

Green Jet and Green Diesel Second Generation Biofuel

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MOVE THE WORLD.

About JetE

- JetE was started by Gordon Ommen – founder of US Bioenergy – in 2010 to develop a modular small scale system to produce drop in replacement middle distillate fuels
- Today we are technically ready to deploy
 - Available lab for feedstock characterization
 - Complete process engineering package



Green diesel and jet fuel

- Green diesel and jet fuel are drop in **replacement** for petroleum middle distillates
- Meet specifications
 - Jet MIL-DTL-83133F
 - Diesel D975
- Obtained by hydrotreating and isomerization of triglycerides (TAG's) and free fatty acids (FFA's).
- TAG's and FFA's are the main components of biologically derived fats, oils and greases (FOG's)
- Simple and well understood chemistry derived – **but not completely identical** – from common petroleum refining operations
- Marketability and suitability of the product already proven by major oil companies
 - e.g. UOP, Neste, ConocoPhillips, OVM, etc.
- JetE process builds on top of this by scaling it down the process and making it independent from existing petroleum refining infrastructure



Green Diesel vs. Biodiesel

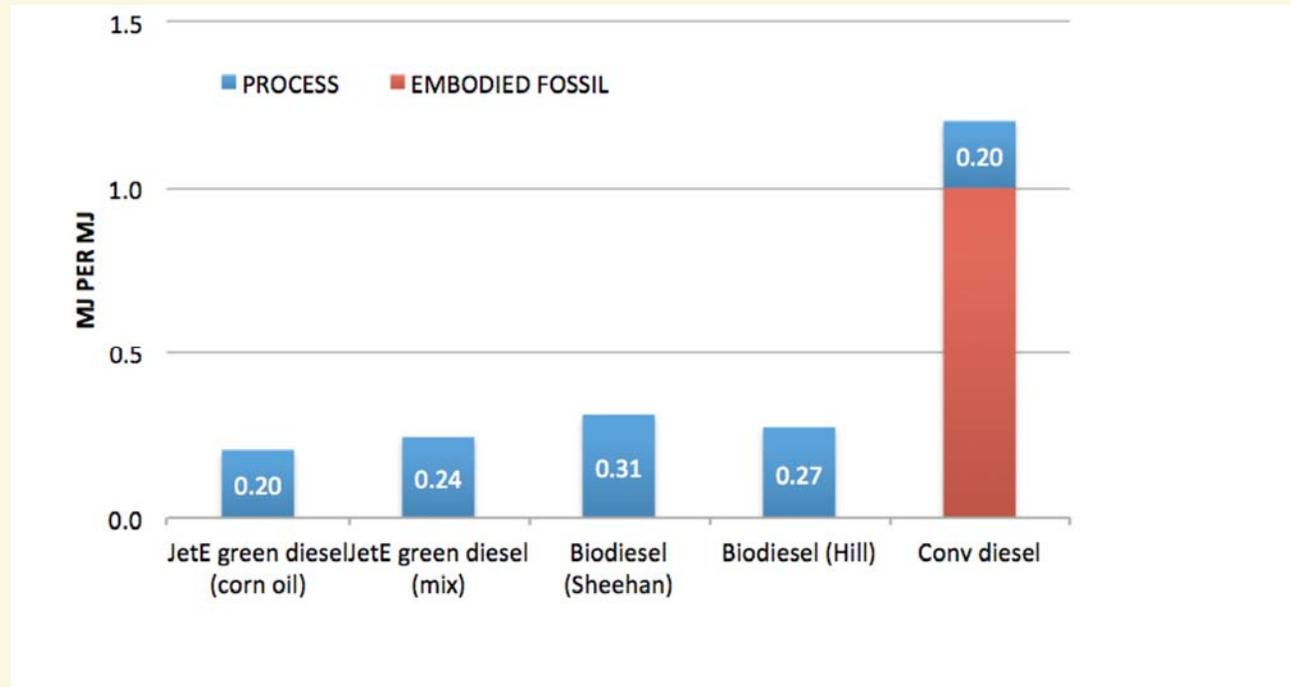
- Hydrotreated FOG's cannot be distinguished from low sulfur middle distillates
- Can be used as is or blended in any percentage
- Have equivalent physical and chemical stability
- Have same energy content
- Are renewable drop in replacement **NOT** a new fuel like biodiesel
- Green Diesel outperforms biodiesel in several criteria

	Biodiesel	Green Diesel
Oxygen %	~ 11	0
Sulfur	< 10 ppm	<10 ppm
LHV (MJ/kg)	~ 38	44
LHV (% of fossil fuel)	88-92	100
Cloud point (°C)	-5	-15 to -30 (after isomerization)
Distillation 10-90 % pt	340-355	265-320
Cetane Number	50	>80



*Indicative published results
Source: UOP, Neste, etc.*

Green diesel. Better than biodiesel and just like “real diesel” with a sixth of the carbon footprint



Better carbon footprint than conventional biodiesel

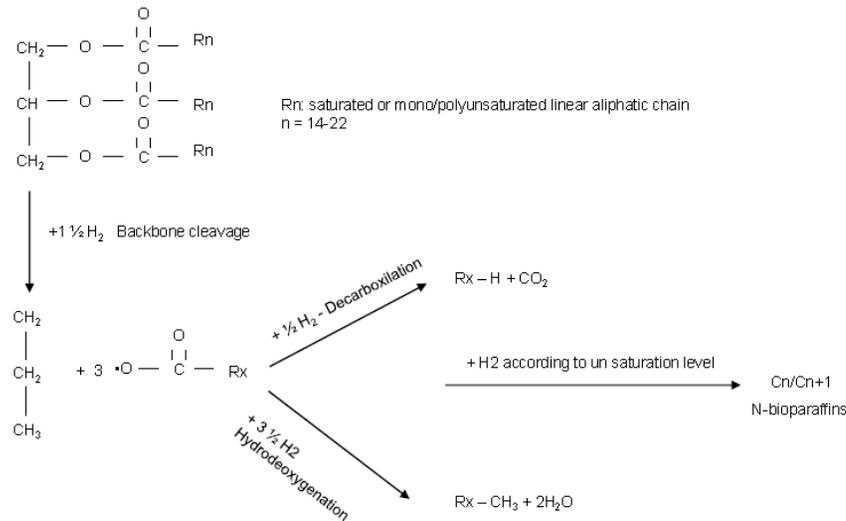
Suitable feedstock

- Any vegetable oil
 - Corn, Soy, Sunflower, Palm, Castor, Camelina, Jatropha, etc.
- Palm oil and its fraction
- Algal oil
- Animal fats and derived products
 - Edible and inedible tallow, yellow grease, trap grease, slaughter house DAF sludge, fish oil, lard
- By- and co-products of the food processing industry
 - Spent restaurant oil

JetE process can accommodate any FOG



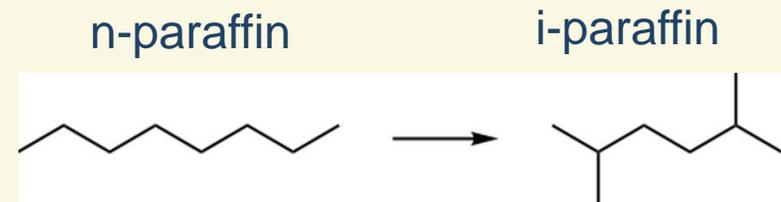
The chemistry of fatty acid



Catalytic reaction over Ni-MO under high hydrogen pressure converts fatty acids into paraffins with high yield (>80% w/w)

Propane co-product is recovered for hydrogen production

Selective hydrocracking and isomerization adjusts paraffins' length and degree of branching to reach desired product specifications



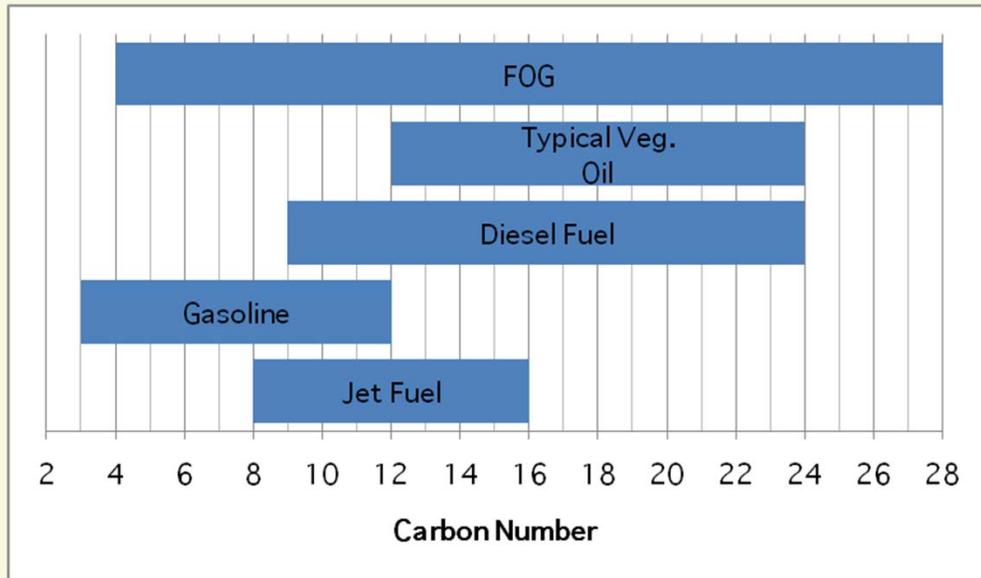
The process does not produce significant quantities of aromatic compounds



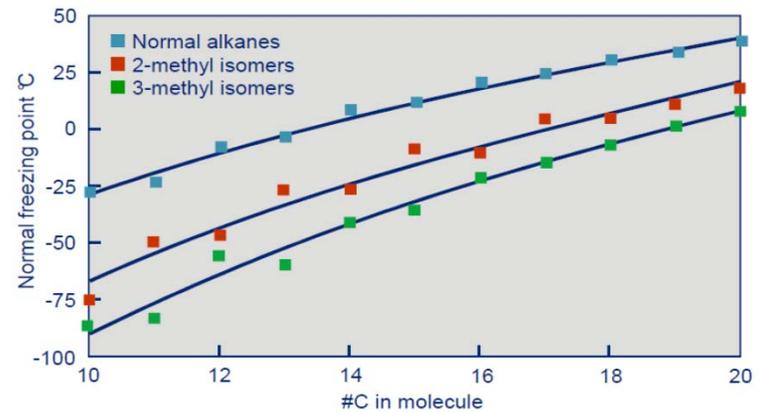
Biomass'11 - Grand Forks, ND

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Importance of carbon number and degree of branching



Chain length controls the product type
Degree of branching controls the freezing point of the product



Hydrotreating

- The reaction takes place over an heterogeneous catalyst (supported metal or zeolites) at medium to high temperature and pressure
- Large variety of commercially available catalysts
- Highly exothermic
- TAG backbone cleavage yields high value propane co-product
- Some other lights are produced by cracking of aliphatic chains
- Main saturations and deoxygenation mechanisms are decarboxylation and hydrodeoxygenation.
 - Some level of control between the steps is afforded by operating conditions
 - Trade off between hydrogen consumption and carbon losses.
- Subsequent isomerization step may be required to meet cold flow characteristics

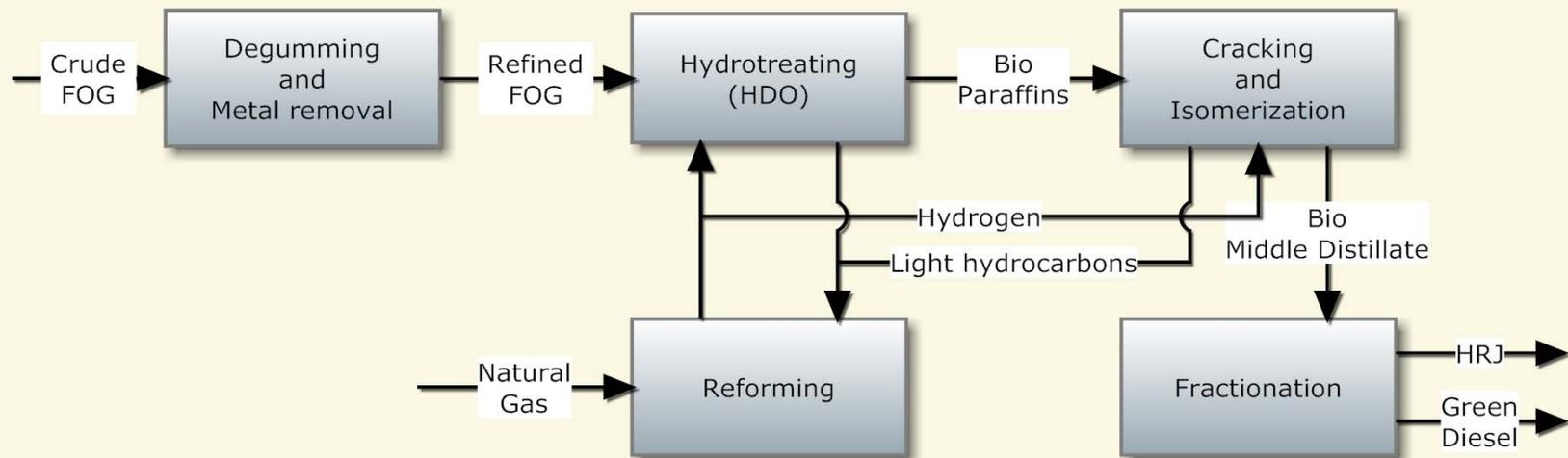
Operating condition	Typical	Min	Max
Space velocity (hr ⁻¹)	1.5	<0.5	5
Temperature (°C)	390	<300	450
Pressure (bar)	50	<30	--



Confidential draft for
discussion

Typical hydrotreater output

Feed	Crude soy bean oil
% Feed	100
% Hydrogen (w/w)	1.5-3.8
Products	Water, CO ₂ , C15-C18, Lights
% Water – CO ₂	12-16
% Lights (<C15)	2-5
% C15-C18	83-89
Cetane	80-100
Sulfur	<10 ppm



Isomerization

- The chemical process by which a compound is transformed into any of its isomeric forms, *i.e.*, forms with the same *chemical composition* but with different *structure* or configuration and, hence, generally with different physical and *chemical properties*.
- Isomerization of linear alkenes lowers their freezing point hence improves the cold flow characteristic of the fuel
- Since isomerization entails cracking, some product losses are unavoidable and the average chain carbon number of the product is reduced.

Operating condition	Typical	Min	Max
Space velocity (hr ⁻¹)	1	0.5	10
Temperature (°C)	330	<200	500
Pressure (bar)	70	30	--

MN Dept of Ag. Next Gen Project

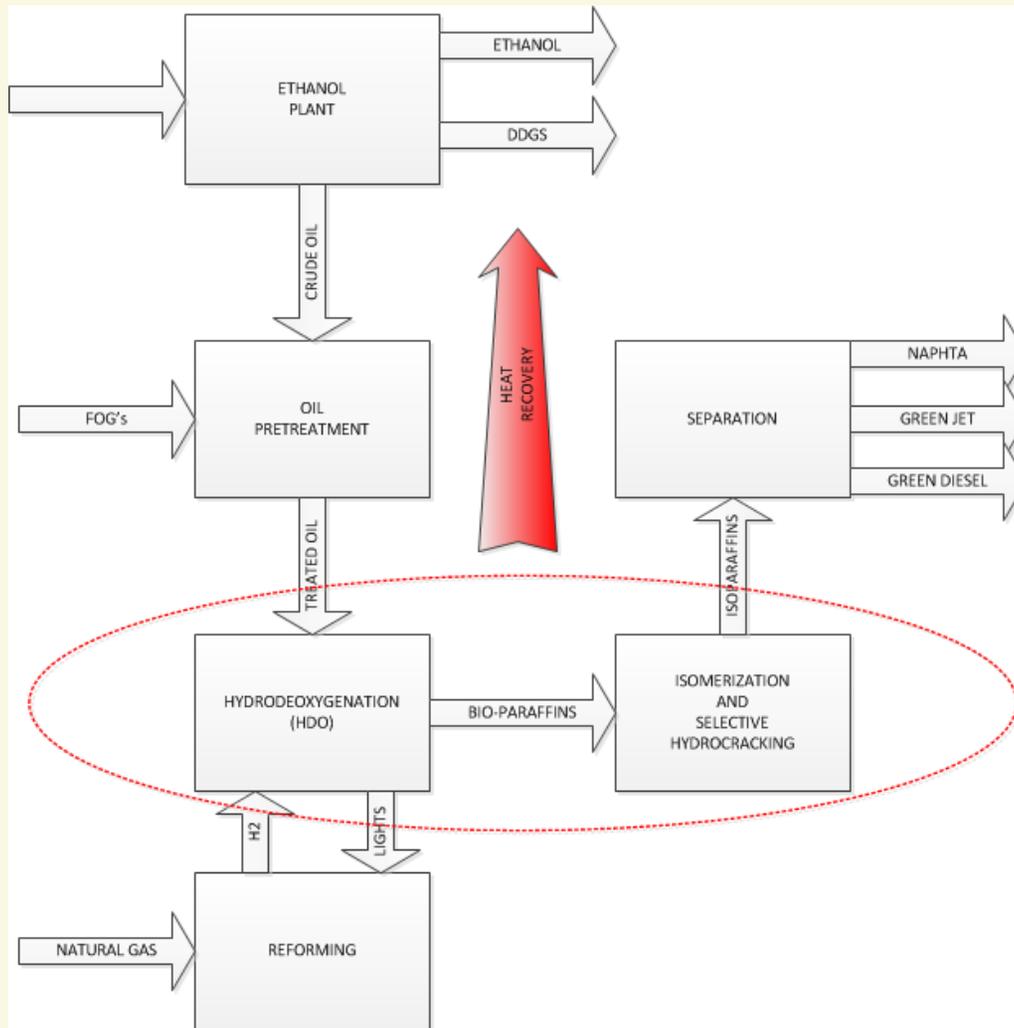
- To: demonstrate the feasibility of integrating the JetE process for drop-in replacement diesel and jet biofuels into an existing corn-ethanol plants
- In collaboration with AI-Corn
- Why it is relevant
 - Drop-in replacement biofuels are biofuels which unlike ethanol or bio-diesel are chemically undistinguishable from their fossil equivalent. No more blending level and compatibilities issues.
 - These 2nd generation biofuels will be increasingly important as the technology develops. Critical relevance for current and future biofuel policies.
 - We need to begin the transformation of corn to ethanol plants into true biorefineries with multiple products and ag based feedstocks.



Project tasks

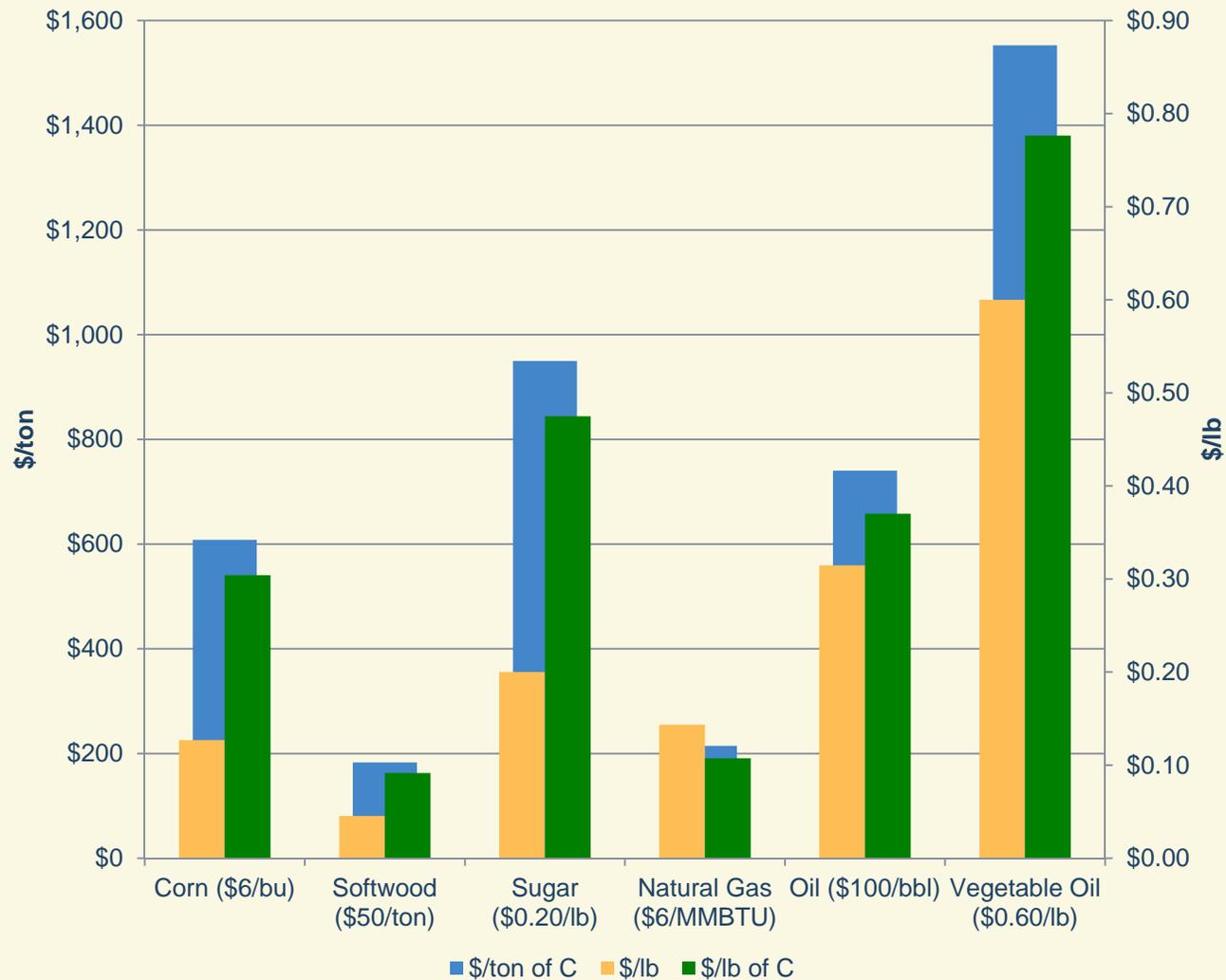
- Completed
 - Feedstock availability and economics
 - Analysis of energy integration
 - Conceptual process engineering
 - Life Cycle Assessment
- Being finalized
 - Local Economic Impact
 - Replicability for State-Wide implementation

Corn Ethanol and JetE Microfiner Integration



Besides using corn oil, the JetE Microfiner can reduce the energy demand of the ethanol plant by driving considerable amount of waste heat to the ethanol production process

The cost of carbon from different feedstock (based on C w%)



These cost do not keep into account the loss of carbon because of reduction.

Because biomass based feedstock are not highly reduced are better feedstock for chemicals than fuels which may require complete reduction

Where we are now?

- The integration and the production of next generation ethanol plants is technically feasible
- The technical and environmental benefits of the fuel are very clear
- Feedstock economics are considerably challenging
- High dependency on mandated support mechanism makes the financing of a plant difficult
- Development of new feedstock is critical and the technology is rather suitable given its flexibility.



Thank you

Q&A

