Green Transportation Fuels from UOP
Honeywell UOP, Renewable Energy & Chemicals
Biomass Research and Development Group

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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
Renewable Technology Portfolio

Inedible Oils
Animal Fats

UOP Ecofining™ Process

Renewable Jet Process™

Green Power / Fuel Oil (now)

Honeywell Green Diesel™

Green Jet

Honeywell Green Jet™

Green Diesel

UOP Scope

Others’Scope

Gasification
Separation
FT Synthesis
Conversion

Green Fuels

Biomass

RTP® (Pyrolysis)

Envergent Technologies – UOP/Ensyn JV

Green Power / Fuel Oil (now)

FCC Co-Processing

Green Fuels

Proven Technologies for Feedstock Flexible Drop In Fuels
Operating Plants Using UOP’s Renewable Technology

- **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

Multiple Feedstock Options

- Natural Oils
- Animal Fats
- Algal Oils
- Used Cooking Oil

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

Flexibility to utilize the lowest cost feedstocks
Without compromising product quality
Alternate Feedstocks have ability to fill future demand

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
RTP – Rapid Thermal Processing

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

Decouples Biomass Conversion from Energy Generation

Forest Residue

Agricultural Waste
Feedstock Sources

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