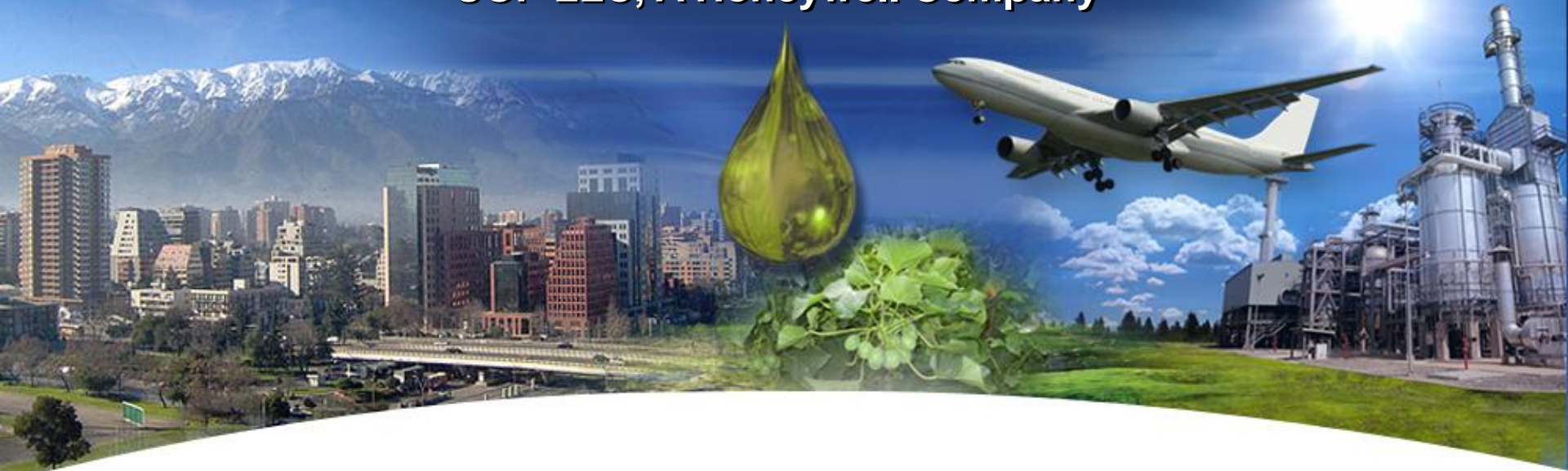


# Current Status of Biofuels Production and Use for Commercial Aviation

**Claudio Bertelli**  
Global Business Development Manager  
UOP LLC, A Honeywell Company



**BIO 2010 - V Seminario Latinoamericano y del Caribe  
de Biocombustibles  
17-18 August  
Santiago, Chile**

- Introduction
- Semi renewable jet fuel:  
Hydroprocessed renewable  
jet synthetic paraffinic  
kerosene (HRJ SPK)
- Fully renewable jet fuel: The  
Path to 100% Renewable Jet  
Fuel



# 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 for over 90 years
- UOP Technology Furnishes: 60% of the world's gasoline; 70% of the world's modern detergents; 60% of the world's para-xylene
- ~3000 employees worldwide
- '08 Financials: ~\$2 billion sales;
- Strong relationships with leading refining and petrochemical customers worldwide
- 70+ processes in 6,000+ units in hydrocarbon processing industry; 300+ catalysts, adsorbents; 31 of 36 refining technologies in use today created by UOP



*2003 National Medal of Technology Recipient*



***Track Record Of Technology Innovation***

# UOP Renewables Vision

- Building on UOP technology and expertise
- Produce real “drop-in” fuels instead of fuel additives/blends
- Leverage existing refining, transportation, energy, biomass handling infrastructure to lower capital costs, minimize value chain disruptions, and reduce investment risk.
- Focus on path toward second generation feedstocks & chemicals

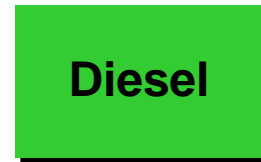
## Oxygenated Biofuels



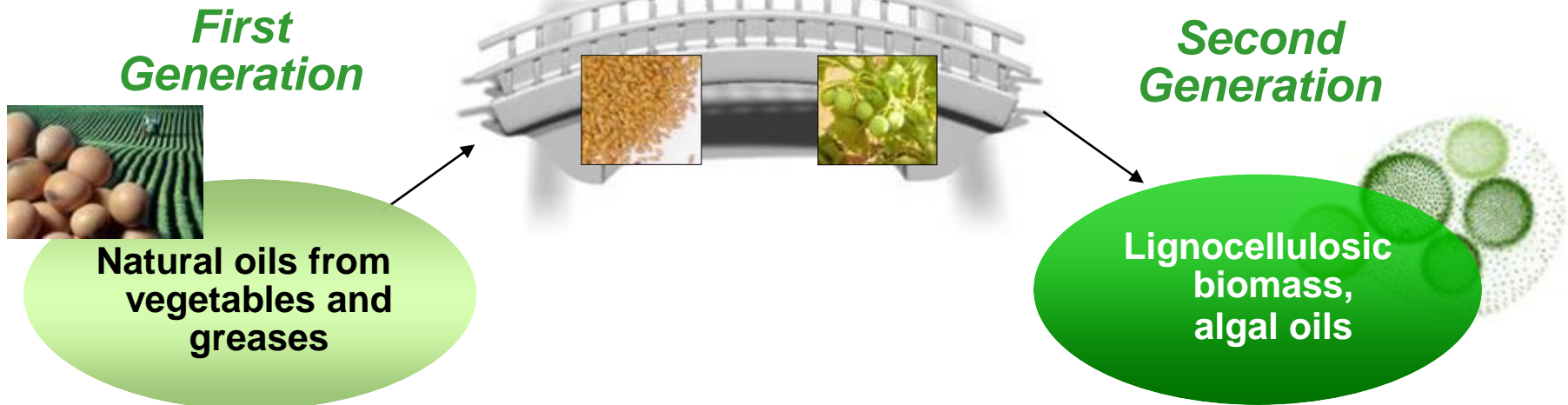
## Renewable Energy



## Hydrocarbon Biofuels

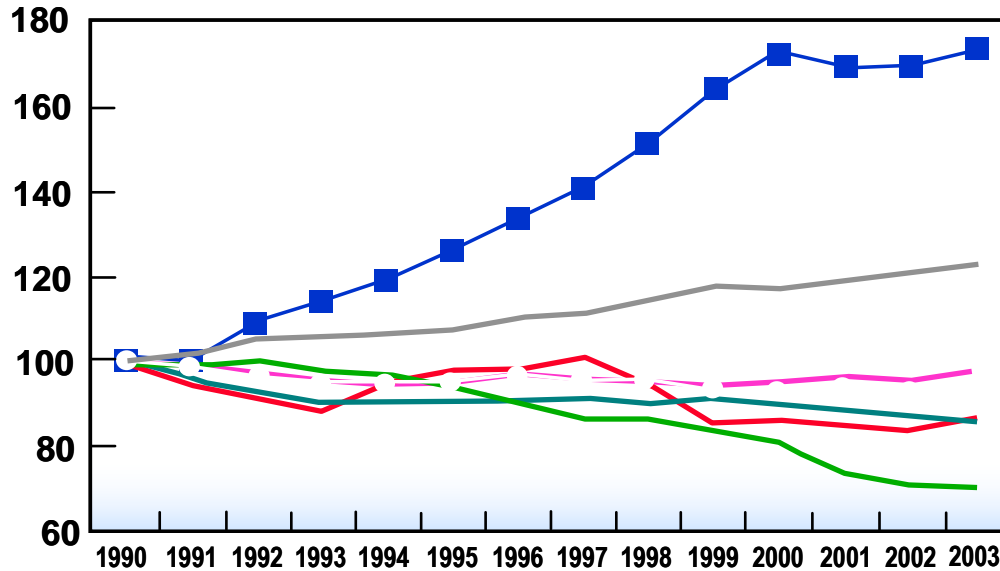


“Other” Oils: Camelina, Jatropha



# Market Drivers/Enablers

EU GHG Emissions by Sector as an Index of 1990 Levels



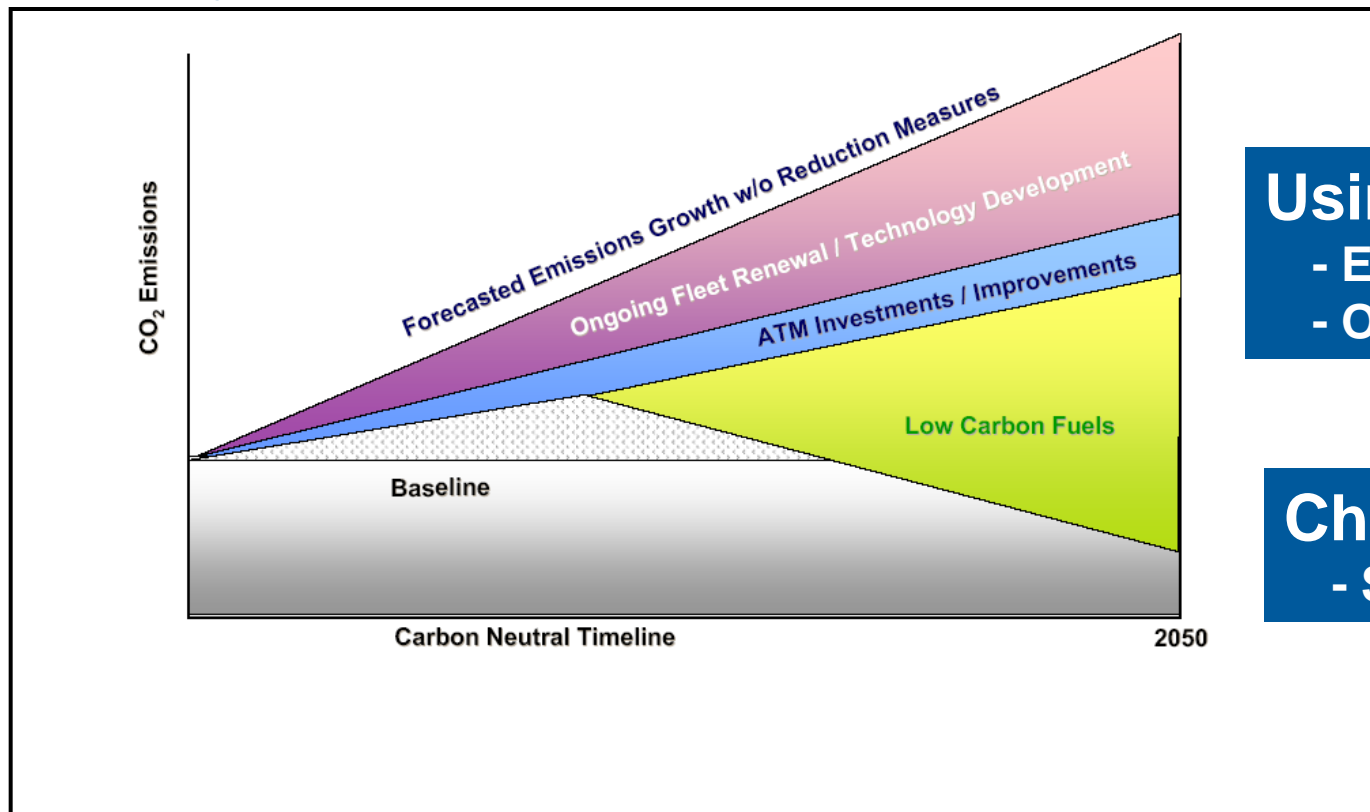
Source: ICAO



- **EU Emission Trading Scheme extending to aviation sector:**
  - Aviation emissions: Fastest growing of any sector
  - 2012 Emissions: 97% of 2005
  - 2013 Emissions, 95% of 2005
- **US Military's National Security driven goals to achieve both greater substitution (~50% by 2020) & GHG reduction,**
- **Aviation industry OEM's drive to render fleets compatible with upto 50% biojet**
- **Major Airline initiatives to use biojet**
- **Accelerated certification efforts**
- **2<sup>nd</sup> gen feedstock initiatives:**
  - Camelina, Jatropha, Algal

# Forecast of Industry CO<sub>2</sub> Emissions

## Key Drivers of Emissions Reductions

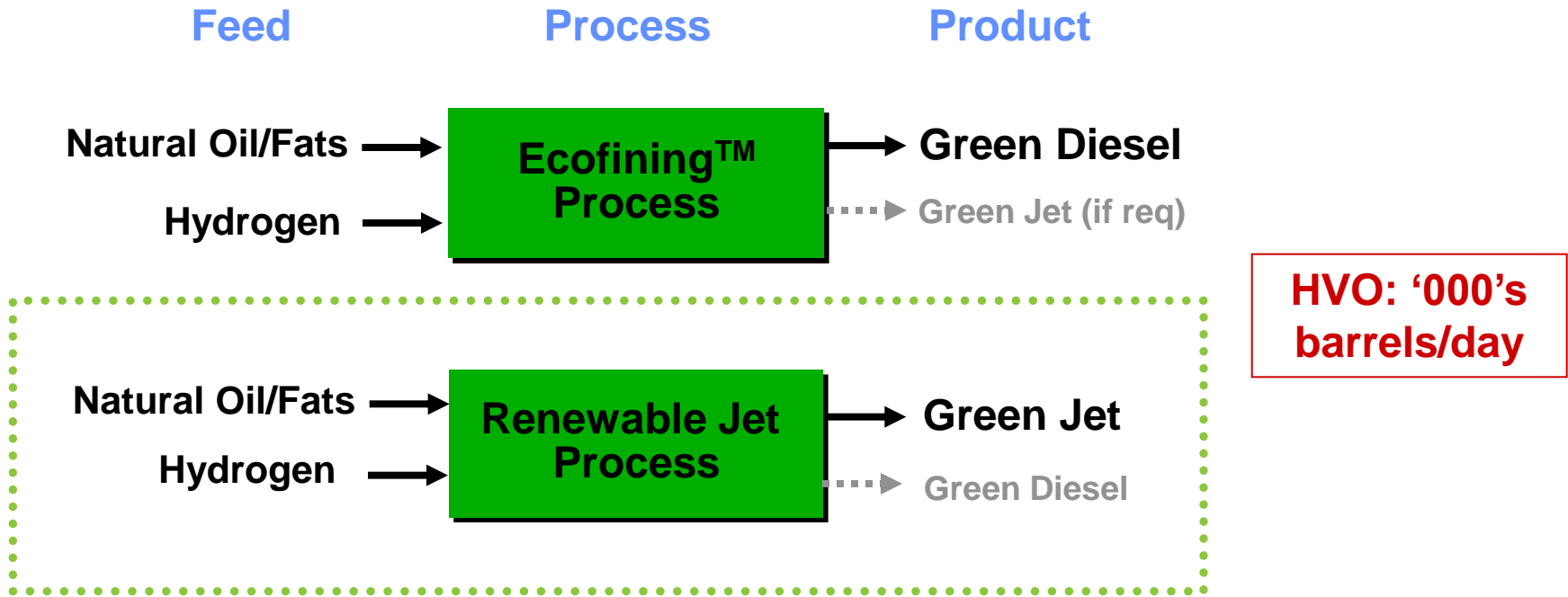


**Using Less Fuel**  
- Efficient Airplanes  
- Operational Efficiency

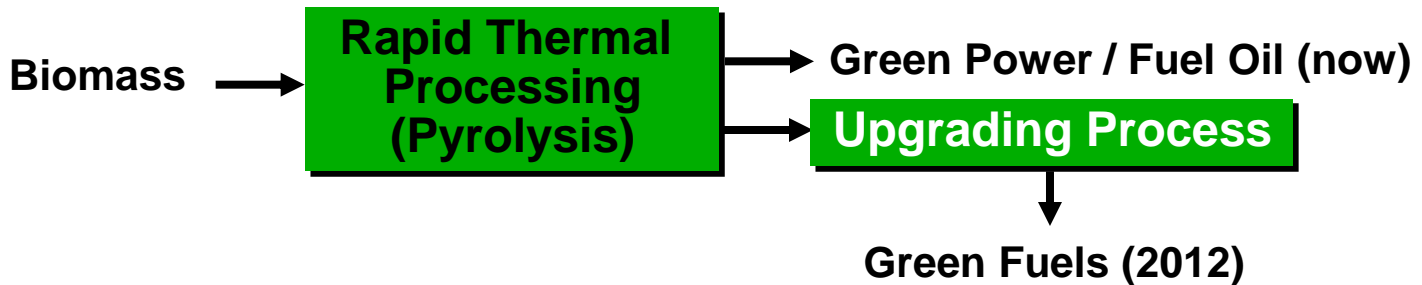
**Changing the Fuel**  
- Sustainable Biofuels

***Low carbon fuels a key part of emissions reduction***

# UOP RE&C Technologies & Capabilities



## *Envergent Technologies – UOP/Ensyn JV*

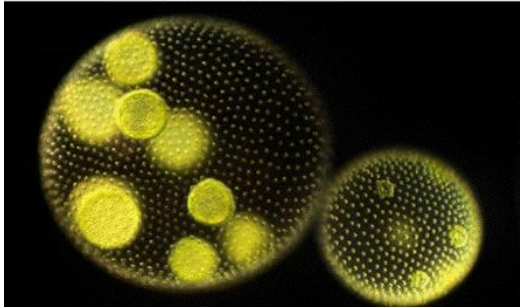


***Sustainable technologies – feedstock flexible & 2nd Gen ready***

# Viable Sustainable Biofuel feedstock alternatives: Commercial Scale Production

## Algae

Ready in 8 to 10 years



### Challenges

- Technological innovation needed for processing
- Algal Oil extraction key hurdle

## Jatropha

Ready in 2 to 4 years



### Challenges

- Limited to warm climates only
- Mechanical harvesting isn't mature

## Halophytes

Ready in 5 to 7 years



### Challenges

- Proven at pilot scale
- Improve agronomy for cost reduction

## Camelina

Ready Now



### Challenges

- Limited total potential owing to yield
- Somewhat tied to grain market swings

***Viability is based on timing, technology and local resources***

# Honeywell Green Jet Fuel™

- Started under DARPA contract to develop process technology to produce military jet fuel from renewable sources.
- Leverages Ecofining process technology.
- Fuel meets stringent requirements for flight.
- Military has ordered up to 600,000 gallons.
- Extend to commercial aviation in partnership with OEMs.

## DARPA Project Partners



**Honeywell**



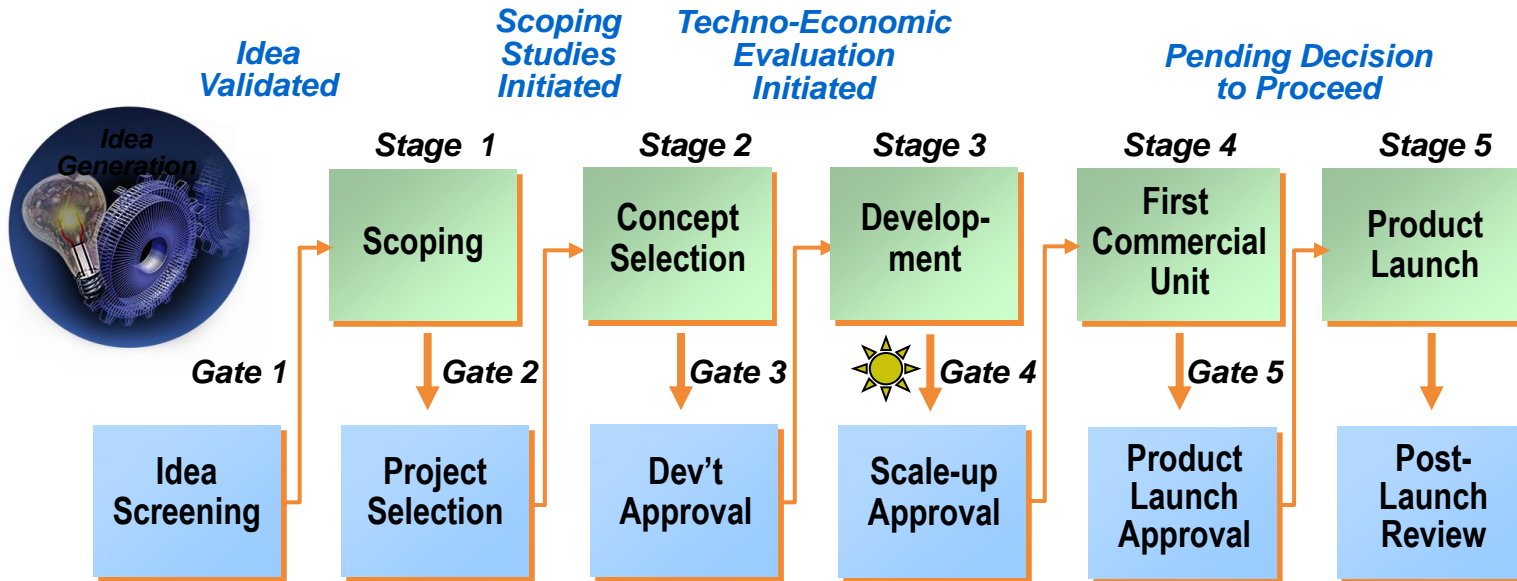
## Demonstration Flights



AIR NEW ZEALAND



# UOP Stage Gate Process for Process Development: Green Jet Process Offered Commercially



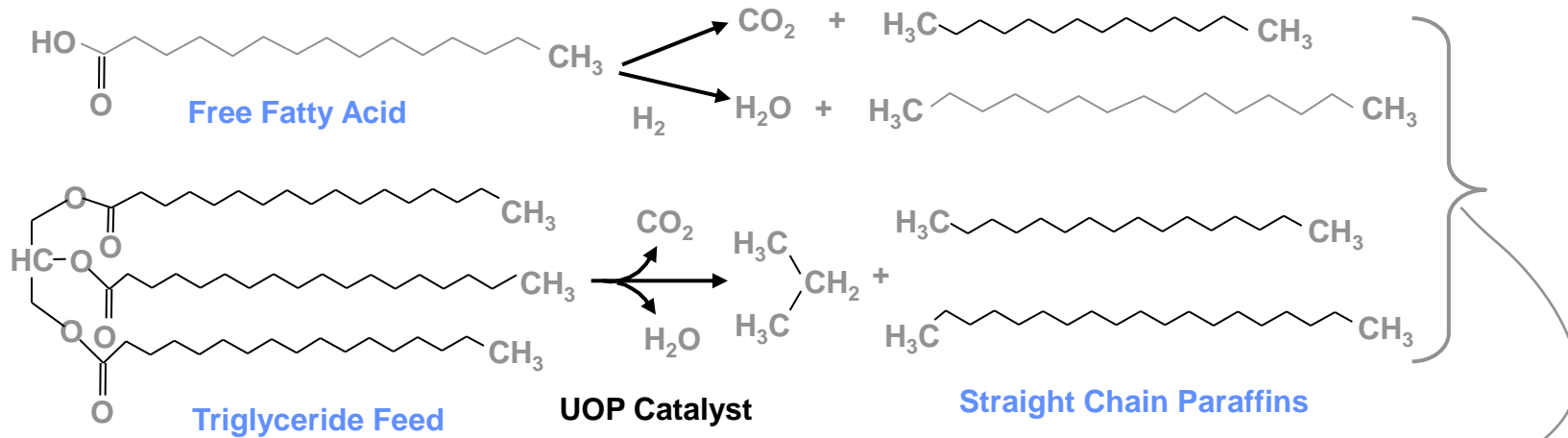
- **Passed Gate 4 in December 2009**
- **Ready For Process Design #1 in 1Q 2010**

***Enables UOP to guarantee new technology***

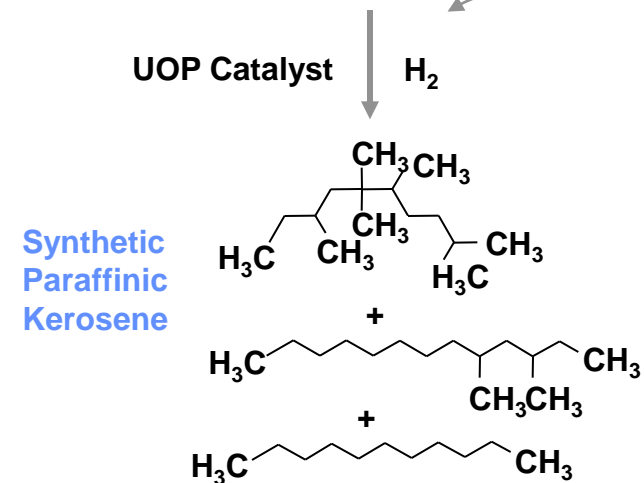
# Renewable Jet (Bio-SPK) Chemistry

## Feedstocks

Rapeseed  
Tallow  
Jatropha  
Soybean  
Algal Oils  
Palm Oil  
Camelina  
Greases

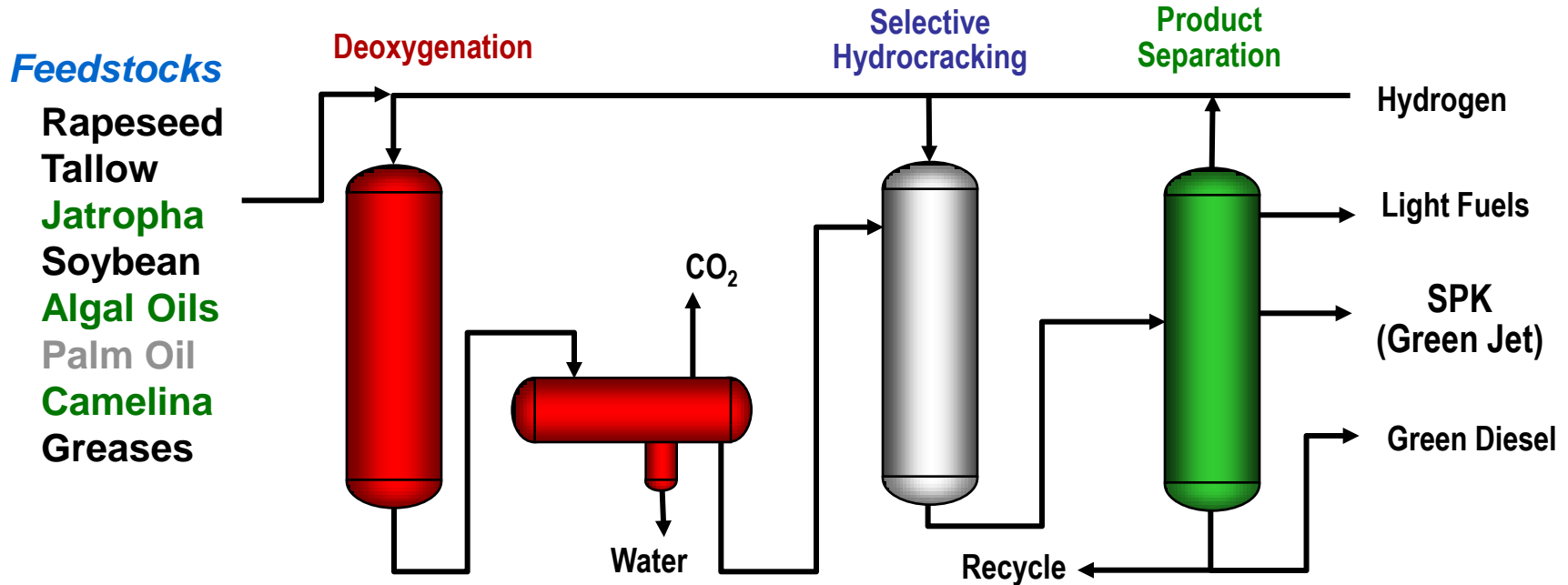


- Natural oils contain oxygen, have high molecular weight.
- First reaction removes oxygen – product is diesel range waxy paraffins
- Second reaction “cracks” diesel paraffins to smaller, highly branched molecules
- End product is same as molecules already present in aviation fuel
- End product is independent of starting oil



**Feedstock flexible, but with consistent product properties**

# UOP Renewable Jet Process



- Feedstock flexible
- Optimised for 50% SPK yield
- Makes valuable hydrocarbon co-products
  - Green Diesel
  - Green Naphtha
  - Green LPG
- Ability to swing anywhere between 'Max SPK' and 'Max Green Diesel' production to meet market demand

***Commercial scale, proven technology***

# Properties of SPK for Demo/Certification

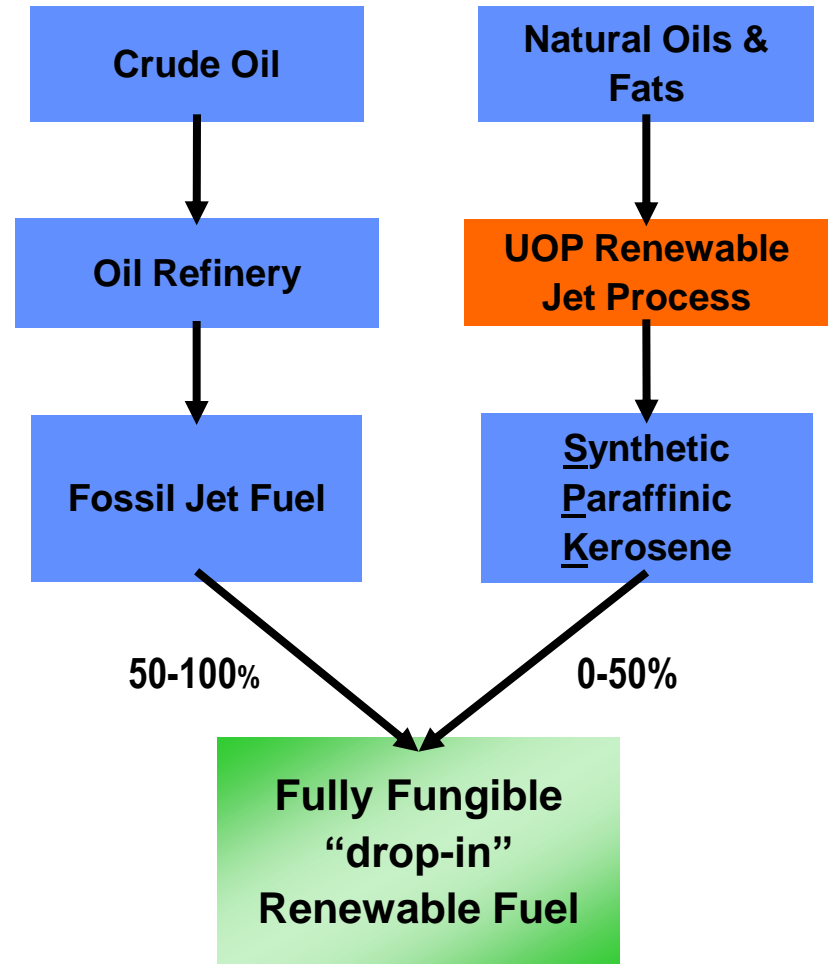
Description	Jet A-1 Specs	SPK (Jatropha)	SPK (Camelina)	SPK (Jatropha/Algae)
Flash Point, °C	Min 38	46.5	42.0	41.0
Freezing Point, °C	Max -47	-57.0	-63.5	-54.5
JFTOT@300°C	Filter dP, mmHg	max 25	0.0	0.0
	Tube Deposit Less Than	< 3	1.0	<1
Net heat of combustion, MJ/kg	min 42.8	44.3	44.0	44.2
Viscosity, -20 deg C, mm <sup>2</sup> /sec	max 8.0	3.66	3.33	3.51
Sulfur, ppm	max 3000	<1	<1	<1

- Over 20,000 US Gallons of Bio-SPK made for demonstration flights
- Certification supply work has uniquely allowed UOP to test the process and the catalyst at large Demo Capacity

***Fuel Samples from Different Sources Meet Key Properties***

# Use of Green Jet Fuel: Semi-Synthetic Jet Fuel (SSJF)

- Green Jet Fuel can meet all the key properties of petroleum derived aviation fuel
  - Flash point
  - Freeze Point
  - Stability
  - Heat of Combustion
- SPK does not contain aromatics so must be blended with a source of aromatics, such as fossil jet fuel



***A 'drop-in' biofuel for aviation***

# Synthetic Jet Fuels

D 1655

Petroleum



Synthetic Jet Fuels

Conventional Refinery Processes



Crude Oil



Syn-Crude



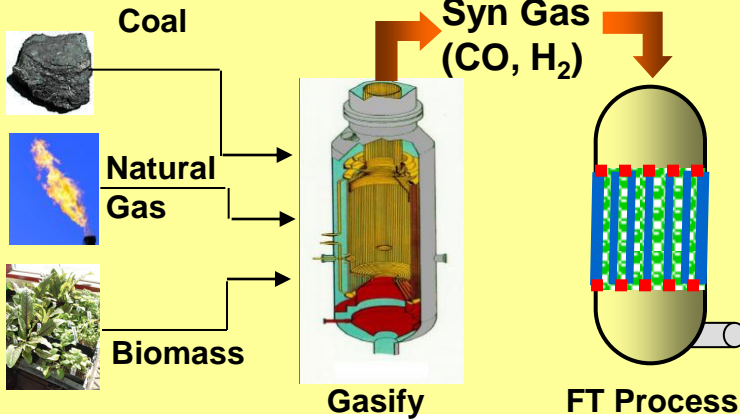
Bio-Crude



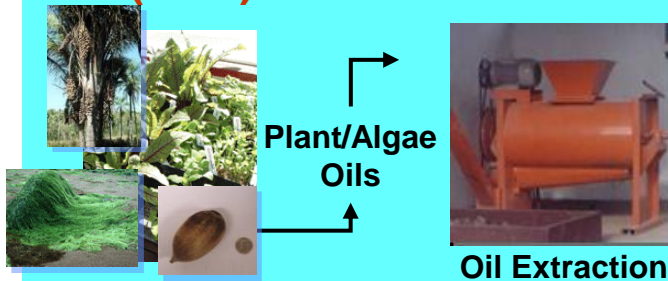
Jet Fuel

Hydroprocessing

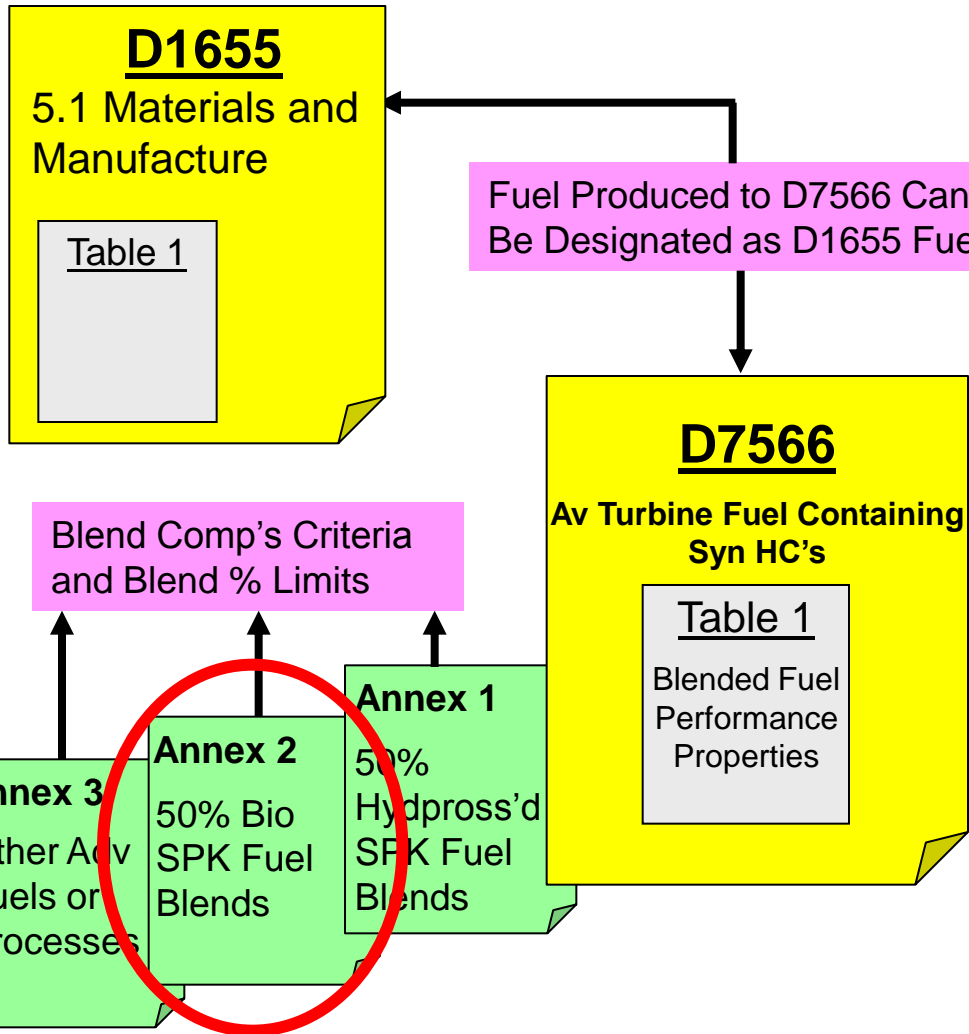
Fischer-Tropsch (FT)



Hydroprocessed Renewable Jet (HRJ) from Bio-Oils

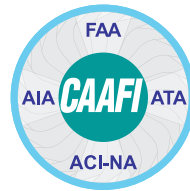


# ASTM D7566 Issued 1<sup>st</sup> Sept 09



- Body of Spec Applies to Finished Semi-Synthetic Fuel
- Annex for Each Class of Synthetic Blending Component
- Allow Re-Certification to D1655
- Annex 1
  - Hydroprocessed SPK
    - ◆ Includes 50% FT Fuel

***Certification of Bio-SPK to 50% targeted for early 2011***



# Completed Flight Demonstrations



**Feedstock:  
Jatropha oil**



• **Successful ANZ Flight Demo Date: Dec. 30, 2008**



**Feedstock:  
Jatropha and algal oil**



• **Successful CAL Flight Demo Date: Jan. 7, 2009**



**Feedstock: Camelina,  
Jatropha and algal oil**



• **Successful JAL Flight Demo Date: Jan. 30, 2009**



• **KLM European Test Flight: November 23, 2009**

42 Observers  
Onboard  
**Camelina**



# Military Testing

- **Military demonstrations**

- Up to 600,000 gallons of fuel made from camelina, algae and animal fats for U.S. DESC
  - U.S. Air Force A-10 Thunderbolt II (camelina)
  - Navy F/A-18 Green Hornet (camelina)
- Royal Netherlands Air Force Apache Helicopter (algae & used cooking oil)



***Green Jet Fuel Meets Flight Specifications***

# US Military Supply Contracts

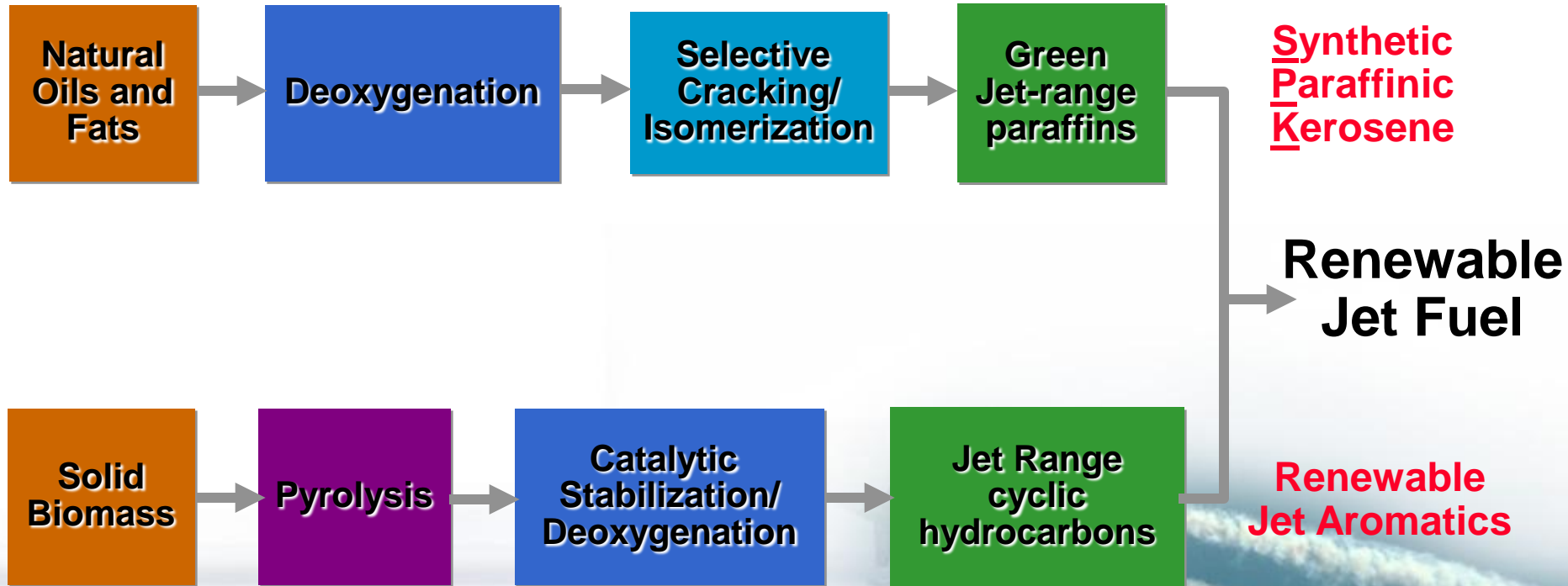
- US Military accelerating their biofuel certification program –
  - UOP is producing up to 600,000 gallons of jet fuel for an unprecedented HRJ-5/8 supply award from DESC

## *Contract awarded:*

Line item	Volume (gallons)	Type of Fuel	Feedstock	Prime	Producer	Comment
1	40,000	Navy HRJ5	Camelina	Sustainable Oils	UOP	
2	150,000	Navy HRJ5	Camelina	Sustainable Oils	UOP	Optional amount
3	100,000	AF HRJ8	Camelina	Sustainable Oils	UOP	
4	100,000	AF HRJ8	Tallow	UOP (Cargill FS)	UOP	
5	100,000	AF HRJ8	Camelina	Sustainable Oils	UOP	Optional amount
6	100,000	AF HRJ8	Tallow	UOP (Cargill FS)	UOP	Optional amount
7	1,500	Navy HRJ5	Algal oil	Solazyme	UOP	

***All from 2<sup>nd</sup> Generation Sustainable Feedstock***

# 2<sup>nd</sup> Generation Renewable Jet Fuel: Fully Renewable Jet Fuel from Oils and Biomass



# The Future: 100% Renewable Jet



***The Boeing hydroplane ran on 98% Bio-SPK and 2% renewable aromatics at SeaFair, Seattle in Aug 2009***

	<b>Jet A1 Spec</b>	<b>Starting SPK</b>	<b>Woody Pyrolysis Oil Aromatics</b>
<b>Freeze Point (°C)</b>	<b>-47</b>	<b>-63</b>	<b>-53</b>
<b>Flash Point (°C)</b>	<b>39</b>	<b>42</b>	<b>52</b>
<b>Density (g/mL)</b>	<b>0.775</b>	<b>0.753</b>	<b>0.863</b>

***Woody Pyrolysis oil aromatics produced through a UOP-NREL-PNNL CRADA***

# Summary

- **UOP's Renewable Jet Process was rapidly developed through key collaborations and by leveraging UOP's world class hydroprocessing technology and expertise**
- **UOP's Renewable Jet Process is ready to produce Bio-SPK in commercial quantities**
- **A multidisciplinary team succeeded in producing and testing sustainable SPK**
- **Certification of SPK to use in blends up to 50% is planned for early 2011.**



# Acknowledgements

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**Preguntas?**

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