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Liebreich, M., The Case Against Hydrogen Blending (October 26, 2023)

The Case Against Hydrogen Blending

What follows is a copy of my response to the UK Government's consultation on hydrogen blending into GB Gas Distribution Networks

MICHAEL LIEBREICH

OCT 26, 2023

I do not usually respond to government consultation requests, but in the case of hydrogen blending I am making an exception. Rarely have I come across such muddled thinking and naked self-interest as in the discussion of hydrogen blending.

By way of background, I earned First Class Honours in Engineering from Cambridge University in 1984 with a prize in Thermodynamics, and an MBA from Harvard Business School in 1990 with a Baker Scholarship. I am a Visiting Professor in the Energy Futures Lab at Imperial College and an Honorary Fellow of the Energy Institute.

In 2004, I founded what is now BloombergNEF, the world's leading information service on net zero energy, transportation and climate finance, and in 2009 sold it to Bloomberg LP. I now have three main sources of income: as a public commentator on net zero and its challenges; as a consultant and advisor to investors, governments and corporations; and as an angel investor, generally in net zero transition technologies.

My angel investments are evenly balanced between electrification and hydrogen-related. They include two fuel cell businesses (Ceres Power and SFC Energy), a green fertiliser business (Atlas Agro) and an advisory role with a hydrogen electrolyser business (Hysata), as well as two electric vehicle charging businesses (PragmaCharge and Chargepoint) and a smart bus company introducing electric vehicles (Zeelo).

I have just finished three years on the UK Board of Trade and six months as a member of the UK Energy Efficiency Task Force, where I chaired the industrial efficiency working group. I have previously advised the UN on Sustainable Energy for All and have sat on the International Energy Agency's Commission on Energy Efficiency, among many pro bono roles.

I doubt there are many analysts in the world who have done more work on hydrogen – encompassing physics, safety, economics, finance, geopolitics, behavioural science and policy. I am neither pro-hydrogen nor anti-hydrogen. I am, however, very much in favour of climate action, of clean hydrogen being used only in sectors where it is needed, and of public money being spent wisely rather than squandered.

My full bio can be found here:
https://www.liebreich.com/bio/

A complete register of interests can be found here:
https://www.liebreich.com/register-of-interest/

The Hydrogen Ladder

The very first line of your Consultation Document reads "Hydrogen can support decarbonisation of the UK economy, particularly in 'hard to electrify' UK industrial sectors, and can provide greener, flexible energy across power, transport and potentially heat."

This embodies an idea – that hydrogen will be pervasive and widely distributed throughout the UK economy – which is wrong. Before any discussion of the pros and cons of hydrogen blending, it is vital to start with an understanding of where hydrogen will play a role in the future decarbonized UK economy – sectorally and geographically – and where not.

Only then can we answer questions like where electrolysers should be built, how to avoid stranded assets, where developers should build renewables, and how to ensure we are not delaying the decommissioning of gas distribution pipelines, as proposed by the National Infrastructure Commission in its Second National Infrastructure Assessment report.

I therefore thought it would be useful to include a copy of the Hydrogen Ladder – a schematic I have been using for three years time to help explain to policy-makers, investors, business executives, civic society leaders where hydrogen will be competitive in the medium and longer term with other decarbonisation pathways, and where it is doomed to fail. It is based on much analysis and crowd-sourced input, and I recently published Version 5.0.

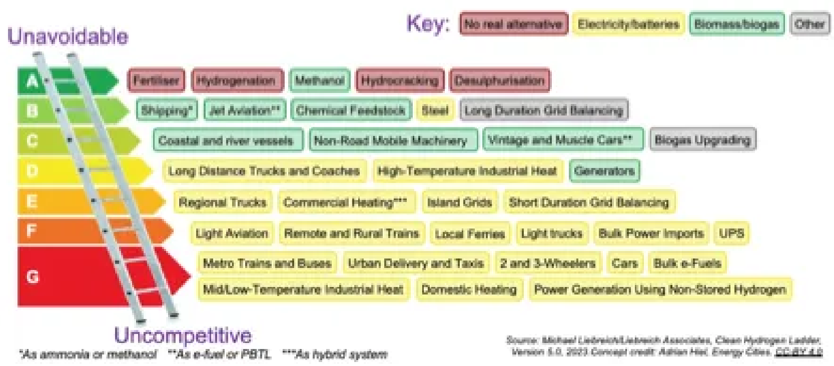

Figure 1: The Hydrogen Ladder, Version 5.0. Source: Liebreich Associates. Concept: Adrien Hiel

Row A consists of current uses of hydrogen – around 100 million tonnes of demand worldwide, representing a $160 billion market. This demand is today overwhelmingly met by hydrogen from fossil fuels, resulting in around 2.3% of global CO2 emissions.

Rows B and C are plausible new use cases for hydrogen that could help the world reach its Net Zero targets. Hydrogen is increasingly unlikely to succeed as you descend through Rows D, E and F. Row G is the Row of Doom.

Given that the supply of clean hydrogen will be expensive and limited for the foreseeable future, and given that for the lower rows of the ladder other decarbonisation pathways present better value for money, a key metric for public policy on hydrogen is whether it focuses on the upper rows of the Ladder.

You can read more about the Hydrogen Ladder here: https://www.linkedin.com/pulse/hydrogen-ladder-version-50-michael-liebreich/

Blending mis-allocates hydrogen to use cases that should be electrified

Your Consultation Document states, "blending 20% hydrogen by volume into the GB gas distribution networks could generate carbon-savings of up to 6-7% on consumption of that gas." While this is technically correct, it raises a question: if we blend hydrogen into the grid, which use cases does it help decarbonise?

The Sankey Diagram for UK gas gives the answer:

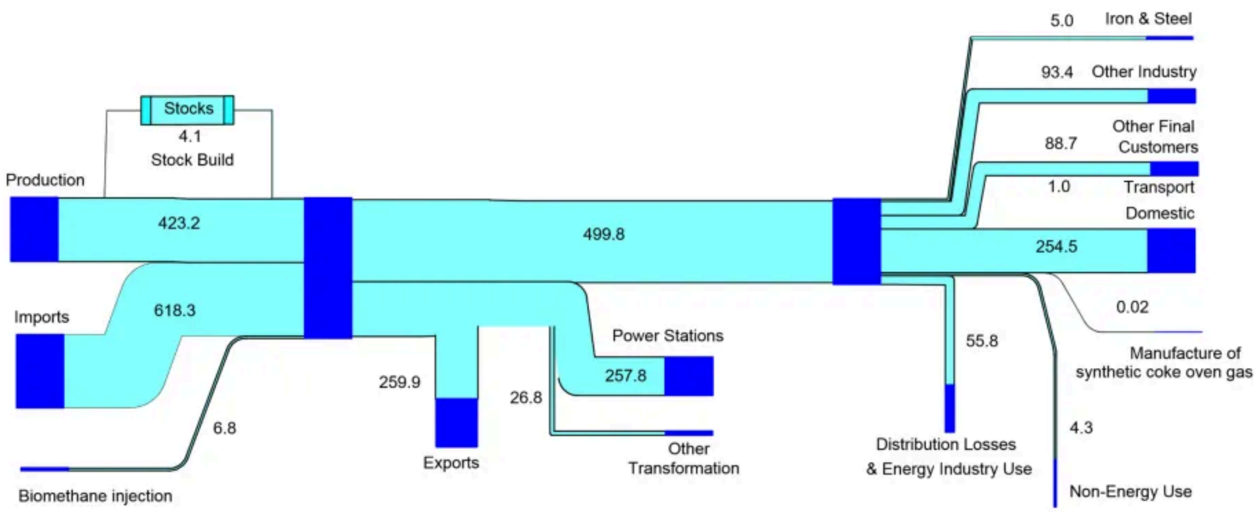

Figure 2: Sankey Diagram for UK gas use, 2022. Source Dukes 2023.

Excluding losses, exports and self-consumption in the energy sector, the UK's natural gas supply goes to domestic heating (37%), power generation (37%), industry (14%), and commercial and public buildings (11%). So that is where blended hydrogen will end up.

Mapping these use cases onto the Hydrogen Ladder shows that fully 80% of blended hydrogen would be consumed in uses cases on Row G. A further 11% would be used to heat commercial and government buildings – where hybrid systems might play a role of some sort. What this means is that around 90% of blended hydrogen goes to sectors that will be more easily and completely decarbonised via electrification.

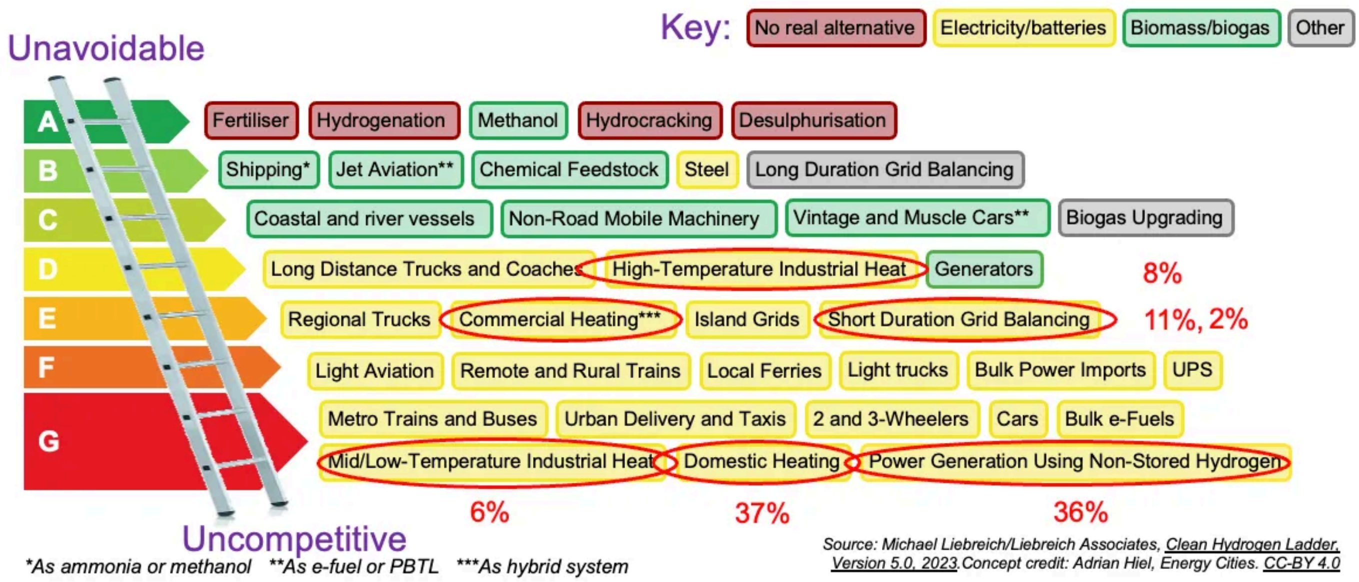

Figure 3: Hydrogen Ladder, showing where blended hydrogen is used. Source: Liebreich Associates

Of particular note is the 37% of blended hydrogen would be routed straight to power stations to be turned back into electricity, wasting around its 70% of input energy on the way. On the Hydrogen Ladder, this use case is called Power Generation Using Non-Stored Hydrogen; it could just as well be called Tearing Up £50 Notes.

All future hydrogen demand will be from industry and located in industrial hubs

In the preamble to the Consultation Document, you state that you are "assessing whether there may be value in having hydrogen blending available to support the early development of the hydrogen economy."

The words "hydrogen economy" again betray adherence to the idea that hydrogen will be used throughout the economy. But let's dig deeper. The Hydrogen Ladder shows that it will be used almost exclusively in three industries: fertiliser, chemicals, and steel – all based in the UK's great industrial centres. Even Long-duration Grid Balancing will be delivered via centralised storage – perhaps hydrogen in salt caverns – and centralised power generation.

Hydrogen is a hard-to-transport industrial gas, which can be handled only under the most stringent of safety regimes. That is why over 90% of current hydrogen use occurs on the same industrial campuses as its production. Hydrogen distributed throughout towns and villages will not be a thing. *Hydrogen high-streets, no, hydrogen hubs, yes.*

One example. There is much talk about hydrogen for long-distance trucks. But how will it be delivered to fuelling stations? Replacing one petrol or diesel tanker requires at least 16 hydrogen tube trailers. That's 16 times the cost, 16 times the traffic, 16 times the risk of accidents. Electrolysing hydrogen at the fuelling station would require installation of 2.5 times the size of grid connection and 2.5 times the generating capacity. Bring the hydrogen in by pipeline, and not only do you have to install hydrogen-resistant pipes, but also you have to purify the hydrogen and compress it to 350 or 700 bar for dispensing. If Daimler and Volvo actually launch the liquid hydrogen trucks they say they are developing, that means liquefaction at fuelling stations – a process with a 40% energy losses and unthinkable safety implications. If hydrogen is used at all in road freight, it will be on a tiny subset of routes.

Another example is hydrogen heating. The gas heating industry has invested heavily in telling the UK public that hydrogen boilers offer an easy route to decarbonisation. The Energy Utilities Alliance was caught funding a PR campaign designed to "spark outrage" about heat pumps. The Competition and Markets Authority is investigating Worcester Bosch's claims about "hydrogen-blend-ready" boilers. It should not be a surprise that the UK comes dead last in Europe in the league table of heat pump installations per 100,000 homes.

No amount of marketing or PR, however, can change the physics and economics of heating. Dr Jan Rosenow has reviewed 45 independent studies – those funded by neither the gas nor the heat pump industries – and found them unanimous in predicting no meaningful role for hydrogen in space heating. Last month the International Energy Agency updated its Net Zero 2050 roadmap and the figure they expect for hydrogen heating in 2050 is *zero*. The 2016 gas-industry-funded Leeds City Gate H21 study concluded (as long as you correctly gross up the cost of converting homes and making them hydrogen-safe) that switching to hydrogen heating would be no cheaper than switching to electrical heating. And that is before reckoning with fuel costs, which will be two to five times higher than natural gas, or the need for increased gas imports to produce the blue hydrogen on which it was based.

This is the type of analysis that underlies the Hydrogen Ladder. It for these reasons that the *only* sectors that look promising for clean hydrogen are in industry, and the *only* future demand for hydrogen will be geographically located in a small number of industrial hubs.

The UKs hydrogen strategy and all related government policy should be focused on spurring rapid uptake of clean hydrogen in industrial clusters. Blending, by contrast, encourages the creation of hydrogen in the wrong places, routing it to the wrong users and transporting it via the wrong infrastructure. It is a costly distraction and a dead end.

Blending creates the wrong sort of advance market and reserve off-taker

The focus throughout your Consultation Document is on the use of blending to create an advance market for hydrogen and a reserve off-take to provide volume certainty in case of the failure of an intended customer.

There already is a perfectly good advance market: the UK consumes (or did before the natural gas price spike caused by Russia's invasion of Ukraine, which is now subsiding) 700,000 tonnes of hydrogen annually. The focus of advance market creation should be on encouraging its users to switch to clean hydrogen, rather than forcing hydrogen into new use cases or encouraging blending.

The subsidy required to encourage new users to adopt hydrogen will inevitably be higher than that required to sell it to existing users – after all, they could already be using low-cost grey hydrogen but are not. To illustrate, suppose grey hydrogen can be made for £1.50/kg and clean hydrogen for £3.50/kg. An existing hydrogen user, offered a subsidy of £2/kg would be happy to switch. For the new user, however, a £2kg subsidy just brings the price back to a level at which they have already rejected hydrogen as a solution.

Logic suggests that the only reason industry is so keen on new use cases for hydrogen is because it is counting on additional "carrots-on-carrots" subsidies on the demand side.

Blending makes an even worse advance market. Not only does it fail to encourage hydrogen production collocated or within transport distance of those with real and existing demand for hydrogen – it takes a valuable chemical feedstock and adulterates it with natural gas, reducing it to its heat value only.

In the example above, instead of being worth £1.50/kg to a customer needing pure hydrogen, as soon as you blend it the hydrogen becomes worth the same as natural gas on a kWh basis, which for large industrial buyers over the ten years prior to Russia's invasion of Ukraine averaged under 2p per kWh – equivalent to just £0.77 per kg of hydrogen.

Before anyone proposes that hydrogen could be physically separated out of the resulting mixed gas stream to be used in those sectors, please consult the extensive literature on the topic. Technically it can be done, affordably not. The laws of thermodynamics are not subject to negotiation.

This leads directly to the answer to the reserve offtake question: what the market needs is reserve offtakers of *high-value hydrogen in industrial hubs* not *an offtaker of hydrogen that instantly halves its value by blending it into natural gas*.

Government policy should focus on building high-value demand and reserve offtake in hubs by doing the following:

> · Supporting the building of hydrogen pipeline infrastructure within and between a small number of hydrogen hubs;
>
> · Supporting the creation markets for trading clean hydrogen within and between these hubs;
>
> · Targeting support for clean hydrogen projects – whether green, blue or pink – only where the production can be delivered to hydrogen hubs.

The resulting infrastructure and markets – connected to those being built by our European neighbours, would make the UK a world leader in the uptake of clean hydrogen in sectors where it is actually needed.

Just to be clear – blending is a false solution for grid bottlenecks

In September, speaking at a Green Hydrogen conference in London, Scottish Energy Minister Gillian Martin advocated for hydrogen heating and the blending of hydrogen into the gas grid as a way of getting around grid constraints. It is perhaps unfair to single her out, there are plenty of others advocating the same thing.

Let's take 1TWh of wind power and see how much space heating can be done via the two relevant pathways in a market on the other side of a grid bottleneck:

> · Use it to make hydrogen, compress it, pump it through pipes and then burn it in a hydrogen boiler – and you end up with around *500GWh of heat*.
>
> · Let's say a huge 20% of the wind power is constrained (the current average in the UK is 3%), and then let's say in addition that an improbably high 10% is lost in the grid – now *700GWh of electricity* arrives at the destination.

In the second case, even *resistive heating* beats the hydrogen pathway. However, if you can put that 700GWh of electricity into a heat pump, even with a Coefficient of Performance (COP) of 3.0, which is very modest these days, you can turn that into 2.1 TWh of heat. That's over twice as much heating as via the hydrogen pathway.

Indeed, unless curtailment reaches an entirely implausible 80%, you are better off putting the remaining electricity into a heat pump rather than turning it into hydrogen and using it for heating. Curtailment is currently around 3% in the UK, so it would have to get worse by a factor of 20 before it would make sense versus routing the remaining electricity into a heat pump.

This is a general finding across all distributed used cases for hydrogen. When green hydrogen is used in heating, 50% is lost between generation and user. In transport, 70% is lost. It is clear that you would have to have gargantuan levels of curtailment before you could possibly make up for the inherent thermodynamic losses involved in making and using hydrogen.

So, by all means, bemoan the fact that wind power is curtailed. But the response should be to reform the CfD framework to stop wind farms being paid not to produce power, and introduce locational pricing to discourage renewables from being built where the grid is constrained and to drive efficient investment in transmission.

Final thoughts

You state that this exercise builds on a previous consultation that concluded: "there is stakeholder support for [the] strategic role of blending [as a reserve offtaker] and its potential to help manage volume risk."

I suppose there may be some stakeholders who, in good faith, see blending as a way developing an early market and a reserve offtaker for clean hydrogen. If so, as we have seen, I believe they are entirely wrong.

The bulk of support for blending – along with the lobbying pushing for it – appears to come from the gas and gas network sectors, for whom the fight for hydrogen heating and other distributed hydrogen uses is existential. For them, I am afraid, blending is just a means of confusing public and policy-makers, slowing down electrification and prolonging the life of their assets.

I hope, for the sake of the planet and all of us, that you reject their arguments.
