Biopropane

Production, economics and carbon footprint

Eric Johnson

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To be perfectly clear....

Assessment of the Market, Renewable Heat Potential, Cost, Performance, and Characteristics of Biopropane for Gas Grid Injection

Watch this tender

Summary
Please scroll down for full details

Threshold: Below OJEU

Organisation: Department of Energy and Climate Change (DECC)
Everyone else has a ‘renewables’ story....
Now LPG has one!

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\]

Biopropane
Biopropane: a renewable you can trust

- Drop-in replacement
- Well-known and proven technology
- Larger carbon savings than other commercial biofuels
- Avoids the food-vs-fuel stigma
Lots of ways to make it

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Process</th>
<th>Outputs</th>
<th>Developer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable oil/animal fat</td>
<td>HDRD</td>
<td>Biodiesel, bio-propane (5-8%)</td>
<td>Neste Oil (NExBTL); Dynamic Fuels, ConocoPhillips</td>
</tr>
<tr>
<td>Cellulosic biomass (wood)/sugar/starch (crops)</td>
<td>MTG gasification</td>
<td>Gasoline, bio-propane (10-30%)</td>
<td>ExxonMobil (MTG); Haldor Topsoe (TIGAS)</td>
</tr>
<tr>
<td></td>
<td>Gasification/direct synthesis</td>
<td>DME, gasoline or bio-propane (significant %)</td>
<td>Japan Synthesis Gas Co</td>
</tr>
<tr>
<td></td>
<td>Fischer-Tropsch gasification</td>
<td>Diesel, naphtha, lubes, bio-propane (small volumes)</td>
<td>Shell (GTL); Maverick Fuels</td>
</tr>
<tr>
<td></td>
<td>Pyrolysis/hydrogenation</td>
<td>Gasoline, diesel, kerosene, bio-propane (up to 15%)</td>
<td>Ensyn (RTP); GTI (IH2)</td>
</tr>
<tr>
<td>Glycerine</td>
<td>Dehydration/hydrogenation</td>
<td>Bio-ethane or bio-propane</td>
<td>Bio-fuel Solution</td>
</tr>
<tr>
<td></td>
<td>Methanol gasification</td>
<td>Methanol, DME, bio-propane (small volumes)</td>
<td>BioMCN</td>
</tr>
<tr>
<td></td>
<td>Aqueous Phase Reforming</td>
<td>Various fuels, including bio-propane</td>
<td>VES (BioForming)</td>
</tr>
<tr>
<td>Sugar/starch (crops)</td>
<td>Supercritical fermentation</td>
<td>Various fuels, including bio-propane</td>
<td>C3 Bioenergy (US)</td>
</tr>
</tbody>
</table>
But only one way, so far, is commercial
Biopropane is the backbone of natural fats
Some 200 ktons capacity now

- Neste
- ENI
- Syntroleum
- Valero
- Conoco, UPM
- Total, Petrobras
- Also licensed by UOP

And potentially a lot more to come.
Investment committee: future capacity
## Mass balance

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetable oil</td>
<td>1.180</td>
<td>tonne</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>0.035</td>
<td>tonne</td>
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<tr>
<td>Natural gas</td>
<td>185299</td>
<td>Btu</td>
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<tr>
<td>Electricity</td>
<td>xxxx</td>
<td>kWh</td>
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</table>

### Outputs

<table>
<thead>
<tr>
<th>Outputs</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewable diesel</td>
<td>1.0000</td>
<td>tonne</td>
</tr>
<tr>
<td>Propane</td>
<td>0.0625</td>
<td>tonne</td>
</tr>
<tr>
<td>Off-gases</td>
<td>0.0188</td>
<td>tonne</td>
</tr>
<tr>
<td>Bionaphtha</td>
<td>0.0063</td>
<td>tonne</td>
</tr>
</tbody>
</table>
Crude oil vs veg oil: are they correlated?

Diagram 1: Price Behaviour of Vegetable Oils and Brent Crude Petroleum
Biopropane is a residue

7% Biopropane

90% HVO biodiesel

Some governments agree, some don’t.
Residue means very low footprint

- Biopropane: 10 g CO$_2$e/megajoule
- Fossil fuel comparator: 77-83.8 g and should be higher
- Carbon savings
  - bioprop: approx 3 t CO$_2$/t substituted
  - rapeseed FAME biodiesel: 1.4 t/t
- And avoids food-vs-fuel debate
Footprints are a tricky business

• Apples and oranges
• The main variables involved
  – Feedstock: palm, rape, soy, PFAD, UCO, tallow
  – For palm: methane capture or not
  – Allocation at the mill and the HVO plant: economic, energy (or mass)
  – Indirect land-use-change (iLUC)
• Defining the envelope, and ‘additionality’

*The answer can range significantly!*
Biopropylene is going commercial