ELECTRO-BIOFUELS FOR AFFORDABLE SUSTAINABLE AVIATION

Hybrid electro-biofuels combine electrolytic hydrogen production with biomass gasification to achieve the perfect blend of syngas for affordable and scalable sustainable aviation fuel (SAF) production.

A perfect marriage

Electrofuels derived from renewable electricity sources and electrolytic green hydrogen may be scalable in the future. These electrofuels are also referred to as power to liquids or PtL fuels.

A pertinent question about electrofuels is whether they are the best use of green electrons whilst there is such a surging demand for electricity around the world and the majority of power generation capacity still relies on fossil fuels.

Gasification of residual biomass, such as forestry cuttings and post-harvest waste, is an alternative pathway to achieve liquid fuels. This pathway to SAF is more affordable than the electrofuels route.

The challenge of this process is that the syngas produced by gasification is very rich in carbon monoxide (CO) but it does not contain sufficient hydrogen to produce liquid fuels such as kerosene and diesel.

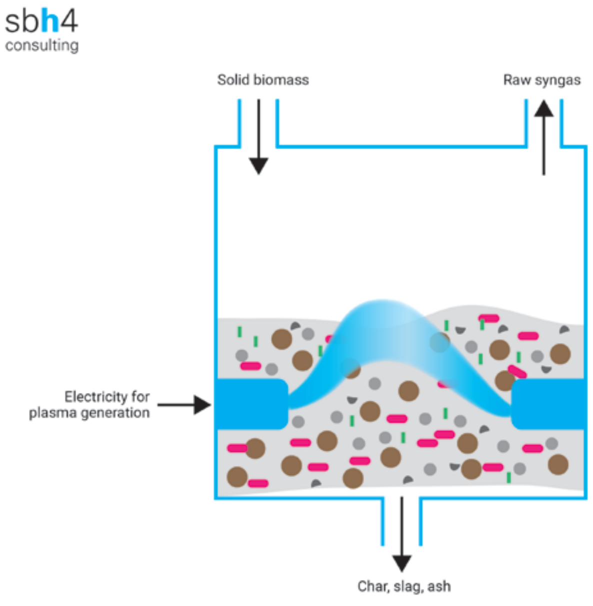
And when we look to the very long term, the amount of available forestry waste is finite and driven by timber production, which is the primary use of the harvested tree.

The combination of these two imperfect processes can create a harmonious synergy. The forestry waste biomass is stretched through the use of electrolytic hydrogen to mitigate the scalability concerns. The carbon from the biomass is fully utilised with minimal carbon dioxide emissions

And the high cost of the pure electrofuel is reduced through combination with the more affordable waste biomass feedstock.

Airbus A350-1000 refuelled with 35% blend of SAF, copyright Airbus

Plasma gasification of biomass



	Plasma gasification of biomass
Biomass feedstock	Municipal solid waste, waste water treatment sludge, woody biomass, waste paper, etc
Target chemical reactions	Biomass + $O_2 \rightarrow 2CO + 4H_2$ Biomass + $H_2O \rightarrow CO + 3H_2$
Additional side reactions	Biomass + $2O_2 \rightarrow CO_2 + 2H_2O$
Syngas composition	38% H_2, 30% CO, 20% CO_2, 12% CH_4
Product gas pressure	From atmospheric pressure to 30 bar
Product gas temperature	~1,000 °C

Putting trash to good use

To ease the pressure on biomass feedstocks municipal solid waste (MSW) and industrial wastes can be used as an alternative to, or supplement to biomass in the gasifier.

Whilst these are not conventional biomass feedstocks, they often contain about 50% of biogenic material. Furthermore, the re-use of the fossil components of MSW to produce fuel avoids the need to extract virgin fossil fuels and thereby reduces overall CO_2 emissions.

Residual forest biomass may cost in the order of €100 per tonne when chipped and delivered to the gasifier. On the other hand, use of MSW will result in a 'gate-fee' revenue stream for waste disposal, in addition to the sale of fuel from the process. This can improve the project economics and tip the balance in favour of using MSW as part of gasifier feedstock.

Fischer-Tropsch Synthesis

Fischer-Tropsch synthesis (FTS) is a core technology for electro-biofuels production. It reacts carbon monoxide with hydrogen to form a mix of hydrocarbons known as synthetic crude or syncrude. Syncrude, like fossil crude, must be refined to yield marketable liquid fuels.

Isomerisation, hydrocracking, hydrodeoxygenation and hydrotreating may be required to achieve the 'Jet' specification for aviation kerosene. These are standard processes which are used on many petroleum refineries today. The emerging world of electro-biofuels can leverage experience and expertise from the established energy sector.

FTS tends to produce a mix of linear, paraffinic hydrocarbons of various chain lengths. Some of these paraffins are too short to be used as diesel or kerosene, and others are too long. The long, waxy molecules can be hydrocracked to make smaller chain hydrocarbons which are suitable for diesel and kerosene. Hydrogen is reacted with the waxes in the presence of a catalyst to crack them.

During FTS, it is likely that some alcohols and esters may be formed. These molecules are referred to as oxygenates. They can be corrosive and damaging to fuel storage infrastructure. So, hydrogen is reacted with these molecules to remove the oxygen atoms and yield water. The chemistry here is like the hydrodeoxygenation of vegetable oils and fatty acids.

Isomerisation for aviation safety

Another processing requirement of FTS syncrude is isomerisation. A mixture of linear hydrocarbons can freeze at the very cold temperatures encountered during high altitude flight. Isomerisation converts the long straight paraffins to branched hydrocarbon isomers. These can be imagined to look like a tree with branches rather than a long stick. Isomerisation takes place in a reactor in the presence of hydrochloric acid and a catalyst, which is often based on platinum.

The isomerisation reaction itself does not consume hydrogen. However, hydrogen is added in the overall isomerisation process to support side reactions such as cracking of carbon-carbon double bonds that may simultaneously take place.

Isomerised, non-linear molecules remain liquid at colder temperatures. This is essential for aviation fuel since the temperature at high altitude can be as low as -40 °C. Thankfully, the 'Jet' fuel specification is very strict about controlling these safety-critical aspects of liquid fuel quality.

Putting it into practice

The energy transition is awash with project 'announcements', many of which never proceed beyond a pre-feasibility study. Sadly, some of them are pure 'investor-bait' or poorly conceived still-born projects.

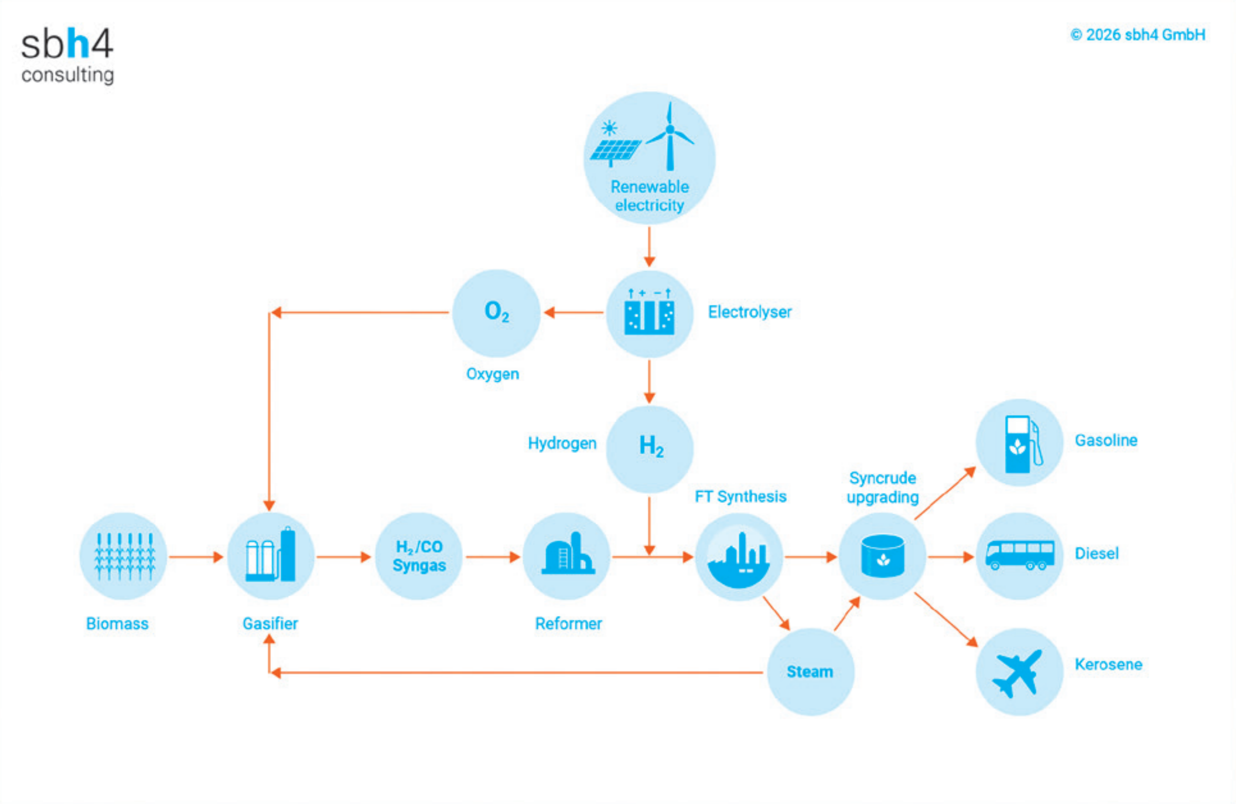
On the other hand, hybrid electro-biofuels projects are perceived by many to be in the sweet spot of clean fuels and are being catalysed by the biofuel and PtL sub-mandates within SAF adoption regulations in the EU and UK.

These are the kinds of projects that should – and will – make it through FEED and FID to commercial operations.

As an example, at their BioTJet project in Pardies, France Elyse Energy has proposed biomass torrefaction, grinding and entrained flow gasification using the thyssenkrupp PRENFLO® technology for syngas generation.

Syngas processing and FTS fuels production and upgrading will then take place using the Axens GASEL® technology. Axens is both an equity partner and key technology licensor that will provide performance guarantees around many aspects of this project.

Hybrid electro-biofuel production for sustainable aviation fuel



32,000 tonnes per year of electrolytic green hydrogen will enrich the hydrogen content of the gasifier syngas to produce SAF and naphtha as bio-electro fuels. The electrolyser park is known as H2-Lacq.

BioTJet and H2-Lacq are two key components of the wider E-CHO industrial hub project, which additionally includes bio/e-methanol production from electrolytic hydrogen and the CO_2 produced during the biomass gasification process. This aspect of the project is referred to as eM-Lacq.

The integrated plant is slated to go online towards the end of this decade.

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