Written Evidence Submitted by ITM Power (HNZ0027)

ITM Power plc is a U.K. manufacturer of electrolysers www.itm-power.com. We export products across the world, have 20 years' experience of designing, manufacturing, deploying and operating hydrogen systems and are the developer, owner and operator of nine public hydrogen refuelling stations in the U.K.

ITM Power is based in Sheffield at a brand new manufacturing facility, which has a world-leading production capacity of 1GW of electrolysers per annum. ITM Power was referred to as a case study in Point 2 of the Prime Minister's recent 10 Point Plan.

Summary of key messages and recommendations

We believe the government's plan needs to be re-focussed to:

- Emphasise the production and use of 'net-zero' hydrogen, not 'low-carbon' hydrogen.
- Prioritise green hydrogen.
- Switch existing hydrogen users away from grey to green hydrogen.
- Improve the RTFO and set a deployment target of 100 hydrogen refuelling stations by 2025.
- Permit the injection of hydrogen blends into natural gas distribution networks via power-to-gas systems.
- Undertake trials and pilots of hydrogen mini-grids for industrial or heat applications based on green hydrogen.
- Trial long-duration underground storage of green hydrogen as a renewable energy lung for the future electricity system.
- Prepare the way for the U.K. to export green hydrogen at scale to Europe via high pressure transmission pipelines.

1. The suitability of the Government's announced plans for "Driving the Growth of Low Carbon Hydrogen"

We believe the government should prioritise its focus on 'net zero' (green) hydrogen, not on 'low carbon' hydrogen. Measures are needed to ensure net-zero hydrogen is produced as soon as possible. Placing the focus on 'low-carbon' hydrogen is no longer appropriate, government should concentrate on 'net-zero' hydrogen production and use.

The U.K. has very large renewable resources, far larger than its European neighbours. This supply of renewable energy is inexhaustible, cheap and too large to be integrated solely within our electricity grid. Therefore, besides electricity generation, this resource needs to be harnessed in molecular form by converting renewable electricity to green hydrogen, so that our high dependency on fossil fuels can be reduced across the energy system. This can be achieved both on-grid and off-grid, and either close to the points of hydrogen demand (such as the network of hydrogen refuelling stations ITM Power operates in the U.K.), or close to the points of renewable power production.

Green hydrogen is a 'net zero' commodity, blue hydrogen is not. Crucially as a form of renewable energy it is storable, unlike electricity. It can be used both to meet our domestic needs across a range of applications and to provide a substantial export income for the U.K. This opportunity has been recognised by several governments including Denmark, Portugal, Australia, Chile and Morocco and the 2050 potential for the U.K.

has recently been quantified in a study by the Offshore Renewable Energy Catapult [1]. However, the U.K. Government's plans seem to largely overlook and underestimate the opportunity for producing hydrogen at scale from our indigenous renewable resource. The government is insufficiently focussed on green hydrogen and the scale of its potential contribution to the U.K. economy. Meanwhile the strategies of most other European nations and the EC prioritise green hydrogen for achieving a net-zero energy system by 2050 [2]. This means the U.K. is at risk of missing the boat on green hydrogen, despite our advantages in terms of natural resource, technology and research capability.

The option of perpetuating natural gas imports by making blue hydrogen and storing the CO2 byproduct here (via CCS) is controversial. Blue hydrogen production needs to be done at scale and requires large investments from the outset; it requires a substantial sink for the hydrogen; it requires the residual GHG emissions associated with CO2 capture and upstream methane emissions to be netted off; and it is characterised by a number of uncertainties and long-term liabilities with respect to CCS and who pays for the CO_2 disposal. Minimising the risks, liabilities and costs equates to limiting the extent of CCS adoption in the U.K., while maximising the adoption of indigenous renewable energy. The government doesn't appear to have grasped this principle. Additionally blue hydrogen will take many years to be produced at scale. The first CCS projects in the U.K. will not come online until 2025 at the earliest. However electrolysers and green hydrogen can be produced at scale today. Electrolyser manufacturing facilities for volume production are already available in the U.K. and are under development in the US and other European countries. A failure to prioritise green hydrogen will prevent significant progress in developing the U.K. hydrogen economy over the next 5 years.

The government's preoccupation with CCS does nothing to help the UK's balance of payments or long term energy security. The plans fail to address the vast scope within U.K. territory for (a) green and yellow hydrogen production, and (b) large scale geological storage of hydrogen rather than CO2. Also other industrially competitive European nations have placed a strategic priority on green hydrogen and allocated much larger budgets for the period to 2030. Their focus on green hydrogen echoes the preferences of the investment community, the electricity industry, the renewables sector, electrolyser manufacturers and the general public. For these reasons the U.K. government's plans present a conflicted position for the U.K., which serves to confuse both the industrial stakeholders and the investment community.

Business models depend on the introduction of policy measures that make fossil fuel use more expensive and net zero hydrogen use more attractive economically, especially during the next 10 years. Internationally, manufacturing industry is scaling up its capacity to produce electrolysers and associated hydrogen equipment thanks to very substantial investments (eg. over £1 billion was raised on the stock market by electrolyser manufacturers ITM Power, Plug Power and McPhy in Q4 of 2020 and ITM Power has recently opened the world's first gigafactory producing PEM electrolysers in the U.K.). Therefore it will not be a lack of manufacturing capacity or renewable energy resource that delays the adoption of hydrogen as a net-zero fuel. At present, it is the lack of policy and regulatory frameworks to facilitate the deployment of electrolysers and green hydrogen that are delaying matters.

There is almost a complete dearth of hydrogen policy. The RTFO is the only measure in place today, but unfortunately it doesn't allow hydrogen production within the electricity grid and it's disconnected from any national infrastructure rollout plan for dispensing the fuel or a support scheme for buying hydrogen vehicles (FCEVs). Hence the RTFO is currently having a minimal impact on facilitating hydrogen mobility in the U.K.. It needs to be overhauled to enable grid-connected hydrogen production at sites appropriate for refuelling FCEVs and so facilitate their wider adoption, with a nationwide spread of refuelling stations by 2030. Getting the RTFO right is very important for the relevant industrial stakeholders to move forward and ensure that the U.K. is seen by international OEMs as a significant hydrogen mobility player on the global map. DfT is due to publish a public consultation in 2021 and its essential that this opportunity is grasped to reform the RTFO and unlock significant levels of investment in green hydrogen within this Parliament.

In general, it appears that green hydrogen will soon be cheaper than blue hydrogen, then cheaper than grey hydrogen and in the long term potentially cheaper than natural gas. For example, it has been predicted that green hydrogen will be cheaper than grey hydrogen by 2030 [3]; and that by 2050 green hydrogen will be less than one-third of the cost of blue hydrogen [4]. The dominant trend across the period is the declining unit costs of renewables and electrolysers and the greater exploitation of our substantial offshore wind resource, which fortuitously is characterised by very high capacity factors when compared with other nations. This creates an outstanding opportunity for the U.K. to exploit progressively cheaper green hydrogen and so it should be the principal focus of the government's plan.

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.

There have been numerous mostly EU-funded hydrogen technology demonstration projects in the last decade and now several hydrogen valleys and multi-billion euro IPCEI activities are emerging across Europe. The U.K. has focussed mainly on 'hydrogen for heat' concepts to support the role of existing gas networks in meeting the heat demand of buildings, with a relatively small number of trials underway (eg. HyDeploy, H100 etc). More recently the use of hydrogen to decarbonise industrial clusters has come to the fore (eg. HyNet, Green Hydrogen for Humberside). To build on this progress requires more deployment in parallel and at an increasing scale. The next steps should be to:

a) Introduce 2030 targets for the refinery sector, the chemicals production sector and the merchant hydrogen market to switch away from grey hydrogen to green hydrogen. Increase the number and upscale the electrolyser deployments at industrial clusters and large sites.

b) Increase the deployment and adoption of hydrogen cars, buses and various types of heavy vehicle. Introduce incentives, targets and a strategic plan to roll out regional networks of hydrogen refuelling stations at bus/lorry/train depots and petrol stations. We suggest as a first step a target of 100 hydrogen refuelling stations by 2025.

c) Trial large scale underground storage of hydrogen produced from renewable power during periods of plentiful supply and its utilisation during periods of deficit. Design an associated market mechanism to facilitate the storage of net-zero energy for long duration supply/demand matching in the future electricity system.

d) Trial further hydrogen mini grids for industrial or heat applications based on green hydrogen production. Investigate how best to scale them up and where appropriate interconnect them in the medium term.

e) Adopt hydrogen blending in gas distribution networks via power-to-gas systems.

f) Engage in cross-border hydrogen projects at the scale of the hydrogen IPCEI's under development across Europe. This should include the 2040 Hydrogen Backbone initiative and establishing relationships with countries seeking to import green hydrogen (eg. Germany).

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.

For transport applications, U.K. engineering and operational experience has been gained since 2015 with public hydrogen refuelling stations for FCEVs dispensing at 350 and 700 bar (mostly located in and around London). The majority of these are based on hydrogen production via electrolysis and storage on-site, but hydrogen can also be trucked in from a regional or centralised location. It is advantageous to ensure both approaches can be adopted as the refuelling infrastructure and hydrogen demand grow from the existing first base position to a more substantial number of facilities at both depots and petrol stations by 2030. FCEVs offer large efficiency benefits relative to conventional vehicles, and rapid refuelling and long range attributes relative to BEVs, but they require exacting fuel quality and refuelling standards. Fortunately previous work has ensured that these now largely exist (eg. SAE J2601, ISO-19880-1, EN 17124, OIML R139, BCGA CP41) and a number of ongoing projects are strengthening the basis for widespread deployment (eg. MetroHyVe, MetroHyVe2, Hydraite, MultHyFuel, PRHYDE). In general, sufficient experience and a clear datum of engineering practice now exists to ensure station and vehicle design are compatible. Clearly refuelling protocols for categories of heavy vehicle need to be defined and the associated refuelling stations rolled out before the vehicles can be deployed commercially.

The combination of increased manufacturing rates for FCs, FCEVs and electrolysers and decreasing costs for renewable energy will result in a cost down progression for hydrogen mobility applications across the 2020's and this will enable market adoption at a nationally-significant scale in the 2030's. The cost of hydrogen per kg does not need to be low to establish early markets. Costs of 8-12 £/kg are acceptable for cars because, as a minimum, this provides cost parity with refuelling a petrol vehicle for the same range. Users need to buy less than 50% of the energy required to travel the same distance as a petrol car. However, costs of 5 £/kg or less are desirable for hydrogen mobility adoption in the heavy vehicle sector. These are within reach for initiating and growing early markets, provided the government implements:

a) a suitable fuel subsidy mechanism (eg. RTFO) for green hydrogen
b) a strategy for expanding the network of refuelling stations and depots
c) a scheme for incentivising the purchase of FCEVs, as has been successfully used for battery vehicles.

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

For transport applications, the short term infrastructure requirement can be met by on-site hydrogen production at refuelling facilities and by taking a 'hydrogen valley' approach in regions where both industrial and transport end uses for hydrogen exist and can be satisfied by implementing a single large hydrogen production facility. This approach can be replicated in most regions and then expanded as demand grows. In the long term, when transport demand has reached a high level, it will be probably be necessary for the heavy-demand refuelling stations to be interconnected by pipeline to underground hydrogen storage facilities fed by large scale green hydrogen production facilities.

For industrial clusters, the short term infrastructure requirement can be met by installing on-site or local hydrogen production and hydrogen pipeline facilities. The long term infrastructure requirement will require pipeline interconnection to more distant underground hydrogen storage facilities fed by green hydrogen production at scale from offshore wind. There is a large additional opportunity to upscale production by interconnecting these clusters with Europe via a hydrogen transmission infrastructure, where the U.K. is the major provider (exporter) of green hydrogen from the north.

For heat applications, the government needs in the short term to decide whether to permit and facilitate the injection of hydrogen blends into the natural gas grid. In the 2010's power-to-gas systems in gas distribution networks were demonstrated across Europe, so injection of low concentration admixtures can commence as soon as the necessary regulatory framework and remuneration mechanism is introduced. The long-term infrastructure requirement is difficult to specify, because it depends on the outcome of the ongoing techno-economic feasibility and safety studies concerning the potential transition of the U.K.'s extensive natural gas grid to an extensive hydrogen grid, or to some combination of bio-methane and hydrogen grids, or to some other level of hydrogen grid for 2050.

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.

Renewable power sources and electrolysers are key to achieving net-zero hydrogen and their operation does not emit CO2. Both are available at multi-MW scale and engineering development will further improve their performance, scale and integration in the 2020s. The green electricity and green hydrogen that they produce should constitute the central plank for achieving Net Zero. The consumption of green hydrogen by fuel cells does not lead to CO2, NOx or particulate emissions and their manufacture avoids the environmental challenges associated with battery materials. The environmental impact of green hydrogen is therefore small, especially when compared with the importation of natural gas to make blue hydrogen which requires CCS facilities and is characterised by residual GHG emissions (including fugitive methane emissions).

In addition to environmental advantages, green hydrogen offers several economic advantages: it doesn't require a huge investment to initiate; it is net-zero compatible; it is based on an inexhaustible indigenous energy supply; it can commence without requiring a gas grid; it can feed into a future hydrogen grid; it can be incrementally deployed across multiple sites so as to establish a stepwise progression in the decarbonisation effect; it can be applied to achieve synergistic economic benefits for renewable power providers, electricity grid operators and hydrogen users; it will result in substantial market growth and jobs creation within the renewables, electrolyser manufacturing and hydrogen utilisation sectors. Conversely blue hydrogen is an end-of-pipe technical fix with dubious economic and environmental credentials; its primary purpose is to protect incumbent organisations in the existing supply chain, so that they can continue to exploit investments in natural gas exploration and infrastructure.

In the short term green hydrogen production can be achieved within the electricity grid at a scale appropriate to the demand level by locating electrolysers close to the points of hydrogen consumption. Importantly, rapid response electrolysers can be operated to assist the integration of renewables into the grid by providing a new market for electricity at times when generation is high but demand is low. This approach can be engaged immediately and will enable hydrogen supply and demand to be grown progressively in the early market. In the medium term it can be substantially augmented by off-grid electrolysis, which can produce hydrogen in bulk at low cost in regions of high renewable resource (eg. the North Sea) and ultimately feed it into a transcontinental hydrogen grid in a similar manner to that originally proposed in the 1970s for establishing a Hydrogen Economy.

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.

There are two areas to prioritise in parallel. First, switching existing users of grey hydrogen to green hydrogen. Second, progressively decarbonising the entire energy system with green electricity *in conjunction with* green hydrogen for applications where there is a need to store energy or where electrification simply isn't feasible.

The main priorities for net-zero hydrogen should be:

a) **Existing industrial users of grey hydrogen.** Several industrial chemical processes and the merchant hydrogen market already consume hydrogen in large amounts. With respect to the refinery sector, the EC's Renewable Energy Directive II permits renewable hydrogen to be used by refineries as an intermediate product in the production of conventional fuels. Accordingly Germany has set a target of implementing 2GW of electrolysis at refineries by 2030 [5]; and France has implemented within the

Finance Law for 2021 a new mechanism where the quantities of green hydrogen consumed by a refinery will generate exchangeable credits similar to the scheme for biofuels (TIRIB) but with a multiplier of two [6]. The U.K. should implement similar targets and policies, but extend them to cover other large chemical processes besides oil refining and to the merchant hydrogen sector.

b) **Industrial thermal processes**. Several of these can utilise green hydrogen to reduce their GHG emissions, including furnaces where it can be used as a reducing agent for steel production (instead of coke or natural gas), for float glass production and for epitaxy in nanotechnology and semiconductor manufacture. In some cases the by-product oxygen from the electrolyser can be utilised by the process as well as the hydrogen. Australia and Germany are considering deploying hundreds of MW of electrolysis per furnace to decarbonise steel production. Similar approaches and trials should be adopted by U.K. government.

c) **Transport applications.** Hydrogen provides the key solution, and in several cases the only technological solution, for achieving zero emission heavy vehicles. It is also an attractive option for light duty vehicles alongside BEVs, especially for users who want rapid refuelling or cannot recharge at home.

d) **Renewable chemistry applications**. The production of green ammonia, green hydrocarbons (from green hydrogen and green CO2), green plastics and other hydrogen carriers, provides a net-zero opportunity for sectors that are otherwise difficult to decarbonise with electricity or hydrogen (eg. long range maritime and aviation). Further development and demonstration funding is desirable, because hydrogen of itself is not a panacea for all end uses or for carrying energy over very long distances.

e) **Large scale energy storage**. The geological storage of green hydrogen underground is a straightforward way of storing very large amounts of renewable energy cheaply. The fundamental principle of using such a store as a lung (ie. both as a sink for storing low-cost or surplus renewable energy and a source for enabling power generation when renewable generation is temporarily low) needs to be demonstrated and then integrated into energy market frameworks, in order to avoid having to use CO2-emitting gas turbines during sunless/windless periods.

References

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