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Commercial Scale Renewable Transportation Fuels

Svebio Advanced Biofuels Conference | Gothenburg, Sweden



Trends in Commercial Scale Renewable Fuels

- **Sweden is Leading Country in Europe**
- **Urgency around Targets in RED II**
- **Continued Uncertainty in RED II**
- **No ILUC is a MUST**
- **Use existing refinery infrastructure**
- **Limited availability of oil & fats feedstocks**
- **Preference for sustainable solid feeds**



Who is Honeywell UOP

Honeywell UOP has *created knowledge through invention and innovation* and applied it to the energy industry for 100+ years

2,000+

Engineers and
scientists



+200 with PhDs

800+

R&D employees



4,900+

Active patents

100+

Years of
Experience

- Process Technology
- Catalysts and Adsorbents
- Equipment
- Services

Refining



Petrochemicals



Natural Gas



Renewables

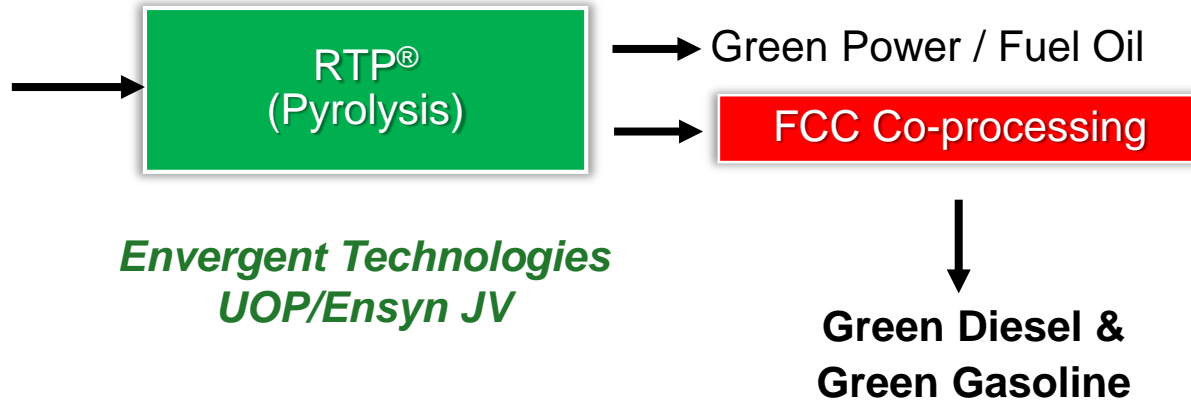


60% of the World's Gasoline, 70% of the polyester, 90% of Biodegradable Detergents Produced with UOP Technology

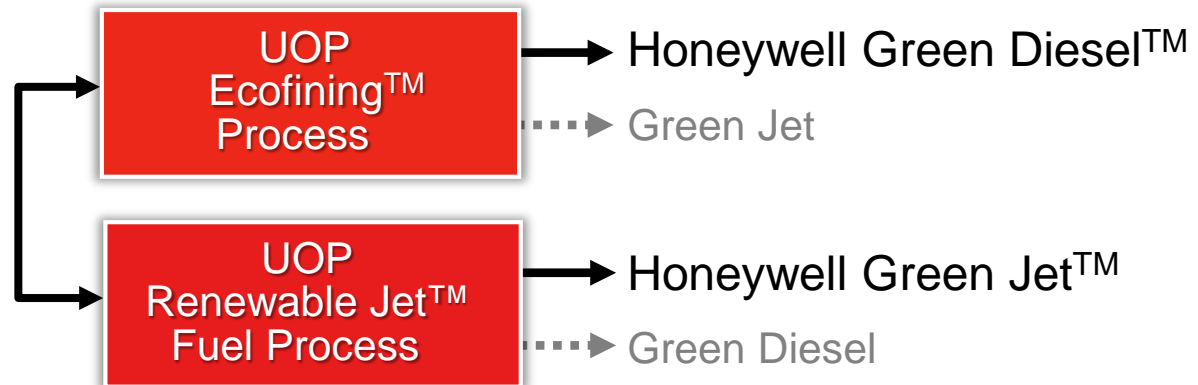
Honeywell UOP Advanced Biofuel Solutions



Biomass



Inedible Oils
Animal Fats



Solutions that meet Advanced Biofuel under RED II



Biomass conversion into RTP Green Fuel

Who is Envergent Technologies



Honeywell
UOP



ENSYN

*Developed RTP™ Technology
in 1980s & has over 25 years
of commercial operations in 6
commercial units*

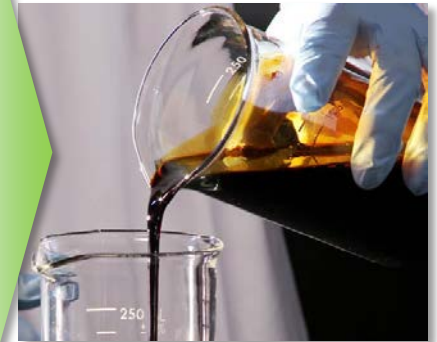


- **Joint Venture formed in October 2008**
- **Provides RTP™ technology to produce fast pyrolysis oil for fuel oil substitution and electricity generation**
- **Development of technology for upgrading pyrolysis oil to transportation fuels**

RTP – Rapid Thermal Processing



RTP green fuel



- **Energy densification relative to biomass**
- **Ease of use and lower transport costs**

RTP™ Green Fuel Properties and Yields

Fuel	MJ/Liter	BTU/US Gallon
Methanol	17.5	62,500
RTP Green Fuel	19.9	71,500
Ethanol	23.5	84,000
Light Fuel Oil (#2)	38.9	139,400

Yields For Various Feeds

Biomass Feedstock Type	Typical RTP Green Fuel Yield (Wt-% of Dry Feedstock)
Hardwood	70 – 75
Softwood	70 – 80
Hardwood Bark	60 – 65
Softwood Bark	55 – 65
Corn Fiber	65 – 75
Bagasse	70 – 75
Waste Paper	60 – 80



Liquid Biomass Fuel for Heating or Transport Fuels

RTP Commercial Projects

- Commercialized in the 1980s
- 7 units operating in the US and Canada



New Commercial Projects

- USA under design
- Brazil under design

Over 55 million gallons (250,000 MT) capacity available in 2020

Worldwide Commercialization Plan

New RTP Project in Canada

- **New RTP plant in Port Cartier, Quebec under construction**
- **Development by Ensyn and local wood industry partners**
- **Process 200 dry tonnes wood biomass per day**
- **Produce 45,000 MT of RTP green fuel per year**
- **Start-up Q3 2018**
- **Deliver volumes into Northeast USA for heating systems**



Largest Biomass Pyrolysis Plant in the World

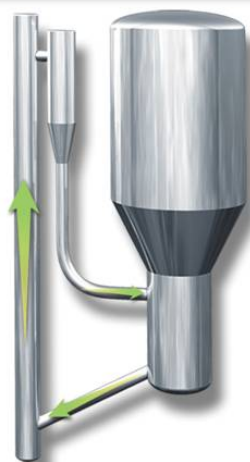


RTP Green Fuel Co-processing for Transportation Fuel

Co-processing RTP Green Fuel to Produce Transportation Fuel



Pyrolysis close to biomass source for densification



RTP Unit

Biocrude
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Co-process in
FCC with VGO

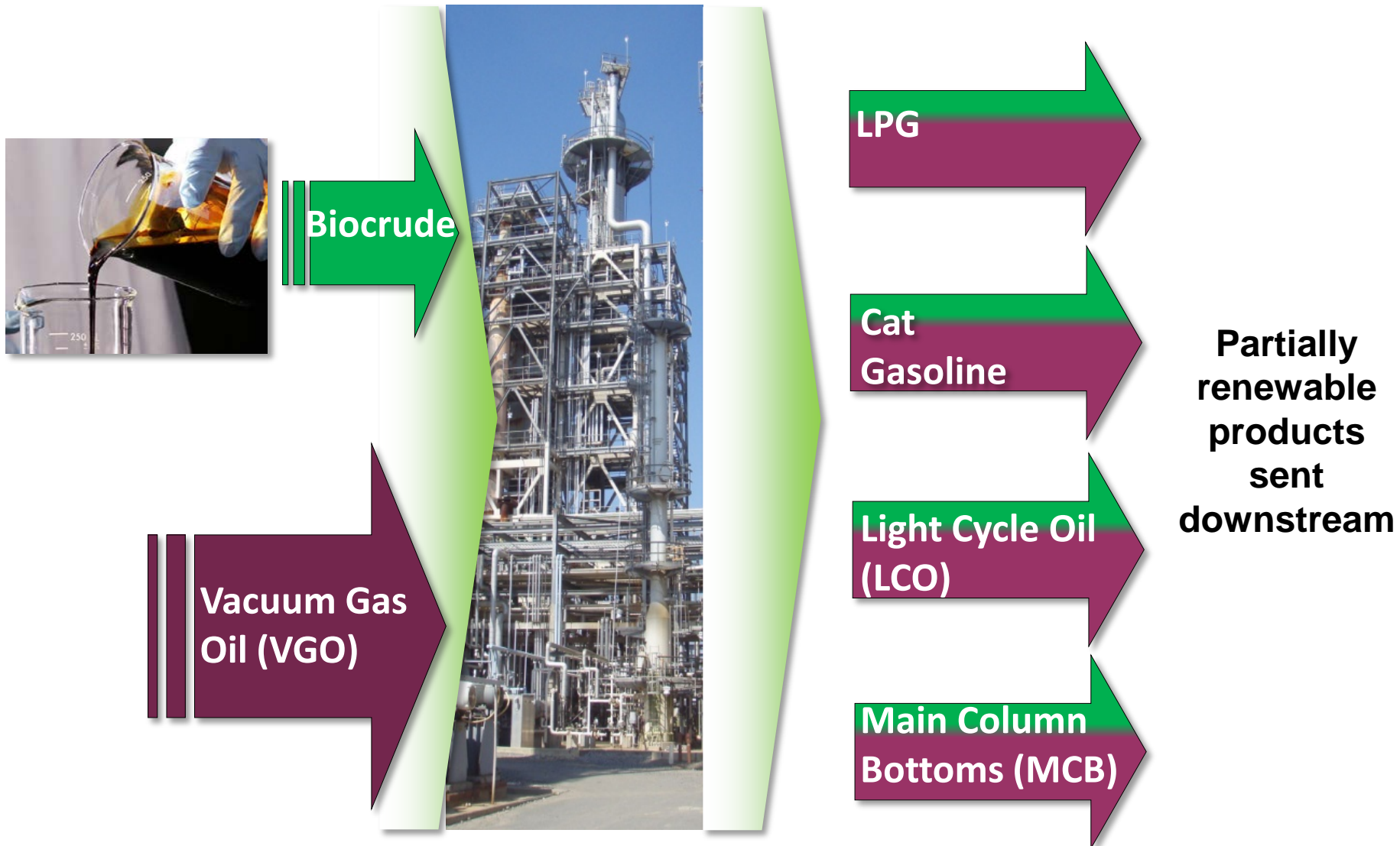
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Partially Renewable Fuel
to Refinery Pool

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Produce Partially Renewable Transport Fuels

Renewable Fuels from Co-Processing of RTP Biocrude



Utilize Existing Refinery Assets & Infrastructure

- **Generate cellulosic gasoline and diesel volumes from residual biomass**

- Similar product yield to petroleum feed
- Same product quality as petroleum feed

- **Processing benefit to refiner**

- No disruption to operations using existing infrastructure
- Minimal capex for implementation
- Short payback time

Weight %	100% VGO	95% VGO + 5% Bio-oil
Dry Gas	3.5	2.8
LPG (C ₃ -C ₄)	13.8	13.8
Gasoline (C ₅ -220°C)	39.9	40.6
Diesel (220-344°C)	20.3	19.6
Bottoms (+ 344°C)	16.1	14.4
Coke	6.4	6.0
CO	0.0	1.0
CO ₂	0.0	0.4
Water	0.0	1.4

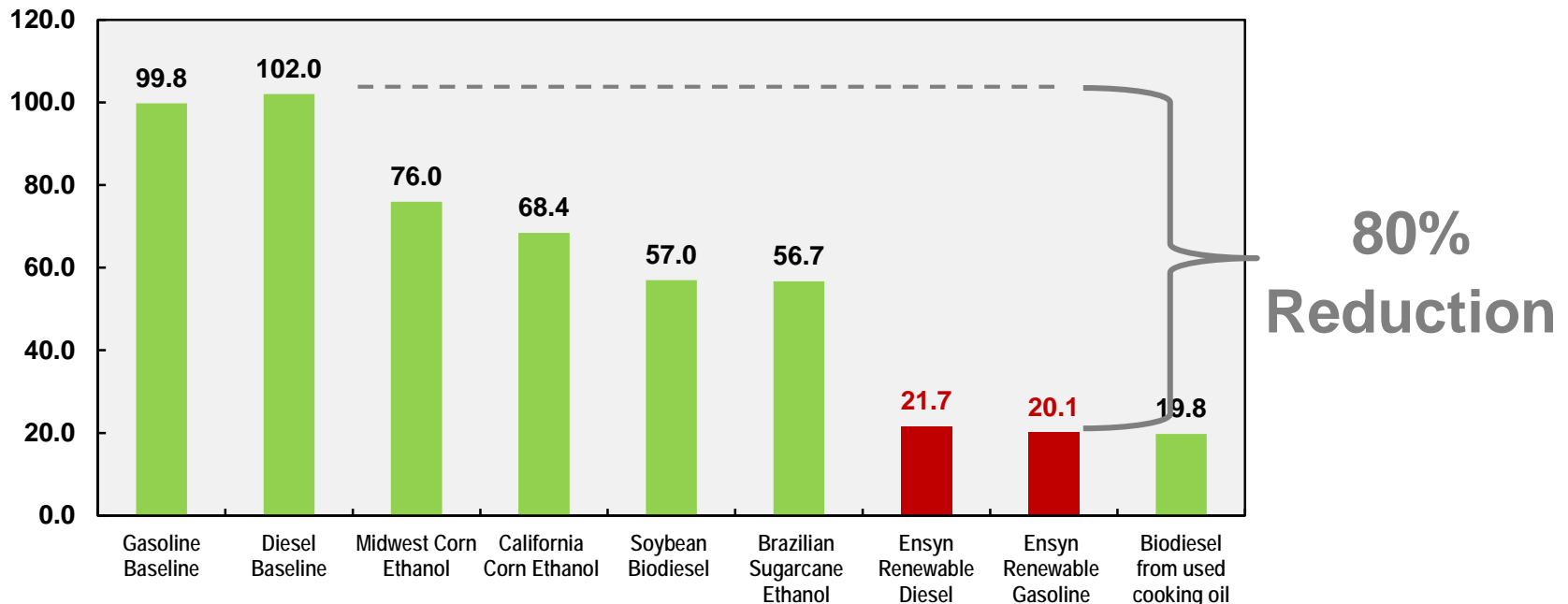
Source:

http://www.energy.gov/sites/prod/files/2015/04/f21/thermochemical_conversion_chum_2_42303.pdf

**Yields vary by FCC
Unit Operation**

- **Large Greenhouse Gas Reductions Co-processing**
 - **79.9% Carbon Emission Reduction for Green Gasoline**
 - **78.7% Carbon Emission Reduction for Green Diesel**

Select LCFS California Pathway Carbon Intensities
(gCO₂e/MJ)



RTP Co-Processing Produces Large GHG Reductions

RTP Biocrude Commercial Status

- **Two commercial scale FCC co-processing trials completed**
- **Multiple full-scale installations of technology scheduled in 2018**
 - USA
 - Europe
- **Regulatory recognition and verification**
 - Completion of US EPA Part 79 Fuel Registration
 - Application of US EPA Part 80 Facility Registration for Co-processing
 - Application of ISCC certification for recognition of biofuel in Europe





Renewable Fuels from Fats, Oils & Greases

Drop-in Renewable Fuels from Honeywell UOP



Plant-derived Oils
Animal Fats & Grease
Used Cooking Oil
Algal Oil



**Ecofining™ Process or
UOP Renewable Jet Fuel Process**



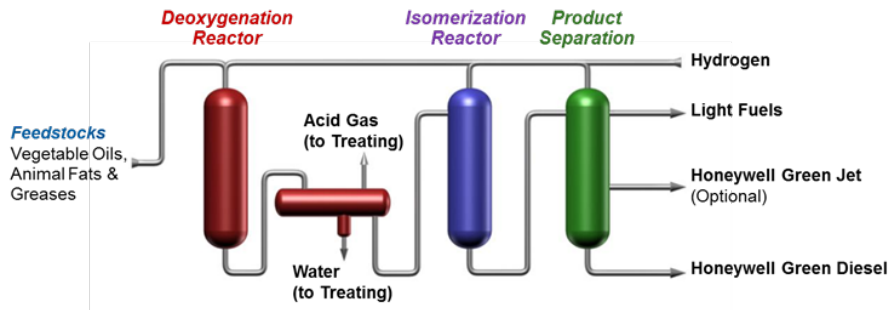
Honeywell Green Diesel™



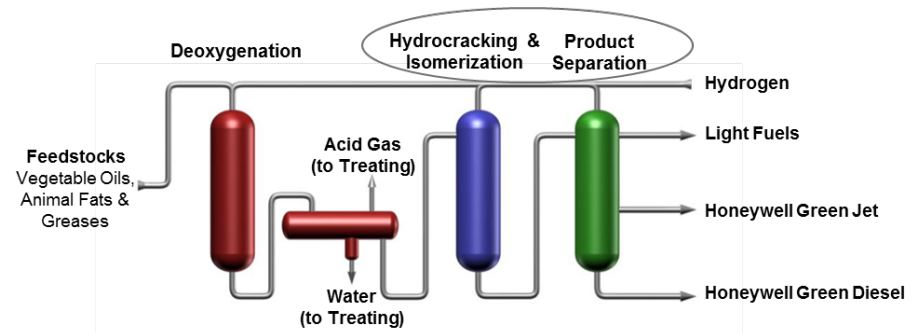
Honeywell Green Jet Fuel™
(HEFA SPK)

Proven Technologies for Feedstock Flexible Drop-in Fuels

UOP's Renewable Refining



Ecofining™ : Renewable Diesel



UOP Renewable Jet Fuel Process

Benefits

- **Higher Margins**
 - Utilize lower cost feeds, while producing higher value product with high yields
- **Capability to produce Renewable Jet or Renewable Diesel**
- **Strong interest from airlines to reduce greenhouse gas emissions**
- **Options to integrate/revamp in refineries to minimize capital costs**

Proven Technologies for Feedstock Flexible Drop-in Fuels

Operating Plants Using UOP's Renewable Technology



2013

Diamond Green Diesel - USA

- 600,000 MTA Feed (12,000 BPD)
- First New Ecofining Unit installed
- Completed expansion to 900,000 MTA (18,000 BPD)



2014

ENI #1 - Italy

- 360,000 MTA Feed (7,200 BPD)
- First refinery retrofit to Ecofining Unit at Venice, Italy
- Expansion to 560,000 MTA (11,200 BPD) in progress



2016

AltAir - USA

- 150,000 MTA Feed (3,000 BPD)
- First refinery retrofit to UOP Renewable Jet Fuel Unit
- Produces Green Jet and Green Diesel



2018 Expected

ENI #2 - Italy

- 720,000 MTA Feed (14,400 BPD)
- Second refinery retrofit to Ecofining Unit at Gela, Italy
- Under Construction

Refinery integration on all four projects with three refinery revamps

Commercial Renewable Aviation Biofuels are now a Reality



United Airlines is first commercial airline in U.S. to use renewable jet fuel on regular scheduled flights (started March 2016 at LAX)

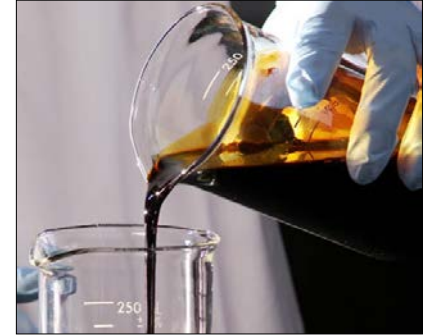


Fuel provided by AltAir Fuels in first dedicated commercial production of HEFA SPK renewable jet fuel using UOP Renewable Jet Fuel Process



Advancing Biofuels Technology in Sweden

- Support and Leadership from both Government Agencies and Petroleum refining industry
- Targeted Programs for the most Sustainable fuel solutions
- Incentivize supply chain at both feedstock development and conversion to renewable transportation fuel
- Honeywell UOP and Envergent Technologies have commercially proven solutions and are available to support Sweden's expansions for the future





THANK YOU

We are committed to providing technology solutions that enable our customers to produce the highest quality renewable fuels