

Bio-Renewable Fuels: Green Diesel

California Biomass Collaborative 4th Annual Forum

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UOP Overview

- Leading supplier and licensor of processing technology, catalysts, adsorbents, process plants, and technical services to the petroleum refining, petrochemical, and gas processing industries
- UOP's technology furnishes:
 - 60% of the world's gasoline
 - 70% of the world's modern detergents
- 3400 employees worldwide
- '06 Financials: \$1.6 billion sales
- Strong relationships with leading refining and petrochemical customers worldwide
- 31 of 36 refining technologies in use today created by UOP

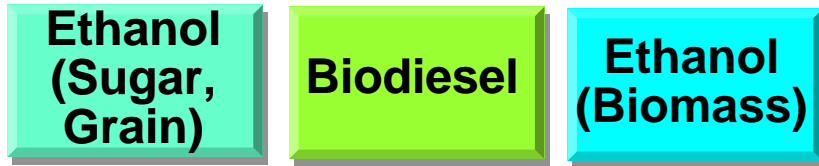


**2003 National Medal of
Technology Recipient**

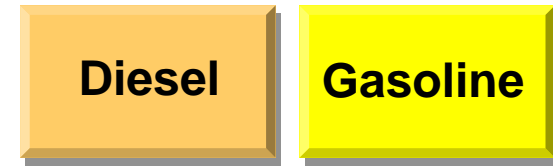


Track Record Of Technology Innovation

Fuel Additives / Blends



Fuels



UOP's Bio-Fuels Technology Goals

Identify and utilize processing and infrastructure synergies to:

- lower capital investment,
- minimize value chain disruptions,
- and reduce investment risk.

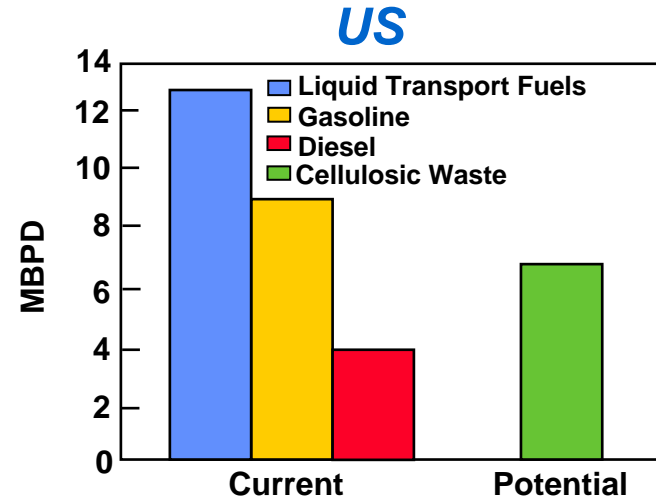
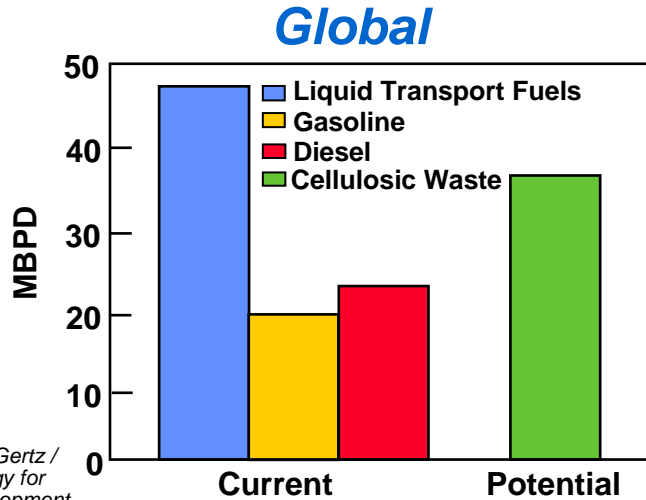
Generation 1

- Vegetable oils and greases to diesel, gasoline and JP-8 (military jet fuel)

Generation 2

- Lignocellulosic biomass and algal oils to fuels

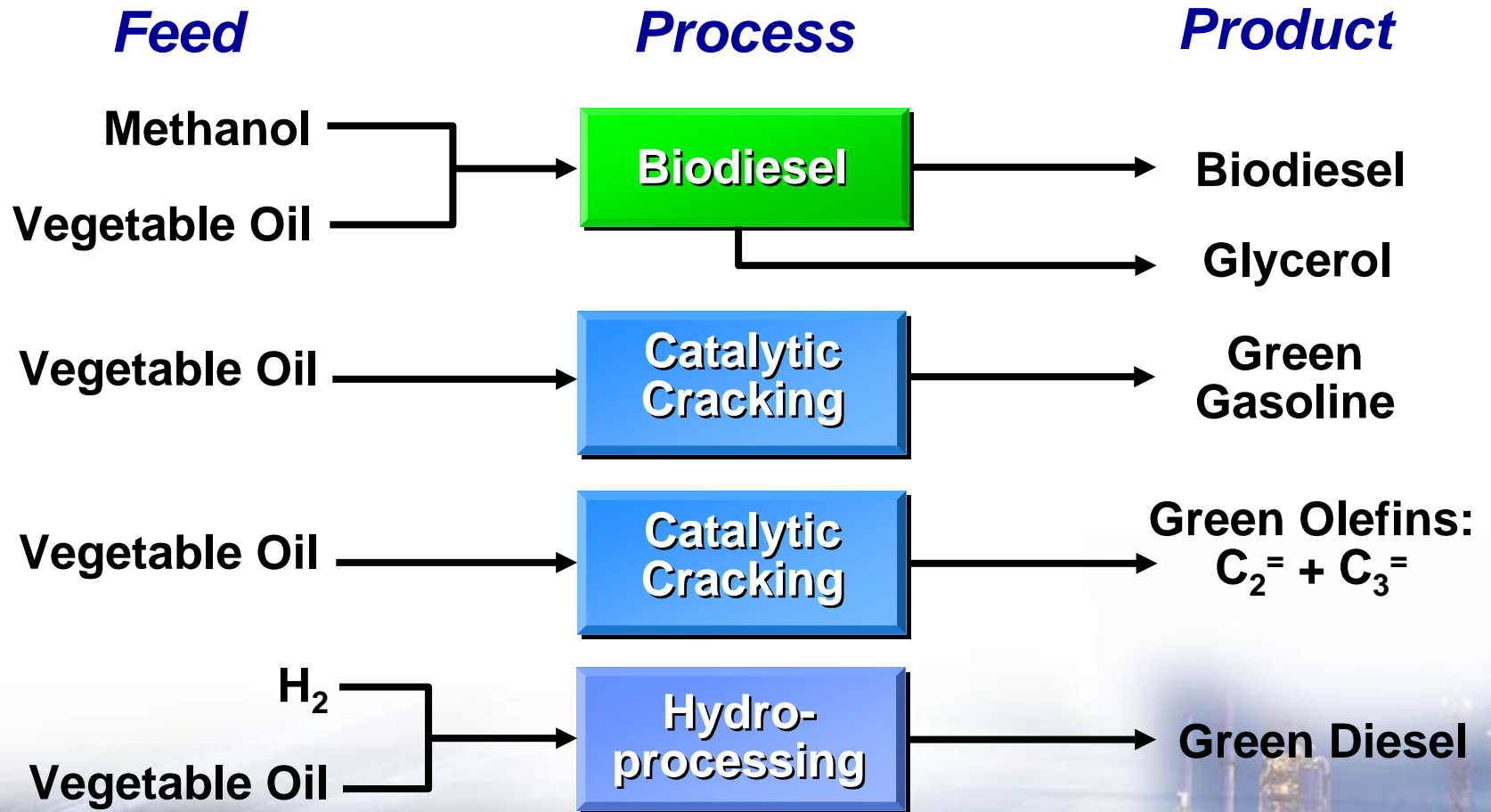
Enablers for a Sustainable Biomass Infrastructure



Source: Purvin & Gertz /
Eric Larsen: Energy for
Sustainable Development,
2000

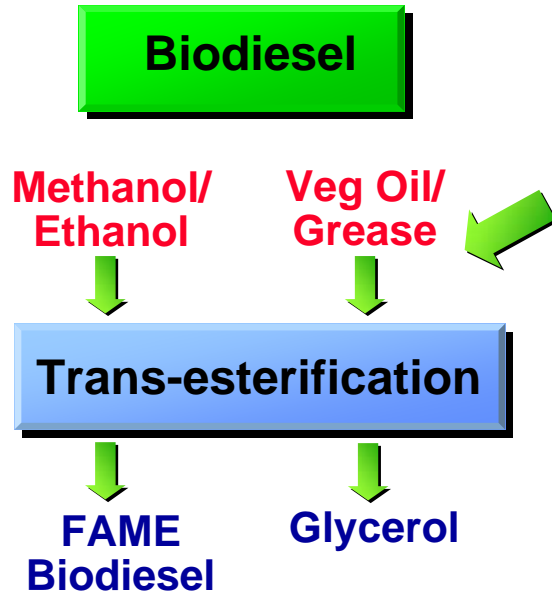
- **Cellulosic waste could make a significant contribution to liquid transportation pool.**

Vegetable Oils Processing Routes

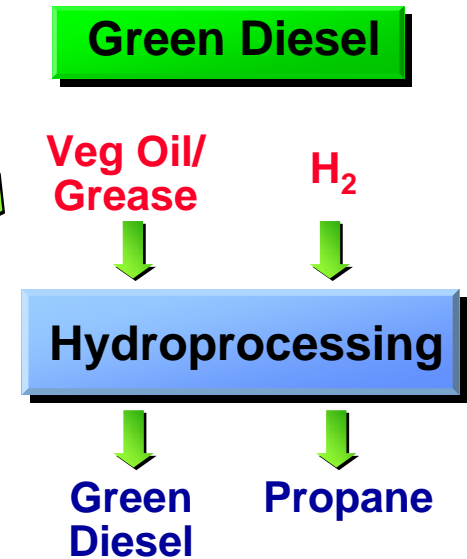


What is Green Diesel?

Trans-esterification Process



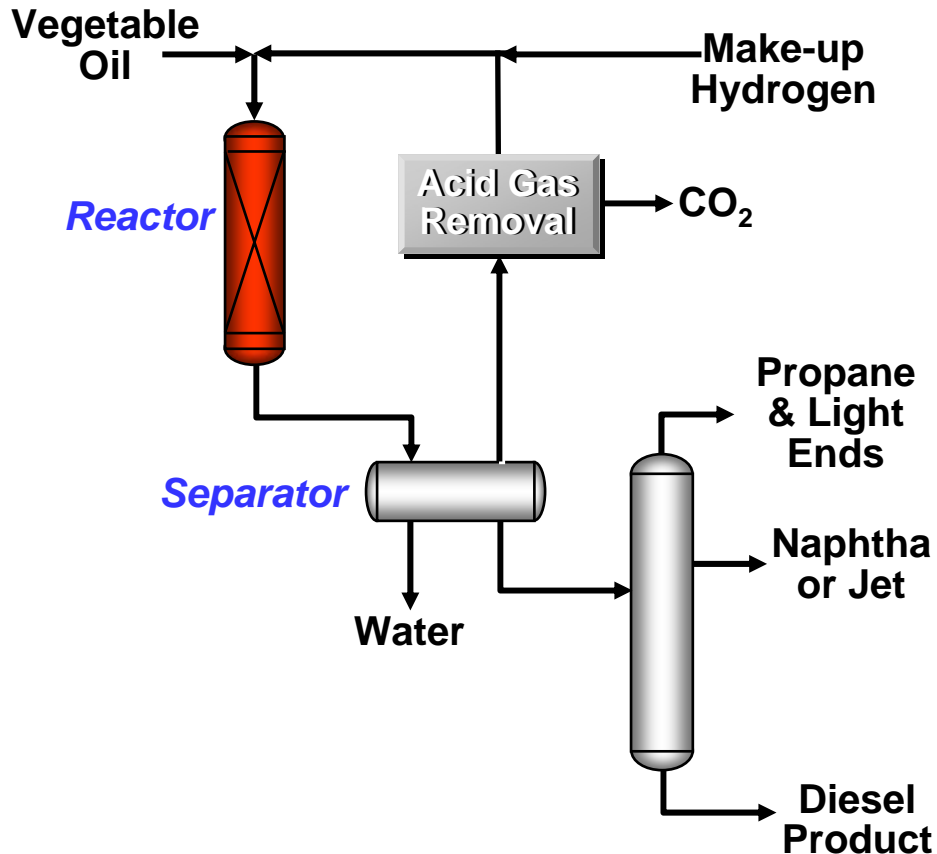
Deoxygenation Process



- Indistinguishable from conventional diesel but made from plant oils.
 - Leverages hydro-processing technology and refinery hardware.
 - Utilizes flexible feeds (vegetable oils, animal fats, FFAs)

Processing Vegetable Oil

Green Diesel Process












- Upgrade vegetable oil using hydroprocessing
- Product is an high cetane diesel blending component
- Hydrocarbon product, not an oxygenated compound
- Co-production of propane, naphtha, and high quality jet fuel possible.

Green Diesel from Oils and Greases

<i>Feed</i>	
% Oil or Grease	100
% H₂	1.5-3.8
<i>Products</i>	
Vol. % Naphtha	< 1-10
Vol. % Diesel	88-98+
Cetane Number	80-100
ppm S	<10

Water and CO_x are produced as deoxygenation products

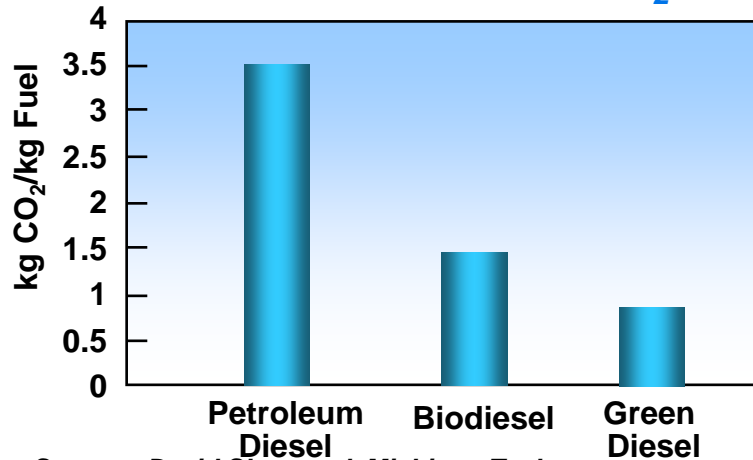
Green Diesel: Product Characteristics

	<i>Petro. Diesel</i>	<i>Green Diesel</i>	
NOx Emission	Baseline	-10 to 0	
Cloud Point, °C	-5	-10	
Energy Density, MJ/kg	43	44	
Density, g/ml	0.83-0.85	0.78	
Energy Content, BTU/gal	129 K	123 K	
Cetane	40-55	75-90	
Sulfur	<10 ppm	<10 ppm	
Polyaromatic	4	0	
Oxidative Stability	Baseline	Excellent	

From a production standpoint, Green Diesel provides significant blending benefits

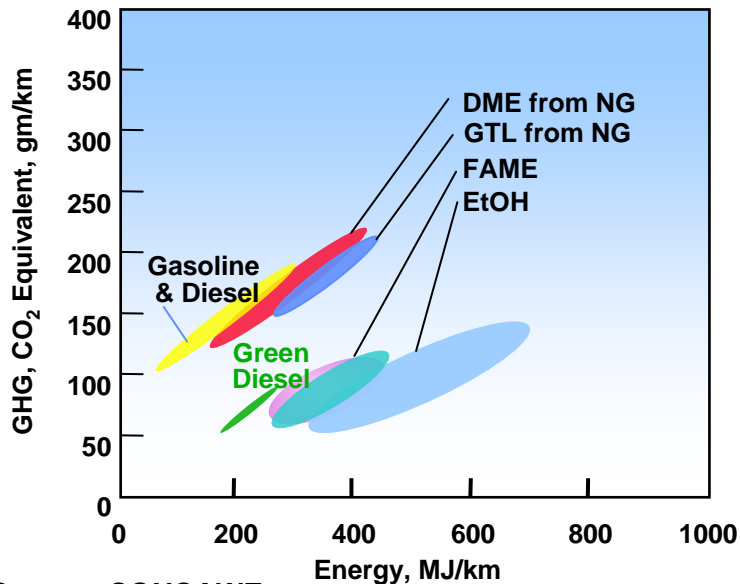
Sustainability: LCA and WTW Comparison

LCA Climate Active CO₂



Source: David Shonnard, Michigan Tech.

WTW Energy /GHG Emissions Clusters



Source: CONCAWE

*Green Diesel is a
Better Overall
Performer
both from
Energy
Consumption
and
GHG Emissions
perspectives*

- **Vegetable oil, grease and pyrolysis oil are feasible feedstocks for conventional petroleum refineries- allowing incorporation of bio-feedstocks into supply chain.**
 - **Near term: conversion of oils to Green Diesel, (also, Green Gasoline and Green Olefins).**
 - **Long term: processing of large volumes of lignocellulosic feedstocks**

UOP's Biorenewables Offerings



- **UOP bio-renewable process technologies enable refiners to:**
 - **Meet existing and pending biofuels mandates or incentives**
 - **Utilize domestic sources of bio-feedstocks**
 - **Explore new/novel sources of bio-feedstocks**
 - **Provide high quality fuel products.**
 - **Maximize use of existing assets**
 - **Facilitate market adoption of green fuels**

*UOP's Value Contribution for
Biorenewables Arena*

Q & A