Written Evidence Submitted by The Health and Safety Executive

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HSE is Great Britain's health and safety regulator. Our purpose is to prevent work-related death, injury and ill health. We apply a range of regulatory tools to improve health and safety, bringing together different interventions to achieve impact. We influence and engage stakeholders, create knowledge and awareness of health and safety risks, and encourage behaviour change through assessments and direct interventions including inspections and investigations. Our science, engineering and analytical capability complements our policy and operational activities. HSE is internationally recognised for developing and supporting practical solutions to workplace health and safety problems.

HSE has had health and safety regulatory oversight of the natural gas transmission, distribution and supply industry for around 40 years. As the industry developed into what we see now, HSE has, together with the industry and other stakeholders, adapted, and where necessary improved, regulatory coverage. We now find ourselves at the beginning of many changes and innovations in the work activities of this and other industries as the UK builds momentum to reach Net Zero. As such we have begun to engage with industry, Government departments and others to help enable important and safe innovation

Overview

The advantage of hydrogen applications lies in the fact that usable energy is liberated by reacting hydrogen with oxygen and the only by-product is water. This allows fuel cells and combustion applications to unlock the potential of hydrogen as a clean energy vector to support Net Zero targets.

The two main production methods for hydrogen today are:

Reforming of natural gas - a long established safe industrial process at operating scale but produces a carbon dioxide waste stream so requires the additional process of CCS.

Electrolysis of water – another well-established process which is considered as safe. Currently still small scale but advancing with ambitions to transition to gigawatt scale plant around the world. It is very attractive as a green technology especially when associated with renewable electricity.

Hydrogen has been safely used as an industrial gas for over 100 years. As with all fuels and hazardous materials the question about safety relates to how applications are engineered to account for specific physical properties and behaviors. Hydrogen is no more or less safe than incumbent fuels, but it is different, so for hydrogen to be used safely those differences need to be identified, understood, engineered and accounted for in applications, operations and process.

The key physical properties of hydrogen include: a low ignition energy, wide flammable range, high diffusivity and buoyancy, high flame speed and increased tendency for deflagration events to transition to detonation under certain conditions These physical properties manifests into practical issues for production, transmission, storage and use.

The practical application of hydrogen sees two main methods for delivery which are:

- Pressurised gas (industrial 200 bar and for novel transport applications up to 700 bar).
- Bulk scale as cryogenic liquid hydrogen.

Each method has differences to incumbent energy systems which need to be understood and risk assessed especially when existing infrastructure will be re-used.

HSE has engaged with industry on hydrogen applications for net zero providing practical solutions, expertise and guidance from policy, regulation and scientific perspectives.

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;

The timescales envisaged by the Government in the various published proposals, most recently the Ten Point Plan for a Green Industrial Revolution, are ambitious but reflect those of other leading nations around the world

There is a significant amount of work to do by industry and others to gather the evidence necessary to address the safety of the increased hydrogen use, from its production, and the associated CCUS, through to its use.

How the proposed measures—and any other recommended measures—could best be coordinated;

HSE needs to work closely with BEIS and other Government Departments such as DfT to ensure that efforts are coordinated and the processes necessary are in place to make sure that hydrogen is delivered by industry in a way that makes it as safe as the fossil fuels it is set to replace.

Arrangements have already been established to allow HSE to provide the necessary safety inputs into BEIS's Hydrogen Grid Research and Development Programme (HyGrid).

HSE has been working with industry for some time now to enable essential hydrogen projects to be designed, established and undertaken in a safe way. These projects are crucial to the understanding of hydrogen and its risks, and how these risks ca be controlled in such a way as to allow for it to become a safe and reliable replacement for today's fossil fuels, including natural gas, petrol and diesel.

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

Industrial-scale methane reforming or similar technology with Carbon Capture and Storage (CCS) producing low carbon hydrogen currently appears to be the primary at-scale option today. From a safety perspective, methane reforming (without CCS) is a well-established industrial process, producing almost all of the hydrogen used today, and has operated for many years. It should not, therefore, provide significant challenges and will likely operate under the UK's control of major accident hazards regimes.

Inevitably more trials and pilot projects will be needed to establish the practicality and feasibility of switching to hydrogen across a range of sectors and applications. It is also necessary to demonstrate that hydrogen production with CCS can be sufficiently low carbon to play a significant role.

Potential business models that could attract private investment and stimulate widespread adoption of hydrogen as a Net Zero fuel.

HSE are not best placed to comment on economic models. However, the speed of scale-up and adoption does have implications on the skills, capability and capacity for the UK workforce operating hydrogen applications. We have worked, and continue to do so, with a range of national and international stakeholders, European Commission, ISO, IPHEA, IEA, the Institution of Gas Engineers and Managers (IGEM) and others on this.

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.

Heating: Focusing on the gas distribution system, blending of hydrogen into natural gas is clearly a first good option. The leading UK project in this area is the Ofgem funded HyDeploy project, led by the gas distribution networks, Cadent and Northern Gas Networks (NGN), which aims to demonstrate that blending up to 20% by volume of hydrogen with natural gas remains safe and is a greener alternative to the gas we use now. The project is using a real gas network at Keele University, and is providing evidence on how customers can safely use existing cooking and heating appliances without any need for modification, which means little if any disruption for them to be part of this change. Should safety be demonstrated satisfactorily, HyDeploy is set to be developed and extended to parts of the public network in NE and NW England. See https://hydeploy.co.uk

The next logical step after blending, is then to move to gas grids transporting 100% hydrogen to people's homes, and commercial and industrial premises. The first UK project to demonstrate this will be the Ofgem funded H100 Fife project, led by the gas distribution network, SGN. Their project is working to construct and demonstrate the UK's first network (supplying circa 300 houses) to carry 100% hydrogen. In doing so it will produce crucial evidence to enable the future safe construction and operation of a 100% hydrogen network. See https://sgn.co.uk/H100 Fife

The next step on this road map is then to repurpose the GB gas grid (distribution & transmission) to operate with 100% hydrogen. The Ofgem funded H21 suite of gas industry projects, led by NGN, is designed to support conversion of the GB gas networks to carry 100% hydrogen. See https://www.h21.green/.

The impact on the consumer will largely be around appliances. Boilers and other appliances will need to be replaced or be 'hydrogen-ready' for a relatively straightforward switch over to hydrogen when necessary. Safety of hydrogen appliances and its presence in the home is being considered in the BEIS Hy4Heat Programme. The focus of this programme is to address the challenges associated with hydrogen and its use in buildings, and the need to develop domestic appliances to burn hydrogen rather than natural gas. This is a large £25M programme that started in 2018 and some of its findings are now beginning to be published. See https://www.hy4heat.info/ . HSE are engaged with Hy4Heat providing inputs and assessment of the safety evidence being gathered to ensure that the appropriate safety questions are being answered by the project.

Stepping up to the GB gas transmission grid (NTS), HyNTS is a National Grid Gas initiative which comprises a number of hydrogen projects, predominantly feasibility studies, relating to the feasibility of the NTS carrying hydrogen. HyNTS includes: NTS study looking at its capability to transport hydrogen; Project Cavendish – a review of the potential of the existing Isle of Grain facility to supply hydrogen including production with associated CCS, storage, and distribution; potential transmission of 2% hydrogen blend in the existing natural gas system to Aberdeen where hydrogen would be 'deblended' from the natural gas system for potential use in power generation, transport and injection into the existing natural gas distribution system (20% blend).

All of these projects and demonstrations are providing critical evidence to inform strategic decisions on the future of the natural gas grid and the future balance between hydrogen and electrification for heat.

HSE has provided scientific and technical support to these projects through a number of commercial contracts with the projects. Also, HSE has provided regulatory support, working with the projects to ensure that they are designed in a way which will provide the necessary safety evidence. HSE has granted the dutyholders involved in HyDeploy an exemption from the hydrogen content specification set out in the Gas Safety Management Regulations 1996 (GSMR) following a demonstration that the exemption would not prejudice safety. The ability for HSE to grant such exemptions has enabled hydrogen-related projects to proceed.

Transport: In the UK, the sale of Internal Combustion Engine Vehicles will now end in 2035, if not before. Decarbonised transport therefore needs to see a rapid shift. Vehicles using battery and hydrogen energy storage both currently exist and are operating in the UK. For hydrogen the limited refuelling infrastructure, as well as the limited supply of vehicles, has slowed take up here and internationally. However, hydrogen powered cars, vans and buses have been operating safely on the UK roads for over ten years. The main challenge with these vehicles has been the high pressure (up to 700 bar complying with internationally agreed United Nations GTR 13 code) on board storage, and the infrastructure to support them. For light duty vehicles this safety challenge has been addressed through the use of incredibly strong, highly engineered composite tanks. In Japan and California thousands of vehicles have been operating safely for several years employing this technology which is proving itself very effective. In addition, hydrogen buses have been operating safely in many cities around the world, including London (operating since 2011) and more recently Aberdeen.

In the short to term it is recognised that for light duty vehicles, while hydrogen vehicles will increase in number, batteries will continue to dominate. However, for other larger vehicles (such as buses, HGVs and trains) hydrogen is expected to rapidly begin to dominate, because of the greater range, reduced weight and much shorter refueling times hydrogen technologies provide.

With this in mind the challenges moving forward is for the use of hydrogen include:

- the increased uptake (quantitative growth) of the types of vehicles currently on the road and the growing infrastructure needed to support them. This will lead to larger refuelling station inventories, with larger stations almost certainly reaching lower tear COMAH within a few years. HSE are involved in the EU project MultHyFuel which aims to contribute to the effective deployment of hydrogen as an alternative fuel by developing a common strategy for implementing hydrogen refuelling in existing refueling contexts. HSE are currently seeking match funding to secure their involvement in this seminal project.
- the need for hydrogen vehicles to be used in the full scope of built infrastructure including tunnels, car parks and other enclosed structures. This is being addressed by the European Commission funded collaborative HyTunnel-CS project to produce prenormative data that will form the basis for the vehicle-infrastructure system to operate safely.
- the accelerating adoption of hydrogen as a means to fuel different transport modes, driven by the need for large and compact energy storage for trucks, trains, boats and ships, and even aviation. Although not on the roads today, these are seeing strong interest including trucks (Nikola & Hyundai), rail (with commercial operations now in Germany and Holland and a number of projects in the UK), maritime (passenger ferry projects in UK and other larger projects internationally such as the Kawasaki LH2 carrier, extensive discussions ongoing with the Marine and Coast Guard Agency).

The safety challenges here will be larger on-board fuel inventories, using similar pressurised storage as referred to above, but for very large amounts using cryogenic Liquid Hydrogen (LH2). Again, LH2 has been used in industry for many years (including most space programmes), but its use for more novel transport application is being addressed by the PRESLHy project (. In its cryogenic liquid state (LH2) hydrogen provides the most efficient storage, largest densities and some intrinsic safety advantages. Therefore, LH2 is attractive for scaling up supply infrastructures for e.g. for fuel cell driven trains, ships or car or truck fleets. In industrial situations industry knows how to handle LH2 safely. However, the new applications imply new conditions and untrained users. PRESLHY, a EU FCH JU 2.0 co-funded research and innovation activity (Project ID 779613), investigates respective knowledge gaps and is working to close these gaps..

Hydrogen offers many opportunities to decarbonise for transport, and by overcoming the remaining infrastructure and safety challenges will enable uptake at scale and a rapid route to decarbonisation can be realised which is coupled with the benefits of improved air quality and public health.

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.

Heating Applications: There are a number of technical, policy and operational challenges to the introduction of hydrogen into the gas networks such as; GSMR not applying to distribution of 100% hydrogen (see next paragraph); alignment of policy and operations on emerging technologies including hydrogen; sufficient scientific resources for regulatory and commercial activity; and future proofing cost recovery.

HSE is currently reviewing GSMR with one of the objectives being to pave the way to make future changes, eg to the safe hydrogen content specification, quickly once there is sufficient evidence from industry. Linked to this, HSE is also considering how any 100% hydrogen trials can be regulated to ensure they are safe (see section 2 above). The review of GSMR has taken longer than originally planned as a result of the time it has taken for the industry to gather and present evidence for HSE to assess demonstrating the safety of proposed changes to safe gas composition specifications. Additional evidence supporting future changes to accommodate hydrogen will be required and the industry's proposed work will help to produce the necessary evidence supporting any future change.

Transport Applications: In terms of the actual vehicles many of the engineering challenges are being addressed internationally (through standards), with growing input from UK organisations in relation to buses, construction vehicles, rail and maritime. This input needs to continue to be supported to ensure its safety and commercial development for net zero. However, of greater importance is addressing the development of supporting infrastructure for transport applications, including refueling, fuel distribution, vehicle repair and built-infrastructure vehicle compatibility. Through participation in international activities HSE is already supporting much of this (through collaborative projects and representational activities), but this needs to continue to grow with increased input and coordination from other stakeholders and government departments.

Industrial Applications: The UK is leader in the thinking around industrial hydrogen hubs in the UK. As these ideas continue to develop into projects it is essential safety and regulation are addressed early with the active involvement of HSE.

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

A significant part of HSE's interest to date has been in the early projects where a 20% blend of hydrogen within natural gas has been tested on a discrete part of the existing gas

network. More consideration is now being given in supporting BEIS's HyGrid Programme which aims to determine whether or not is safe to repurpose the exiting natural gas network for the transmission and distribution of 100% hydrogen. The increased production, storage, distribution and use of hydrogen and any associated CCS will inevitably lead to an increase in potentially hazardous activities being undertaken. It is essential that HSE works with industry and other stakeholders to ensure that the risks associated with such an increase are adequately controlled. In addition to the physical infrastructure, there is a need to ensure the continuity of supply in specialist testing and research facilities, particularly in the area of large-scale trials and testing. These facilities are currently driven by the needs of the market but are not being considered in a strategic context. The UK position would be strengthened if the need to deliver such tests and trails were included in the strategic approach to the safe and effective delivery of hydrogen. In addition, this would help to support public confidence in the safe operation and delivery of hydrogen.
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.
HSE not best placed to provide evidence in response to this question but picture from international market is that CBA advantage of hydrogen in certain key applications is clear.
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.
While hydrogen is not the complete answer to achieving net zero, as an energy vector it provides a number of advantages that will ensure it will be part of the solution for applications across the energy system. There are engineering and regulatory challenges that need to be addressed to achieve this, but in addition clear synergies between potential applications that will bring added value to ensure safety and effectiveness. To accelerate this process and the achievement of net zero, the UK should look to build on its internationally recognised leadership in hydrogen engineering through the establishment of a center for hydrogen safety and engineering (lead by HSE SD and NPL) to more effectively coordinate and manage activities across applications and stakeholders in the UK.

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