Petrogenium.

Biomass-based liquid fuels by (co)processing in refinery units

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Who is Colin Schaverien ?

Petrogenium

- **Practice Lead Renewable Resources**: 2017 – present

Shell

- 30 years in various R&D and Innovation leadership roles including **Biorefining R & D Programme Leader**: 2005 - 2015

Education

- Postdoctoral Fellowships at UC Berkeley and MIT
- BSc & PhD at University of Bristol

Introduction to Petrogenium.

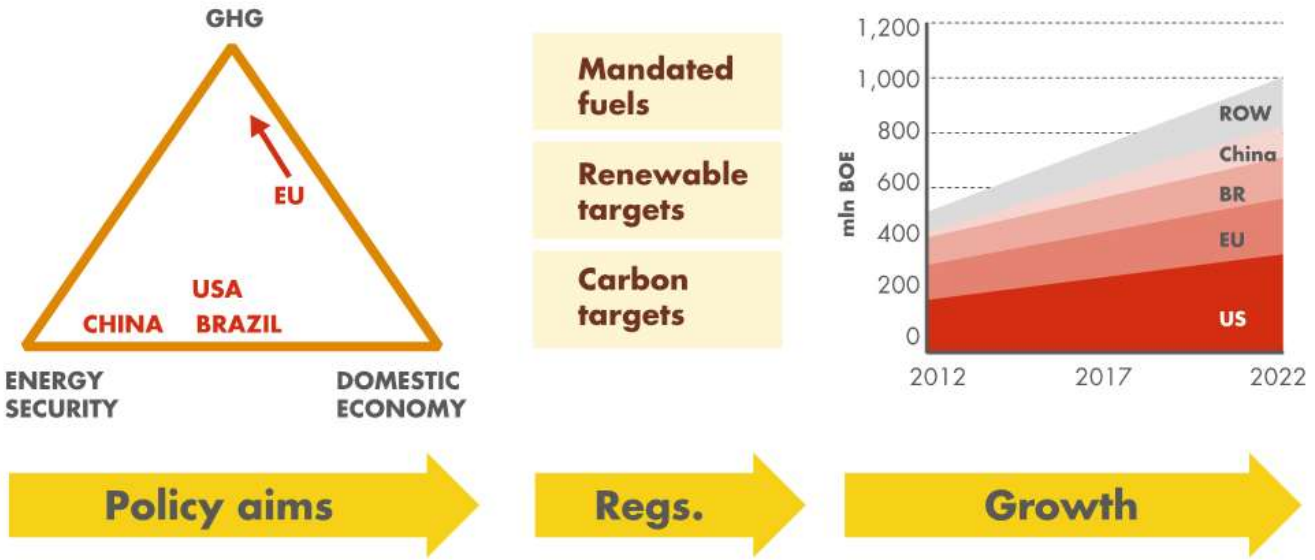
- Company founded in 2015
- Office in Amsterdam area, the Netherlands
- Currently about 50+ consultants, target 65 by end 2019
- Most consultants are international world-class technical, commercial and consultancy experts with 25+ years of oil industry experience in asset owner roles.
- Petrogenium provides support to Downstream Oil, Petrochemicals Industry, Upstream and the **Renewable Resources** areas in:-
  1. Technical and operational support
  2. Business improvement
  3. Strategy consulting
  4. License to operate

Why do biofuels ?

Government policies drive change in form of mandates.

More than 65 countries have developed renewable transport fuels policies

Biofuels global demand outlook



Today's road transport fuels

- The most widely used transport biofuels are ethanol and biodiesel
- Ethanol usually made by fermenting crops high in sugar
- Biodiesel (FAME) is made from vegetable oil crops through transesterification
- Hydro-treating (HVO) uses a different process and can be blended at higher concentrations

Organic raw material

Sugar cane Corn Wheat

Rape seed Palm oil Soya bean

Process	Product
Fermentation	Ethanol (blend with gasoline)
Transesterification	FAME (blend with diesel)
Hydro-treating	HVO (blend with diesel)

RED II: Renewable energy targets for 2030

- Member states must require fuel suppliers to supply a **minimum of 14** % of the energy consumed in road and rail transport by 2030 as renewable energy.

- Increasing from **1.5 % in 2021** (in energy terms) to **6.8 % in 2030**, including at least **3.6 % of advanced biofuels**.
  - Advanced biofuels: feedstocks in Annex IX, part A (e.g. no vegetable oils). Double-counted towards both 3.6 % and 14% target.

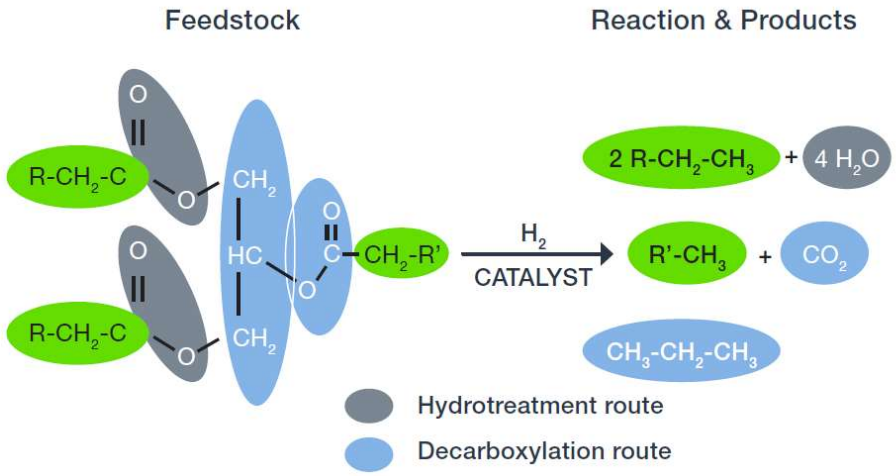
  - Biofuels from feeds in Annex IX, Part B (only UCO & animal fats) **capped at 1.7 % in 2030**. Also to be double counted towards the 14% target.

- Advanced aviation (and marine) fuels count 1.2 times their renewable energy content.

- To minimize indirect Land-Use Change impact, **food-based biofuels** to be reduced from **7 % in 2021 to 3.8 % in 2030**.

Hydrotreated Vegetable oils (HVO)

FAME blending limited to 7% by OEMs. Constraint overcome with HVO



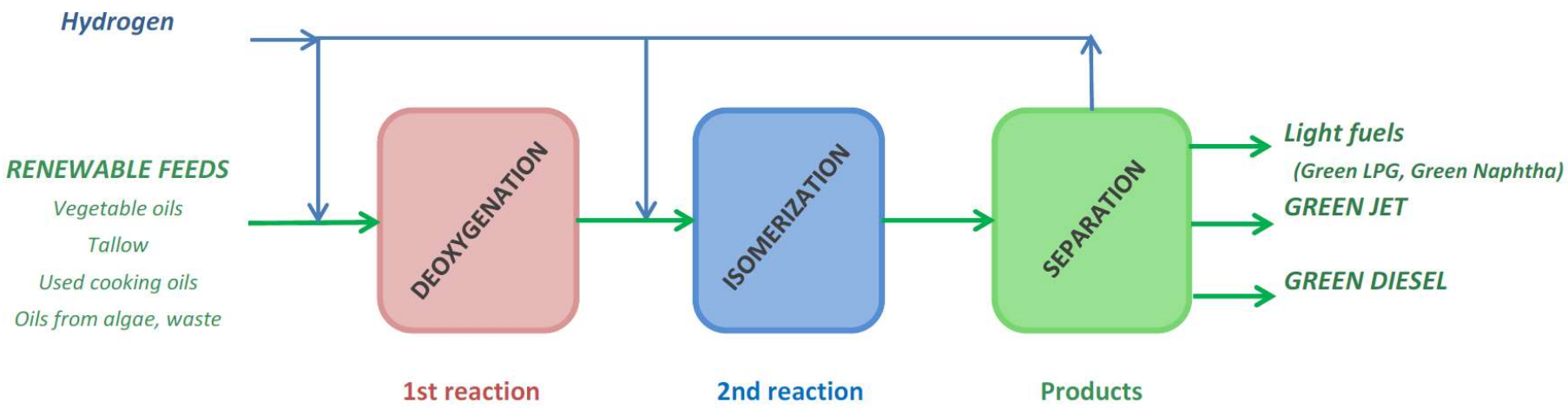
Yields (wt %):

HVO	80
Propane	5
H_2O	9
CO, CO_2	6

} Ratio depends on T, cat, pp H_2

H_2 consumption 3 wt %

Simplified HVO manufacturing scheme



Fatty acids + triglycerides	Straight chain alkanes	Branched alkanes
	▪ T = 320 °C, ▪ > 60 bar H_2/H_2S ▪ CoMo or NiMo	▪ ≥ 350 °C, 60 bar ▪ Rigorous separation of H_2S, CO, CO_2, H_2O ▪ Pt/C dewaxing catalyst

Vegetable oil hydrotreating (HVO)

Advantages:

- Uses known refinery technologies
- The end product is a **high quality pure bio-alkane**, fully fungible with diesel, allowable in multi-product pipelines, with improved cold flow properties, high cetane (~80) and no blend wall limits.
- **WTW GHG emissions** are similar, or lower, than FAMEs based on the same feedstock i.e. ~30 – 50% reduction over fossil diesel (higher if using waste oils)
- **HVO quality premium** in blending versus FAMEs
  - Lower density
  - Similar energy content per unit volume
  - Infrastructure requirements
  - Cost of FAME biodiesel

Co-processing in AGO HDS unit

Co-processing ca. 5 wt % vegetable-oil like feeds to make 10 ppm S diesel containing in-situ bio-component

High Sulphur Gas oil + 5 wt % vegetable oil

H_2 →

On spec AGO containing bio-hydrocarbons

(+ C_1, C_2, C_3, CO, CO_2, H_2O)

Done at Preem (Gotenburg), Repsol (Cepsa) and Galp (Sines) and others

Vegetable Oils to biojet

Aviation growing at 5 %/year. Currently accounts for 2 - 3% of worldwide CO_2 emissions

No mandates (RFS2), RINs or subsidies to support low carbon biojet in USA. Although REDII will include renewable jet. Biojet should:-

- Meet fuel performance requirements
- Require no change to airplanes or engines
- Require no change to infrastructure

- 5 pathways qualified in ASTM D7566 “Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons”; only 1 of which is commercial

- > 100,000 commercial flights used low carbon fuels in the last 10 years according to IATA

- Almost all biojet from Neste and World Energy (ex AltAir) in Paramount refinery, LA.

Fischer Tropsch routes (BtL)

CHORen history

- 1 MW_{th} pilot plant in Freiburg operated 1988 – 2004. Fuel to DaimlerChrysler & VW for testing
- In 2003, gasifier scaled up from 1 MW_{th} to 45 MW_{th} (= 15 kta BtL)
- In 2005, Shell Fischer Tropsch technology licensed. Shell, DC and VW invested.
- In 2009, gasification section commissioning started
- In 2011, bankruptcy proceedings began

- **CHORen technical challenges**
  - FT very sensitive to syngas impurities
  - Technology works - pilot plant ran for many years. But i) getting correct H_2/CO ratio and ii) high enough purity - as syngas from biomass very different to syngas from NG or coal

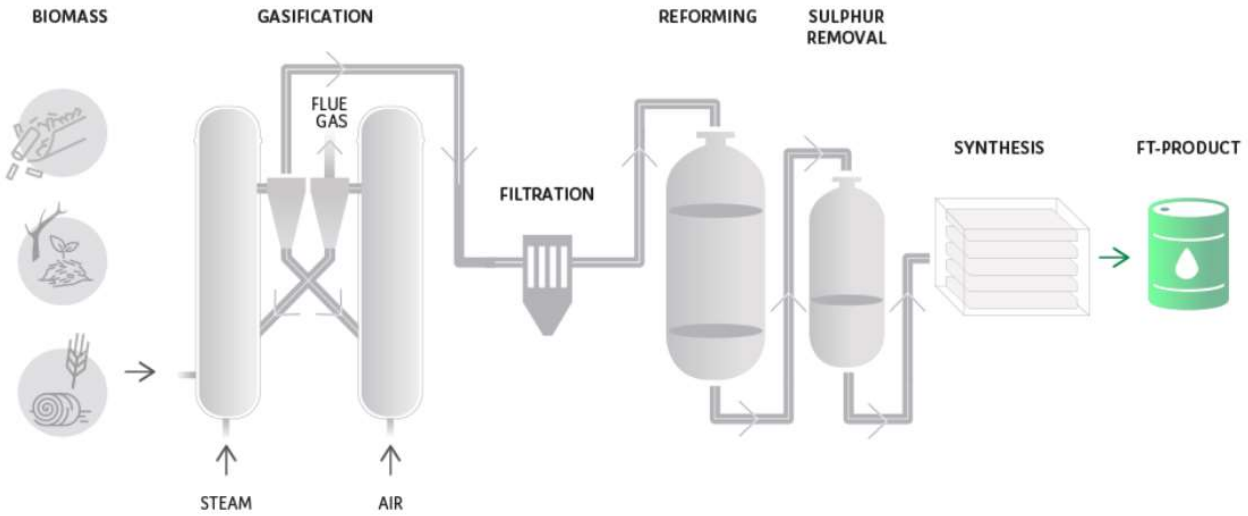
Current BtL projects

- Fulcrum Bioenergy to convert Municipal Solid Waste via gasification and FT. Constructing commercial plant ("Sierra plant") near Reno, NV, USA. To start up early 2020.

- Red Rock Biofuels to construct demo in Oregon

COMSYN

Compact Gasification and Synthesis process for Transport Fuels for the decentralized production of FT-wax



Challenges

- Syngas clean up before FT
- Route to technology maturation and scale up ?
- Consistency of biomass composition ?
- Although chain length needs to be reduced for transport fuel applications, FT wax is, in itself, a valuable product.

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Renewable Resources: because carbon matters

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