Frazer-Nash Consultancy – Written evidence

Thank you for the opportunity to provide written evidence to the committee. Frazer-Nash Consultancy is a systems and engineering consultancy that has a track record of providing engineering and techno-economic advisory services on both batteries and fuel cells to government, technology manufacturers, and project developers. We are pleased to provide our response relating to the current and future roles of batteries and fuel cells as part of the transition to Net Zero.

Battery and fuel cell technologies are currently contributing to decarbonisation to varying extents, but both will play an increasing role in decarbonisation of the transport and electricity sectors.

Batteries are already contributing to decarbonisation of the transport sector due to their increasing usage in electric vehicles (EVs). It is expected that hydrogen fuel cells will be used in large-scale, heavy duty transportation where the weight and recharging time required for batteries means they are not suitable.

In particular, batteries have a key role in making sure power is available when electricity consumers need it, through supporting the security of supply and reliability of the grid in the transition to net zero. In order for batteries to provide this role successfully, the UK must continue to focus efforts on standardisation in the electricity sector. This includes standards relating to health & safety and technical electricity system standards.

In order to support the wider deployment of batteries and fuel cells to support decarbonisation in other sectors, the UK must develop infrastructure for recycling batteries and fuel cells, and design and implement a strategy to ensure security of supply of the critical materials.

Responses to questions

1. To what extent are battery and fuel cell technologies currently contributing to decarbonisation efforts in the UK?

As of February 2021, the UK has 1.1 GW of installed and operational battery storage with a further 15.7 GW of battery storage projects in the pipeline[1]. The four pathways described in National Grid ESO's future energy scenarios 2020 suggest that between 6 and 16 GW of total energy storage will be required by 2030, increasing to between 25 and 60 GW by 2050[2]. The proportion of electric

[1] Renewable UK, "Press release: UK's total pipeline of battery storage projects now stands at over 16 gigawatts," 05 02 2021. [Online]. Available: https://www.renewableuk.com/news/550773/UKs-total-pipeline-of-battery-storage-projects-now-stands-at-over-16-gigawatts.htm [Accessed 18 03 2021]
[2] National Grid ESO, "https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents," 07 2020. [Online]. Available: https://online.flippingbook.com/view/621114/20/ [Accessed 26 03 2021]

vehicles (EVs) with on-board energy storage is increasing, in preparation for 2030, when the sale of new petrol and diesel cars and vans will be phased out, and 2035 when all new cars and vans will be zero emission at the tailpipe[3].

Hydrogen fuel cells are at an earlier stage of deployment than Li-ion batteries in Great Britain. Recently, there have been some pilot schemes employing hydrogen fuel cells, such as the introduction of a fuel cell electric bus (FCEB) in Aberdeen in preparation for more to be delivered in the future. Shipments of fuel cells worldwide cover a variety of applications, including passenger cars, heavy duty vehicles, trains, maritime applications, stationary applications and more. However, fuel cell shipment is still only in the tens of thousands per year[4].

6. In what sectors could battery and fuel cell technologies play a significant role?

What will be the likely balance between battery and hydrogen fuel cell technologies (and other options) in a fully decarbonised land transport sector (e.g. heavy and light vehicle transport)?

Both batteries and fuel cells will be vital in decarbonising the transport sectors, with different technologies relevant to different vehicle types. Whilst cars and light goods vehicles (LGVs) can be electrified, and short distance heavy goods vehicles (HGVs) may be able to undergo electrification, there is significant debate surrounding how long distance heavy good vehicles could be electrified. For such large vehicles to travel such distances, the weight of the batteries required will be significant. Furthermore, the time taken to recharge would not be ideal for vehicles intended for high utilisation. The same considerations apply to the maritime transport sector. Ferries that undertake short journeys can be electrified or use biogas or biofuel. Ships with a typical journey length of several hours will require hybrid solutions. Long distance ships will require a fuel-based technology, such as fuel cells, to be able to undertake journeys potentially lasting days or weeks.

To achieve decarbonisation of the aviation sector, batteries, fuel cells and synthetic aviation fuels may all play a role, and the successful technology will depend on technical, economic and safety considerations.

What are the engineering and commercial challenges associated with using these technologies, or deploying them to a greater extent, in these sectors?

Frazer-Nash Consultancy has been supporting the Rutherford Appleton Laboratory in research funded by the Science and Technology Facilities Council (STFC) to investigate the use of ammonia in solid oxide fuel cells (SOFCs) to

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[3] UK Government: DfT and BEIS, "Government takes historic step towards net-zero with end of sale of new petrol and diesel cars by 2030," 18 11 2020. [Online]. Available: https://www.gov.uk/government/news/government-takes-historic-step-towards-net-zero-with-end-of-sale-of-new-petrol-and-diesel-cars-by-2030 [Accessed 24 03 2021]

[4] E4Tech, "The Fuel Cell Industry Review 2020," March 2021

generate power. For extensive use of hydrogen fuel cells in transport, effective hydrogen vectors are required. Frazer-Nash view ammonia as an important vector as it can be split into nitrogen and hydrogen, and this could be useful for road, aviation and maritime transport. Ammonia is a good vector for transporting hydrogen, as it is easier to store. Before this is a commercially viable technology, several challenges must be overcome. Firstly, ammonia is hazardous. Secondly, the hydrogen used in fuel cells must be extremely pure as the fuel cell components are sensitive to corrosion by contaminants. It should be noted that ammonia could be used in fuel cells or as fuel for modified internal combustion engines. Like batteries, there would need to be the development of standards to ensure the safety of extensive hydrogen usage, due to the likelihood of leaks and its buoyant nature, and Frazer-Nash Consultancy has been involved in understanding the safety aspects for hydrogen.

7. How should battery and fuel cell technologies be integrated into the wider UK energy system, and what are the challenges associated with integration (e.g. infrastructure, deployment, system operation, regulatory frameworks)?

To what extent can batteries (including vehicle batteries) be used for energy storage and frequency management on the grid, and what needs to happen to enable this?

The dominant battery storage technology for providing energy storage and frequency management is Lithium-ion (Li-ion), with significant advantages in energy density, power density and cost over alternative technologies. Li-ion batteries can provide the majority of the UK's emerging energy storage and frequency management needs over short to medium time scales (up to a few hours).

Batteries can be combined with modern power electronics (such as power converters) and control algorithms to provide a range of grid services in order to keep grid voltage and frequency within safe and efficient levels. These grid services include those services that have traditionally only be provided by large traditional power stations such as nuclear or coal-fired plants.

In order to enable provision of these grid services, the UK health and safety (H&S) regulatory and standards framework must evolve to ensure that systems continue to operate safely. Frazer-Nash was commissioned by the Department of Business Energy and Industrial Strategy (BEIS) to review the current H&S standards for electricity storage, identify potential gaps and propose solutions to close these gaps.

The H&S regulatory and standards framework of the future needs to evolve in three key ways: 1) focused standardisation efforts (including industry working groups supported by government funding) for rapidly commercialising technologies such as Li-ion 2) training and education to industry and emergency fire services on new and existing H&S standards related to batteries 3) working groups to support adoption and communication of standards.

In addition to these general changes, it is important that the H&S standards address "second life batteries"- refurbished electric vehicle batteries used in stationary storage applications. The available supply of second life batteries will increase as the uptake of electric vehicles increases. There needs to be a set of standards that mitigate hazards resulting from use of second life batteries, particularly those that have experienced previous damage or degradation.

In December 2020, the Government and Ofgem published a white paper detailing an independent review into electrical engineering standards[5]. A technical analysis of the topic areas was undertaken by Frazer-Nash Consultancy[6] and we believe that several outcomes of the review are relevant to enabling wider deployment of batteries in the electricity sector. It is important that the UK electricity standards landscape continues to be reviewed regularly to ensure safety, efficient grid operation and security of supply throughout the transition to net zero

In particular, a key outcome of the review was that additional standardisation work is required to support interoperability of electric vehicles with the grid. Development of interoperability standards will further support the application of electric vehicle batteries to provide grid services, as well as supporting roll out of vehicles to the transport sector through improving vehicle owners' user experience.

8. What are the life cycle environmental impacts associated with batteries and fuel cells (e.g. in resource extraction, product manufacture, operation, reuse and recycling), and how can these be managed as production and usage increase?

Given a potential global vehicle fleet approaching 2 billion vehicles by 2050, will all of the materials needed for battery and fuel cell production be available for manufacturing based in the UK?

The manufacture of Li-ion batteries and fuel cells requires many key elements which are not abundant. Since 2011, the EU have undertaken four assessments and published a list of critical raw materials (CRMs). These refer to materials that are very important to the EU economy and their future supply could be at risk of interruption. The list has been updated every 3 years to reflect development in markets, production and technology. The most recent list was published in 2020 and featured 30 materials.

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[5] BEIS, "Electricity Engineering Standards Review: Independent Panel Report," 2020

[6] Frazer-Nash Consultancy, "Electricity Engineering Standards Review: Technical Analysis of Topic Areas," Report Prepared for BEIS, 2020

Of the elements listed in the 2020 EU CRM report, EV and stationary storage batteries require many CRMs, including lithium, cobalt and graphite. Hydrogen fuel cells also require many CRMs, including precious metals (usually platinum and sometimes ruthenium) and graphite. The main global producers and main EU suppliers of the CRMs are outside of the EU, including China, Democratic Republic of Congo and Chile[7].

For UK based manufacturing of battery and fuel cell technologies, supply disruptions of the key materials should be mitigated against. This can be achieved in two ways.

1. The UK needs to ensure a strategy is in place to ensure access to the required raw materials. The UK does not have a specific strategy for ensuring security of supply of critical raw materials as responsibility for developing this strategy is not aligned with a single government department.
2. The dependence of the manufacturing industry on the supply of raw materials could be reduced by improving recycling and recovery of the key materials from existing technologies at their end of life. This is also relevant to the goal of transitioning towards a circular economy.

There are several challenges to ensuring that the key materials are recycled and recovered. It needs to be ensured that the recycling technology exists to recover the critical materials and that the infrastructure is in place to ensure collection of the assets to be recycled. For example, the platinum group metals (inc. platinum and ruthenium) can be often substituted for each other and are highly recyclable. The challenge is ensuring the materials are collected for recycling at the end of life of the product. Cobalt also has a very high recycling input rate whereas graphite has a very low end of life recycling rate. Finally, lithium in batteries is not currently recyclable and industrial scale recycling of lithium is not economically viable.

In order to resolve this, recycling of current battery technologies must improve and development of battery technologies for which remanufacturing, or recycling is more feasible will be required. This has been recognised by the UK Government and £246 million was invested in the Faraday battery challenge in 2018 which aimed to fund projects in developing new battery technologies, improving performance and reliability, and developing whole life strategies[8].

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[7] European Commission, "Study on the EU's list of Critical Raw Materials - Final Report," 2020

[8] UK Government: Engineering and Physical Sciences Research Council, Innovate UK, and UK Research and Innovation, "Faraday battery challenge: Industrial Strategy Challenge Fund," 04 12 2018. [Online]. Available: https://www.gov.uk/government/collections/faraday-battery-challenge-industrial-strategy-challenge-fund [Accessed 26 03 2021]