

FoT Giving Hydrogen the Green Light?

Tuesday 13th April



Q&A Day 1 – 13th of April - Should we be... giving Hydrogen the green light?

- *Will electricity costs in the UK be low enough to make the production of green hydrogen competitive?*
 - *Clare Jackson:* Great question. Competitive with what is the key here. There are several different counterfactuals. Hydrogen will be competitive for some applications but perhaps not others.
- *Are there any definitions of emissions intensity (e.g. Co2e/kWhr) for the different types of Hydrogen (Blue, Grey, Green, etc.)?*
 - *Sam French:* Sorry Paul, do you mean how we defined the GHGs in the slides? - if so, these came from the IEA report on Hydrogen. There is also a recent report from the Hydrogen Council that shows the LCA of full chains, which is maybe what you are asking - I can post a reference if you want.
- *On 11th February, in his article 'Pursuing the hydrogen economy as a climate solution will be a big mistake' David Cebon, professor of mechanical engineering at Cambridge University wrote: '...the international fossil fuel industry, which is under existential threat from electrification, is promoting hydrogen as a solution: to create confusion among politicians and the public and delay its own demise.'*
 - *Sam French:* If we could go directly to green hydrogen, I would not advocate blue hydrogen, but we can't to the right scale or cost. If we could get a stable, cost-effective secure energy system across all sectors purely with renewables we would not be talking about hydrogen. We need multiple solutions for multiple sectors. O&G companies need to reinvent themselves and many are - as energy companies. They are among the largest investors in renewable projects today - is this a bad thing? These companies have capital

and resources and need to change so we should be using this as part of the transition. We must make sure they are not dragging their feet and lobbying for lower standards, etc.

- *Since the climate change forecast suggests water will be in short supply, can you comment on the quality of water needed for this process? Sea water?*
 - *Sam French:* Currently most electrolysis processes can't use sea water. You can desalinate, but that is a cost, both money and energy.
- To Johnson Matthews - you give some indicative hydrogen production prices, given it has to be moved to the end customer and profits added, what are the indicative commercial/consumer estimates?
 - This question was answered live – please refer to the video recording.
- *Regarding transport of H2 fuel, can you please comment on the leakage of this very light gas, and the potential for high losses?*
 - *Sam French:* There are 1,000skm of hydrogen pipelines, but these are optimised. There is a lot of work going on by the likes of DNV, NGN, Arup, etc. looking at the issues around loss and safety. Here is one example - <https://www.h21.green/building-h21-houses/>
- *Same price as natural gas per m3, kg or energy?*
 - *Sam French:* Energy
- *Running an electrolysed intermittently is very costly and affects hydrogen prices. We will need huge amounts of renewable electricity for heat so how will this all work without cost the general public?*
 - *Clare Jackson:* We will also use blue hydrogen for heat as well as green. Displacing half of current heat demand with green hydrogen would take 42GW of dedicated offshore wind. This does not seem unreasonable in a 2050 timeframe.
- *It would be interesting to see a full lifecycle analysis for different production methods, including both energy input and embodied.*
 - *Sam French:* <https://hydrogencouncil.com/wp-content/uploads/2021/01/Hydrogen-Council-Report-Decarbonization-Pathways-Part-1-Lifecycle-Assessment.pdf>
One element that is important in this report is that they have included emissions from capital/construction, etc. - which is not the case in REDII, but I believe it is important.
- *Grey Hydrogen pricing from Sam French is being detailed without the associated transportation costs, so add \$4.00 per kg.*
 - *Sam French:* Grey hydrogen is very rarely transported far - as mentioned it is used where it is made.
- *The 75,000 jobs - are they additional to the jobs that will be lost with refinery closures and associated peripheral job losses?*



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- *Clare Jackson: 75,000 are gross jobs so don't take into account jobs lost.*

- *How do you get enough hydrogen on to an artic tractor unit for 600km range when liquefaction of hydrogen loses 30% of the energy and has to be stored at -250 deg C and the boil-off dealt with?*
 - *Sam French: Others might know better - but I believe it is Daimler that are pushing liquid hydrogen. Most other offers are pressurised tanks.*

- *What are some of the main temperature-management related challenges in the development of hydrogen-based vehicles (fuel-cell-based or otherwise)?*
 - This question was answered live – please refer to the video recording.

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Wednesday 14th April



Q&A Day 2 – 14th of April - Are supply developments...giving Hydrogen the green light?

- *Given that China makes some 450,000 buses and coaches and, in the UK, we have three manufacturers that have a capacity of just 4,500 buses, how can you compete long term given the different economies of scale? The cost of FCEV driveline, etc. needs to come down by a factor of 10 to be grant free?*
 - *Brian Maybin:* International competition is normal for Wrightbus. We have already been successful in selling BEV buses which is currently a key competence of China. Wrightbus have very competitive volume versus price for FCEV in the international bus market. We "seem" to have a cost advantage in Europe and USA at the moment. But we know the international competition will come.
- *What is the tube trailer capacity and pressure? How do you deal with the pressure drop as the trail empties?*
 - *Brian Maybin:* Each trailer (depending on type) carries 350kg to 500kg. The current trailers are rated at 240bar but the equipment within the refuelling rig contains a compressor so virtually all trailer capacity can be used. Like everything else, better trailers are coming. Ideally hydrogen will be conveyed in the national natural gas pipe system in the future.
- *What are the energy efficiencies of the different production methods?*
 - *Gareth Williams:* This report from Deloitte can give you a lot of the details you are requesting - although there are many other papers in the market, including from other panellists such as E4Tech.
<https://www2.deloitte.com/content/dam/Deloitte/cn/Documents/finance/deloitte-cn-fueling-the-future-of-mobility-en-200101.pdf>
- *Question for Wrightbus - do they see themselves developing the bus tech into an HGV offering?*



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- *Brian Maybin:* I know that our own Jo Bamford is already investigating collaboration with other commercial vehicle makers.

- *For transport, one of the key questions is when is the fuelling infrastructure going to be in place and what will it be (liquid/gas, 350 or 700bar)? Are there any initiatives in place to accelerate this?*
 - *Brian Maybin:* Today our buses are designed for 350bar. From 2023 we will use 700bar storage tanks.

- *Will this have a significant effect on the cost of the tanks?*
 - *Brian Maybin:* We are told the Type3 polymer tanks are less expensive.

- *Given that yesterday Baroness Brown told the select committee that the green hydrogen priority is to replace grey hydrogen in the first instance and to do so it needs 200 Terawatts of consistent electricity generation. Where and when will this be built to meet this demand? And where do the associated 20 billion litres of demineralised water come from?*
 - This question was answered live – please refer to the video recording.

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Thursday 15th April



Q&A Day 3 – 15th of April - How instrumental is infrastructure in... giving Hydrogen the green light?

- *How do you see the H2 infrastructure developing? Liquid or Gas?*
 - *Amanda Lyne:* The current on-board vehicles solutions that meet the safety standards are all based on compressed gas.
- *How does a fuel cell cope with the varying load demands of a road application, e.g. bus?*
 - *Ashley Kells:* A role of the balance of plant and controls is to ensure that the fuel cell stack has the required fluids supplied, i.e. Air, H₂, cooling. With these correctly specified the fuel cell is able to cope with transients.
- *For Amanda - is the hydrogen you are considering made by methane conversion/CCS, or electrolysis of water?*
 - *Amanda Lyne:* The hydrogen that is likely to be commercially available for the next 5-10 years will come from stranded and curtailed renewables.
- *Thanks Amanda, but I was referring to the actual manufacturing method, not the energy source to do it. Can you comment please?*
 - *Amanda Lyne:* The best and most direct way to make hydrogen from renewable electricity is electrolysis.
- *What is Chris Gear's take on France's decision to ban short haul flights?*
 - *Chris Gear:* I think it is a bit early to make that decision and goes against the trends of EVTOL aircraft who are all about short range no CO₂ emission vehicles. It will also slow the introduction of larger net-zero carbon emission vehicles that will be detrimental to aviation in France.



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- *Thank you for the fascinating presentations. My question is open to all the presenters: Do you have any thoughts on the EU Hydrogen Strategy launched last year, particularly in terms of its strengths, weaknesses, and areas of improvement when it comes to its hydrogen infrastructure policy?*
 - This question was answered live – please refer to the video recording.

- *For Amanda Lyne, in your last slide, HyICE has a significant share in 2050. Will the fuel cell drivetrain outweigh HyICE as the efficiency of FC is higher than HyICE and no NOx emissions?*
 - *Amanda Lyne:* The opportunity exists to make hydrogen ICE at similar efficiency to commercially available fuel cell - depending on the duty cycle and application.
- *The efficiency of FC could be 60% or higher while it will be very difficult for ICE to match it.*
 - *Amanda Lyne:* It may be by 2040/2050 that the extra % value savings that MAY be possible from FCE over ICE will make the balance shift, however current data on real-world use of FC in the variety applications does not show a massive difference - we see around 45% for the FC and a similar efficiency for zero emission use of H2.
- *I think that the advantage of HyICE is power density and low requirement for fuel-hydrogen purity.*
 - *Amanda Lyne:* Yes, that is very true too.

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Friday 16th April

Q&A Day 4 – 16th of April - Who in the world is... giving Hydrogen the green light?

- *Increasing the use of Hydrogen for the transport sector will have a significant effect on the overall electrical power required (to generate the hydrogen). Has the government recognised this and if so, is a commitment to increased energy demand in place?*
 - This question was answered live – please refer to the video recording.
- *Are there going to be any incentivised programmes of support to firmly root manufactured systems for H2 revolution in UK, such as household boilers, fuel cells, H2 tanks, pipelines, valves, etc?*
 - This question was answered live – please refer to the video recording.
- *How much hydrogen do you expect we might import versus generating (green) in the UK? The cost curve suggest high solar / wind locations could provide a net-zero supply.*
 - This question was answered live – please refer to the video recording.
- *Does the McKinsey work address the significant energy cost of long-distance transport of hydrogen vs local production? Liquefaction or conversion to ammonia incurs energy penalties. Kiwa representative makes a strong case for pipeline delivery over ~1000km.*
 - This question was answered live – please refer to the video recording.
- *Question for Laura Finney, are you investing in H2 for combustion engines (H2 ICE), or just for use in fuel cells?*
 - *Laura Finney:* We invest across our entire portfolio through both ICEs and fuel cells. I have certainly seen a number of both come across my desk.
- *I wanted to ask the speakers what impact they think policy intervention at devolved level might be. The Scottish Government adopted a hydrogen policy statement in December 2020, and this might encourage similar moves in Wales and N Ireland. Energy policy is reserved to*

UK level but some aspects like economic development, transport and planning are devolved, and devolved public bodies adopt their own procurement practices.

- This question was answered live – please refer to the video recording.
- *Would Juergen perhaps comment on maturity of hydrogen storage solutions for transport - cost, life cycle, certification, etc.*
 - *Juergen Guldner:* There are good, certified carbon fibre solutions available, cost reduction is a major topic of future work.
- *Question for Juergen Guldner - Do you see any application for the hydrogen ICE in your future products?*
 - *Juergen Guldner:* Not in passenger cars since they are less efficient than fuel cells which directly translates into range.
- *Question for Juergen Guldner - approximately, how heavy are the tanks in the new BMW car - for comparison with an equivalent BEV battery?*
 - *Juergen Guldner:* The overall system weighs slightly less than the equivalent BEV system.
- *Interesting that the UK commitment for H2 is £240m, South Korea is \$2.3bn!*
 - This question was answered live – please refer to the video recording.
- *How do we create a UK USP to invest here rather than elsewhere?*
 - This question was answered live – please refer to the video recording.
- *Thank you to all the presenters. My question is for Juergen. There seems to be a consensus that hydrogen is the way forward for commercial vehicles. But for passenger vehicles though, how does an automaker like BMW balance investing in hydrogen technology versus putting everything into BEVs?*
 - This question was answered live – please refer to the video recording.