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HEATING & HOTWATER INDUSTRY COUNCIL

Hydrogen Appliances

June 2022

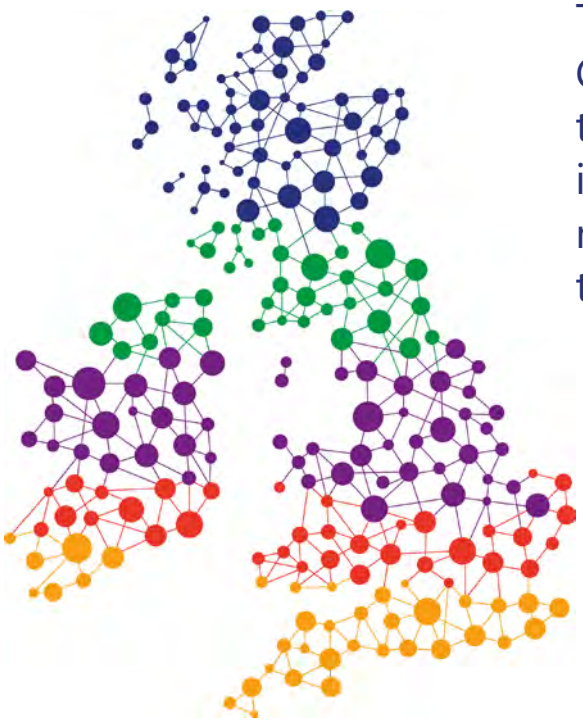
Outline

The UK Government has committed to cut UK Green House Gas emissions to a Net Zero level by 2050. This will mean that all sectors of the economy will need to decarbonise at a faster and deeper rate than had previously been modelled for. In some sectors this is already well underway such as for electrical power, although gas still supplies a significant proportion of the demand at peak times. For other sectors the pathway to decarbonisation appears to be clear, such as utilising electric vehicles to decarbonise domestic transport. However, no single solution offers a simple route to decarbonisation and a mixture of technologies are likely to be required.

Heating sector

Decarbonising heat remains less clear. There are a number of technologies available, though all face significant barriers and complexity. Trying to mitigate costs is also a challenge, especially as millions of households in the UK are living in fuel poverty. The energy trilemma is at its most acute when it comes to decarbonising heat.

Currently there are broadly two main strategies for decarbonising the majority of homes in the UK; expansion of the electrical network with installation of heat pumps and changeover to a low carbon hydrogen gas grid for properties on the existing gas network.



To meet our Net Zero 2050 targets, the Committee for Climate Change has suggested that both technologies will need to be employed in the future. However, neither direction has a mass market pathway established, and several trials are underway exploring each approach.

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Decarbonising heat

For the roll out of hydrogen compatible appliances there are broadly three routes:

1. Blending up to 20% by volume of hydrogen into the UK natural gas network to reduce carbon emissions meaning less disruption for consumers as many already installed appliances are compatible.
2. Installing hydrogen-ready appliances that work on natural gas when first installed and following a simple conversion, are modified to use 100% hydrogen gas at a future date.
3. During the phased switch over of the grid to hydrogen gas, new hydrogen gas appliances could be installed at the same time, which have left the factory configured and tested to burn 100% hydrogen gas.

Hydrogen-readiness (100%) has been demonstrated in gas boilers, but this is more complex for domestic cooking appliances and space heating such as gas fires, where a large variety of appliances are currently installed in UK homes. Testing and demonstrations of such appliances are currently underway, for example the Cadent, NGN and BEIS funded demonstration home in Gateshead and the Hy4Heat project.

The purpose of this paper is to communicate the three options for hydrogen in the home. To establish the definition of hydrogen-ready domestic appliances that could be supplied for a 100% hydrogen gas concentration, (after a short conversion process) and includes boilers, cookers and gas fires. Any costs in this paper are assumptions based on industry information and use of available data.

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Hydrogen Blend Projects

In the UK and Europe projects such as HyDeploy and THyGA are assessing the potential to add hydrogen to the current gas networks to reduce carbon emissions and introduce a greener gas.

The HyDeploy projects first phase has been completed proving that blending up to 20% volume of hydrogen with natural gas is safe and a greener alternative to the gas we use now. It has provided evidence on how customers do not have to change their cooking or heating appliances to use the blend, which means less disruption and appliance replacement cost. It is also confirming initial findings that customers do not notice any difference when using the hydrogen blend. It is anticipated that no changes to products in people's homes, commercial and process plants are required.

The project allows the industry to learn more about the distribution and working practices associated with hydrogen, along with production using electrolysis. As part of the HyDeploy project it has been calculated that, if the gas network contained 20% blended hydrogen that the carbon saving would be equivalent to taking 2.5million cars off UK roads. As the first stage at Keele is now completed, HyDeploy has moved to a larger demonstration on a public network at Winlaton in the North East. Following this a further larger 'whole town' demonstration is proposed. These projects are designed to test the blend across a range of networks and customers so that the evidence is representative of the UK as a whole

Note - gas products currently on the market and installed in UK homes which are able to burn natural gas with a blend of up to 20% hydrogen are not of the hydrogen-ready type discussed later in this paper. When you buy a new gas product manufacturers are communicating the benefits of the hydrogen blend by including a logo on their websites and in their sales literature which is detailed in the product identification section of this paper. Other projects in Europe are also exploring the potential for gas appliances to burn a hydrogen blend, but again, these products are not of the hydrogen-ready type (100% hydrogen) discussed in this paper.

Hy4Heat – Hydrogen Appliances (100%)

The Hy4Heat Research and Innovation Programme explores a transition from natural gas to 100% hydrogen gas for cooking, heating and hot water in the UK. The programme has established that is is technically possible, safe and convenient to use zero-carbon hydrogen gas in residential and commercial buildings and gas appliances. This has enabled the UK Government to proceed to a community trial phase called the H100 project.

On successful completion Government will then look to move to a larger trial site. This project is laying the foundations for this change while giving residents the opportunity to be at the leading edge of the low carbon economy.

Note - when hydrogen-ready products are available on the market and installed they are able to burn natural gas with a blend of up to 20% hydrogen and are the hydrogen-ready type which can be converted in situ to 100% hydrogen and are discussed later in this paper.

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Hydrogen-ready product definitions (100% concentration)

Domestic Hydrogen-Ready Appliance (100%)

A gas appliance that "out of the box" is designed and approved to be installed for use with natural gas and, following a conversion and re-commissioning process in situ, can then operate safely and efficiently using hydrogen

Hydrogen-Ready Boiler (100%)

A boiler of any type (Regular, System or Combination) that "out of the box" is ready to be connected to the Natural Gas Network and following a conversion and re-commissioning process in situ, can then operate safely and efficiently, maintaining equivalent comfort levels and providing a sufficient supply of heating and hot water using hydrogen.

Hydrogen-Ready Local Space Heater (100%)

A gas fired local space heater of any type (Flue-less, Conventional or Balanced-Flue) that "out of the box" is ready to be connected to the Natural Gas Network and, following a conversion and re-commissioning process in situ, can then operate safely and efficiently using hydrogen.

Hydrogen-Ready Domestic Cooking Appliance (100%)

A gas cooker of any type (Free-standing or Built-In cooking appliance) that "out of the box" is ready to be connected to the Natural Gas Network and, following a conversion and re-commissioning process in situ, can then operate effectively, safely and efficiently using hydrogen.

Note: - When installed as a natural gas appliance the Hydrogen-ready appliances can also operate using the 20% blend. The hydrogen-ready appliance would initially be installed, commissioned and serviced exactly like a typical Natural Gas-Fired model and the normal British Standards, Building Regulations, Gas Safety Installation and Use Regulations would apply, as would the normal Gas-Safe Registration requirements with which installing engineers are required to comply.

When converting to hydrogen gas, the Hydrogen-Ready appliance can be converted using a small kit of components and a fast, simple procedure to burn 100% hydrogen gas. The appliance would then be recommissioned by a suitably qualified, competent engineer. There is no need to exchange the complete appliance for a new version. For boilers, no re-plumbing work would be needed and the flue system, controls, heating system and pipework would all be retained.

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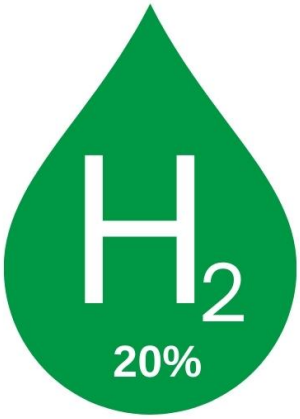
Product Identification

Hydrogen Blend

When you buy a new gas product manufacturers are communicating the benefits of being able to run on up to a 20% hydrogen blend by including the this logo on their web sites



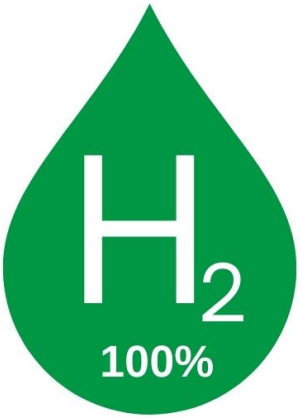
Hydrogen-Ready

As hydrogen-ready appliances are placed on the market (likely by 2025/6) they will be identified with a label that advises they are manufactured to be suitable for use with natural gas with up to a 20% blend of hydrogen. When converted by a gas safe registered engineer these hydrogen-ready appliances can then use a hydrogen concentration of up to 100%. (≥98%)The following label identifies these products.

Note: Hydrogen-Ready appliances must be clearly identified on the appliance data plate, that they are certified for operation on a 100% Hydrogen gas category.

100% Hydrogen

Any hydrogen gas appliance sold in the future for direct installation on a fully functioning 100% (≥98%) hydrogen gas network without conversion will be identified with the following label.



Please note, the colour of the identifiers shown are in green and will be supplied in monotone but alternative colours can be used at the manufacturers discretion for marketing purposes

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Hydrogen-Ready Approval and Safety Testing

Each appliance manufactured and sold today is approved and tested to the Gas Appliance Regulation. In conjunction with other regulations and harmonised European and British standards, this allows manufacturers to apply the UKCA mark or CE mark. UKCA and CE marking is a certification mark that indicates conformity with health, safety, and environmental protection requirements for products sold within the UK and Europe. These requirements apply only to placing the product on the market, and thereafter the safe installation and commissioning of those appliances are the responsibility of the installer (Gas Safety Installation and Use Regulations GSIUR).

Note: - Products sold in Northern Ireland are identified with a CE mark

Supporting Standards

Currently, installation standards for appliances are the responsibility of the British Standards Institute and IGEM. These standards are in the process of being updated for hydrogen gas.

PAS4444

BSI has developed a new specification, PAS 4444, to be used primarily in the Hy4Heat programme. The aim is that, along with the current European and British Standards, it forms the basis for wide-scale standardisation of hydrogen-fuelled appliances. It is an additional guide to be followed by appliance manufacturers and Notified Bodies regarding functionality, safety, installation, operating and servicing requirements for 100% hydrogen appliances.

All aspects of gas appliance manufacture currently require 3rd party certification, by a UK Approved Body. This includes any hydrogen gas conversion kit and 100% hydrogen appliances. The same arrangement would continue and encompass all aspects of the convertible appliance.

Carbon Emissions

The Energy Systems Catapult reports that heating accounts for about 37% of total UK carbon emissions when including industrial processes. The breakdown of UK carbon dioxide emissions from heating is:

- Space heating (including a relatively small amount of cooling) = 17%
- Hot water = 4%
- Cooking = 2%
- Industrial processes = 14%

Of the 17% of carbon emissions from heating (and cooling) in buildings, about 13-14% can be attributed to domestic homes. Today the gas network supplies natural gas to around 24.5 million homes for heating and hot water.

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Hydrogen-Ready Approval and Safety Testing

Eliminating Carbon Emissions and Reducing NOx

While the major benefit in using hydrogen for home heating and production of hot water is no carbon emissions, like natural gas, burning hydrogen will produce pollutants that are by products of this process. Nitrogen oxides (NOx), are a group of gases which include nitrogen dioxide (NO2).

To ensure a reduction in NOx levels from domestic gas boilers, a maximum NOx level is a requirement of the Energy Related Products Directive. This was a mandatory piece of legislation specified by the European Commission introducing new lower requirements for heating and hot water systems. This legislation includes minimum levels for product efficiency, NOx and introduced energy labelling for products. Natural gas boilers manufactured prior to 2005 had a typical NOx value of between 30-70mg/kWh. The latest legislation introduced in 2018 requires a maximum NOx limit of 56mg/kWh (Gross CV) for natural gas and LPG boilers up to a maximum output of 70kw. Since Brexit this legislation has transferred into UK law.

The requirements for Ecodesign, which includes efficiency and NOx measurements, are included in test standards (BS EN 15502-1) managed by the European organisation CEN via a mandate from the European Commission. These standards specify the tests completed by manufacturers, which are also required to be independently tested by a suitable Notified Body.

Typical NOx Values For Hydrogen Boilers

The latest domestic boiler designs have much lower NOx levels when burning natural gas than the current maximum requirement of 56mg/kWh. Manufacturers who have developed 100% Hydrogen-Ready boilers report a value of around 10mg/kWh to 25mg/kWh (dependent on boiler type) when converted to the hydrogen mode.

Note – NOx is measured in laboratory conditions due to the specialised equipment that is required to accurately measure down to the level of milligrams per kw/hr that is specified in the European legislation.

It is early days in the development of hydrogen-ready boilers and we expect further reductions in emissions as the technology matures. The elimination of CO2 and the results declared by manufacturers and checked by the Notified Bodies appear to indicate a large reduction in NOx when compared to the limit set by the Ecodesign Regulation of 56mg/kWh.

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100% Hydrogen Conversion Approval

It is suggested that, as part of the approval submission of a Hydrogen-Ready Appliance, manufacturers would include in their risk assessment, the hydrogen gas conversion process and procedure, with instructions as per the Gas Appliance Regulation. The Notified body would assess the suitability and safety of the conversion process and any components or kit required, along with the risk assessment. Approval of the Hydrogen-Ready appliance including the relevant components or kit for conversion would be obligatory to allow the use of the Hydrogen-Ready label, and the appliance would be registered in a suitable product data base.

Quality Control Example

Hydrogen-Ready appliances will be tested using current working practices for natural gas before leaving the factory. It is envisaged that as part of the quality Audit process, a number of hydrogen-ready appliances will be converted to the hydrogen mode and tested using a hydrogen supply. The audit plan will be based on a suitable Acceptable Quality Level (AQL).

Conversion process

Manufacturers will be responsible for the approval and provision of the conversion instructions and the relevant kits or components where required. Suitable quality plans should be in place for suppliers of components included in the conversion process.

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Identification and Location

Product: Information is required by gas distribution networks (GDNs) regarding which properties have Hydrogen-Ready appliances installed in order to know if the appliance installed in a home can be converted. For this, it would be beneficial for a label to identify a hydrogen-ready appliance to the end user, and include make, model and serial number.

Location: A centrally-held database that links each hydrogen-ready installation location with the manufacturer and part number of the required conversion kit would assist with the conversion process. Digital Benchmark has been recently introduced and will hold all of the relevant data on such installations and could be adapted to include conversion information.

Example

- Category II appliance (Cat II2H4(x))
- Conversion kit/component availability assured (by manufacturer) for product lifetime
- Conversion kit cost capped with reference to the product cost (under review)
- Total duration of conversion process, including commissioning, less than an 1 hour
- Conversion process requires minimal updates to standard skillset

Additional requirements

i) Administration and management of a product database for all 100% Hydrogen-Ready appliances along with details of the conversion process.

ii) The administration and management of a database detailing location of the installed Hydrogen-Ready appliances.

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Nationally Accredited Certification Scheme (ACS)

The conversion of individual appliances and the whole house gas system to hydrogen must be carried out by an appropriately qualified Gas Safe registered engineer. This work would be carried out under the direct supervision of the Gas Distribution Network Operator that is undertaking the wider conversion. This is essential to ensure safe conversion. Upon conversion to hydrogen, the appliance must be re-commissioned to reflect the new gas qualities and the commissioning engineer must hold relevant qualifications in both Natural Gas and Hydrogen Gas.

Energy & Utility Skills are the organisation responsible for "Competence Framework" for the training, accreditation, and registration of gas engineers working with hydrogen.

The framework will enable personnel working with hydrogen-burning gas appliances to acquire the required knowledge and skills to operate in a competent and safe way. This framework will address the gap that currently exists within the gas industry in relation to the training and registration of professionals to work with hydrogen in the domestic environment, and for a limited scope of non-domestic installations.

References

- https://www.gov.uk/government/news/uk-becomes-first-major-economy-to-pass-net-zero-emissions-law
- https://hydeploy.co.uk/
- https://www.hy4heat.info/
- THyGA project https://thyga-project.eu/
- euskills-new-competency-framework-for-hydrogen
- BSI PAS4444
- https://www.bsigroup.com/en-GB/iso-9001-quality-management/

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