POWER UP, POWER ON

In energy circles, a great debate was stoked when Michael Liebreich launched his hydrogen ladder to put use cases for hydrogen in a merit order. Here, Founder & MD of CNG Services **John Baldwin** borrows the concept to deliver a Biomethane Ladder, representing his verdict on biomethane's best uses.

Before we can discuss the best utilisation option for biomethane we have to define what we are talking about and how much fuel there is to distribute.

Biomethane, made from biogas in anaerobic digesters (ADs) exists today, with around 7 TWh injected into the British gas grid at the end of 2022. Ecotricity believes grassland can be a significant contributor to biomethane production in addition to food waste, sewage, manures, and crop residues. A realistic target is **~20 TWh/per annum** (pa) by 2030 as market shifts result in much biogas currently burnt in combined heat and power plants (CHP) being upgraded to biomethane and injected into the gas grid. If we can reform the planning system, we can aim for **30 TWh/pa** as there is pre-existing biogas generating electricity (total renewable methane is around 19 TWh/pa).

With higher long term gas prices of around 3 p/kWh there is new interest in making biomethane in countries with huge resources of organic feedstock available, in Central and South America, Africa, and the Far East. The existing liquefied natural gas (LNG) supply chain can be used to transport this biomethane to the UK. With all the bio-CO_2 captured and sequestered, **20 TWh/pa** by 2030 is credible: thank you Brazil (that's equal to 20 LNG ships of 70,000 tonnes).

Then we have pipeline biomethane from Ukraine, which has huge potential as a key component of the post-invasion recovery plan. High quality soil, sun, rain, and an empty gas pipeline that used to carry fossil gas to Germany means it is reasonable to expect 120,000 scmh of Ukrainian biomethane /annum which is another **10 TWh/pa**.

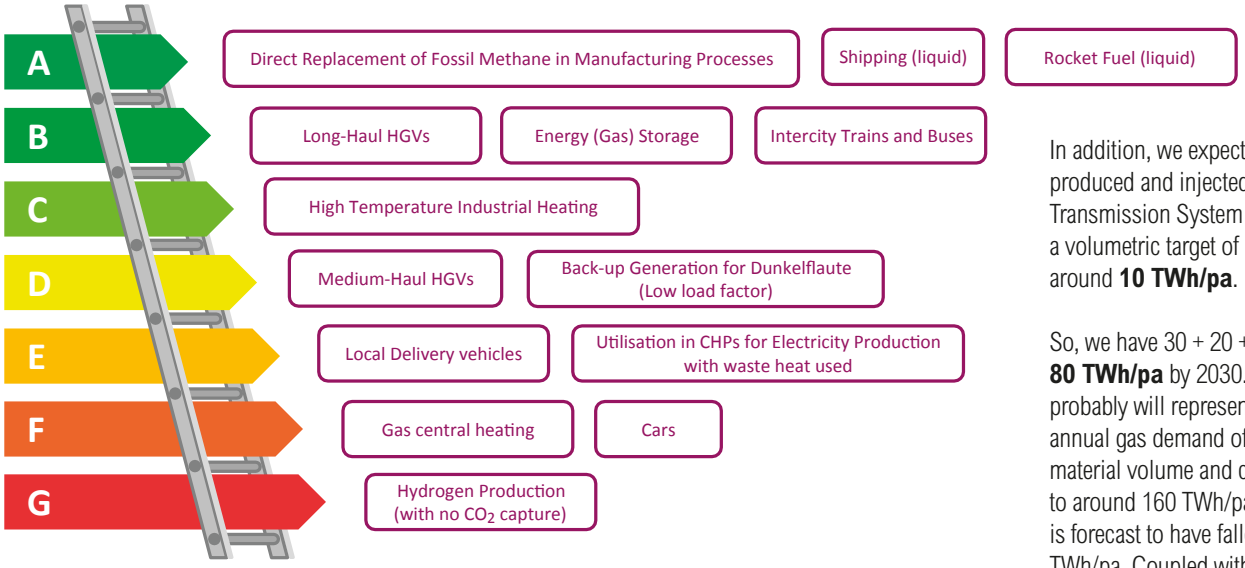
Green synergies

Next, we have Bio-SNG which is CH_4 made from the gasification of waste wood or refuse-derived fuel (RDF), followed by conversion of the syngas to CH_4. I started my career in British Gas in 1983 and worked on a plant at Westfield that successfully turned coal into CH_4 (SNG), so I know from experience that bio-SNG technology is feasible, it has just needed a high CO_2 price.

ABSL is developing its first large-scale industrial plant taking 120kt of waste

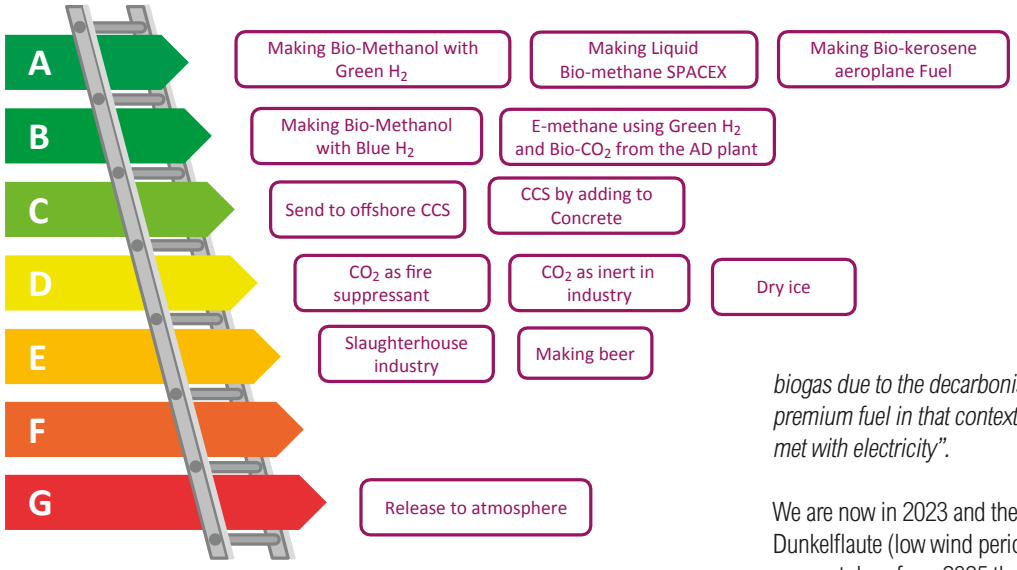
Biomethane Ladder (March 23)

And it is assumed that all the Bio-CO_2 from the AD plant is captured, liquefied and used as per the Bio-CO_2 ladder



Bio-CO_2 Ladder (March 23)

And it is assumed that all the Biomethane goes into the gas grid and is used as per the Biomethane Ladder



wood and converting it into 320GWh of CH_4 and 100kt of high-grade CO_2, situated in the Protos Energy Park near Ellesmere Port in Cheshire. This scale up follows on from the success of the pilot plant and the commissioning of the demonstration plant in Swindon. The facility will be able to produce biohydrogen and biomethane while capturing the CO_2 with no polluting air emissions and no particulate or dioxin emissions. Future ABSL plants based on RDF (diverted from landfill or export) will produce 1 TWh/pa per plant, so let's aim for 5 of them by 2030, another **5 TWh/pa**.

Next, we have e-CH_4, which is the production of CH_4 from bio-CO_2 and hydrogen (made from wind). There is so much offshore wind on the way, a key challenge will be to utilise it, which explains the DESNZ (Department for Energy Security & Net Zero) support for Green Hydrogen. Going forward, obviously, all bio-CO_2 will be captured and so by 2030 we should have something like 2.5 million tonnes of bio-CO_2. This can react with H_2 to make around **5 TWh/pa** of e-CH_4.

In addition, we expect to see green hydrogen produced and injected in the National Transmission System starting in 2024, with a volumetric target of 5% by 2030, indicating around **10 TWh/pa**.

So, we have 30 + 20 + 10 + 5 + 5 + 10 = **80 TWh/pa** by 2030. That's a good start and probably will represent around 15-20% of total annual gas demand of 500 TWh/pa. That's a material volume and can be doubled by 2050 to around 160 TWh/pa when total gas demand is forecast to have fallen to around 200 – 250 TWh/pa. Coupled with technologies such as CCS at St Fergus we can probably be 100% green gas, no net emissions.

Net zero drivers for biomethane

Next, what do we do with that green gas now, in 2030 and 2050? Below is the latest version of the Biomethane Ladder that reflects 2023 thinking. Making hydrogen without CCS is the worst use, cars and gas central heating are not much better.

I attended a meeting with the Committee on Climate Change (CCC) on 21st April, 2010, and one of my notes is as follows:

David Joffe [who is still with the CCC] said that he believed that *"in the 2020 + period it would not be appropriate to generate electricity locally using biogas due to the decarbonisation of the electricity grid. Any biogas would be a premium fuel in that context and should be used for applications that could not be met with electricity".*

We are now in 2023 and there is no doubt that David's belief is spot on. Odd Dunkelflaute (low wind period associated with cold weather in winter) days apart, on most days from 2025 the majority of UK electricity will be from wind and once we are almost always producing <100 gCO_2/kWh of electricity it makes no sense to burn biogas to make electricity outside of particular off-grid/island situations and out to 2030 where waste heat is utilised.

Biogas CHP is s a transitionary technology if most of the waste heat is utilised as this increases the overall efficiency and is not so bad. But that probably only gets to 2030, by which time high temperature heat pumps, e-boilers and hydrogen will sort out the heat part. CHP plants should therefore be incentivised to switch to biomethane production and make sure all the Bio-CO_2 is captured.

In the period out to 2030, logistics companies are trying to get to Net Zero, with companies like John Lewis Partnership and others in the parcel delivery sector moving their entire fleets to biomethane by 2025. The trucks exist, made by

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Biogas Futures

Scania, Iveco and Volvo, the biomethane fuel exists and these companies cannot wait. Glenfiddich operate around 30 Iveco Bio-CNG trucks and it will be a surprise if the entire whisky industry is burning any diesel after 2025. When your main product uses the purest spring water, you do not want diesel trucks on your sites and if you are able to fuel all your trucks on waste, that's a great option.

For farms, the New Holland biomethane tractor is available now and can be a direct replacement for the equivalent diesel tractor. There are no electric or hydrogen farm tractors on the market.

Specialist chemicals are a high value use of biomethane with no alternatives. On the top rung of the ladder, we have liquid methane as the fuel Space X will use for flights to Mars, made either in AD plants or by reacting Bio-CO_2 with hydrogen.

Storing biomethane in the existing salt caverns built for natural gas is a very good option for the backup gas needed to get through a Dunkelflaute and Germany in particular aims to move its biogas CHP into biomethane which can be stored for this purpose. Having a gas grid is particularly valuable and the good news for biomethane is that it uses the same assets (2 bar pressure pipelines and above) that are used for the gas engines that backup the Dunkelflaute. No biomethane projects inject into the low-pressure gas grid.

Future fuels

The Bio-CO_2 Ladder is complementary to the Biomethane Ladder and shows how valuable bio-CO_2 is likely to be as we approach 2050. Lots of Green Hydrogen molecules will be seeking a partner and making E-methane and delivering it via the gas grid is a compelling proposition.

If you think about it, global heating is caused by 420 ppm CO_2 in the atmosphere and countries like Norway and UK are funding pilot projects to hunt those molecules down and send them to a sequestration site. So, if you have 98% CO_2 coming out of the biomethane plant the last thing you will do is vent it! 98% is 980,000 ppm CO_2.

Remember the golden rules for new biomethane projects – no venting of bio-CO_2, no use of diesel, no burning raw biogas and ideally exporting the biomethane by pipeline the use of which can and will change over time. But starting with trucks is a pretty good idea, as Amazon, UPS, John Lewis et al are already doing.

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