THE LIQUEFIED PETROLEUM GAS BIO-BUZZ

Ironic as it may seem, liquefied petroleum gas (LPG) can play an increasingly important role for developing biomass fuel markets as a whole. The specific characteristics of LPG and its advantages over other fuels – fossil and non-fossil alike – along with its current uses suggest LPG may be exceptionally well suited to act as a "bridging" fuel for renewables. Commercial pathways to produce Bio-LPG are emerging and the race is on to secure production and distribution.

LEAVING ASIDE THE APPARENT CONTRADICTIONS of a "liquefied gas" or having "bio" and "petroleum" in the same term, Liquefied Petroleum Gas (LPG) is a generic name for commercial blends of light gaseous hydrocarbons, predominantly propane (C_3H_8) and butane (C_4H_{10}). These change from a gaseous state at normal temperature and pressure to a liquid state when cooled or compressed at moderate pressure. This liquefaction property increases the density and, in its liquid state, the energy content of LPG on a per-tonne basis is higher compared to other fuels including most oil products.

LPG is extracted as a by-product from crude oil refining or separated out from natural gas or oil production streams. LPG is normally refrigerated for shipment by sea and storage of large volumes at receiving terminals whereas smaller volumes are usually stored and distributed in pressurised vessels. It burns readily and cleanly in the presence of air giving off a hot flame with low NO_x, SO_x, aromatics and ultra-low soot emissions. LPG in itself is not a greenhouse gas (GHG) and is non-toxic. However being heavier than air it is hazardous and explosive.

Residential sector largest user

Being a function of oil and gas production LPG is supply driven. According to the 2013 "S*tatistical Review of Global LP Gas*" jointly published by Argus and the World LP Gas Association, 2013 global LPG production reached just over 280 million tonnes and consumption was 265 million tonnes, both up just over 2 percent on 2012 figures, whereas the 15 million tonne gap between supply and demand remained the same. LPG accounts for around 2 percent of global primary energy supply.

From a renewables perspective it is worth noting what LPG is used for. The residential sector is by far the biggest user, accounting for around 46 percent of all LPG consumed. In developed regions its use is highest in off-gas grid locations for heating and cooking whereas in other regions cooking fuel is the dominant use. Non-energy use in the petrochemicals sector accounts for about 25 percent of consumption whereas transport, industry, refinery and agriculture make up the balance. In Europe an estimated 6 million vehicles use LPG, "Autogas" as it is often called, as road transportation fuel and specific applications include machinery operating in confined spaces.

BioDME and LPG

Dimethyl ether (DME) is another non-toxic gas under normal temperature and pressure conditions but liquefies at about 6 bars and has properties similar to propane. According to the International DME Association, global DME production is a modest 5 million tonnes per annum and it is produced from a variety of fossil and biomass feedstock, notably methanol. DME has been used for decades as an aerosol propellant in the personal care industry. More recently it is attracting attention as a (bio)fuel for backup power generation, heating, cooking or transportation. In June the Swedish renewable DME producer **LTU GREEN FUELS AB** revealed that its BioDME is being tested for industrial heating usage blended with LPG (propane) in a project with **FLOGAS SWEDEN AB**. A subsidiary of UK-headed Flogas Europe, it is the country's largest supplier and distributor of LPG having a 55 percent share of an "addressable" Swedish market of about 340 000 tonnes, the vast majority of which is propane used in industry for process heat.

The BioDME from LTU Green Fuels is produced by gasification of black liquor, a by-product of the pulp industry, at its 1 000 tonne-per-annum pilot plant in Piteå, northern Sweden. In the project a first delivery of 20 percent BioDME-blended LPG has been shipped to an asphalt plant located by Stockholm Arlanda airport where it is currently being tested. Operated by Svevia, one of the largest road infrastructure construction and maintenance companies in Sweden, its Arlanda asphalt plant uses around 800 tonnes of LPG per annum supplied by Flogas Sweden. According to Jan Ström, Regional Manager, Flogas Sweden, the switch to using BioDME-blended LPG is easy and the market demand for renewable LPG is unquestionably there.

– If we had sufficient volumes of BioDME tomorrow we could switch all our customers, Ström remarked during a visit to the Svevia asphalt plant in conjunction with the recent Advanced Biofuels conference in Stockholm Arlanda, Sweden.

According to Ström up to 20 percent blend of BioDME in LPG is technically possible without any need to adjust equipment, whereas higher blends up to and including 100 percent BioDME require slight modifications. Based on its current market volume, a 20 percent blend for Flogas Sweden translates into a BioDME demand for around 37 400 tonnes of BioDME.

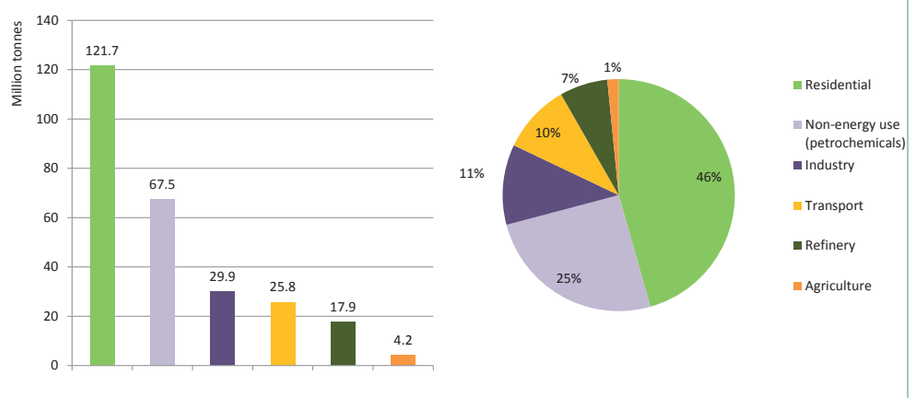
It seems though that commercial-scale BioDME from black liquor, in Sweden at least, may take some time. According to Jonas Rudberg, Director for **PORCUPINE**, a consultancy company and one of the developers behind the LTU Green Fuels pilot plant, if and when commercial-scale BioDME from black liquor becomes a reality is dependent on stable long-term policy, a minimum of 13 years when allowing three year plant build.

– It's a policy-dependent financing issue. The technology for producing and using BioDME works. The black liquor feedstock is available and, as we can see, the market is ready and waiting. To build the first commercial 100 000 tonne-per-annum facility will require an investment of around SEK 3 billion (≈EUR 322 million), said Rudberg, during the said conference pointing out costs are likely to come down for subsequent plants.

Biogas to BioDME or biopropane

Others are building commercial BioDME but at much smaller scales and using different feedstock. Last year US-based **OBERON FUELS, INC.**, received US Environmental Protection Agency (EPA) approval for its biogas-based DME for inclusion under the Renewable Fuel Standard (RFS) and earlier this year its DME was approved as a "legal" vehicle fuel by the State of California. Oberon Fuels has developed proprietary skid-mounted units that convert methane and carbon dioxide (CO_2) to DME from feedstock such as biogas and natural gas. Capacities are in the range

Figure 3: World final energy consumption of LPG by sector, 2013



* Including non-specified other final consumption.
Source: Menecon Consulting analysis; WLPGA/Argus Media (2014).

– We have developed an innovative renewable product family based on our NEXBTL production technology. BioLPG is the latest addition to our list of renewable products, said Kaisa Hietala, Executive Vice President of Renewable Products at Neste. Production of BioLPG at its Rotterdam biorefinery is expected to begin by end of 2016.

– Someone has to build the first commercial 100 000 tonne-per-annum facility and to do that they need sufficient confidence in the investment. Taxation and other steering instruments affecting the price of BioDME relative to fossil gas need to remain stable over time, said Jonas Rudberg, Director, Porcupine.

– From a technical standpoint it is easy to switch to using BioDME blended LPG. If we had sufficient volumes of BioDME tomorrow we could switch all our customers, remarked Jan Ström, Regional Manager, Flogas Sweden, during a visit to Svevia Arlanda asphalt plant in conjunction with the recently held Advanced Biofuels conference in Sweden.

3 000 to 10 000 gallons per day of (Bio)DME.

An alternative biogas route is methane to propane. In July, **ALKCON CORPORATION**, a newly formed US-based company specialising in developing natural gas processing equipment announced it had entered into an "exclusivity agreement" and signed a Letter of Intent (LoI) with **FLOGAS EUROPE**. Alkcon recently filed a provisional patent for its methane-to-propane conversion process and is currently developing a series of industrial gas conversion technology products directed at flare gas recovery, coal seam gas conversion and biopropane production from biogas.

It is the latter that the approximately US$60 million deal involves. Flogas Europe has the exclusive right to market and sell Alkcon's proprietary methane-to-propane gas conversion technology in Belgium, France, Ireland, the Netherlands, Norway, Sweden and the UK. Under the terms of the agreement, Flogas will purchase a minimum number of Alkcon's "MP32K" gas conversion systems annually for five years. Flogas intends to install the units at biogas production sites throughout Europe. Each system could produce up to 1 600 tonnes of biopropane annually. The resultant biopropane will be used to enrich biomethane, increasing its caloric value, before it is injected into national gas grids. The first deliveries are expected to begin in 2016.

BioLPG straight

For the moment it seems that Finnish oil refiner and renewable fuel producer **NESTE** have the upper hand when it comes to producing BioLPG at scale. In September it broke ground on what is described as the world's first BioLPG production and storage facility at its renewable fuel refinery in Rotterdam, the Netherlands. Announced in December last year the new facility will have a production capacity of 40 000 tonnes per annum of BioLPG for the European market. With a production process designed by Finland-based technology, engineering and project management company **NESTE JACOBS**, the new facility will purify and separate BioLPG from the side-stream gases produced by the Rotterdam refinery, which primarily produces its NEXBTL renewable diesel from various waste, residues and vegetable oils.

Exclusive distributor for Neste's BioLPG is the Dutch-headed 'off-grid' energy supplier **SHV ENERGY**, which will market and sell the BioLPG. Production at the EUR 60 million facility is scheduled to begin by the end of 2016 and SHV Energy are to supply 160 000 tonnes of BioLPG over a four-year period to clients across the full range of standard LPG applications in six European countries.

– BioLPG is a wonderful addition to our product portfolio, and our customers can benefit as it can be used within a full range of existing LPG applications, from transport and commercial heating to retail leisure cylinders, demonstrating the versatility of the fuel without having to change conventional equipment. This provides our customers with an even cleaner rural energy alternative to the high-carbon fuels many are dependent on in off-grid areas, said Fulco van Lede, Management Board Member of SHV Energy.

It seems that the new biofuel is gaining recognition from policy-makers in some quarters. For instance the UK Department for Transport has issued Renewable Transport Fuel Certificates (RTFCs) for BioLPG under its Renewable Transport Fuel Obligation (RTFO) accreditation.

Bio-isobutene, blessing for butane

For butane, the other major LP gas, the situation is slightly different as there is yet no renewable source of butane. Bottled butane is a major consumer gas used for cooking, camper stoves and portable heaters amongst others. In France, **COMITÉ FRANÇAIS DU BUTANE ET DU PROPANE** (CFBP), an industry organisation representing six major gas supply and distribution companies, announced a partnership with **GLOBAL BIOENERGIES**, one of the few companies worldwide and the only one in Europe that is developing a process to convert biomass into some of the key petrochemical hydrocarbons, such as isobutene, via fermentation. The company operates an industrial pilot in France and has begun the construction of its demo plant in Germany. The company is preparing the first full-scale renewable isobutene production plant in France, IBN-One, through a joint-venture with **CRISTAL UNION** with construction expected to begin in 2017. According to current regulations, bottled butane gas may contain a high proportion of isobutene. Using bio-isobutene is an attractive solution to some 10 million French households that use bottled butane.

– Blending isobutene from renewable resources into domestic bottled gas is a practical and everyday application of benefit to a large number of households, commented Marc Delcourt, CEO of Global Bioenergies.

Last July, CFBP and Global Bioenergies started a series of tests based on a batch of bio-isobutene produced by Global Bioenergies at its French pilot site in Pomacle, Marne. The tests focused on the product's compatibility with the logistics chain and domestic appliances such as cookers.

– At this stage the tests show that renewable isobutene produced by Global Bioenergies is compatible with commercial butane. The CFBP is keen to continue this collaboration to enable the addition of renewable energy in bottled gas in the short term, said Joel Pedessac, CEO of CFBP.

With all the bio in LPG buzz, perhaps its time to introduce Liquefied Renewable Gases, LRG?

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