Achieving scale in Renewable Propane production

Dr Keith Simons, Head of Research and Development
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Global LPG production

- Fossil Propane/butane traditionally a by-product from gas processing/refining
- Currently only one commercial route (HVO/HEFA) to renewable Propane based on fats and oils
- rLPG often reformed to hydrogen to reduce the CI of diesel/SAF
- The market is comparable/bigger than aviation fuel!
- SHV Energy has the bold ambition to replace all the fossil fuel volume we sourced in 2015 with 100% renewably and sustainably sourced energy by 2040
- WLPGA membership targeting up to 50% substitution of the 2050 global non-chemical LPG demand
Our business provides decentralised, low-carbon and clean energy solutions to 30 million business and residential customers worldwide.

We are a leading global distributor of off-grid energy, such as LPG and LNG, and active in sustainable fuels and renewable energy solutions.
Our domestic, leisure, commercial, industrial and transportation customers benefit from using our cleaner energy sources.

**Heating**
LPG is used in off-grid homes with boilers and heating appliances, in offices and by farmers for heating greenhouses.

**Transport**
LPG is the world’s most popular alternative automotive fuel. It’s used in over 25 million vehicles around the globe.

**Cooking**
LPG provides a cleaner energy source for cooking than coal or heating oil, and it can be connected to any home cooking appliance.

**Commercial**
LPG is used by commercial customers to reduce their use of higher-carbon, polluting energy sources. In developing countries, LPG replaces hazardous solid fuel used for cooking stoves.

**Industry**
LNG is used for a wide range of industrial applications and processes, such as heating, cooling, drying, processing and food production.

**Domestic**
LPG provides energy for the home, as well as for a range of leisure activities from BBQ grills to caravanning and mobile catering.
How We Supply Energy
- A scaled solution

The fastest route to decarbonization is defossilisation via drop-in replacement fuels

This infographic depicts the most extensive version of our supply chain and is not representative of every supply chain within the group.
The technical challenge facing the renewable fuels sector – On-Purpose Production (and oxygen removal)

- Feedstock potential
- Increasing feedstock availability
- Conversion Selectivity to target fuels

- HVO Propane
- Renewable Propane
- HEFA SAF
- rDME

- Fossil Fuels

Thermodynamic gap
- Excess Heat
- CO2
- Coke
- Other “Off-gas”
- (Expensive) Water
On-Purpose Route to renewable LPG from bioethanol

- Ethanol to Hydrocarbon route based on modified Methanol to Gasoline Process
- Catalyst screening has identified viable pathway from to produce LPG together with aromatics in a 2:1 ratio
- Deactivation by coking inhibited by using proprietary catalyst
- Mono-aromatics have potential to be qualified as ASTM SAF
- Hydrogen free!
- Ethanol market currently in rapid growth (1st generation market size in 2021 ca. 80M tonnes)

(Process also in development by UGI/Vertimass, Ekobenz and others)

Screening the conversion of Ethanol to hydrocarbons over catalyst candidates. (Note only conversion to C3 and C4s shown).

Stable two week operation of conversion of Ethanol to hydrocarbons over proprietary catalyst. (Forced conditions at 400 hours leading to a successful air regeneration at 500 hours)

*Aromatics
Benzene
Toluene
Ethyl-Benzene
Para-Xylene
1-ethyl-3-methyl benzene
1,2,4 trimethyl benzene
1-methyl-2-isopropyl-benzene
Currently being scaled-up through pilot scale and beyond!

At Drochaid Research, St Andrews and GTI Energy, Chicago plus 3rd party commercial catalyst developer
On-Purpose Route to renewable propane from butyric acid or n-butanol via hydrothermal liquefaction

Collaboration with Aston University, UK

• 95% hydrocarbon selectivity to propane
• Ease of separation
• CO₂ capture-ready (low-/negative-carbon)
• Similar results with n-butanol
• Hydrogen free!

Future Challenges

• Switch from a batch to a continuous process
• Process Scale-up
• Identify Earth-abundant catalysts
• Deployment of ABE process for feedstock
On-Purpose Route to renewable propane from CO₂ and hydrogen – “Power to Propane”

- Colours represent distinct catalyst formulation
- The results are for single pass conversion
- Every jump indicates the results of a different experimental condition
- The reaction conditions are comparable to typical Fischer Tropsch conditions
- CO₂ conversion is around 10 – 15 %
- C₃ is mainly paraffins (upto 80% selectivity)
- As expected CH₄ was also produced
- H₂:CO₂ ratio barely affects the selectivity
- Syngas also a viable feedstock
- Also being investigated by CO2MOS EU Project and others

Using H₂ and CO₂ as the feed (H₂:CO₂ ~ 3-4)

SHV Energy – unpublished results
On-Purpose Route to renewable propane from Anaerobic Digestion biogas

BioLPG for Clean Cooking in Sub-Saharan Africa: Present and Future Feasibility of Technologies, Feedstocks, Enabling Conditions and Financing; Chen et al Energies 2021, 14(13), 3916
Conclusions

• Renewable propane is an important defossilised clean burning fuel for many applications and customers where a connection to the natural gas grid is not available
• The market size is comparable to aviation fuel (300ktpa)
• A range of viable on-purpose routes to renewable propane are under advanced development
• Major willingness for LPG sector to engage with technology developers
• The market is already at scale, technology routes under development can benefit from existing feedstock options
• Enough feedstock to replace existing and future market
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