners
- National Laboratory capabilities and facilities
- Publications list with links to downloadable publications




## Customers & Outreach Plan

- Email blast from BETO leadership announced website
- Updated with new publications, reports, and webinars
- Subscribers will receive periodic email updates

# Task X- External Engagement

## Webinars

- Presented live
- Recordings available at https://www.energy.gov/eere/bioenergy/fcic-webinars
- Opportunity for industry and academia to hear our work and provide feedback
- *Feedstock-Conversion Interface Consortium Introduction*
  - Dr. Ed Wolfrum, Chemical Engineer, NREL
  - December 9, 2020
  - Follow up email sent to solicit industry response and advice
- *Developing Modeling Tools for the Emerging Biorefinery Industry (computational modeling approaches to predict the behavior of biomass feedstocks)*
  - Dr. Yidong Xia and Dr. Peter Ciesielski
  - February 11, 2021
- Future webinars may include feedstock variability, materials wear, TEA/LCA case studies, and topics identified through participant feedback


Dr. Ed Wolfrum


Dr. Yidong Xia


Dr. Peter Ciesielski

# Task X- Industry Advisory Board

## Description

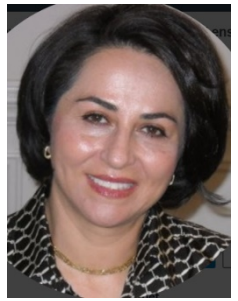
The FCIC Industry Advisory Board (IAB) was rebuilt to offramp members that had completed service, update remaining members, and invite new members. The new IAB is a small diverse group of industrial and academic advisors chosen for expertise in their respective fields.

Foster Agblevor, Utah State University

Brandon Emme, ICM

Glenn Farris, Lee Enterprises

Emily Heaton, University of Illinois



Reyhanneh Shenassa, Valmet

## Value

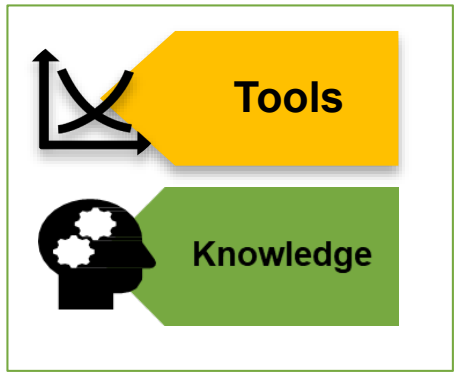
- The IAB will provide feedback on TEA case studies, outreach plans, and individual task plans and accomplishments
- This feedback will ensure industrial relevance and focus on specific industrial issues

## Outreach Plan

- Quarterly virtual meetings to update IAB on consortium activities and accomplishments
- Invite to annual FCIC meeting
- Virtual meetings as necessary to solicit input

# Task X- Outreach Materials

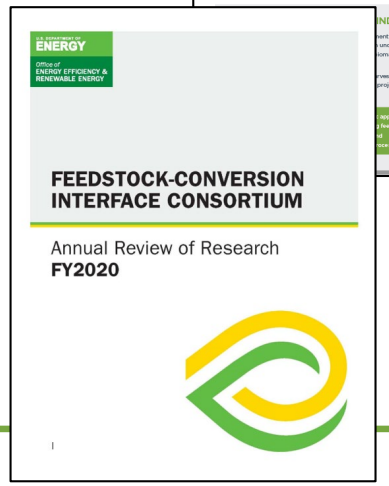
## Tools and Knowledge Slides




**Overview Factsheet:** A two-page introduction to the consortium for external partners, https://www.energy.gov/eere/bioenergy/downloads/feedstock-conversion-interface-consortium-fact-sheet

## Annual Review

- Overview of the FCIC accomplishments in fiscal year 2020
- Key research achievements of each task
- Provides planned FY 2021 work that will build on FY 2020 accomplishments


## Technoeconomic Case Studies

- One to two page summaries of TEA case studies
- Digestible presentation of relevance and findings

# Task X- Quality by Design (QbD)

**QbD Tools Summarize Critical Parameters**

**Process**
- Pathway (low or high temperature)
- Process Area
- Unit Operation

**Attribute**
- Potential Critical Attribute Name & Type (chemical, physical, mechanical)
- Units / Range (Low/High)
- Affects which Downstream Area/Unit Ops

**Criticality**
- Criticality Literature Data
- In Past/Current Scope
- Potential Future Scope
- Rationale for Criticality

## QbD

- Implementing and overseeing in a systematic way
- Organize and quantify critical attributes, linking them across the value chain
- Represent multiple disciplines and expertise

## QbD Tools

- Internal Excel based document
  - Identify and quantify the Critical Attributes for each of the unit operations being examined
  - Provide easy-to-use internal tool for communicating high-level views of the work
  - Currently tracking ~330 attributes
- LabKey “DataFinder” tool for external audience
- Handbook of critical attributes for industry

# Task X- Consortium Management

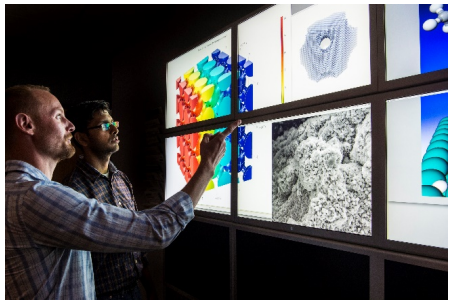
## Coordination of Material Needs and Data Handoffs Across Consortium

- We track and coordinate material needs and data handoffs
- Eliminates the possibility of missed deliverables
- Needs are gathered during yearly project planning and revisited monthly
- PM coordinates communication to ensure all handoffs are completed on time
- We are coordinating over 100 in FY21. In FY20 we coordinated over 50 handoffs.

## Business processes

- Annual operating plans
- Annual meetings
- Targeted meetings
- Reporting consistency
- Consistent client management
- Consortium level preparation for peer review, merit review, presentations
- Learning opportunities (Jenike & Johanson solids handling course, communicating science course)

| 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 |



# Summary

## Management

- ✓ Provide organization and leadership to the consortium
- ✓ Proactively engage industry, Industrial Advisory Board, and DOE
- ✓ Identify both scientific and management risks continually to allow for course corrections

Thank you!

## Technical Approach

- ✓ Provide oversight and guidance of technical work
- ✓ Coordinate task efforts for unified vision and impactful deliverables
- ✓ Align work to ensure industrial relevance
- ✓ Utilize Industrial Advisory Board
- ✓ Provide organizational support to consortium
- ✓ Develop Annual Operating Plans, Project Management Plan, and Communication Plan
- ✓ Provide financial oversight and recommendations
- ✓ Facilitate transfer of data

## Impact

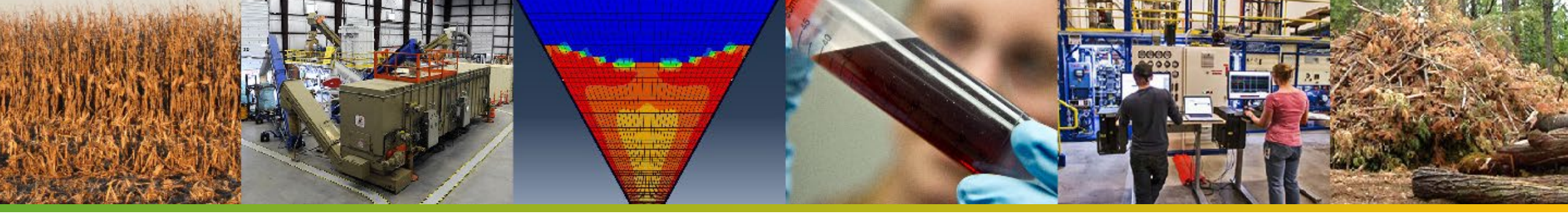
- ✓ Well-run consortium
- ✓ Feedstock and processes are connected across the value chain
- ✓ Tasks have a unified vision
- ✓ Common QbD framework & language
- ✓ Deliverables are timely & complete, milestones are SMART
- ✓ Risks identified & mitigated in advance
- ✓ Industry is heard & proactively engaged
- ✓ Communication plan ensures appropriate stakeholder engagement
- ✓ Accomplishments and tools are publicly available and promoted

## Progress

- ✓ FCIC website launched
- ✓ Webinars offered
- ✓ Outreach materials created
- ✓ IAB established
- ✓ QbD lists established
- ✓ Consortium managed

## Future Work

- ✓ Proof-of-concept Failure Mode and Effects Analysis
- ✓ Expand & refine QbD lists
- ✓ Apply tools and knowledge to other feedstocks
- ✓ Grow industrial relationships for advice and guidance



# *Thank you*

## energy.gov/fcic

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Bioenergy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

fcic
FEEDSTOCK-CONVERSION INTERFACE CONSORTIUM

# Quad Chart Overview- FCIC, Task #

## Timeline

- 10/1/2018 - 9/30/2021

| | FY20 | Active Project |
|---|---|---|
| **DOE Funding** | $650K | FY19- $400K<br>FY20- $650K<br>FY21- $720K<br>Total- $1,770K |

## Project Partners (N/A)

## Barriers addressed

| Barrier ID | Program Code | Barrier Title |
|---|---|---|
| **19Ft-E** | **FSL** | **Feedstock Quality: Monitoring and Impact on Preprocessing and Conversion Performance** |
| 19Ft-G | FSL | Biomass Physical State Alteration |
| **19Ft-J** | **FSL** | **Operational Reliability** |
| **19Ct-A** | **CONV** | **Defining Metrics around Feedstock Quality** |
| 19ADO-A | ADO | Process Integration |

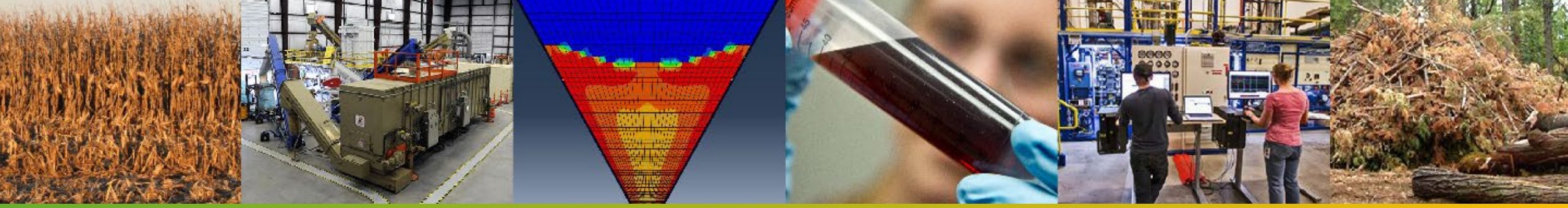
## Project Goal

The objective of the FCIC Project Management project is to 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 on tools and knowledge across the conversion value chain. Provide report to DOE and publish as a standing resource for the bioenergy community and to promote the consortium success

## Funding Mechanism (N/A)



# *Additional Slides*

fcic
FEEDSTOCK-CONVERSION
INTERFACE CONSORTIUM

# Responses to Previous Reviewers' Comments

## Recommendation 5: Aggressively promote the Feedstock-Conversion Interface Consortium results and visibility.

This task has met this recommendation through a communication plan, new FCIC website, webinars, and publicly available publications.

## Recommendation 3: Develop innovative ways to immerse the national laboratories with industry.

This task has met this recommendation through IAB engagement and webinar feedback. We anticipate increasing our industry engagement in coming years as well, making our tools and knowledge public and accessible.

# Publications, Patents, Presentations, Awards, and Commercialization

**Overview Factsheet:** A two-page introduction to the consortium for external partners, https://www.energy.gov/eere/bioenergy/downloads/feedstock-conversion-interface-consortium-fact-sheet

**Annual Review:** A review of FY20 work, https://www.energy.gov/eere/bioenergy/downloads/feedstock-conversion-interface-consortium-annual-review-research-fy2020

**Webinars:** A review of FY20 work, https://www.energy.gov/eere/bioenergy/fcic-webinars