

# The All-Party Parliamentary Engineering Group

26 April 2019

## Hydrogen - for the supply, storage and distribution of energy

*Discussion over lunch in the Cholmondeley Room, House of Lords*

**Chair** – Professor the Lord Broers

### **Speakers:**

- Hugo Spowers- Chief Engineer and founder of Riversimple
- Jon Salmarsh - Head of Built Environment Technology and Systems within the Department of Business, Energy and Industrial Strategy (BEIS)
- Mike Muldoon - Head of Business Development & Marketing for Alstom UK & Ireland

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### **Introduction**

Lord Broers, Chairman of the group, began by thanking everyone for attending, then introduced the three speakers and briefed the audience on the areas of expertise of each speaker. Lord Broers – “Hugo Spowers (Chief engineer and founder of Riversimple) will talk about hydrogen cars, then Mike Muldoon (Head of Business Development & Marketing for Alstom UK & Ireland) will talk about hydrogen trains, after which, Jon Saltmarsh (Head of Built Environment Technology and Systems within BEIS) will give us some concluding thoughts and talk about low carbon technologies for heating (boilers).”

### **Hugo Spowers**

“Good afternoon and I am honored to be speaking to you today. I am Hugo Spowers from Riversimple and we are developing hydrogen cars and, perhaps more importantly, the strategies for bringing them to market.

As Lord Broers said, I got out of motor racing for environmental reasons and didn't know what I was going to do but knew it was going to be nothing to do with cars; I thought the only future for sustainable cars was better batteries and that requires big labs, big budgets and big companies - not my sort of world at all - and then I heard about fuel cells.

I believe the technology is available, here and now, to make a viable hydrogen fuel cell car, but we do need a step change in the way we make cars, the architecture of cars, the manufacturing strategies and the business model through which we supply them to customers. The real barriers are not technical but to do with people, politics and business

inertia.

I set up Riversimple in 2001 so we are an 18-year-old pre-revenue startup. We are taking the long view, investing in technology that can be truly sustainable - because '*less unsustainable*' is still not sustainable. If there is one lesson that I took from motor racing it is that "There is never enough time to do the job properly, but there is always enough time to do it twice" - and the evidence of that temptation is all around us.

We are now building 20 of the cars that Lord Broers mentioned, for a trial in Monmouthshire. These were developed with the support of a grant from Brussels, dare I say it, and the trial is supported by a grant from the Office of Low Emission Vehicles.

Despite what the media portrays, most major manufacturers have been very consistent for 15 years that hydrogen is the end game but, despite this, we appear to be the only independent hydrogen fuel cell car company in the world."

Hugo then went on to note some of the key technical features of a hydrogen powered vehicle:

- "A fuel cell electric vehicle, or FCEV, is an electric vehicle but without the batteries, and all the limitations of range and charging time.
- Instead of batteries, energy is stored onboard as hydrogen and this is used to create electricity on demand in a fuel cell - to drive the vehicle
- A fuel cell is simply electrolysis in reverse
- In the school experiment of electrolysis, you put energy into water, in the form of electricity, to break the hydrogen-oxygen bond in water molecules and release hydrogen and oxygen as gases
- When they combine, lots of energy is released, usually in the form of heat; this is what happens if you use hydrogen in a normal combustion engine.
- However, in a fuel cell, we allow the hydrogen and oxygen to combine without burning, and the energy is released instead as electricity.

Despite being demonstrated in 1839, it has only been used until recently by NASA; all the Apollo and Shuttle missions have generated electricity in space for running onboard systems. They did this for the same reason that we are using fuel cells in cars; it is much lighter to take cylinders of gases and a fuel cell into space than taking up batteries - getting every kg out of the earth's gravitational field is very expensive.

In cars, efficiency is the key metric we have to chase if we are ever going to have widely available yet sustainable personal transport. Efficiency is hugely dependent on weight so, although battery electric vehicles can be very efficient for short range, and we need them for this, batteries are very heavy and so as you design for longer range, BEVs rapidly become very inefficient. We reckon we can make a more efficient hydrogen vehicle for

any range over about 120 miles and for the sort of range to which we have become accustomed, 300 miles or so, it is head and shoulders ahead of batteries.

There have been 2 problems with this for cars. Combustion engines are very power dense - you can get a lot of power out of a small volume - but fuel cells are rubbish. This was OK for running computers in a space capsule but it's much harder to get enough power to drive a car. The second is that NASA is not a very price sensitive customer but the automotive market certainly is!

But this all creates a fantastic opportunity because the real breakthrough with hydrogen cars is at the system level; the technology is available here and now but we do need to develop a different architecture of car rather than put fuel cells into a technology that has been refined around petrol engines for a hundred years and try to persuade them to behave like petrol engines, which they don't do very well.

And what's so exciting is that, paradoxically, big step changes like this can be done quickly and cheaply by small teams of people; incremental development of mature technology, like conventional cars, requires lots of time, money and people. There are not many advantages to being a startup but having a clean sheet of paper, no legacy constraints, is an enormous advantage. The Toyota Mirai is their hydrogen car and it has the same acceleration as our car, 0-60 in 9.5 secs, yet it uses a fuel cell over 13 times as powerful to achieve this and it uses over 3 times as much hydrogen per mile.

And in the UK, we're very good at this system level innovation. In my old field, there is a perfect analogy. In the late 50s, we in the UK were nowhere in motorsport - it was dominated by Ferrari who had hundreds of people making the most beautiful engines but then along came 5 men in a shed in Kingston and built the Cooper Grand Prix car, using an engine that they bought off the shelf that was much less powerful than Ferrari's. But they built a different sort of car; they won the first GP at Monaco and then won 8 out of 9 GPs that year. They were followed by Lotus and together they built on this and it led to the dominant position that the UK enjoys to this day, yet the amazing thing is that neither Cooper nor Lotus ever built an engine.

This is all being enabled by the new technology of fuel cells and supercaps, but there is another big change in the context in which we are living which leads to different business models, and these profoundly affect the design of the car.

We have historically regarded natural resources as infinite, which was understandable when we were but a pinprick on the side of the planet, but now, because of increasing population, affluence and the accelerated rate of consumption enabled by modern technology, we are facing peak resource issues - not just oil but anything we care to think about - copper, cobalt etc. We can debate when those peaks will be but we can't argue with the direction of the trend - the consumption of finite natural resources.

If you sell cars, you make more money by selling more cars. This directly rewards the maximisation of resource consumption; this is betting future company profits against known trends. But Riversimple is probably the only car company in the world that hopes never to sell a car; we will supply cars under a service contract, including all costs such as fuel, and after the end of the contract we supply the car to a second, third, fourth hand owner, so we are rewarded for maximising resource conservation.

Buckminster Fuller said that "You never change things by fighting the existing reality; you change things by making a better model that makes the existing model obsolete", so at Riversimple we are trying to build a business that makes more money from doing the right thing than business as usual, makes from doing the wrong thing.

Because of these constraints, we are moving from a linear economy, dominated by the sale of product, to a circular economy that rewards resource conservation. Or at least I hope we are, because I don't see how we can ever have a sustainable industrial society based on rewarding industry for the opposite of what we are trying to achieve.

Finally, I would just like to place this use of hydrogen in cars in the context of the wider energy system. Like electricity, it is a common denominator in that it can be made from any energy source and it will inevitably become our other key energy vector, converting our gas grid back to hydrogen; it used to be 60% hydrogen anyway in the days of town gas and I thought this would take 50 years or so but Leeds is planning to turn their grid over to hydrogen by 2025.

If we use hydrogen as a key vector for cars, we can collaborate on the technology and infrastructure standards, on a global basis, while every region around the world can use whatever is their local mix of renewables - and these are distributed much more evenly around the planet than oil, so this is why I think it is so important for the future of our energy systems."

## **Mike Muldoon**

The UK Government has announced that diesel-only trains will be phased out by 2040. Mike Muldoon explains that hydrogen is involved and develops on the alternatives we currently have.

Mike Muldoon welcomes everyone and says the problem around the issue is to "*get the best solution*" out of all the possible ones.

*Developing on hydrogen as an alternative to diesel and those lines where "the wires can't go" due to different reasons (e.g. cost). Hydrogen trains have an essential role on lines (where diesel trains are currently operating) for which electrification cannot be used (a number of railways in the UK could never viably be electrified that's where hydrogen can play a very useful role).*

Mike Maldoon drives a comparison between hydrogen and battery-operated (battery-powered) trains and lists several advantages for the use of hydrogen ones.

- hydrogen – great density of energy (120 MJ/kg)
- batteries used for the hydrogen trains are much lighter
- not capable of operating on longer distances

Developing on that Mike Maldoon stated that not only are the battery-powered/ battery-operated trains' batteries are heavier (even though hydrogen trains use hydrogen as a primary energy store, it also uses batteries to build up an energy reserve, their batteries are much lighter) but it takes a very long time to charge them and they can't yet operate on long distances due to their energy density being low. That's where one can clearly see hydrogen trains advantage. Basically, in Mike's words, you need a lot of time and energy to keep the battery powered trains moving when with hydrogen trains you won't have any of the issues listed above.

Mike Maldoon emphasised that hydrogen trains are, however, "no silver bullet", one should not see hydrogen as the only technological solution/ alternative and its very important to work together on replacing all diesel trains within the next 20 years, but hydrogen trains can and should play its important role in it.

### **Jon Saltmarsh**

Jon Saltmarsh welcomes everyone and says hydrogen addresses the problem of carbon emission (therefore the problem of climate change). It can be described as both: huge opportunity and huge challenge. Jon develops on the topic that will be covered – hydrogen as an option for the future which can be used not only for transport but also to heat our homes and buildings.

3 areas will be covered:

- 1- production and supply
- 2- transmission and distribution
- 3 how to use hydrogen in your home at the moment

Jon Saltmarsh says there are possible way to provide a lower cost hydrogen (currently it's phenomenally expensive to use it for heating purposes). A £20 million program has been launched that has exciting proposals on how this can be reached. Jon says that he cannot unfortunately share them with the audience yet, but we will hear about them soon.

To start using hydrogen for heating some issues must be addressed first:

1. Safety (developing product standards)
2. Equipment, it needs be decided if any other equipment would need to be converted (e.g. boilers, Bosch is working on developing such).

After what Jon Saltmarsh states that hydrogen is definitely a solution for the future as:

1. Decarbonising heaters is essential
2. Hydrogen is one of the several options to decarbonise the heat
3. Much more innovation to be expected to reduce the costs of hydrogen

Lord Broers concludes Jon's speech by stating that hydrogen is a real player and asks if anyone has questions on any of the topics covered.

#### Questions:

**Q - Rt Hon Stephen Timms MP** – What are the general safety concerns around hydrogen technology in vehicles?

**A-Hugo Spowers** – Hydrogen is generally expected to be safer than petrol. As petrol is highly explosive

**Q- Stephen Metcalfe MP** – What impact will other technologies (not hydrogen) and autonomous vehicles will make on your business model?

**A- Hugo Spowers** –

- Our business is not specific to hydrogen
- It's far beyond vehicles (other industrial things as well)
- Quotes: "Do what you can, with what you have, where you are"
- Our company is sustainable not hydrogen car company
- There are clearly benefits for road safety

**Q- Chi Onwurah MP** – Asks regarding the gender balance in the sector and mentions she is the first women at the event to speak. Ms Onwurah's second question is- We are still using the system of the past (horse power) on what works currently. When will we be able to see dramatically different type of hydrogen vehicles?

**A- Mike Muldoon:** This room is far more balanced than the environment as a whole. To change that we need to inspire the young generation. As to the second question:

- Ideal hydrogen product for rail- converted train to reduce the market to spread the network of the refining
- Next generation will be able to do it (something completely new and very different to what we have now) with the use alternative materials make lightweight vehicles etc

- But our first goal and what we are working on now is making the vehicles we already have as efficient as possible first (providing them with a base for creating something completely new)

**Q- Baroness Walmsley** – asks a question regarding ships, fuel they use and whether they are looking for any sustainable alternatives. Another question to which she refers as practical – Is it possible to retrofit the domestic boilers or do you have to build the new ones?

**A - Mike Muldoon:** Ships cause a lot of pollution and unfortunately, it's correct to say that ships are using the dirtiest of all fuels. A number of ships however (Norwegian cruise ships) are being changed/ developed. (e.g. modern technologies are being incorporated into new ones and retrofitted onto older ships which helps to address the issue and minimize emissions).

**Jon Saltmarsh:** As for the boilers, you can't use the old ones, but in longer terms, hydrogen boilers are better.

**Q- Ludavica (Uppingham School)** – What are the long-term drawbacks in using hydrogen if any?

**A- Mike Muldoon:** I don't know if there are any. The more obvious issues are related to not implementing them. However, we should remember there are other technologies that have become available.

**Q- Ross McKibbin (Aecom & Aviation)** – Does the aviation industry have any plans on employing hydrogen?

**A- Jon Saltmarsh:** There is a little work going on. It's one of the biggest challenges as there is no obvious way of incorporating it yet.

**Hugo Spowers-** We have a long way to go to electrify an aircraft.

**Q- Lord Davies-** Are British companies going to respond? Are we going to see them working on employing hydrogen & developing sustainable transport / energy?

**A- Jon Saltmarsh** – In the projects I have talked about there were some brilliant British companies involved. An innovative environment in the UK will help to produce more innovative companies that will make even a greater contribution.

**Hugo Spowers** – We have a chance re-establish a global leading position. Level of expertise in the UK is high so it is possible.

**Q- Sam Beer (UTC Portsmouth):** What are the differences between German and British hydrogen trains?

**A- Mike Muldoon:** We were first with trains (so we have a particular size for the tunnels & trains). Germans tunnels therefore trains are the biggest – UK ones are the smallest. Therefore, we could not use a German train on the UK rail system. However, we can adopt the technology to what we have.

**Q – Thales:** Which (type) of hydrogen is the most sustainable?

**A- Mike Muldoon:** Hydrogen comes in many colours (it actually does not have any colour it's a metaphor). The train will run on anything (any type). Our issue is we must take into consideration our operators' opinion and how they want that hydrogen to be provided. Corporately we support- green or blue – as they are most renewable.

**Jon Saltmarsh:** We are not currently producing a lot of renewable hydrogen. It is also much easier to decarbonise cars than it is boilers. So, it's a challenge we are currently facing.

**Hugo Spowers:** We can make it from any energy source. Green electricity to make hydrogen is the wrong way to go. Much more progress is in decarbonising. We should make hydrogen from all sorts of materials on this stage.

Lord Broers concluded the Q&A portion of the day's proceedings, at which point he thanked all the attendees and speakers and concluded by stating that he hoped to see everyone at our next event.