Written Evidence Submitted by Rolls-Royce plc (HNZ0029)

Rolls-Royce pioneers cutting-edge technologies that deliver clean, safe and competitive solutions to meet our planet's vital power needs. We are a UK-based company with customers in more than 150 countries. We employ over 20,000 people in the UK and invested over £1.46 billion on research and development globally in 2019. Our business is focused on three core areas in Civil Aerospace, Defence and Power Systems and we lead the UK Small Modular Reactor (UK SMR) Consortium in the Nuclear sector. Rolls-Royce is committed to playing a leading role in enabling the sectors in which we operate to reach net zero carbon by 2050 through the development of new products and technologies, including aviation, shipping, rail, and power generation.

1. *The suitability of the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen", including:*
    - *the focus, scale and timescales of the proposed measures;*
    - *how the proposed measures—and any other recommended measures—could best be co-ordinated;*
    - *the dependency of the Government's proposed plans on carbon capture and storage, any risks associated with this and how any risks should be mitigated; and*
    - *potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel;*

The proposed measures are a sensible baseline for an initial investigation of the mainstream rollout of Hydrogen as a fuel in the UK. However, the timeline and milestones provided are relatively conservative in both their scope and urgency. Whilst there is some uncertainty associated with predicting energy futures, it seems unlikely that any future scenario would exist where a wider rollout of Hydrogen, at some level, is not required. Therefore, early work to understand the cost and potential impact of a more rapid development and demonstration of Hydrogen energy systems would seem appropriate given HMG's legal commitment to 'Net-zero' and the UK's potential for taking a leading international role in this domain.

The UK is well placed to exploit its capability in nuclear engineering and infrastructure deployment to demonstrate a route towards reliable net-zero Hydrogen production. Plans are already in place to deploy a fleet of UK Small Modular Reactors (UK SMR) as part of the UKRI Industrial Strategy Challenge Fund (ISCF) Low Cost Nuclear (LCN) challenge. Combining the LCN programme with an accelerated vision for the deployment of SMR in the UK would allow HMG to demonstrate, validate and then quickly deploy reliable net-zero carbon hydrogen production at scale across the UK. The LCN programme, led by Rolls-Royce as part of a broader UK industrial consortium, is already attracting interest from potential investors with the vision, financing and desire to support the funding of such as rollout. This option would provide a simple, effective route to nation scale hydrogen production, creating tens of thousands of jobs across the regions of the UK and ensuring the availability of cost competitive hydrogen to consumers in multiple sectors.

2. *The progress of recent and ongoing trials of hydrogen in the UK and abroad, and the next steps to most effectively build on this progress;*

Some significant early work has been conducted in the UK, such as the HyNet project, that are developing a leading understanding of the challenges, barriers, risks and benefits of moving towards a Hydrogen energy system. Similar projects exist in multiple nations around the world and the UK is well positioned to learn from such activities and incorporate this learning into future projects in the UK. Significant potential exists for the UK to partner at a global level, should it choose to be pro-active in doing so.

As is the case in many areas of energy policy, the UK has a choice between investing at a state, industrial and individual level to take a leadership position, or to be more reactive to future developments in other nations and 'wait and see'. Again, as is the case with Question 1, it is unclear why the UK would adopt the latter approach, given that virtually all forms of future energy system will require some level of Hydrogen production, storage, distribution and management solutions. Even a small fraction of the global energy market of approx. $6 Trillion would be a valuable position with the potential to generate thousands of skilled jobs; that is before taking into account any spin-off benefits relating to science, R&D and adjacencies.

3. *The engineering and commercial challenges associated with using hydrogen as a fuel, including production, storage, distribution and metrology, and how the Government could best address these;*

Many technical challenges remain in turning low-carbon Hydrogen from a fringe and expensive option that it is today, into a mainstream energy vector with widespread adoption.

New approaches to Hydrogen production, for example coupled to novel energy generation such as small nuclear, must be explored and commercial models developed and implemented. Understanding how much impact variable renewables can truly have at a whole system level needs to be a priority. It is likely that curtailed renewable electricity may only be able to account for 10-15% of total energy demand for Hydrogen; as such it plays an important but relatively niche role when mainstream Hydrogen deployment is considered.

Will the production of Hydrogen be best served centrally, with a broad distribution network (such as with natural gas today)? Or will a more distributed model, with Hydrogen produced locally via electrolysis be more cost effective if the costs of nation scale storage and distribution prove too significant? What commercial models fit in either scenario? How do we transition from the commercial frameworks of today's energy system to those required for this future system? How does HMG (and society) ensure a level of energy justice within that transition so that fuel poverty can be addressed and the faults within today's system can be reduced or eliminated?

HMG must provide clarity of purpose and desired outcomes via integrated, sustained and straightforward energy policy. Support must be offered to new projects, R&D and product/service development to allow new technologies and commercial models to be trialled. This must take place at scale and with pace so that socio-economics and environmental requirements can rapidly evolve 'winning' solutions that meet the needs of the nation.

4. *The infrastructure that hydrogen as a Net Zero fuel will require in the short- and longer-term, and any associated risks and opportunities;*

There are two major challenges that must be addressed in order to scale up Hydrogen as a mainstream energy vector.

I. The Investor Paradox – Significant funding will be required to develop the technology, infrastructure and markets for the deployment (and revenue generation) of Hydrogen energy systems. However, without a clear route to generate returns, investors will be cautious and may be reluctant to invest in a large enough quantity early enough in the system / infrastructure development cycle.

   Government has a key role to play in providing financiers with confidence that Hydrogen energy systems will serve an important purpose within the future UK energy marketplace. This will require long term, strategic and sustained interventions with the purpose of incentivising investment into low-carbon Hydrogen projects (at scale) whilst disincentivising high-carbon alternatives over time, to gradually transition the UK energy system from one to another whilst minimising the risk of disruption and ensuring that such a transition takes place in a timely manner (in line with Net-zero obligations).

II. Establishing a Hydrogen energy system infrastructure is only meaningful in the context of decarbonisation if Hydrogen generation is powered by low-carbon technologies as part of a net-zero economy. To do so at scale will require a significant further expansion of nuclear and renewable electricity generation – with the express purpose of the primary application of the electricity generated by such infrastructure being used for Hydrogen production rather than for grid electricity end use.

   At present, there is no definitive statement of intent from HMG that this is the desired route forwards at a scale required to meet net-zero. As such, uncertainty prevails within the investment community and significant levels of private finance may not be forthcoming in the future (at the rate of scale required for Net-zero obligations). The UK is host to vast potential for the deployment of renewables and plays host to significant capability for new nuclear (both large and small), but this potential must be turned into reality via the combined action of Government and industry if we are to achieve Net-zero.

5. *Cost-benefit analysis of using hydrogen to meet Net Zero as well as the potential environmental impact of technologies required for its widespread use; and*

It is too early to provide a definitive final answer on cost-benefit analysis of Hydrogen adoption and deployment. Significant work in this field has been undertaken by both the ETI, Energy Systems Catapult and research groups such as that at Imperial College London. These (and other) groups should be supported to continue to develop analysis as the understanding of technologies, commercial models and future system configurations evolves.

6. *The relative advantages and disadvantages of hydrogen compared to other low-carbon options (such as electrification or heat networks), the applications for which hydrogen should be prioritised and why, and how any uncertainty in the optimal technology should be managed.*

Again, whilst it is too early to provide a ‘final’ answer, much work has already been undertaken by the likes of the ETI, Energy Systems Catapult and research groups such as that at Imperial College London in the UK. Additionally, the Royal Society report on Nuclear Cogeneration of Hydrogen signposts important opportunities for near term (Small Modular Reactor – SMR) and longer term (Advanced Modular Reactor – AMR) low carbon technologies that the UK could lead in developing to serve both UK and export markets. Once more, the UK must decide if it wishes to play a ‘lead’ or ‘follower’ role in the development of the full-spectrum of Hydrogen generation infrastructure from energy source to end-user. Mixed approaches may be viable, but with obvious consequences to UK export potential and the sustainability of national low-carbon job creation.

Internationally, significant work is ongoing in the USA as part of the National Renewable Energy Laboratory (NREL) Hydrogen programme. Additionally, similar work is underway supported by Hydrogen Europe and in Japan as part of the Japanese Government’s ‘Basic Hydrogen Strategy’. It is important to recognise that energy has dominated global geo-politics since the beginning of the industrial revolution, and it seems unlikely that this will change substantively in the future. Having a strong national capability in Hydrogen energy may be of significance beyond the core focus of Net-zero.

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