Written Evidence Submitted by Riversimple Movement Ltd (HNZ0076)

Introduction to Riversimple:

I am submitting evidence to this inquiry on behalf of Riversimple. We have been developing Hydrogen Fuel Cell Electric Vehicles (FCEVs) for 20 years. I am an ex-motorsport engineer and I changed career for environmental reasons. I set up Riversimple as a sustainable car company rather than a hydrogen car company but I concluded that nothing else can be as efficient as an FCEV for the sort of range to which we have become accustomed. We are currently in low volume production building a fleet of 20 cars for a trial in Monmouthshire, with support from OZEV under the Hydrogen Transport Programme. We have installed a hydrogen refuelling station in Abergavenny and the trial will start as soon as Covid restrictions allow. The 2 seat Riversimple Rasa has a range of 300 miles, does 0-60mph in 9.5 seconds and has energy consumption equivalent to 250mpg.

Reason for submitting evidence:

I am submitting evidence because, although I now have a commercial interest in the appropriate use of hydrogen, I have come to this through a focus on sustainability. I wish to suggest smart strategies for transitioning to a sustainable energy system, and the role of hydrogen within it, from our current starting point. I will also draw attention to limitations to the use of hydrogen.

Summary of key messages

- We face multiple environmental and social issues beyond carbon emissions and we cannot pick each problem off independently. We need system-level solutions and so we cannot look at energy independently of transport; nowhere is this more true than when considering the role of hydrogen (Point 1).
- Hydrogen and electricity are complementary; an electricity grid and a hydrogen grid between them can maximise economic utility from a given renewable energy capacity – with less time, less money and less despoiling of the environment (Points 2-6).

- Transport is the primary early market opportunity for hydrogen, particularly if the focus is on local vehicles concentrating demand and building a commercial case for each refueller (Points 10-15).
- When it comes to transport, developing both FCEVs and Battery Electric Vehicles (BEVs) will decarbonise the sector much faster (Point 17).
- However, nothing can approach the efficiency of FCEVs for the sort of range to which we have become accustomed – with none of the behaviour change required by battery electric vehicles or the resource constraints (Points 18-23 and 27-31).
- HGVs do need hydrogen, as highlighted in the 10 Point Plan, but it has nothing to do with their size; range and utilisation are the limiting factors (Points 24-25).
- HGVs are also long haul vehicles; a nationwide network is needed in order to unlock the market so they are not a realistic starting point for an infrastructure strategy (Point 26).
- Green hydrogen has to be the endgame but the development of the uses of hydrogen and a green hydrogen supply chain can be developed independently; forcing them to evolve in lockstep will hobble them both (Point 16).

- Carbon capture and storage, whilst it may well have an interim role, can never be a long term solution as millennial storage is finite; amortisation of investment in such technologies over a decade or two must be weighed against long term investments that can be amortised over centuries (Points 35-36).
- For heating, efficiency and sources of hydrogen will dictate the optimal mix of hydrogen, electricity with heat pumps and local heat grids; a single solution will be the wrong solution and using hydrogen generated from electricity will only make sense from curtailed electricity sources (Points 37-40).

- A step change in technology is both essential and possible; the breakthrough is through systems integration in both the energy system and the automotive sector, exactly what the UK is so good at and where the most significant opportunities lie.
- In these circumstances, incremental solutions take longer, cost more and lead to less optimal outcomes – as David Lloyd George said, “There are times you need the courage to take a great leap; you can't cross a chasm in two small jumps.”
- Technology neutrality is a laudable aim. The fuel cell was invented by Sir William Grove, in Swansea in 1839, so would it not be appropriate, and restore technology neutrality, to match the Faraday Challenge by launching a Grove Fuel Cell Challenge?

The End Game: Green hydrogen and electricity as complementary vectors

1. We face multiple environmental and social issues beyond carbon emissions – resource depletion, bio-accumulation of toxic waste, biodiversity loss, energy security – and we cannot pick each problem off independently; we need a whole system approach to solving the gamut of problems. Specifically, we cannot address challenges facing the energy sector independently of the transport sector; nowhere is this more true than when considering the role of hydrogen.

2. We have 2 national grids carrying 2 vectors, electricity and gas; there's only one sort of electricity but the optimal end game is a gas grid carrying green hydrogen to complement it. They are fungible and together can be the foundation for a completely renewable energy system. The grid has carried hydrogen before – until conversion in the 1960s, the grid was carrying town gas, which was over 50% hydrogen.

3. Both hydrogen and electricity are energy carriers not energy sources – they have to be generated from an energy source – and both are 'common denominators' in that they can each be generated relatively directly from any energy source. The ability to support either grid from any energy source maximises the flexibility that we need so badly for the transition to a renewable energy system; methane does not offer this flexibility.

4. Some sources generate hydrogen more efficiently and some electricity; hydrogen from methane (natural gas or biogas) is 75% efficient whereas electricity from methane is 49% efficient on the UK grid (DUKES 2020). In addition, some demands are met more efficiently by electricity and some by hydrogen.

5. By running these 2 parallel energy vectors, with efficiency gains both at source and demand ends of the pipe, these efficiencies compound; through efficiency improvements, and both reducing and smoothing demand on the electricity grid, the cost and the time of achieving a renewable energy system are both reduced.

6. A single solution, a silver bullet, is always a temptation but channelling all energy through the electricity vector will be much less efficient than an integrated energy system based on electricity and hydrogen; it will require more renewable capacity, more capital investment and more despoiling of the environment. We can achieve much greater economic utility from a given renewable energy capacity with these 2 energy vectors (plus local heat grids – see Points 37-38). It also allows us to collaborate globally on all our energy and transport technology and infrastructure, whilst every region can use their local mix of renewable energy sources; those sources are spread much more evenly around the planet than oil.

The transition from a capital-based energy system to a revenue-based energy system

7. As with money, sustainability means living off revenue rather than capital, and renewables are a revenue stream in contrast to capital resources such as oil. We can draw down capital at any rate we like but it won't last very long; the rate at which we draw

revenue down is limited – but it lasts indefinitely. This requires a change of mindset, toggling from managing supply to meet demand – which is how the fossil fuel model operates – to managing demand to meet supply.

8. In this scenario, to achieve Net Zero as quickly and cheaply as possible, we must prioritise energy efficiency in all sectors; reducing demand achieves quicker and cheaper progress to Net Zero than installing more renewable generating capacity.

9. We must also backcast a strategy at a system level in order to avoid investing heavily in interim measures that are dead ends, as they must necessarily be superseded. A forecasting strategy may reduce emissions in the short term but it tends to prioritise 'low hanging fruit', solutions that are less bad but have no prospect of ever being sustainable – dead ends. Dead ends are bad news as we cannot get to our end goal and we must write off the investment we have made in getting to the wrong place and start again; any investment we make must take us closer to our end goal. Carbon Capture and Storage is an example of an interim technology.

The role of transport in catalysing the hydrogen economy – Infrastructure

10. Transport is the primary early market opportunity for hydrogen as transport fuels can support a premium over grid energy and it be introduced incrementally at low risk by focussing on local vehicles. A focus on local vehicles resolves the oft-cited 'chicken and egg' problem of hydrogen infrastructure for transport – who is going to invest in infrastructure before the cars are on the road and vice versa.

11. The critical scale of infrastructure to create a commercial market for intercity, motorway vehicles in the UK is of the order of 300 refuelling stations – a nationwide network and a significant speculative investment that will take years to break even.

12. On the other hand, the critical scale of infrastructure to create a commercial market for local vehicles – local buses, cars, last mile delivery vans etc. – comes down from 300 filling stations to just one.

13. Local buses, last mile delivery vans all operate in a local area, depot-based. There are more than 3 million cars in the UK that never travel outside a 25 mile radius and these are an analogue for depot-based fleets. All these vehicles can be supported if refuelling infrastructure allows retail access.

14. A filling station in a small city only creates a small market but it is a commercially viable market unlocked with a small upfront investment. By concentrating demand it creates a strong investment case for installing a hydrogen pump that is independent of 300 other installations; if 100 vehicles are deployed in that city, rather than spread around the country, the filling station has 100 captive customers straightaway and quickly breaks even.

15. The refuelling network can be expanded one filling station at a time; each station is a commercially viable investment and this allows the development of a nationwide network without ever taking a nationwide gamble.

16. Green hydrogen has to be the endgame but the development of the sources of green hydrogen and the uses of hydrogen can and should be developed independently. Mandating the use of green hydrogen only would be a sub-optimal deployment of our growing renewable energy resources as these should be allocated to displacement of as much carbon as possible as quickly as possible. In many instances, such as transport, using natural gas to generate grey hydrogen for transport will displace more carbon than using it to generate electricity; forcing them to evolve in lockstep would hobble them both.

Battery Electric Vehicles (BEVs) and hydrogen Fuel Cell Electric Vehicles (FCEVs)

17. We need both BEVs and FCEVs, different solutions for different applications. They are complementary and we can decarbonise the transport sector more quickly with both. We don't argue about whether solar PV or wind turbines will 'win' the renewable energy race; they're different, we need them both and it's rather a silly question. The same is true of BEVs and FCEVs.

18. FCEVs are better suited than BEVs to three challenges that we face; a) longer range applications, b) vehicles with high utilisation and c) vehicles that carry heavy payloads. Note that size is <u>not</u> one of the criteria for choosing between batteries and hydrogen; the same criteria apply irrespective of size, from HGVs to forklifts – which is why hydrogen forklifts are the first sector in which hydrogen fuel cells are well established.

a) Range:

19. BEVs are very efficient for short range applications but the efficiency of a vehicle also depends heavily on weight. Batteries are heavy and so, as the range for which a BEV is designed increases, it rapidly becomes very heavy and the efficiency collapses; every additional battery adds less range than the previous one. This is the principal reason why the likes of Toyota have been very consistent for over 20 years that FCEVs are the answer for cars with the sort of range to which we have become accustomed.

20. An oft-cited Pareto principle for cars is that 80% of journeys are of less than 20 miles; this is used to argue that a short range is enough for most people. The corollary of this is that 80% of the miles are driven in the other 20% of journeys so this accounts for a much larger proportion of the problem.

21. There is an equally oft-cited argument that the powertrain efficiency of an FCEV can never match that of a BEV, which is true. The powertrain efficiency measures the proportion of the energy put into the car gets to the wheels, but not how much energy is needed at the wheels, which also depends on weight. A high efficiency powertrain in a heavy vehicle will still be an inefficient vehicle.

b) Utilisation:

22. The problem with vehicles with high utilisation is downtime required to recharge the vehicle. One must remember that a standard petrol pump is transferring energy at 20MW into a petrol tank; this is over 150 times as fast as even a Tesla Supercharger. We could charge cars with higher power chargers but the capital costs go up, the spikes on the grid get more severe, the safety risks increase, the efficiency falls and the battery life suffers; it is simply a brute force approach to the problem and we need a bit of Aikido thinking if we are to build resilient solutions.

c) Payloads:

23. As discussed above, batteries are heavy and more batteries are needed the heavier the vehicle. HGVs are an extreme example of inappropriate use of batteries because not only are so many batteries required but they also compete with the payload.

HGVs

24. The 10 Point Plan highlights the need for hydrogen for HGVs; this is certainly the case but it has nothing to do with their size.

25. As in Points 18-23 above, the choice of batteries or hydrogen fuel cells is dictated by range and utilisation and this applies for any size or weight. It would be easy to build a battery HGV with a 50 mile range but for the range required in long haul transport, and the utilisation, the weight of batteries and the recharge time can never match the performance of hydrogen.

26. Furthermore, HGVs are by definition long haul vehicles and so need a nationwide network of refuellers in order to create a market – a significant investment with a long payback – so they are not a realistic starting point for an infrastructure strategy.

Other challenges for BEVs

27. Unlike BEVs, FCEVs demand no behaviour change, as they refuel in a similar time to a combustion-engined vehicle and have a similar range.

28. It should be noted also that 38% of UK households have no access to overnight charging at home; FCEVs offer an alternative to those households.

29. The infrastructure challenge for BEVs is greater than for FCEVs, although this is not widely appreciated. Although charging for BEVs at small scale is more cost effective than hydrogen refuelling, as the penetration of vehicles increases, this situation reverses. A hydrogen pump can support hundreds of cars, like a petrol pump, whereas a charger can only support a handful. A Jülich University study recently concluded that at 1 million cars hydrogen refuelling was more cost effective; the UK car parc is over 30 million cars.

30. As an example of the costs at scale, if the 20 pumps in a modest motorway services were to be replaced by Tesla superchargers to support the same throughput of cars, 120 chargers would be required as, generously, it takes 6 times as long to charge. Each supercharger is 120kW so a 14.4MW substation would be required for that one site. This is equivalent to the average consumption of 32,000 homes in the UK and, even if power lines were on hand, this is a significant investment.

31. As highlighted in a report to the Climate Change Committee from a consortium of institutions led by the Natural History Museum, meeting the challenge of vehicle electrification with Battery Electric Vehicles alone in the UK requires an unrealistic quantity of finite natural resources. For 31.5 million vehicles, they calculated that we would need twice the annual global production of Cobalt, a year's production of Neodymium, 75% of a year's production of Lithium and half the annual production of Copper. This is for 31.5 million vehicles; there are 1 billion vehicles on the planet, and growing so, at the very least, to pursue this strategy would pose a huge economic risk to the UK.

Sources of hydrogen

32. We must consider the entire energy and transport system in order to develop a transition strategy. We need to bring down our carbon emissions as much as possible as quickly as possible. Therefore, as we continue to develop renewable energy capacity, it should be deployed so as to maximise the displacement of carbon.

33. Whilst electrolysis of water using renewable electricity has a key role to play, direct generation of green hydrogen from renewable sources should be prioritised; all forms of biomass are rich in hydrogen and the conversion process to hydrogen is more efficient than that to electricity. Hydrogen is also being generated commercially from mixed waste streams. Other technologies have been demonstrated but not yet commercialised such as photocatalysis (direct cracking of water using solar energy rather than via solar PV and electrolysis) and algae giving off hydrogen as a waste product.

34. An obvious exception to this is the capture of any curtailed electricity supply when demand is insufficient; hydrogen can be stored more cheaply than electricity and electricity can be transmitted to where hydrogen is required tomorrow and electrolysed and stored there.

35. Carbon capture and storage, whilst it may well have an interim role, can never be a long term solution. There are 2 finite forms of natural capital – non-renewable resources and the sink capacity of the ecosystem to absorb our waste. CO_2 waste from human society is exceeding the sink capacity of the planet but CCS requires storage over millennia and that is also finite.

36. Therefore CCS, whilst it may well have an interim role in the transition we are navigating, has no long term role in a sustainable industrial society. Any investment in

interim measures has little time to pay back; amortisation of any such investment over a decade or two must be weighed against long term investments that can be amortised over centuries (see Point 9).

Heating

37. For heating, efficiency and sources of hydrogen will dictate the optimal mix between hydrogen, electricity with heat pumps and local heat grids using waste industrial heat.

38. The appropriate solution for each location will depend on housing density, availability of waste heat locally and the sources of green hydrogen that are available.

39. Any single solution will be the wrong solution, such as using green hydrogen generated from renewable electricity as our standard heating vector; it will make sense in certain cases, such as using curtailed electricity sources to top up hydrogen from biomass, but if the electricity can be used directly it will be more efficient – even without the factor 3 benefit of using a heat pump.

40. However, if a plentiful supply of hydrogen is available from direct sources and curtailed electricity generation the picture is very different and it could readily be adopted in existing oil or gas-fired heating systems.

Potential value to UK economy

41. Vehicles are potentially a catalyst to the development of the hydrogen economy. Energy that can be used for mobile applications carries a premium over stationary grid energy and an application at a premium over industrial hydrogen is an early market opportunity to stimulate the development of green hydrogen supply.

42. FCEVs are much less mature than BEVs and offer more opportunity for innovation, which plays to UK strengths; the UK has the strongest community of automotive technology and motorsport companies in the world. The real opportunity is to build a different sort of car, with a different pattern of relationships, that makes the most of fuel cell technology and hydrogen's characteristics. The innovation is at the system level and that is where the UK excels, as evidenced in the UK's dominance of motorsport.

43. As the FCEV industry is immature, there are also significant opportunities to establish an early position in an emerging global supply chain.

44. FCEV manufacturing will also retain more value in the UK economy than BEVs. A significant proportion of BEV cost is in the battery and 70% of that cost is in the raw materials.

45. Investments already made in battery manufacturing in China especially mean that there is no prospect of the UK achieving a competitive position globally. Battery manufacturing is also an extremely highly automated production process and creates very few jobs. As demand for commodities goes up, the price goes up, not down, and the likelihood is that battery cost is shortly going to start climbing rather than reducing. China also controls a significant proportion of those commodity materials.

46. As Baroness Brown recently stated, "The UK missed the boat on wind technology and missed the boat on batteries. We can’t afford to miss the boat on hydrogen.”

UK Government approach

47. The UK Government has only cited HGVs as suitable for hydrogen. As companies like Toyota and Hyundai have consistently suggested (and we ignore their conclusions at our peril), hydrogen has a much wider role to play and this wider role will have compounding benefits. In particular, infrastructure development will be very challenging if HGVs are to the target entry point.

48. The government's stance on technology neutrality is welcome but the Faraday Battery Challenge alone provides over 10x the funding support to BEVs compared to funding for HFCVs under the Hydrogen Transport Programme (HTP). Even then, HTP is for the deployment of vehicles rather than for their development and so most of those funds have been used to subsidise the purchase of FCEVs from Japan and Korea rather than supporting technology R&D in the UK.

49. The fuel cell was invented by Sir William Grove, in Swansea in 1839, so would it not be appropriate, and restore technology neutrality, to match the Faraday Challenge by launching a Grove Fuel Cell Challenge?

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