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Green Transportation Fuels from UOP

Honeywell UOP, Renewable Energy & Chemicals
Biomass Research and Development Group



Honeywell UOP Biofuels Vision

- Builds on UOP's 100+ years of expertise in refining crude oil
- Produce real “drop-in” fuels, chemically identical to petroleum fuels; superior to fuel additives
- Leverage existing refining/transportation fuel infrastructure: lowers capital costs, minimize value chain disruptions and reduce investment risk
- Focus on path toward feedstocks with a high level of sustainability



Solutions are Needed to Meet Climate Challenges

Renewable Technology Portfolio

Inedible Oils
Animal Fats



UOP
Ecofining™
Process

Honeywell Green Diesel™

Green Jet

Renewable Jet
Process™

Honeywell Green Jet™

Green Diesel



Biomass

Gasification
Separation
FT Synthesis
Conversion

UOP Scope
Others' Scope
Green Fuels

RTP®
(Pyrolysis)

Green Power / Fuel Oil (now)

FCC Co-Processing

Green Fuels

Envergent Technologies – UOP/Ensyn JV

Proven Technologies for Feedstock Flexible Drop In Fuels

Operating Plants Using UOP's Renewable Technology

Multiple Feedstock Options

Natural Oils



Animal Fats



Algal Oils

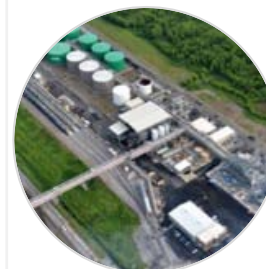


Used Cooking Oil



- Diamond Green Diesel
 - Ecofining Unit at Norco, Louisiana
 - Adjacent to existing Valero refinery
 - 10,000 BPD (500,000 MTA) Capacity
 - Diesel
 - Expansion to 18,000 BPD in progress
- ENI
 - Ecofining Unit at Venice, Italy
 - Retrofit of existing refinery units
 - 7,500 BPD (375,000 MTA) Capacity
 - Diesel
 - 2nd Ecofining project in progress
- AltAir
 - UOP Renewable Jet Fuel Unit at Paramount, California
 - Retrofit of existing refinery units
 - 2,500 BPD (125,000 MTA) Capacity
 - Diesel and Green Jet

2013



2014



2016



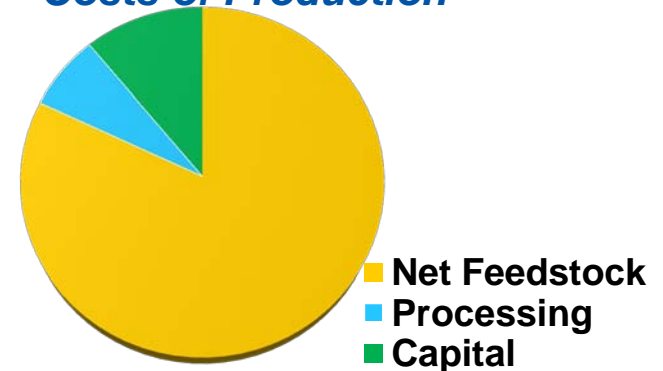
Commercial Production of Green Fuels Since 2013

Potential Feedstocks for Ecofining & UOP Renewable Jet Process



- Plant Oils
 - Rapeseed/Canola
 - Soybean
 - Palm, PFAD
 - Carinata
 - Camelina
 - Jatropha
 - Inedible Corn Oil
 - Tobacco oil
- Animal Fats
 - Tallow (beef)
 - Choice White Grease (pork)
 - Poultry Fat
- Waste Greases
 - Used Cooking Oil
 - Yellow Grease
- Algal and Microbial Oils

*Green Diesel & Jet
Costs of Production*



*Flexibility to utilize the lowest cost feedstocks
Without compromising product quality*

Next Generation Feedstocks for Ecofining & UOP Renewable Jet Process



Cover/ Non-Food Crops

- Carinata
- Camelina
- Jatropha
- Pongamia
- Tobacco seed
- Pennycress

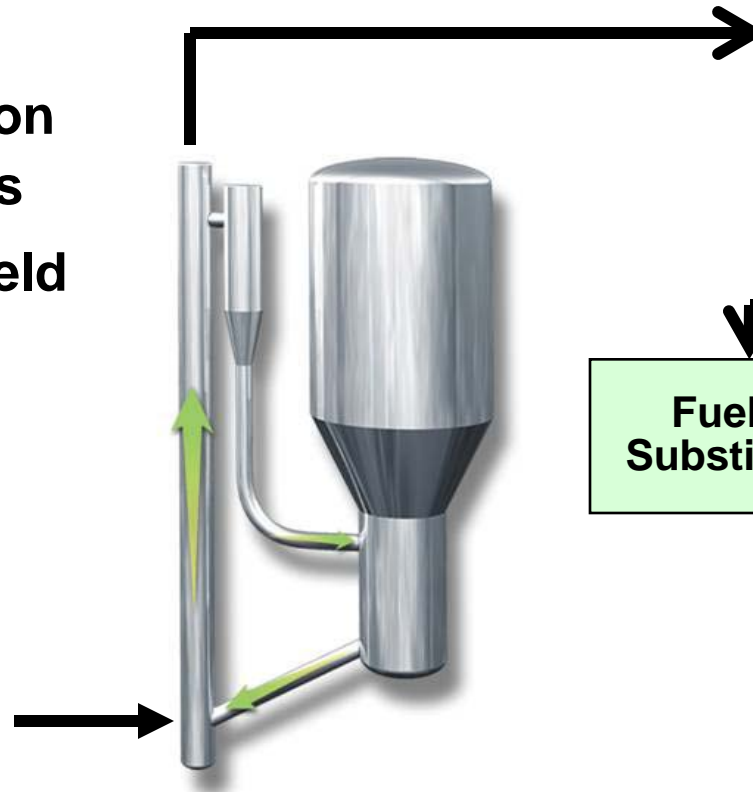
Algal and Microbial Oils

These feeds are in various stages of development, with many having the capability to ramp up production when demand requires, filling feed gap with high value feedstocks

Alternate Feedstocks have ability to fill future demand

RTP – Rapid Thermal Processing

- Transportable fuel
- Energy densification relative to biomass
- Maximum liquid yield 65 – 75 wt%



RTP Green Fuel



Fuel Oil
Substitution

Electricity
Production

Upgrade to
Transport
Fuels
(Gasoline,
Jet & Diesel)

Decouples Biomass Conversion from Energy Generation

2nd Generation Feedstocks

- **Forest Industry**

- Wood chips, sawdust and bark
- Forest Residues

- **Agricultural**

- Residues – corn stover, expended fruit bunches from palm (EFB), bagasse
- Purpose-grown energy crops – miscanthus, elephant grass



Second Generation Feedstocks Highly Available

Coprocessing RTP green fuel to produce Transportation Fuel



Pyrolysis close
to biomass
source for
densification



RTP Unit



Co-process in FCC
with VGO



Partially Renewable Fuel
to Refinery Pool



Same Product Quality With A Renewable Component

Neat Upgrading of RTP Green Fuel

- Instability of fast pyrolysis bio oils leads to plugging in fixed bed reactor systems
- Solution lies in the ability to stabilize or partially upgrade the bio oil prior to full hydroprocessing
- Issue is not can it be done but rather how to do it economically
- UOP continues to explore technology solutions for neat upgrading



Solutions are Needed to Meet Climate Challenges

The AltAir Renewable Jet Fuel Project

- **Technology:** UOP Renewable Jet Fuel Process
- **Feedstock:** 2,500 bpd (124,000 tpa)
- **Products:** Green Jet Fuel & Green Diesel
- **Location:** Los Angeles, CA
- **Specifics:**
 - Retrofit part of an existing petroleum refinery
 - United Airlines and World Fuels off-take a substantial portion of the products
 - Producing Renewable F76 for Naval Distillate Contract to Defense Logistics Agency for use by US Navy “Great Green Fleet”
- **In Operation Since Jan 2016**



AltAir Project Phases & Timeline

- Fuel Testing & Certification (2009-2013)
 - Conversion of Feedstocks
 - Department of Defense
 - Commercial Aviation
- Project Development (2010-2013)
 - Location & Definition
 - Revamp Studies
 - Financing
- Project Implementation (2013-2015)
 - Engineering, Procurement, & Construction
 - Pre-commissioning
- Operation (2016-present)
 - Start-up
 - Initial Fuel Deliveries
 - Ongoing Operations



A vibrant green forest scene with a dirt path leading through tall, slender trees. The foliage is dense and bright green, creating a sense of a healthy, sustainable environment.

HONEYWELL RENEWABLE ENERGY & CHEMICALS

THANK YOU

Honeywell is committed to *providing technology options* that better enable our customers to produce better quality renewable fuels for a more sustainable future