



**VIRENT IS A WORLD LEADER IN CREATING
SUSTAINABLE FUELS AND CHEMICALS.**

Our patented BioForming[®] process transforms sugars
from renewable feedstocks into everyday products
such as gasoline, diesel, jet fuel and chemicals.

Catalytic Conversion of Carbohydrates to Hydrocarbons

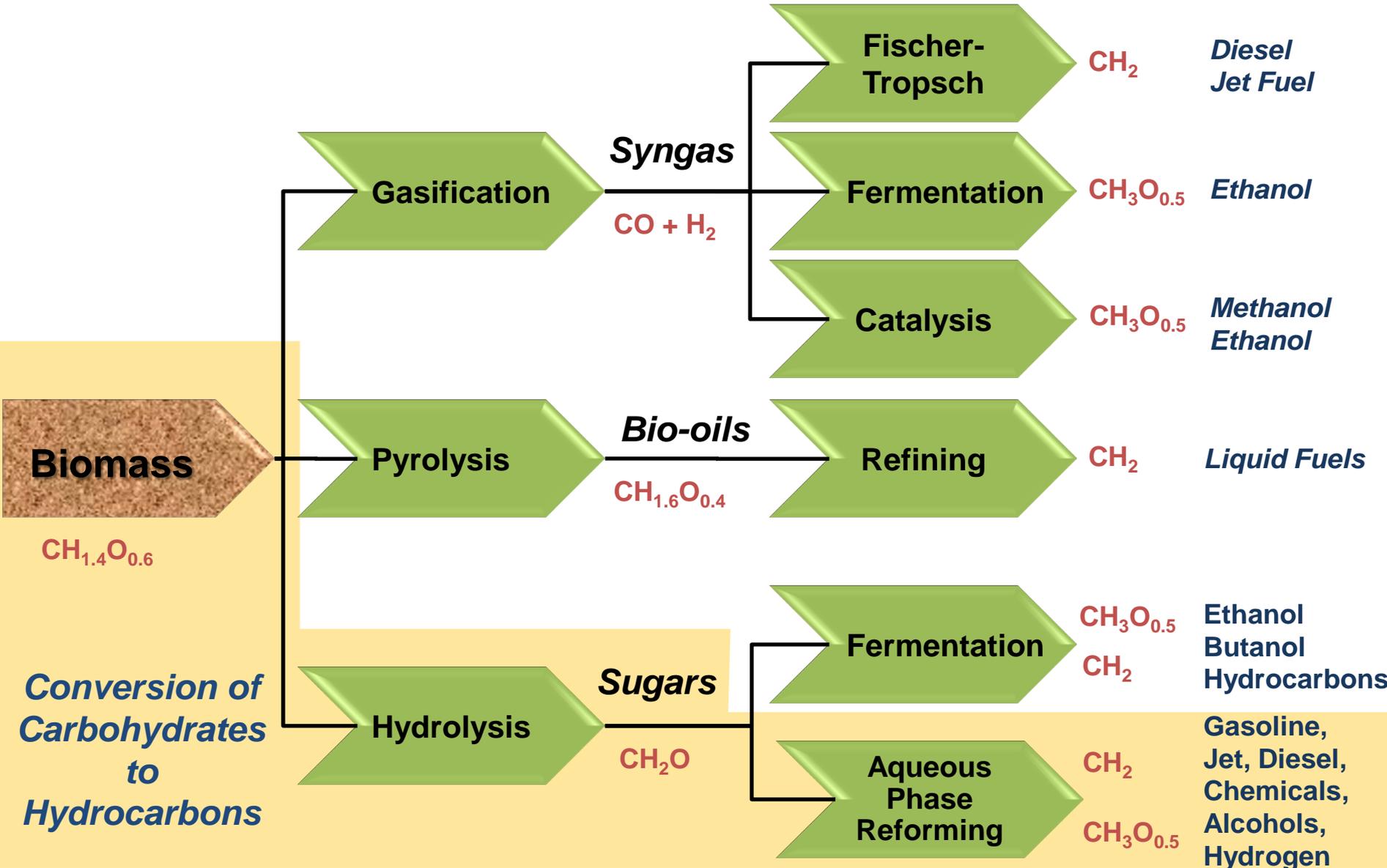
DOE Biomass R&D TAC Meeting

May 19, 2011

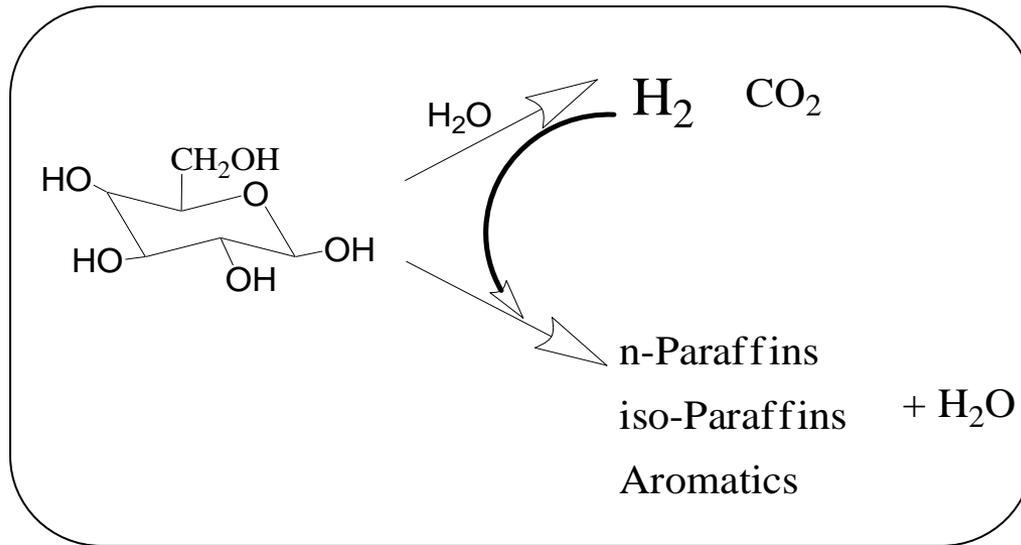
Paul Blommel, PhD

Director of Process Chemistry, Virent Energy Systems, Inc.

BioFuel Pathways from Biomass

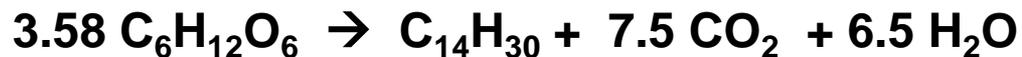


Generation of Hydrocarbons from Carbohydrates with *In-situ* Hydrogen Generation



	Potential Carbon Yield	Potential Energy Recovery*
Ethanol Fermentation	67%	96%
Catalytic Conversion <i>in situ</i> hydrogen	65%	94%
Catalytic Conversion <i>ex situ</i> hydrogen	100%	144% (90% including H ₂)

Overall Theoretical Stoichiometry with *in situ* hydrogen generation



Hydrocarbon contains 65 % of Sugar Carbon
Hydrocarbon contains 94% of LHV of Sugar

*Potential LHV of liquid fuel product/LHV of carbohydrate feed

Catalytic Carbohydrate Conversion Technology



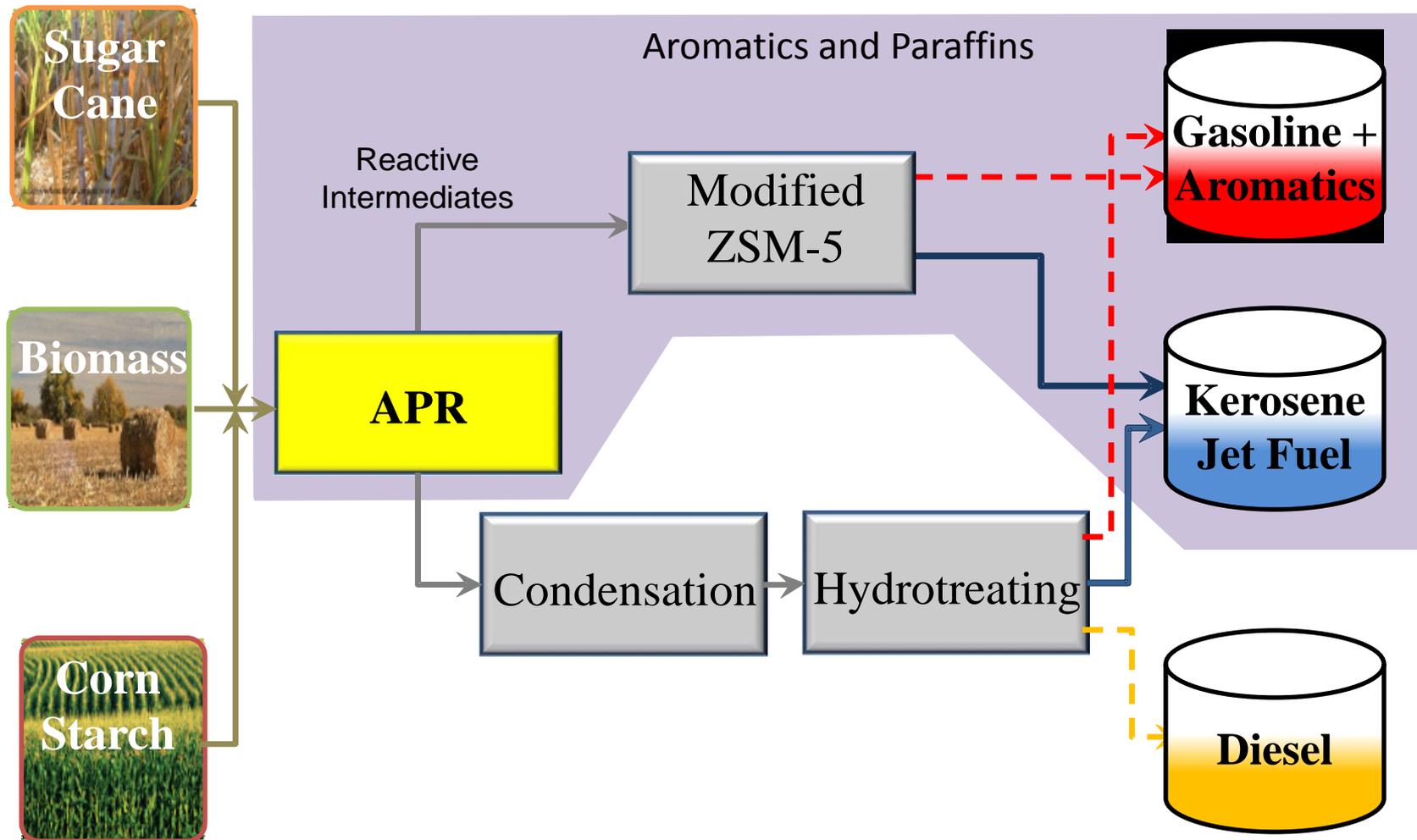
A catalytic route to renewable hydrocarbon fuels and chemicals.



- **Feedstock Flexible**
 - Conventional Sugars
 - Non-Food Sugars
- **Drop-in Products**
 - Liquid Fuels and Chemicals
 - Tunable Platform
 - Infrastructure Compatible
- **Fast and Robust**
 - Inorganic Catalysts
 - Moderate Conditions
 - Low Residence Times
- **Energy Efficient**
 - Exothermic
 - Low Energy Separation

Virent Demonstration Plant

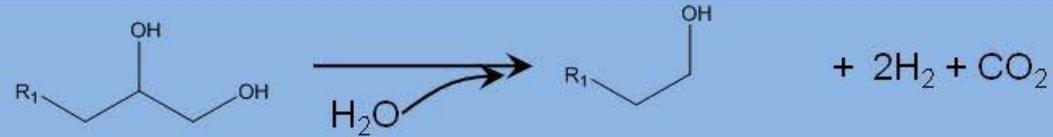
BioForming® Platforms



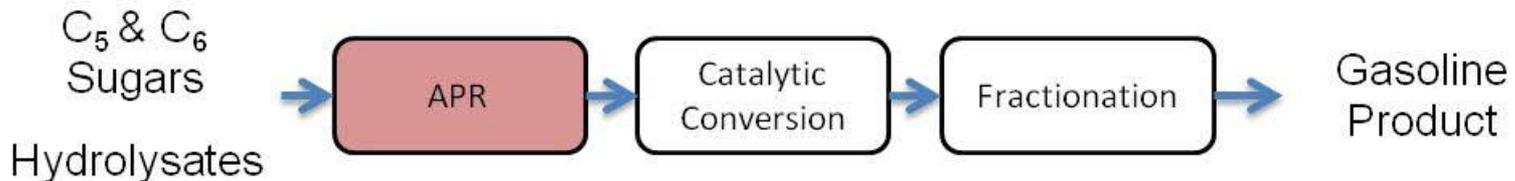
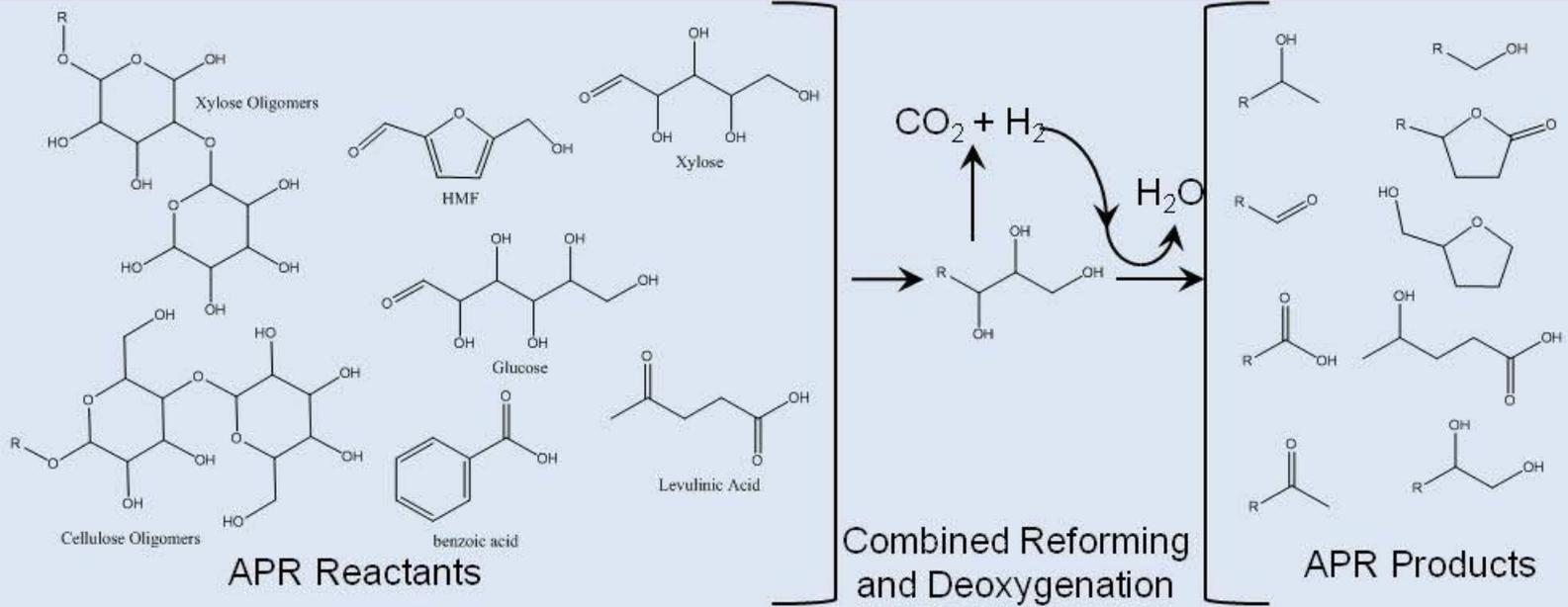
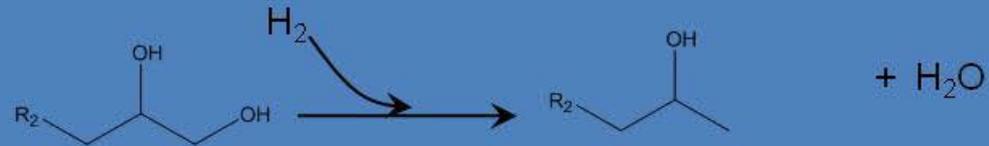
Generation of Reactive Intermediates



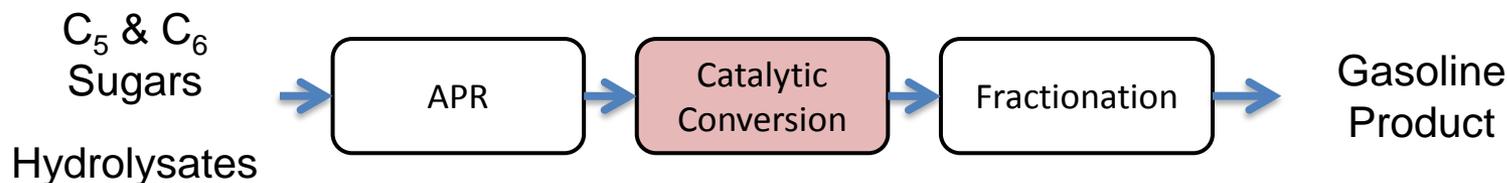
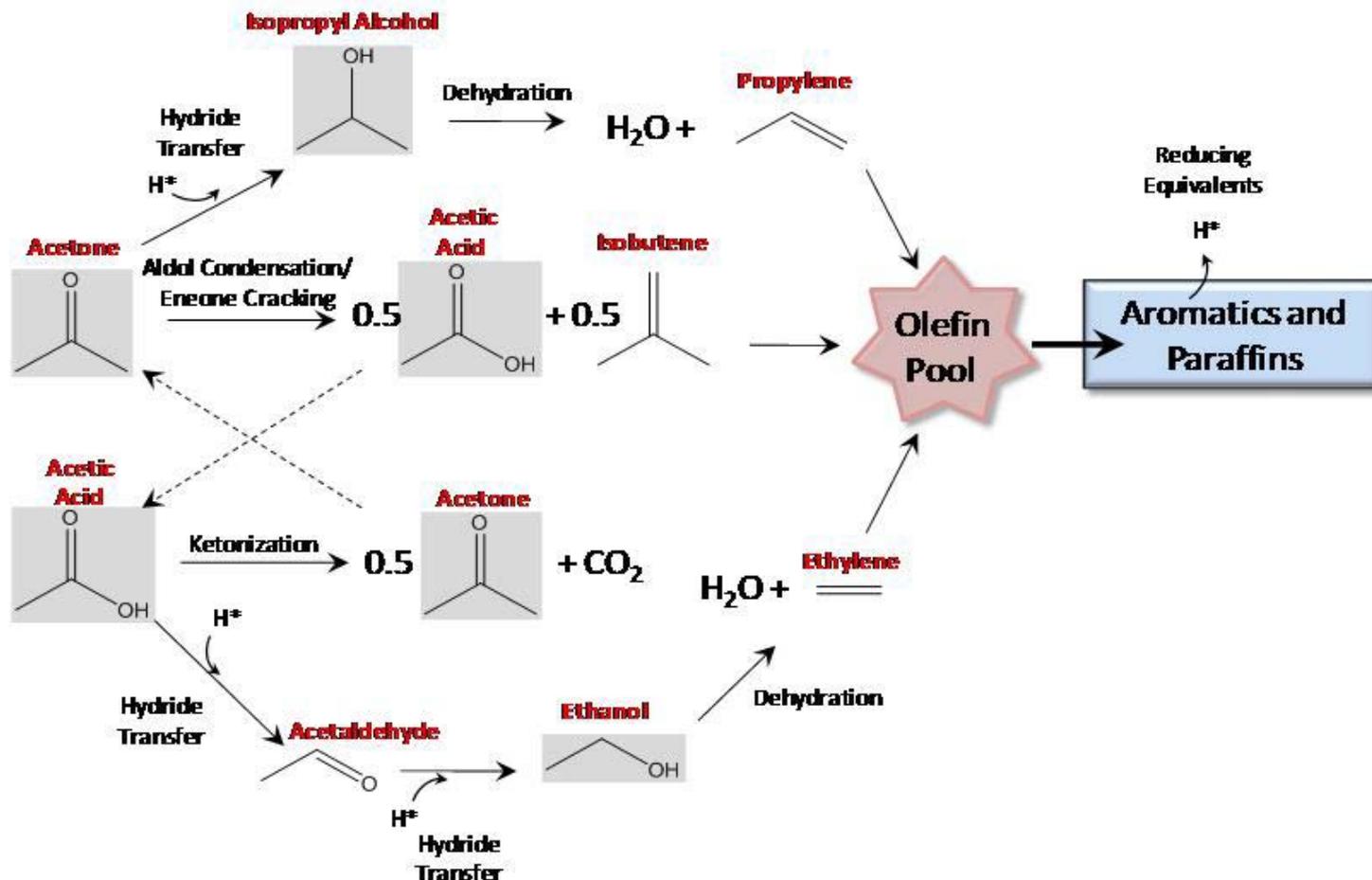
Reforming



Deoxygenation

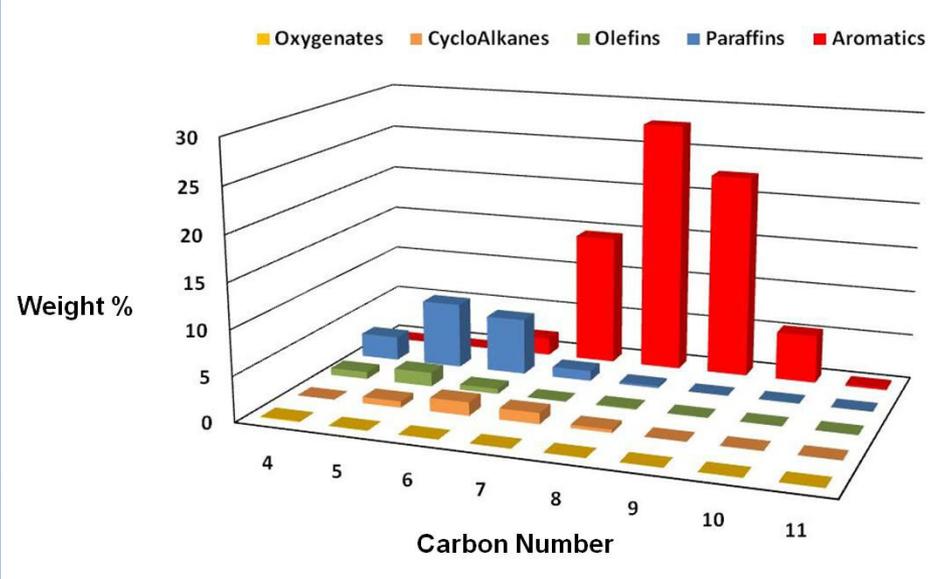


Production of Hydrocarbons from Reactive Intermediates



BioGasoline Product

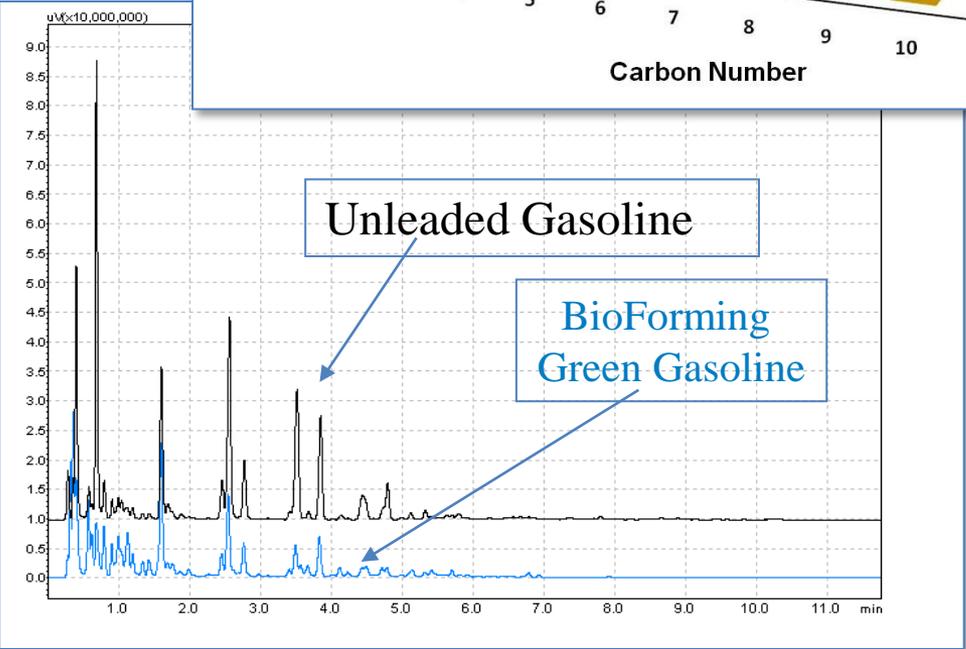
Premium product with the same components as petroleum derived gasoline



Unleaded Gasoline
115,000 BTUs/Gal

BioForming BioGasoline
+120,000 BTUs/Gal

Ethanol
76,000 BTUs/Gal

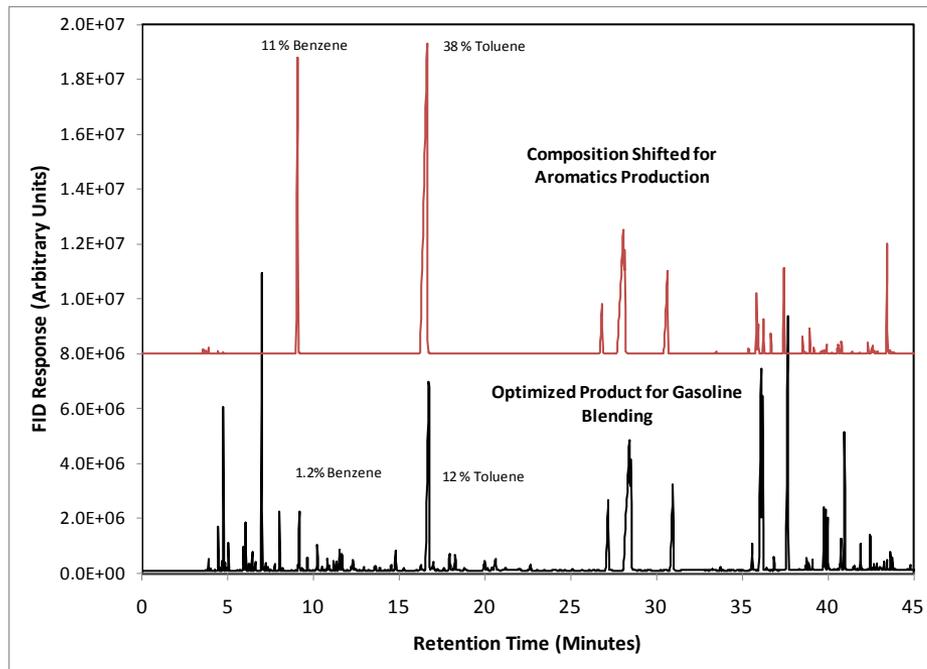


~ 20 liters of sugar derived gasoline from Virent's BioForming process.

Catalytic Processing Offers Flexibility to Replace More than Fuels

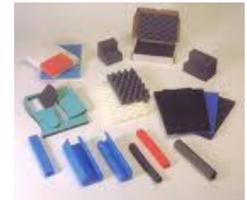


Bio-reformate can replace typical reformat which is dominant feedstock for many chemicals, fibers, and plastics in use today.



Product Composition Flexibility

- Benzene
- Toluene
- Para-Xylene
- Meta-Xylene
- Ortho-Xylene

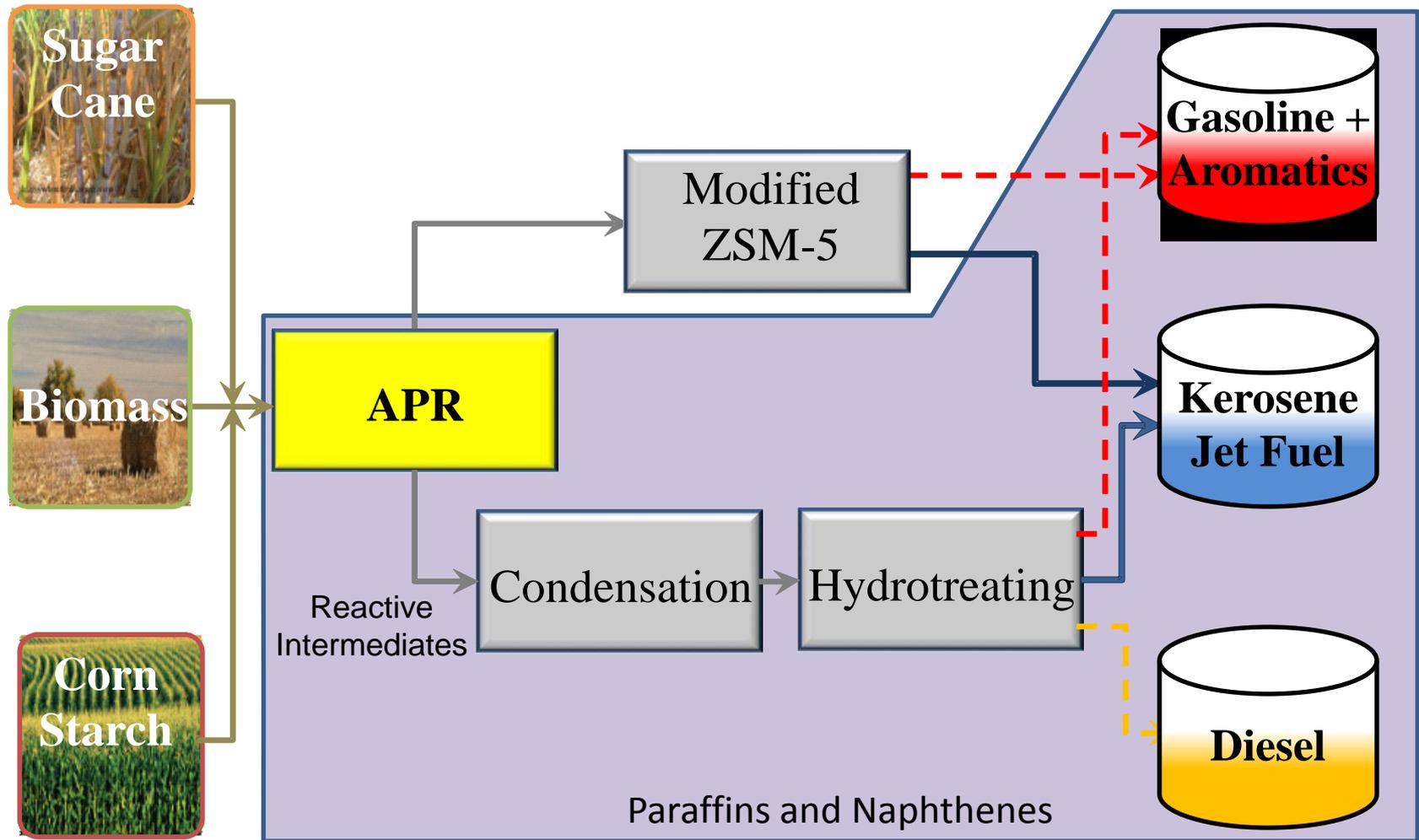


Process Scale Up – Gasoline/Aromatics

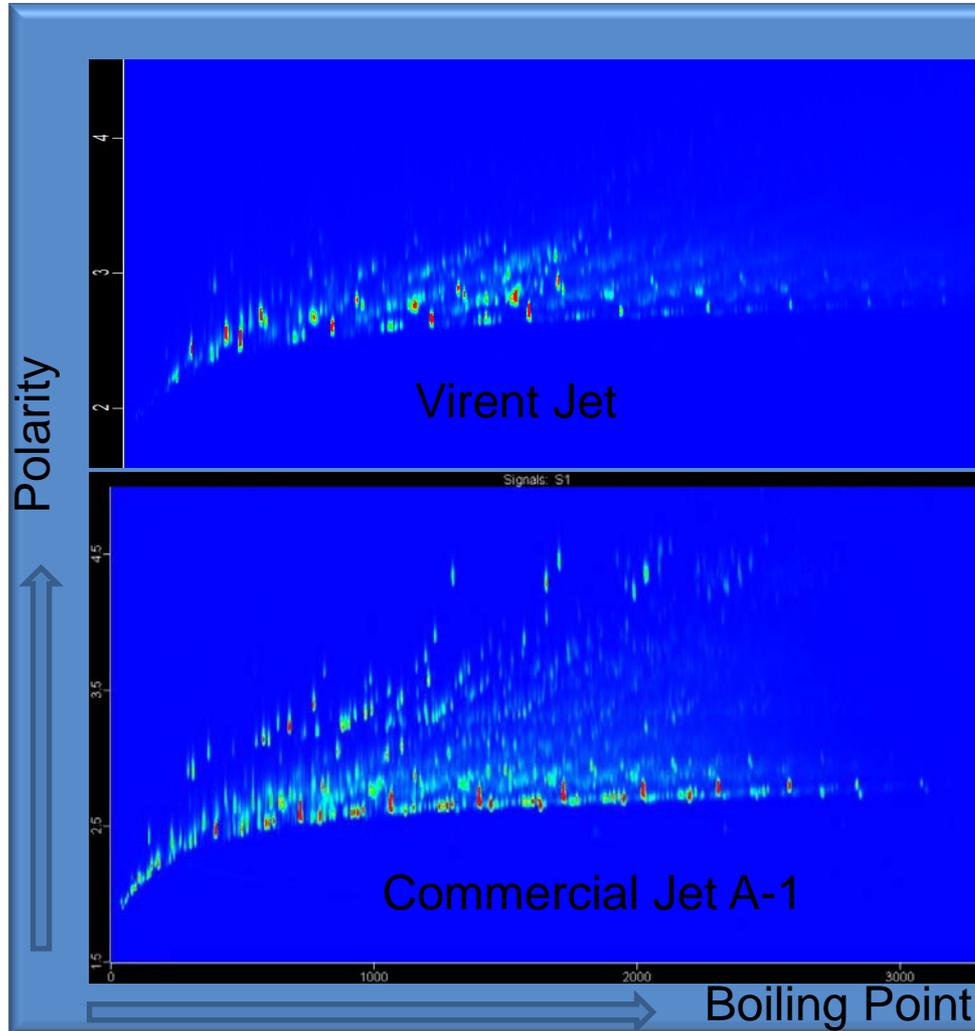


- Carbohydrates-to-Aromatics process
- Scale-up of x100 from pilot plant
- 10,000 gallons per year
- Full Length Reactor and Commercial Scale Catalyst
- Product volumes for registration and fleet testing
- Feedstock handling and purification system flexibility
- Operations started in November 2009
- Overall success: On time, under budget, high quality product

BioForming® Platform - RPN



Virent RPN Characteristics



	Max Jet	Max Diesel
Gasoline	20%	20%
Jet	50%	0%
Diesel	10%	60%
Process Oil	20%	20%

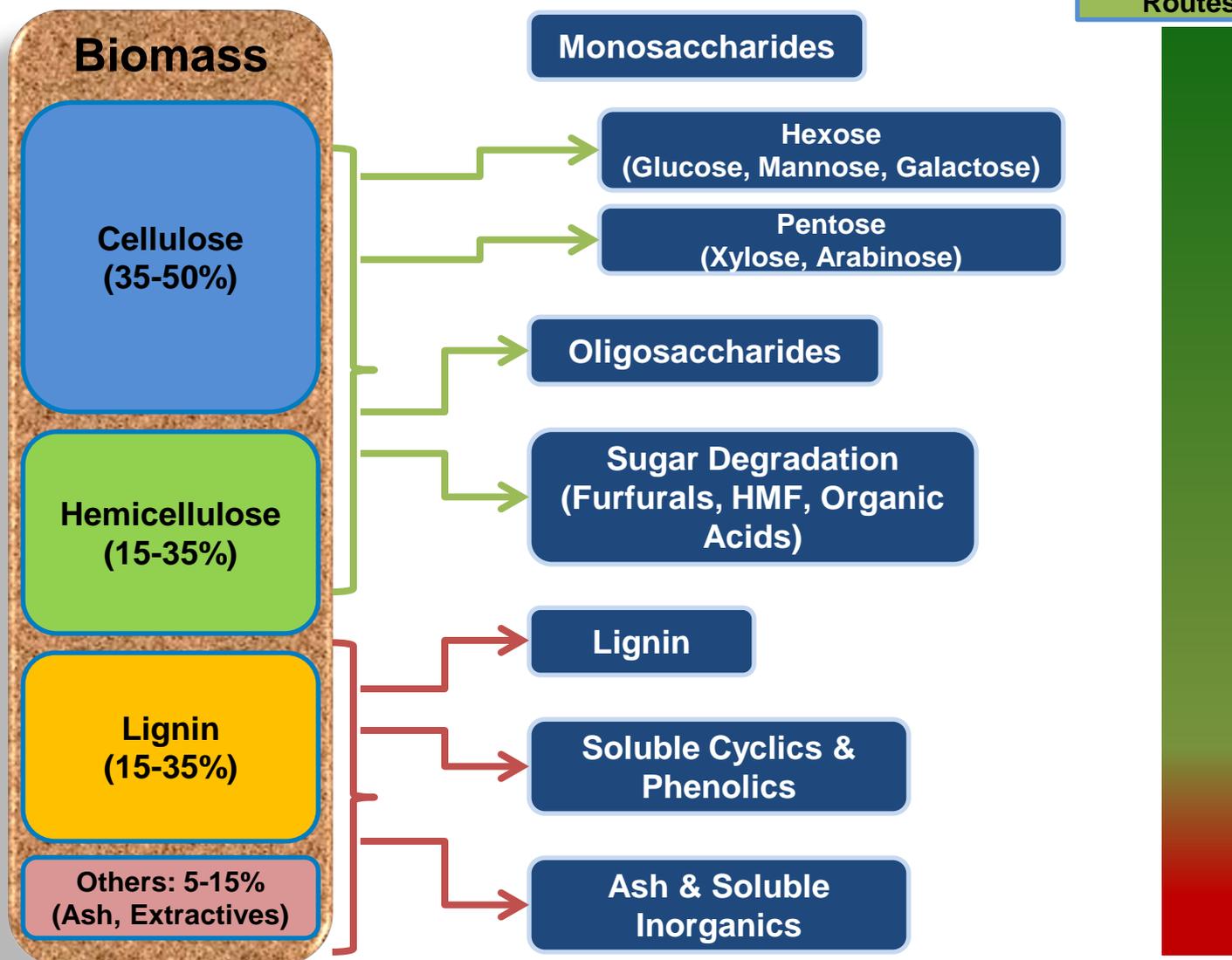
- *Flexible product slate*
- *Product is uniquely advantaged due to both component classes and ability to meet broad boiling point specifications*
- *Jet certification challenging and requires large volumes*

Feedstock flexibility for catalytic conversion

Catalytic Routes

vs.

Microbial Conversion

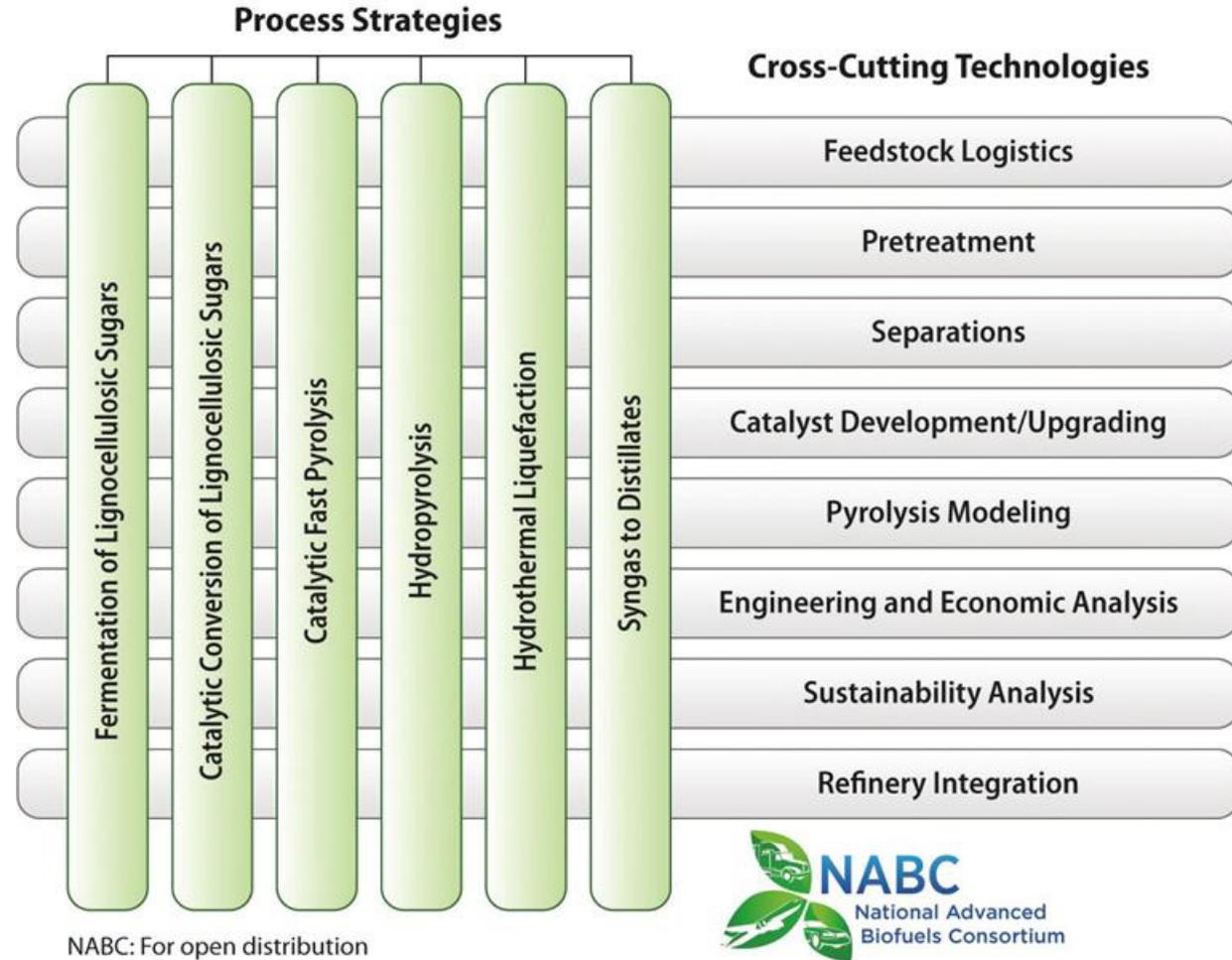


Consortium Leads

National Renewable Energy Laboratory
Pacific Northwest National Laboratory

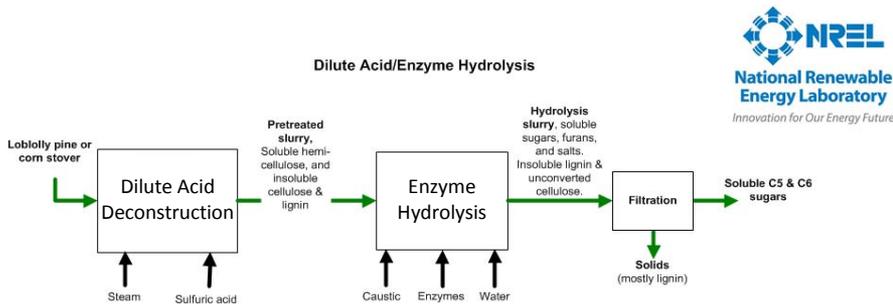
Consortium Partners

Albemarle Corporation
Amyris Biotechnologies
Argonne National Laboratory
BP Products North America Inc.
Catchlight Energy, LLC
Colorado School of Mines
Iowa State University
Los Alamos National Laboratory
Pall Corporation
RTI International
Tesoro Companies Inc.
University of California, Davis
UOP, LLC
Virent Energy Systems
Washington State University

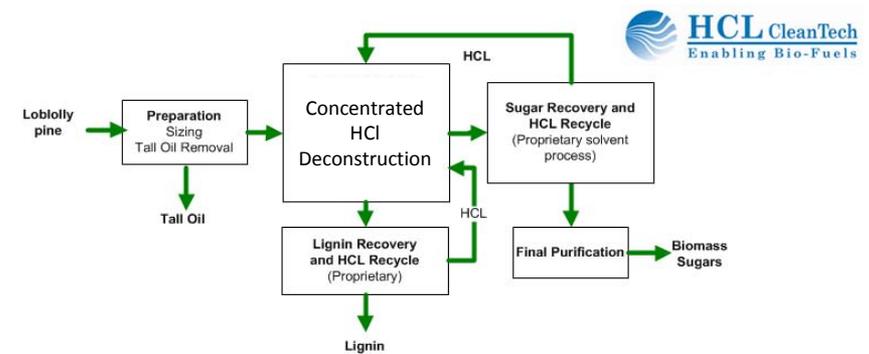


Virent leads the Catalytic Conversion of Lignocellulosic Sugars (CLS) strategy. The underlined parties above are currently collaborating within the CLS strategy.

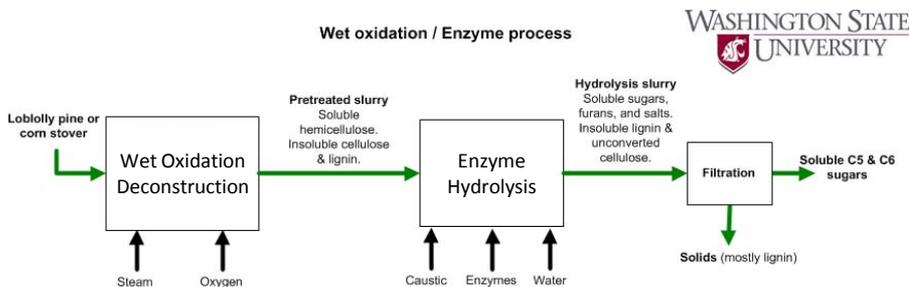
- Dilute acid pretreatment and enzyme hydrolysis



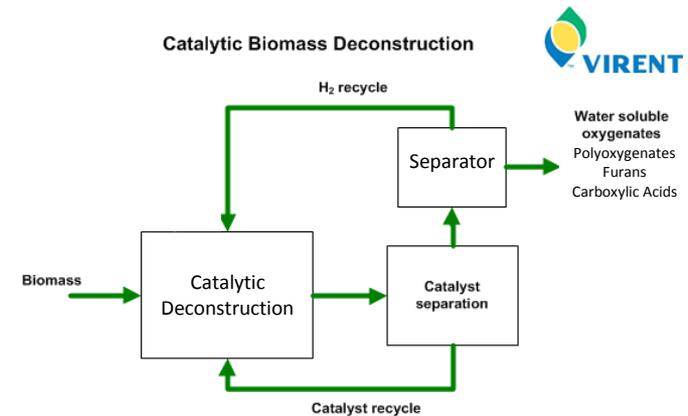
- Strong acid pretreatment



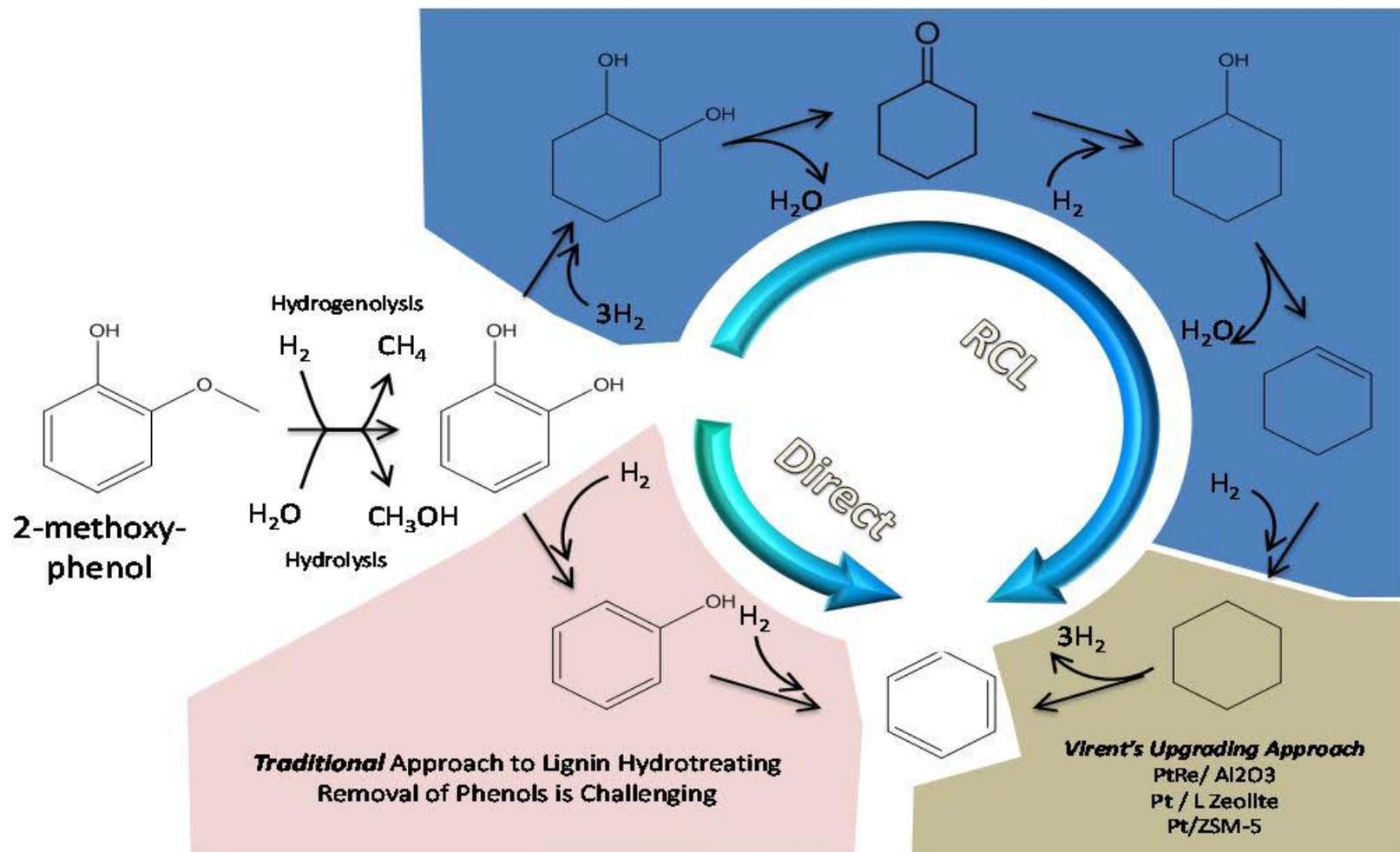
- Wet oxidation and enzyme hydrolysis



- Virent catalytic deconstruction



Catalytic Lignin Conversion



IF YOU CAN GROW IT,
we can convert it into everyday fuels, plastics and chemicals.



VIRENT