



Quality By Design: A Primer

Zia Abdullah
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Feedstock Conversion to Products Is Designed to Process Multiple Inputs

Conversion Technologies



Woody Biomass



Grasses



MSW



Crop Residues

Feedstock

- Agricultural Residues
- Energy Crops
- Forest Resources
- Organic Waste
- Algae



Intermediates

- Sugars
- Intermediate Chemical Building Blocks
- Bio-Oils
- Gaseous Mixtures



Products

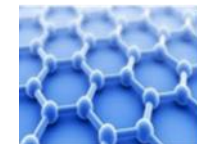
- Fuels
- Chemicals
- Materials



Fuels



Chemicals



Materials

Feedstock Variability Induces Significant Processing Challenges



www.123rf.com



Forest Residue Pile



Residue Chips



Clean Pine Chips



Fresh Corn Stover



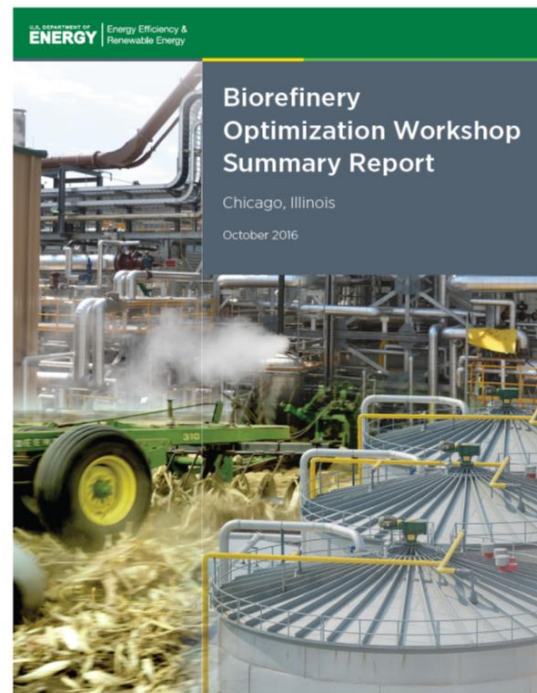
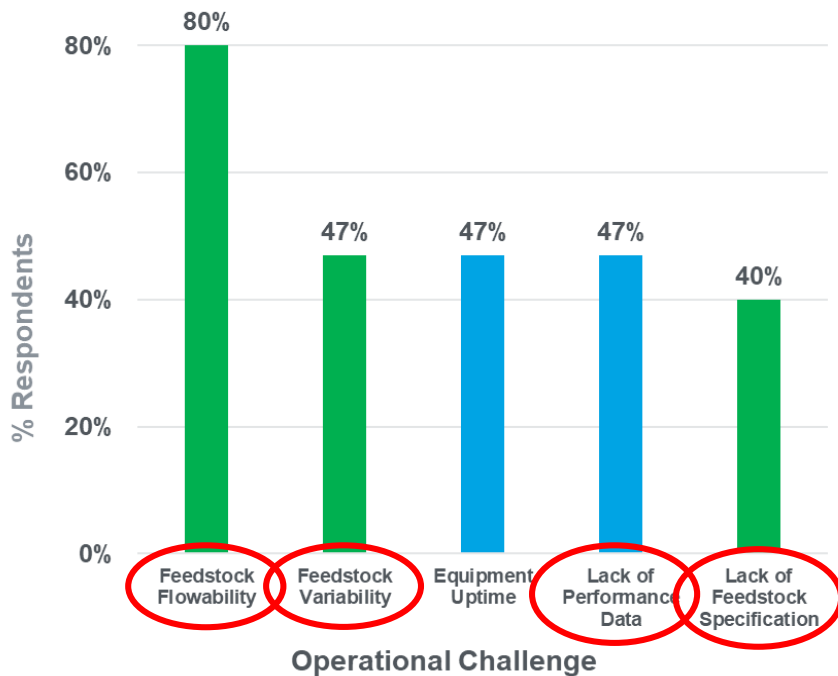
Stored Corn Stover



Deteriorated Corn Stover

2016 Biorefinery Optimization Workshop Identified Feedstock Flowability and Feedstock Variability as Key Challenges

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



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

BETO Has Set Up the FCIC Consortium to Address Feedstock Related Issues with Biorefineries

Objective:

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

Principal Investigator:

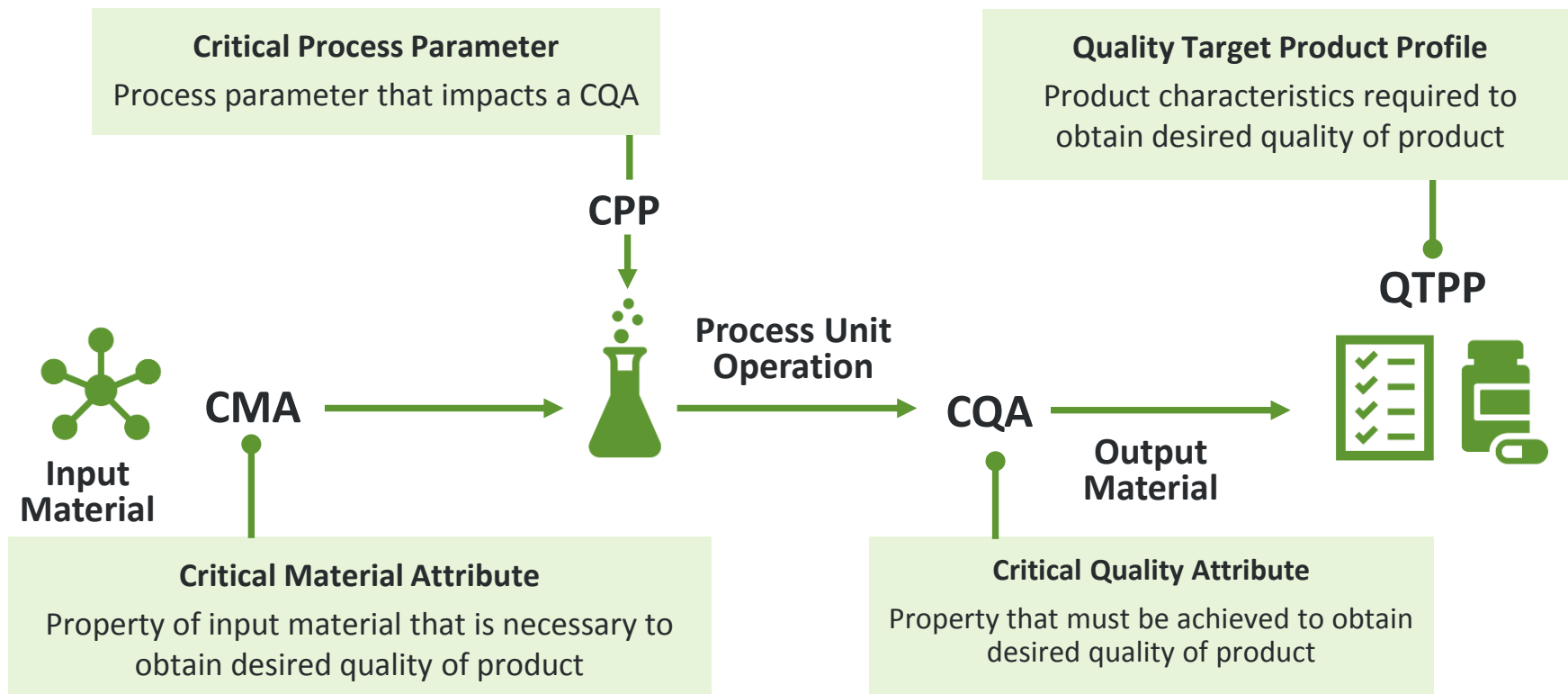
- Ed Wolfrum
Ed.Wolfrum@nrel.gov

Program Manager:

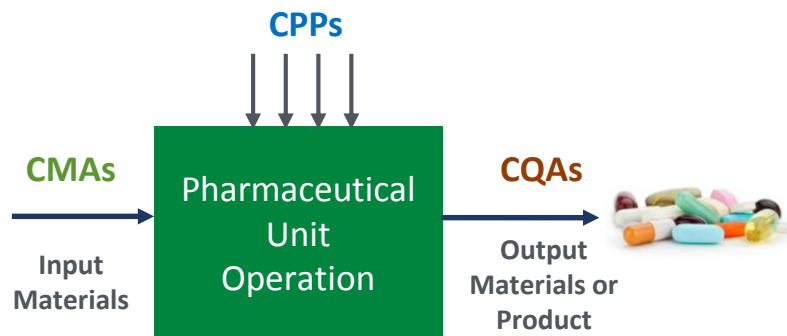
- Amie Sluiter
Amie.Sluiter@nrel.gov



FCIC Uses the Quality by Design (QbD) Approach Originally Developed for the Pharma Industry



Quality by Design Approach Can Be Analogous for Biorefinery Operations

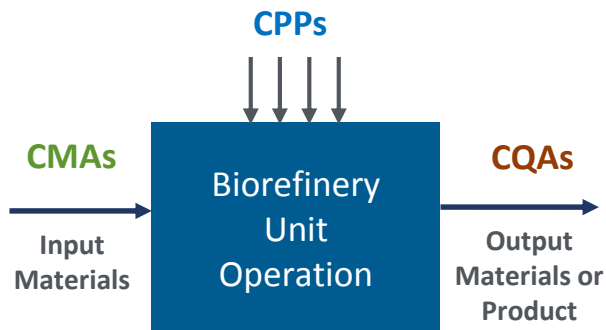


Example: Blending/Mixing of Medical Tablet

CMA: Particle Size Distribution

CPP: Mixer Load Level

CQA: Blend Uniformity



Example: Jet Fuel Production

CMA: Lignin Content, H₂ Content

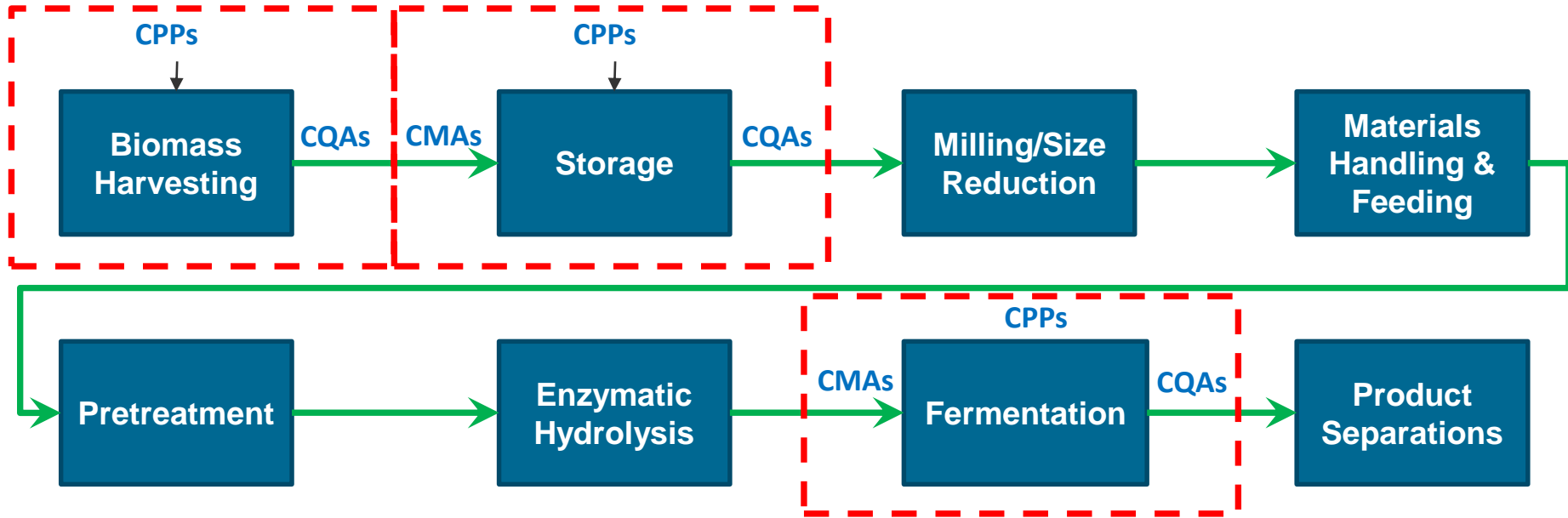
CPP: Process Design and Operation

CQA: Aromatic Content <25%

QTPP

Sustainable Jet
Fuel Compliant
with ASTM
D4054

Quality by Design for Biomass Value Chain



CMAs:

Moisture content
 Barium sulfate content
 Carbohydrate content
 ...

CPPs:

Harvesting method (e.g. single-pass, double-pass)
 Storage strategy
 Harvester height

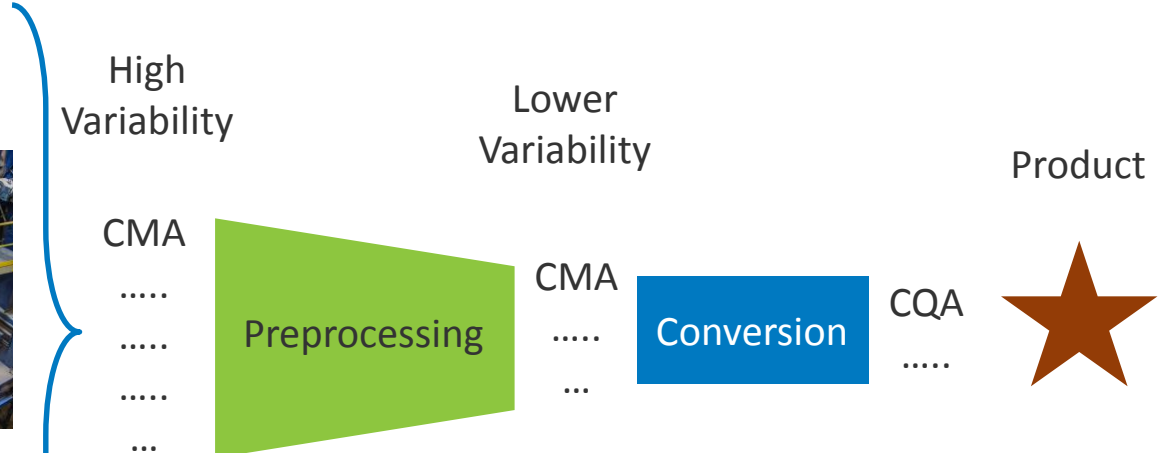
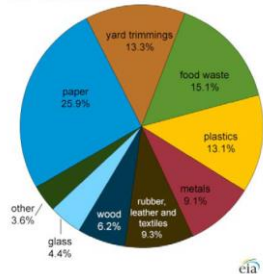
CQAs:

Moisture content
 Barium sulfate content
 ...

Quality by Design Approach May Be Useful To Process Municipal Solid Waste With High Variability



Total MSW generation in the United States by type of waste, 2015
Total = 262 million tons



Thank you

www.nrel.gov

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| | |
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