# Feedstock Pretreatment and Biological Conversion Platform

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IEA Task 42 | Platform Overview

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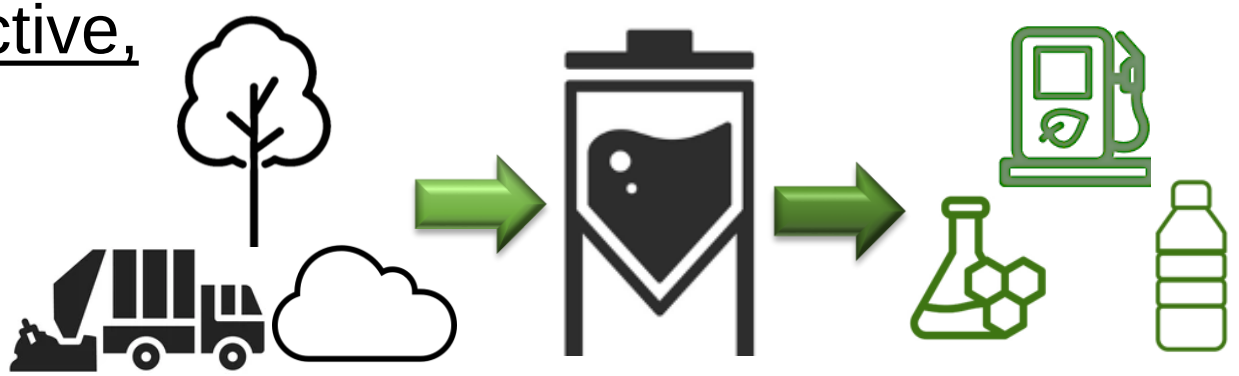
*Photo from iStock-627281636*

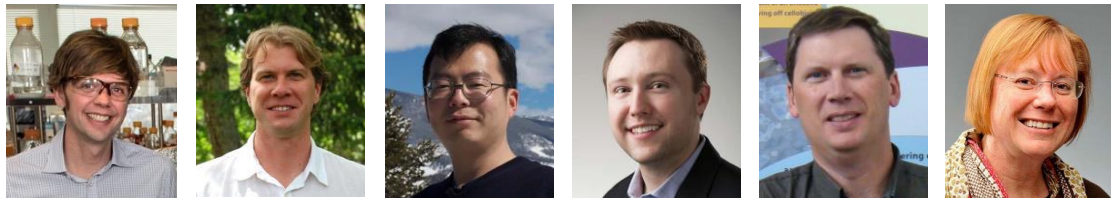
# Pretreatment & Biological Conversion Platform Portfolio Snapshot

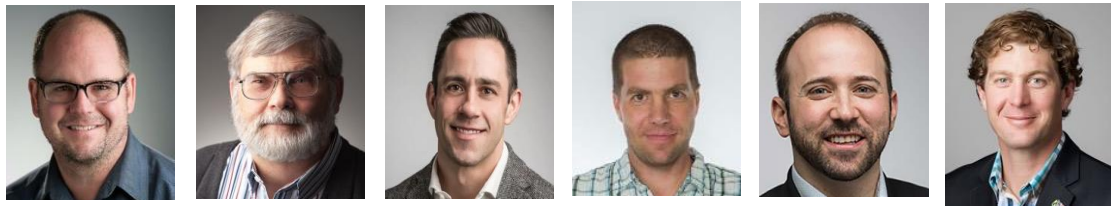
**Mission:** Develop and integrate cost-effective, scalable deconstruction and bio-based conversion technologies to decarbonize transportation, agricultural, and industrial sectors.



## Core Capabilities

- Feedstock characterization and deconstruction
- Bio/electro/chemical conversion and separations technologies
- Techno-economic analyses and resource assessment
- Computational modeling and virtual engineering


Gregg Beckham | Yannick Bomble | Xiaowen Chen | Ryan Davis | Steve Decker | Nancy Dowe

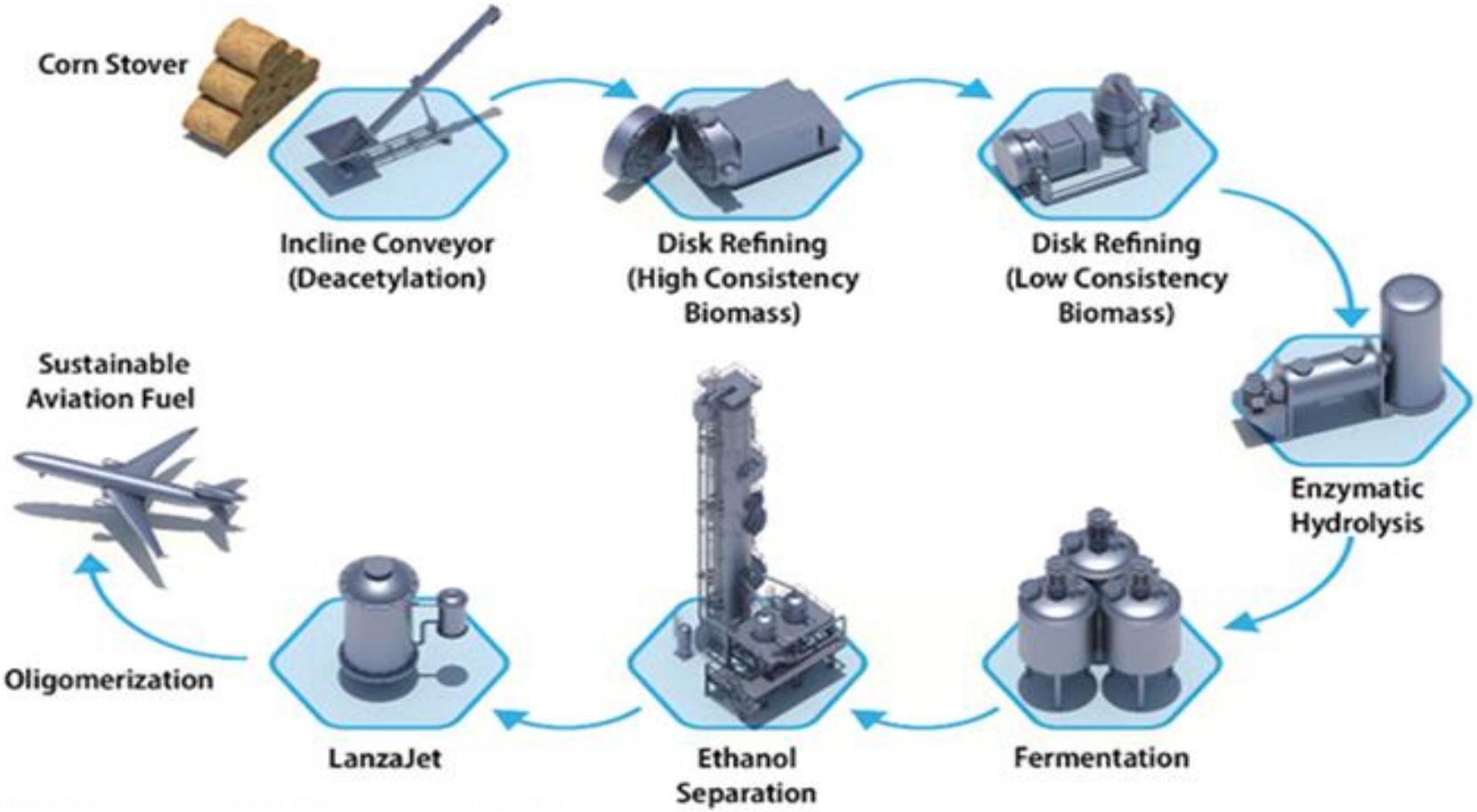

Kevin Harrison | Mike Himmel | Chris Johnson | Jeff Linger | KC Neyerlin | Mike Resch


Violeta Sanchez | Dan Schell | Hari Sitaraman | Justin Sluiter | Ed Wolfrum | Min Zhang

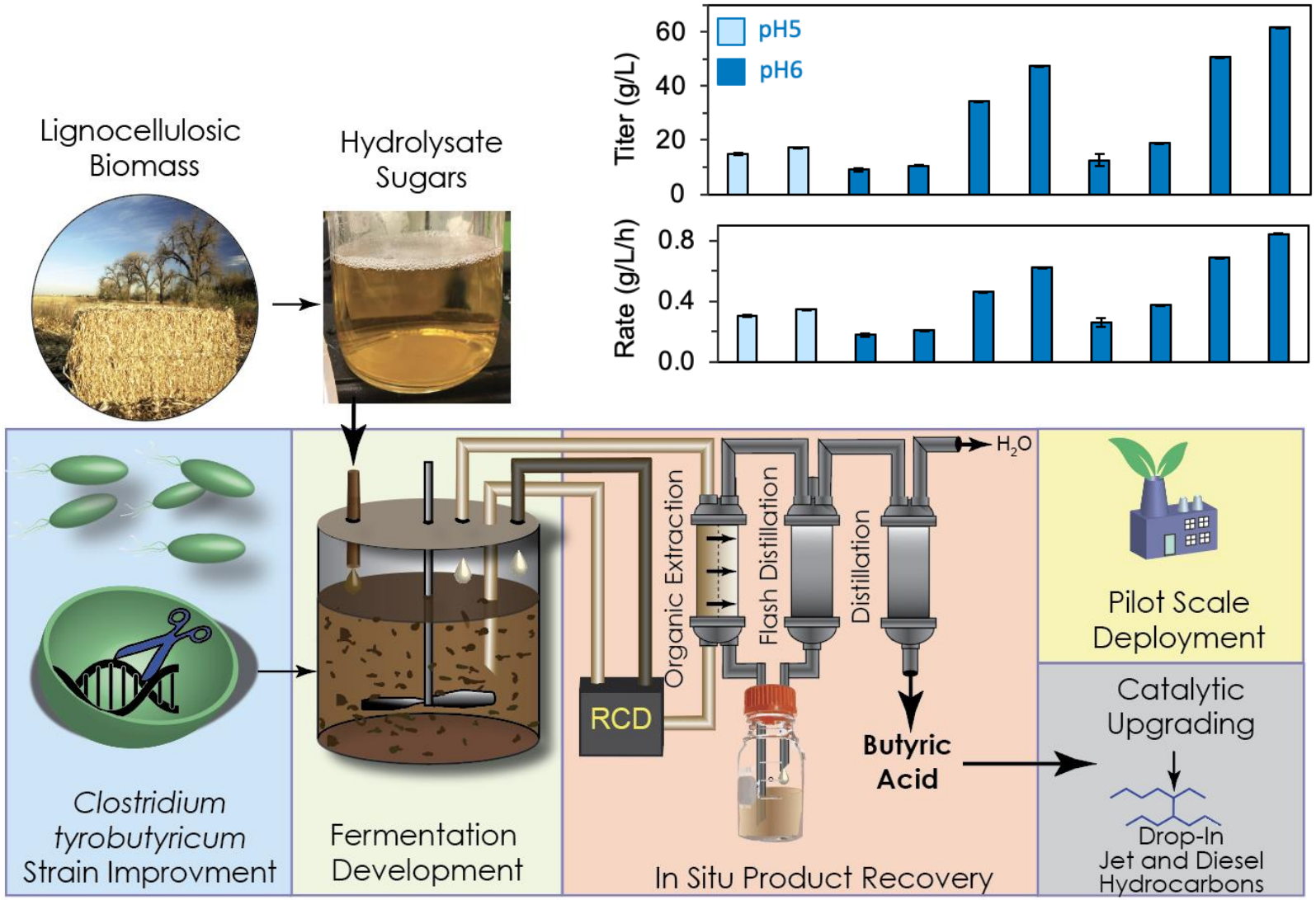
# Project SAFFiRE: Gen2 EtOH-to-SAF

**Target Technology**: Reliable, low-GHG production of Sustainable Aviation Fuel (SAF) from corn stover in a fully integrated, Gen2 10 tpd pilot plant.

- TEA/LCA establishes a viable path to CI15 and $2.75/gallon SAF.
- Based on corn stover resources in the U.S., in 2040 SAFFiRE technology will produce 7.5 Bgal SAF/yr from ~180 commercial plants.

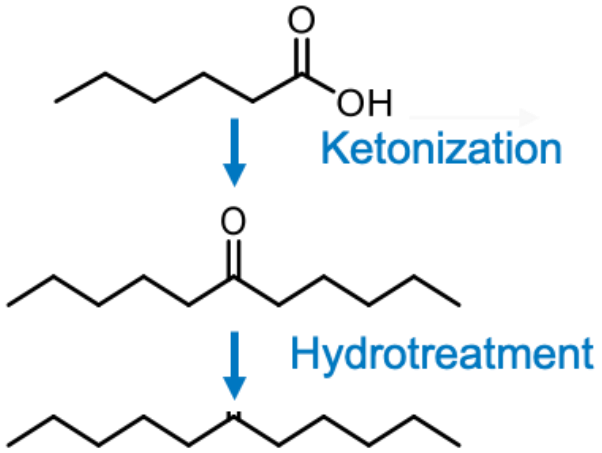


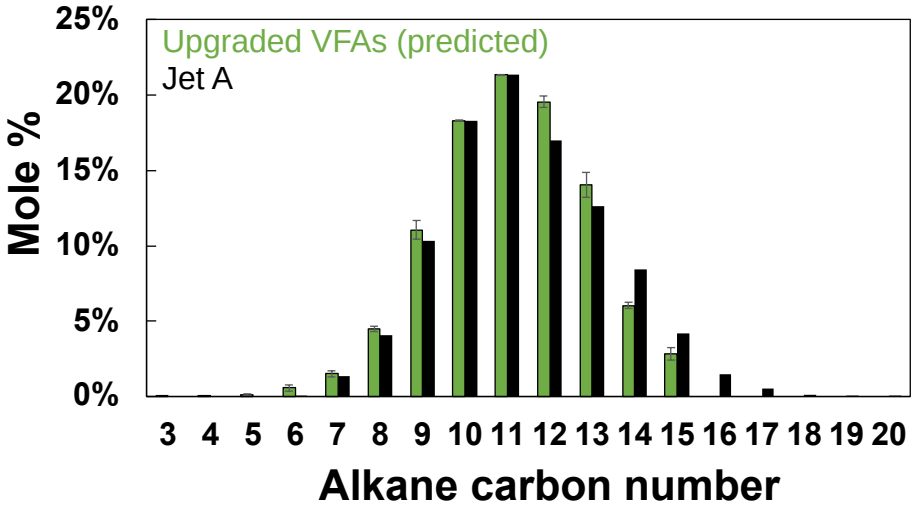
# Beyond Ethanol: Organic Acids-to-SAF







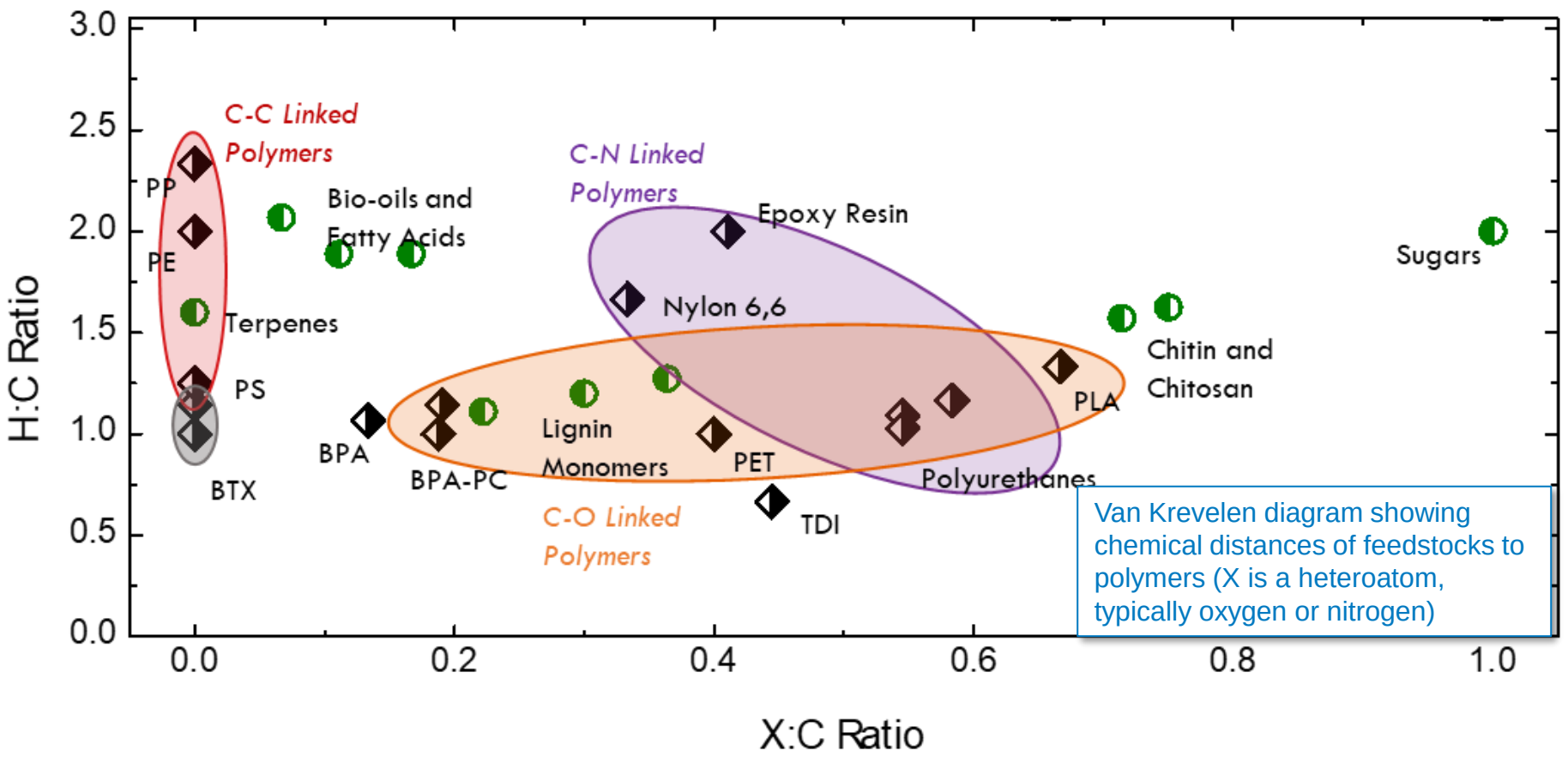





Salvachúa, D., Saboe, P, et al. *Cell Reports Phys Sci* 2021

# Performance Advantaged Bioproducts from Biomass



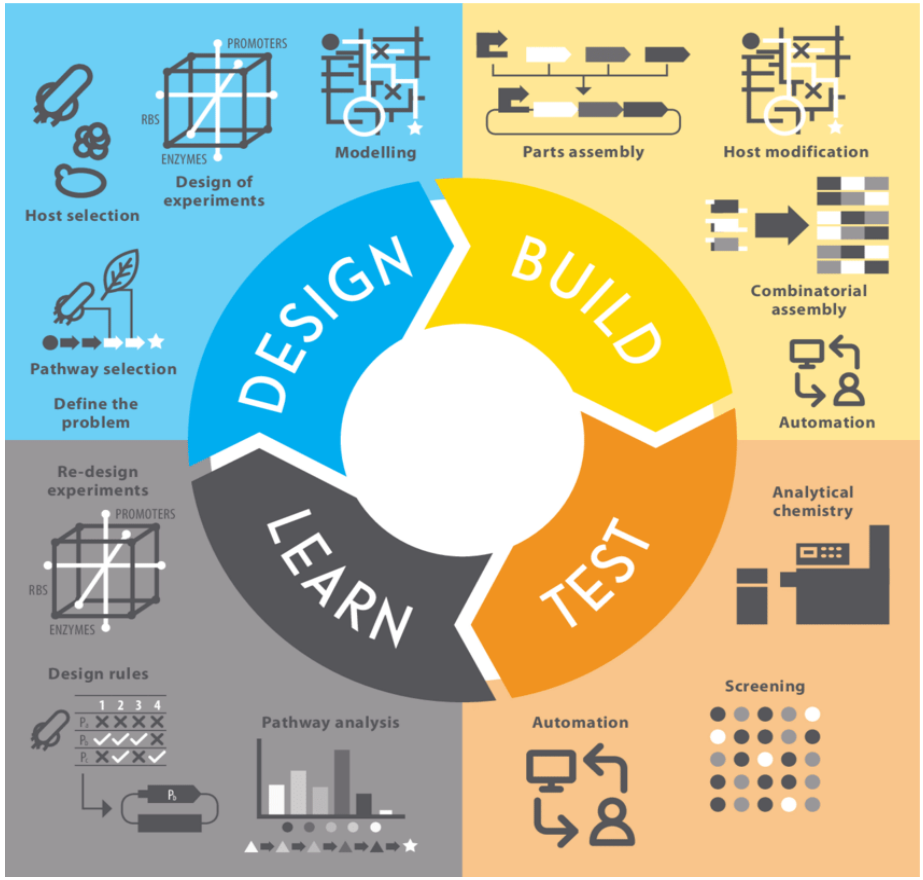

Van Krevelen diagram showing chemical distances of feedstocks to polymers (X is a heteroatom, typically oxygen or nitrogen)

- The heteroatom functionality of biomass makes it ideal for PABPs, including polymers
- Ultimate goal – set of analysis, computation, and experimental tools to narrow PABP design space

# Agile BioFoundry Reduces Time to Bioprocess Scale-up

Agile BioFoundry

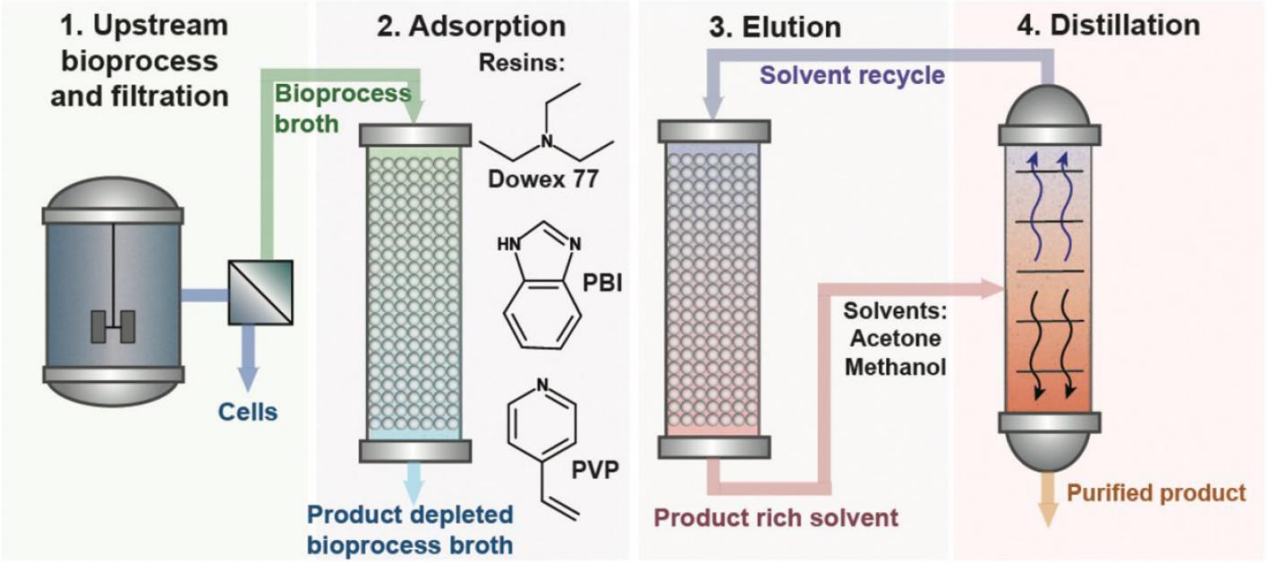
Argonne NATIONAL LABORATORY · BERKELEY LAB Bringing Science Solutions to the World · Pacific Northwest NATIONAL LABORATORY · Los Alamos NATIONAL LABORATORY EST. 1943 · NREL NATIONAL RENEWABLE ENERGY LABORATORY · OAK RIDGE National Laboratory · Sandia National Laboratories




- The Agile BioFoundry is a consortium of 7 national laboratories dedicated to accelerating biomanufacturing and decarbonizing the economy.
- Collaborates with industry and academia to rapidly innovate the development of bio-based products.
- Unites the unique capabilities of the national laboratories through a **Design-Build-Test-Learn** platform.

# SepCon: Enabling Cost-Effective Separations Solutions

BIOPROCESSING SEPARATIONS CONSORTIUM




- The Bioprocessing Separations Consortium aims to develop separations technologies that are cost-effective, high-performing, and scalable through coordinated research at the National Laboratories.
- The Consortium's portfolio includes the development of new capabilities that include separation technologies and materials for product recovery and process intensification.

# Analytical Development and Support (ADS)

- ADS develops capabilities that support evaluation and monitoring across the biofuels production process.
- The project's laboratory analytical procedures are used worldwide to quantify feedstock and intermediate materials for biofuels production.
  - Procedures for solid samples to measure structural carbohydrates, lignin, extractable materials, protein, and ash
  - Procedures for liquid samples to measure oligomeric and monomeric carbohydrates, lignin, and byproducts


**Determination of Structural Carbohydrates and Lignin in Biomass**

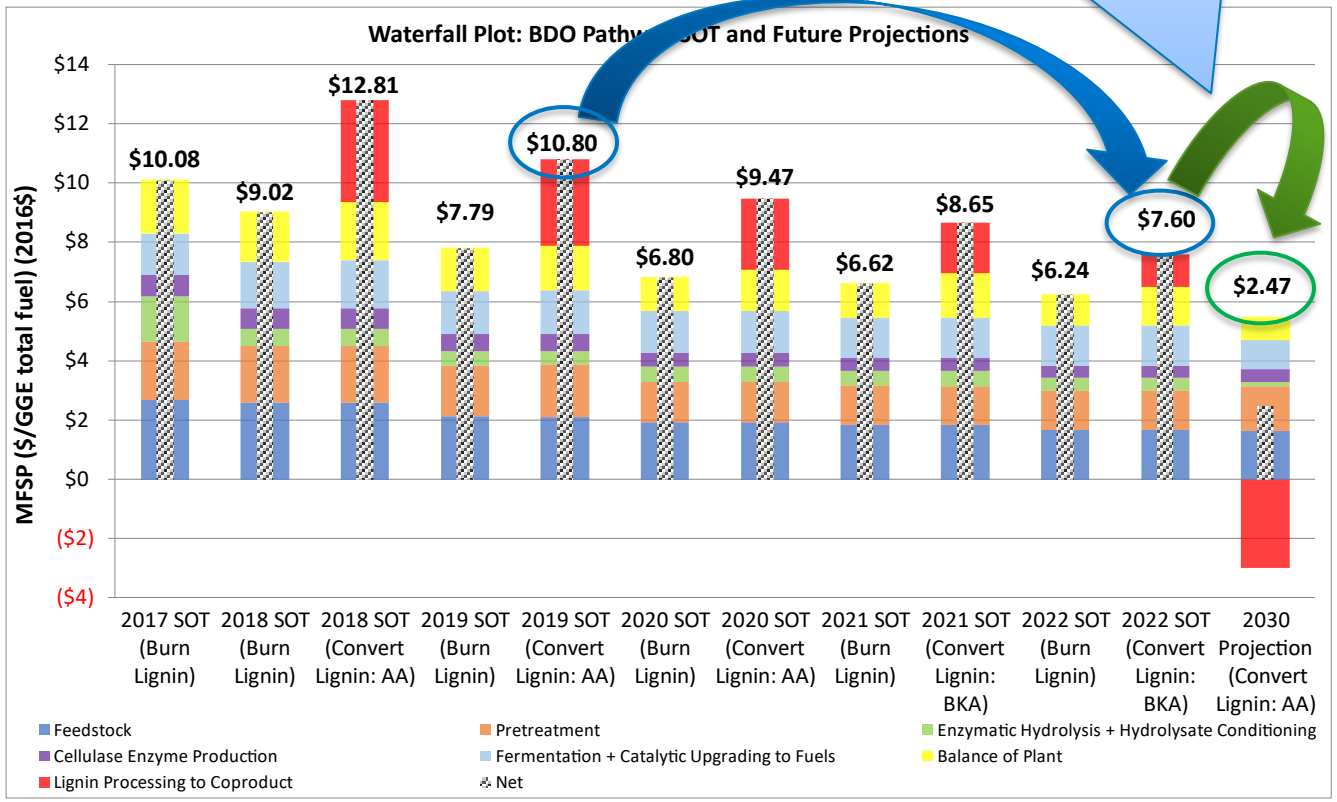
**Laboratory Analytical Procedure (LAP)**

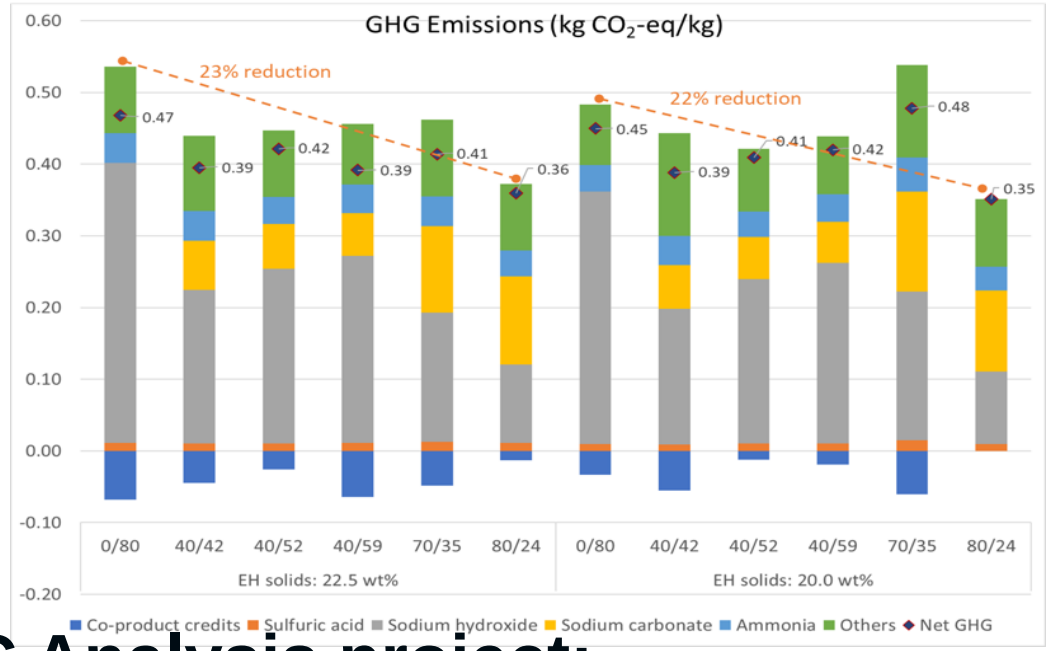
•http://www.nrel.gov/biomass/ analytical_procedures.html

# BC Platform Analysis: Guiding Priorities Through TEA + LCA

***R&D drivers for improved future MFSP:***

- Increase sugar yields
- Reduce deacetylation loss
- Improve fermentation rates
- Lower catalysis costs
- Improved lignin valorization performance

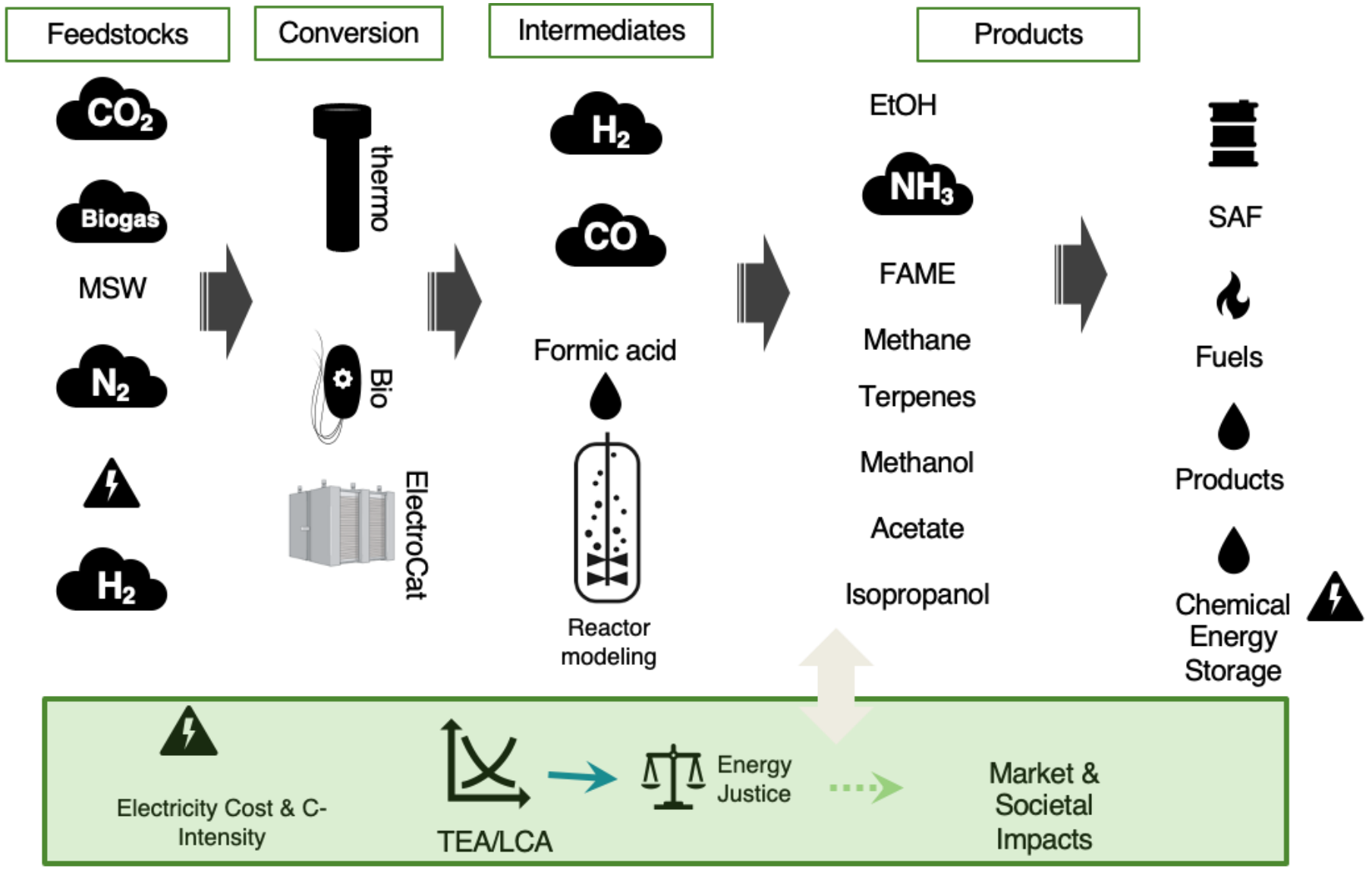


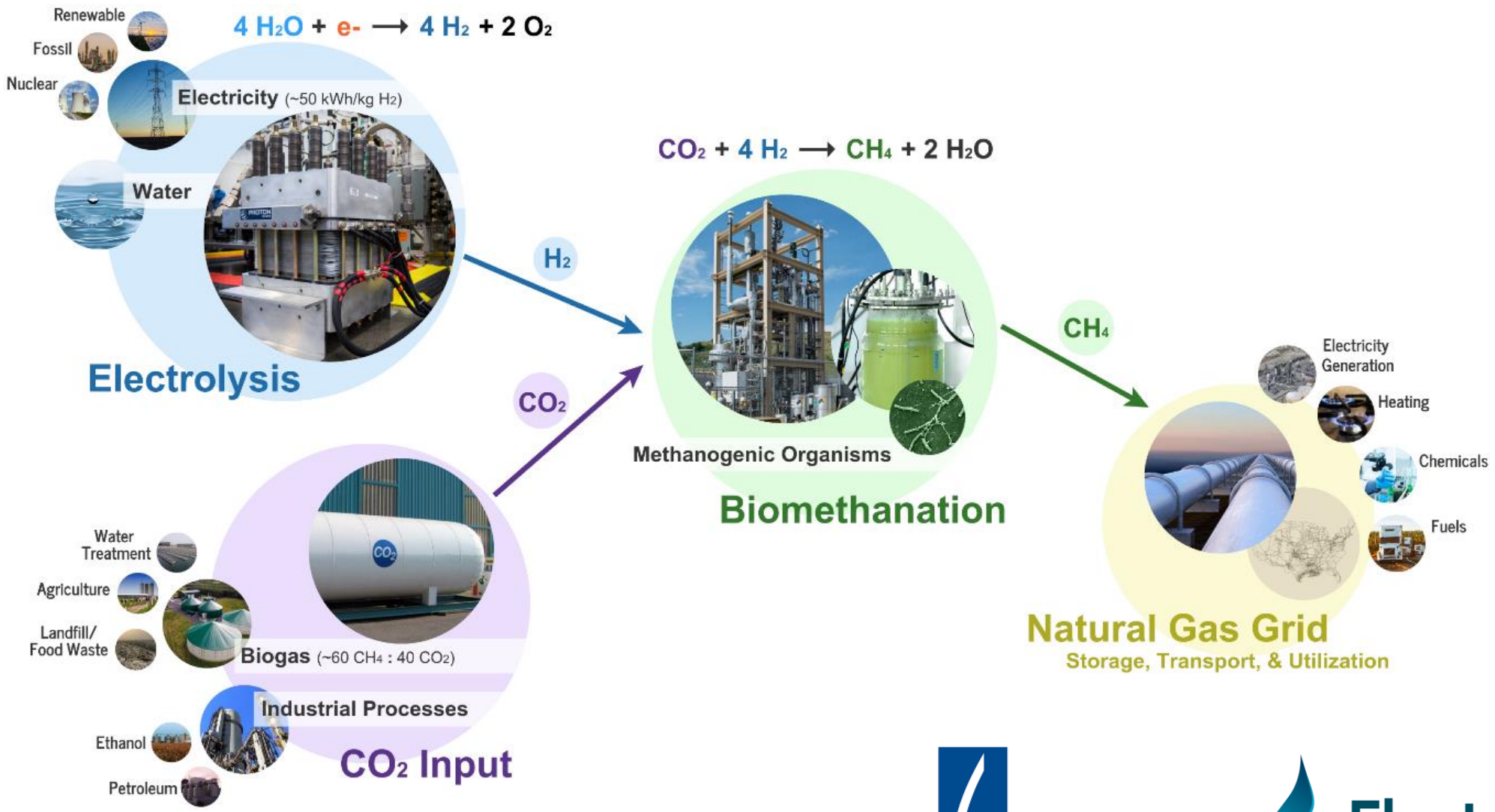

## BC Analysis project:

- Guides R&D platform priorities, link to “so-what” impacts on cost (MFSP), LCA (GHG)
- Establishes design case *targets*, track progress via *SOT benchmarks*
- Establishes new design case updates supporting BETO shifts to >70% GHG reduction, maximizing SAF, emphasizing deployment potential

# Beyond Terrestrial Biomass: Conversion of Gaseous Feedstocks

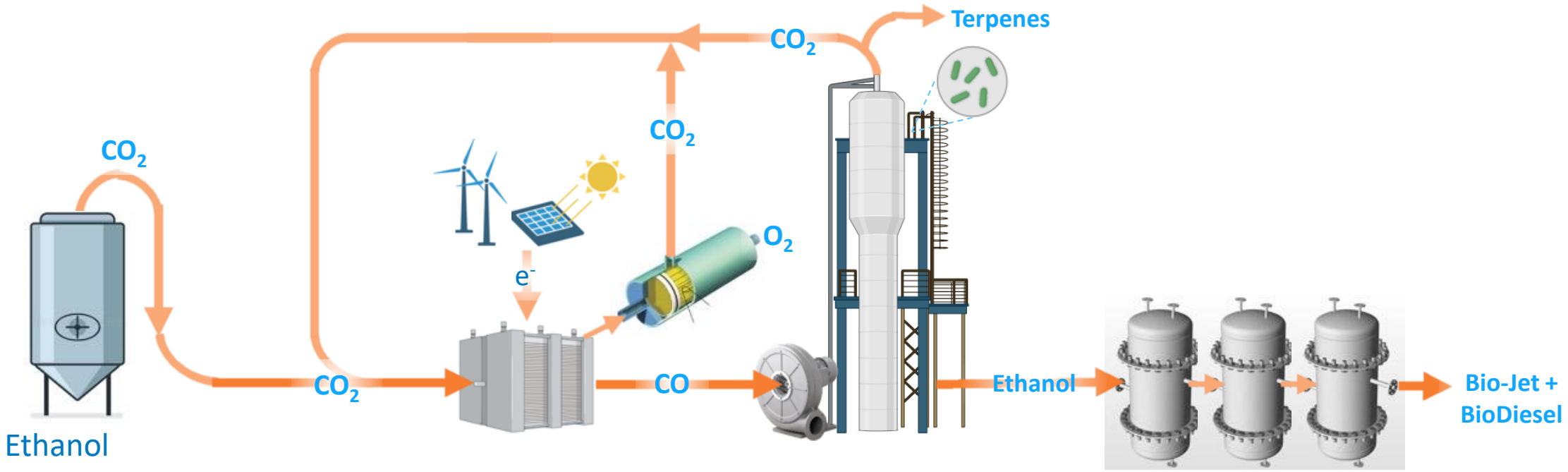


# Integrated Electro-Bioconversion Enables Biomethanation




SoCalGas™ Electrochaea

# $CO_2$ to Sustainable Aviation Fuel via Bio-Electro Integration




- Improve electrolyzer robustness to industrial flue gas components, carbon and energy efficiency.

- Improve molecular biology tools and terpene co-production
- Evolve strains via ALE and directed strain engineering

- Integrate system to demonstrate the process of converting $CO_2$ into fuels and chemicals
- Identify two near term industrial sites with low cost electrical and $CO_2$ feedstocks

NREL Transforming ENERGY

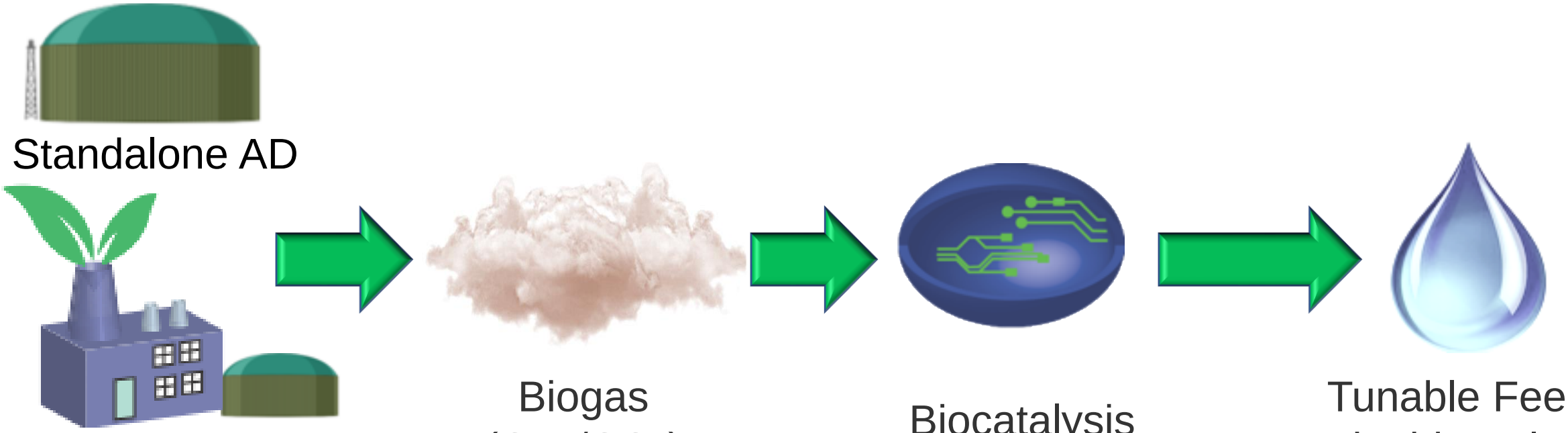
LanzaTech

OAK RIDGE National Laboratory

CO2 Fuel Dioxide Materials™

# Biogas Biocatalysis Enable Gas-to-Liquid Converison

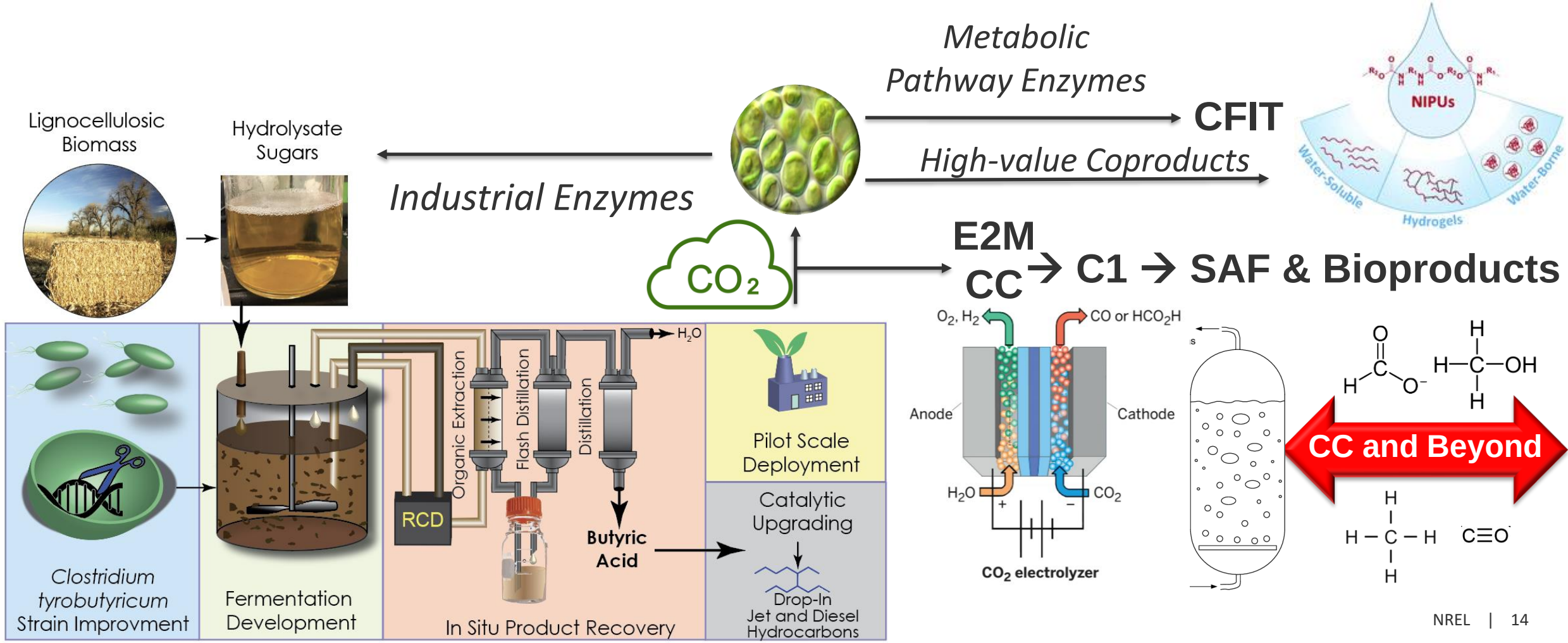
- Biological gas-to-liquid conversion offers a means to valorize biogas, improve bioprocess sustainability, and reduce risk of waste and biomass processing.




**Value:** Biogas presents large market and energy value: > 35B GGE (> 4 Quad btu)
**SOT:** Biogas is primarily flared or used to produce combined heat and power (CHP)
**Goal:** Develop biocatalysts and gas fermentation tech to enable gas-to-liquid conversion achieving biogas valorization and improved process economics and sustainability.

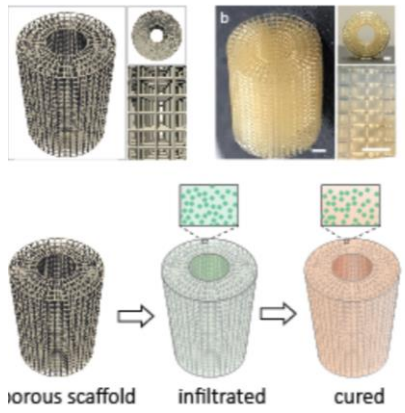
# Towards Circular Biorefining…

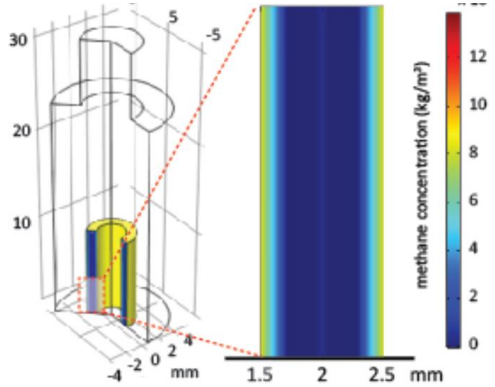
- *NREL is uniquely positioned to develop and deploy **integrative, hybrid technologies to recapture and utilize biogenic $CO_2$***

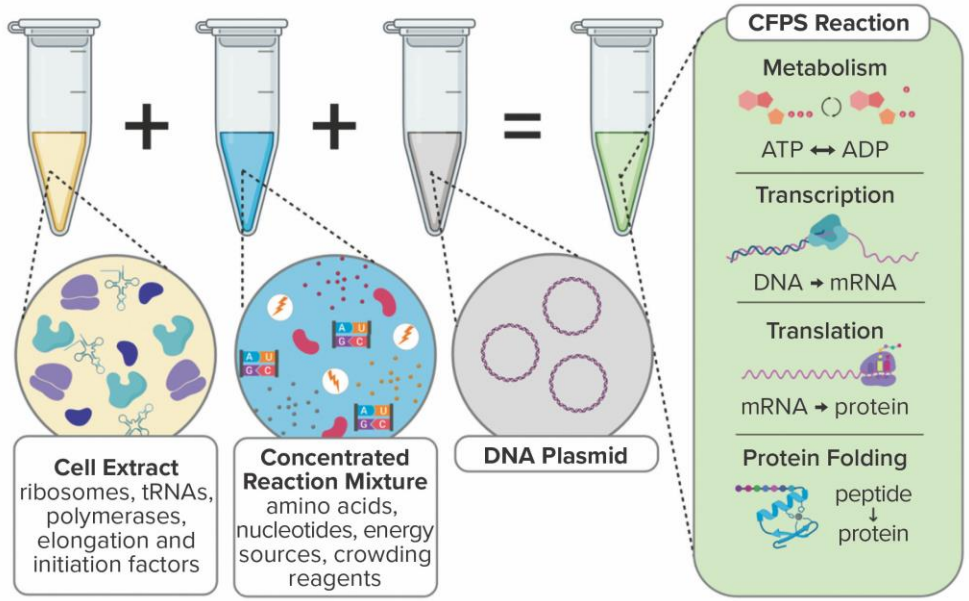


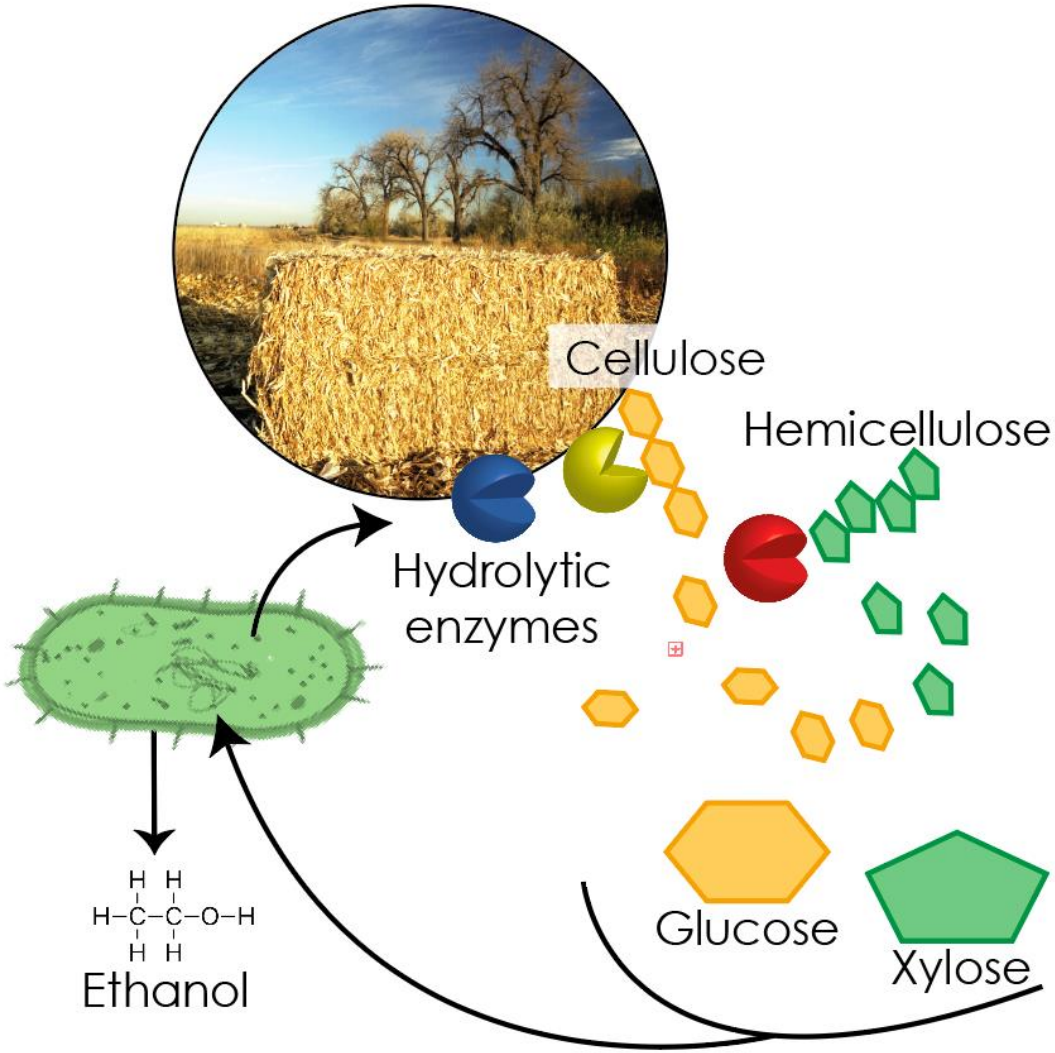
# Next-Gen Biocatalysis: CFIT, CBP, and Beyond

***Process Intensification Enables Bypass of Conventional Tech & Cost Barriers to Improve TRY***



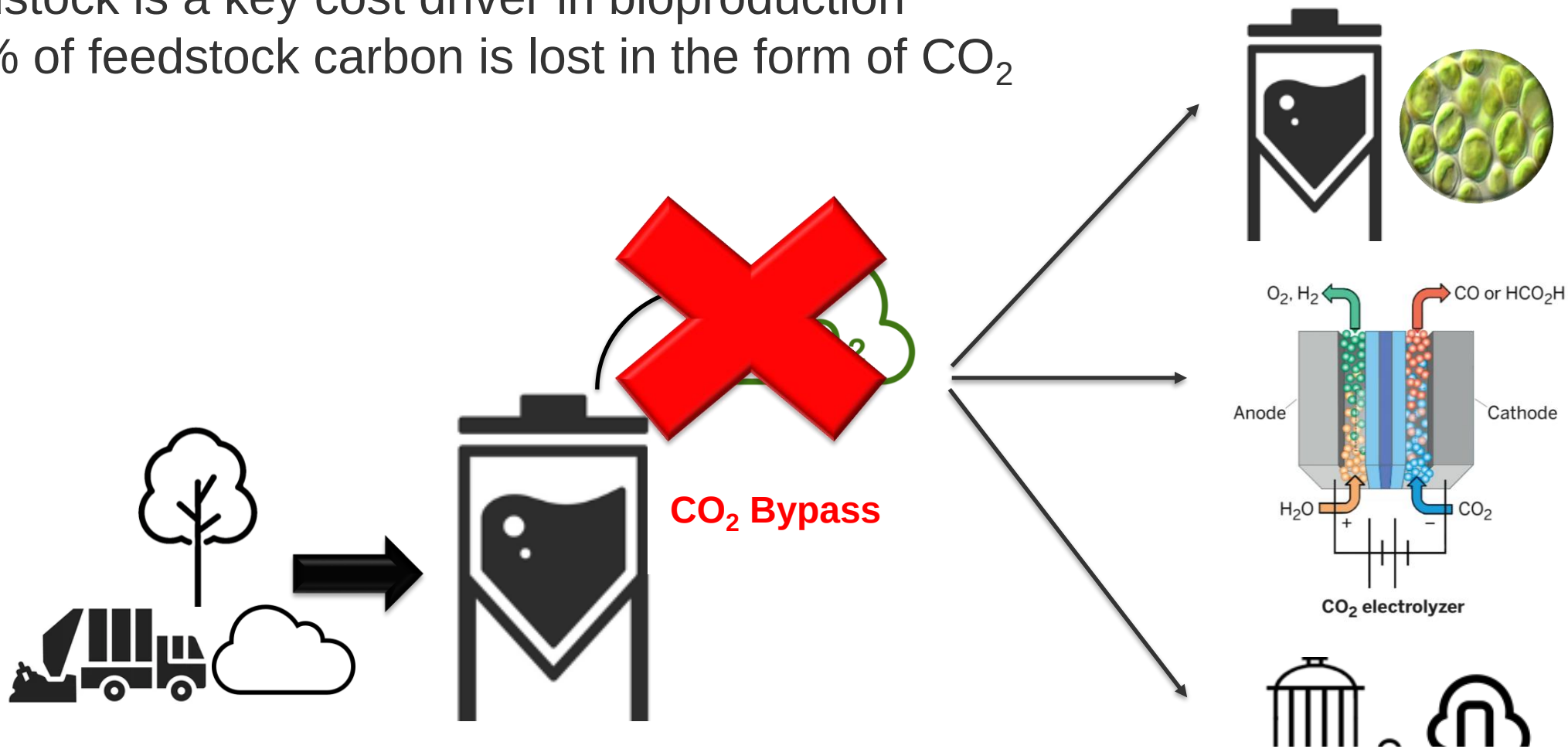



# Towards Negative CI Conversion Technologies…

- Feedstock is a key cost driver in bioproduction
- ~30% of feedstock carbon is lost in the form of $CO_2$




***Rewire biocatalysts to avoid $CO_2$ losses before they happen.***

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