



Department for
Business, Energy
& Industrial Strategy



Hy4Heat

demonstrating
hydrogen for heat



Hy4Heat Progress Report November 2018

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Foreword from Mark Taylor

I'm pleased to report that the Hy4Heat programme has made good progress and has achieved its first year milestones.

As set out in the Clean Growth Strategy, the BEIS Energy Innovation Programme is investing around £505 million across the energy sector with the aim of accelerating the commercialisation of innovative, clean energy, technologies and processes into the 2020s and beyond. BEIS is stimulating developments in a range of technologies which could form part of the solution to decarbonise heat. These include: biogas, energy efficiency and storage solutions, carbon capture and use, heat pumps, heat networks, nuclear technology and hydrogen gas as a replacement for methane.

Hy4Heat is a £25m innovation programme, commissioned by BEIS, to determine whether it is technically possible, safe, and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances.

Achieving clean growth, while ensuring an affordable energy supply for business and consumers is at the heart of the government's Industrial Strategy. This sets out proposals for decarbonising all sectors of the UK economy through the 2020s, explaining how the whole country can benefit from low carbon opportunities, while meeting national and international commitments to tackle climate change.

In the UK we face some unique challenges in relation to decarbonising heat and the Hy4Heat programme is a collaboration between government and industry. The UK's gas network is the largest in the world. Our domestic market for gas boilers is also the biggest, so it's fitting that we're leading the way in supporting the research and development of potentially repurposing the extensive existing gas network. Finding a low carbon alternative to methane is a key challenge for the UK and BEIS has a number of programmes running which are focused on exploring and de-risking ways this might be achieved.



The Hy4Heat programme has been established to address two of the biggest challenges associated with hydrogen as an option for decarbonising heat: the safety issues associated with using hydrogen in properties; and the need to modify appliances to burn hydrogen rather than methane. It has also been established to plan and prepare for potential community trials, should a decision be taken to proceed to this stage.

My contention is that success of innovation is not simply about technology, but is also reliant on ensuring that robust business models are in place and that people are at the forefront of our thinking.

Innovation isn't just about reducing costs, but about finding different ways of working and solutions that are acceptable to members of the public.

The UK has the opportunity to lead the way in the area of energy development, which is why BEIS's innovation investment is aimed at stimulating positive change across energy systems to achieve a sustainable, affordable, low carbon future. I'm looking forward to seeing the results and outcomes of the Hy4Heat programme in the coming years and, ultimately, the evidence it produces which will help inform policy makers' decisions in important areas of clean growth.



Mark Taylor
Deputy Director for Energy Innovation
Science and Innovation for Climate and Energy
BEIS

Letter from Mark Neller

The past year for Hy4Heat has been challenging and rewarding in equal measure and I expect the next couple of years to be much the same. A collaborative approach is at the heart of the programme and, from the very start, we've worked hard to be as transparent and open as we can be as well as inclusive as possible with a large number of stakeholders from across the industry attending our engagement events. We have a 300 strong group of stakeholders who are keen to stay informed about progress. The success of the programme depends on finding innovative solutions to the carbon footprint problem caused by using natural gas to heat most of the UK's homes. Of course, the key advantage of hydrogen over methane is that it does not release carbon dioxide during combustion, unlike methane and all hydrocarbons.

Hy4Heat is formed of a full multidisciplinary, cross functional programme management team. Arup has partnered with hydrogen and industry specialists; Kiwa Gastech, Progressive Energy, Yo Energy and Embers to oversee the programme on behalf of BEIS. The Hy4Heat team is defining and managing the delivery of work packages that together form the overall programme.

We've made strong progress in the first year. Contracts are in place for the majority of the programme's work packages including ones to: develop hydrogen gas standards; review certification for appliances; and conduct research into commercial and industrial appliances. Several manufacturers have also recently been appointed to be part of a small business research initiative (SBRI) pre-commercial procurement competition to develop new domestic hydrogen boilers, cookers, fires and innovative gas appliances. This competition is worth between £8m and £9m of the overall £25m budget.



In all cases we've been impressed with the strong calibre of submissions and we are delighted to be working with such high quality colleagues and industry experts.

The programme is rapidly moving into its delivery phase and there's still much to do. Proving the safety case, clearly, is a critical element and the whole programme is focused around planning and preparing the way for a potential community trials, if BEIS makes the decision to proceed to this stage.

I'm encouraged by the industry's positive response to the challenges that Hy4Heat has set in the first third of the programme and I'm confident this will continue through to its completion in 2021.

Decarbonising heat is necessary to ensure the UK meets its carbon reduction targets and the Hy4Heat programme has an important role to play in assessing whether hydrogen replacing methane could be part of achieving these goals.



Mark Neller,
Director Arup, Hy4Heat

Our mission

Our mission is to establish if it is technically possible, safe, and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances. This will enable the government to determine whether to proceed to a community trial.

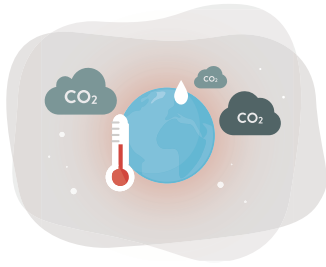
About us

The Department for Business, Energy & Industrial Strategy, BEIS, has appointed Arup as the named programme manager for the Hy4Heat programme. Arup has joined with technical and industry specialists: Kiwa Gastec, Progressive Energy, Embers and Yo Energy, and together we oversee the programme and technical management of the entire programme.

Hy4Heat is exploring whether replacing natural gas (methane) with hydrogen for domestic heating and cooking is feasible, and could be part of a plausible potential pathway to help meet heat decarbonisation targets. To do this the programme is seeking to provide the technical, performance, usability and safety evidence to demonstrate whether hydrogen can be used for heat in buildings.

As outlined in the government's Clean Growth Strategy* there are a range of low carbon heating technologies with potential to support heat decarbonisation but, at present, it is not clear which will work best at scale. BEIS is working with industry and other stakeholders to build understanding of the different approaches, to prepare for decisions in the first half of the next decade about the long-term future of heat. Hydrogen gas as a replacement for methane is just one of several routes that BEIS is considering to decarbonise heat - others include, for example: electric heat pumps, heat networks, hybrid heat pumps and biogas.

*Clean Growth Strategy, published 12 October 2017



Why hydrogen?

More than 35% of the UK's CO₂ emissions comes from the combustion of natural gas, so the government is looking to reduce this. The majority of these CO₂ emissions are from heating people's homes and cooking. In fact, the gas network supplies over two-thirds of domestic energy needs, so finding a low carbon alternative to methane is an important challenge.

The main advantage of hydrogen is that it does not release carbon dioxide during combustion, unlike methane and other hydrocarbons.

The Hy4Heat programme is initially addressing two key challenges with hydrogen; demonstrating the safety case associated with using hydrogen in buildings, and the need to have appliances that can burn hydrogen rather than methane. Hydrogen has very different combustion characteristics to methane and so current appliances are unsuitable for use with hydrogen.

This is a similar challenge to the one faced in the 1960s when the gas network was converted from 'Town gas', a blend of 50% hydrogen with methane and carbon monoxide, to natural gas. In the late 1960s and early 1970s all households' appliances were converted to use natural gas.

There is a separate, Ofgem-funded, programme researching the possibility of re-purposing the gas network 'upstream of the gas meter'. Ofgem has commissioned the gas distribution network operators (GDNOs) to research the technical and safety challenges of using hydrogen in the gas distribution system.

Stakeholder engagement and communication

Stakeholder engagement is an integral part of the Hy4Heat programme. Our work is delivered through work packages by appointed suppliers and supported by a range of different stakeholders. We have sought to consult and engage a wide range of different stakeholders throughout the programme and have held four engagement events across the year to:

- communicate the Hy4Heat programme effectively
- build relationships with interested parties
- create an open forum to have a dialogue and hear other people's views
- provide networking opportunities to increase collaborative working

As well as holding our own engagement events we have brought the programme to a wider audience by presenting the Hy4Heat programme at external events such as:

- Scottish Renewables Conference & Low-Carbon Heat Conference
- Hydrogen and Fuel Cells conference
- IGEM conference
- Installer 2018
- Low Carbon Networks & Innovation Conference

We have also attended briefing sessions held by trade groups such as the Association of Manufacturers of Domestic Appliances (AMDEA) and the Industrial and Commercial Energy Association (ICOM) and presented at the all party parliamentary group for energy studies.

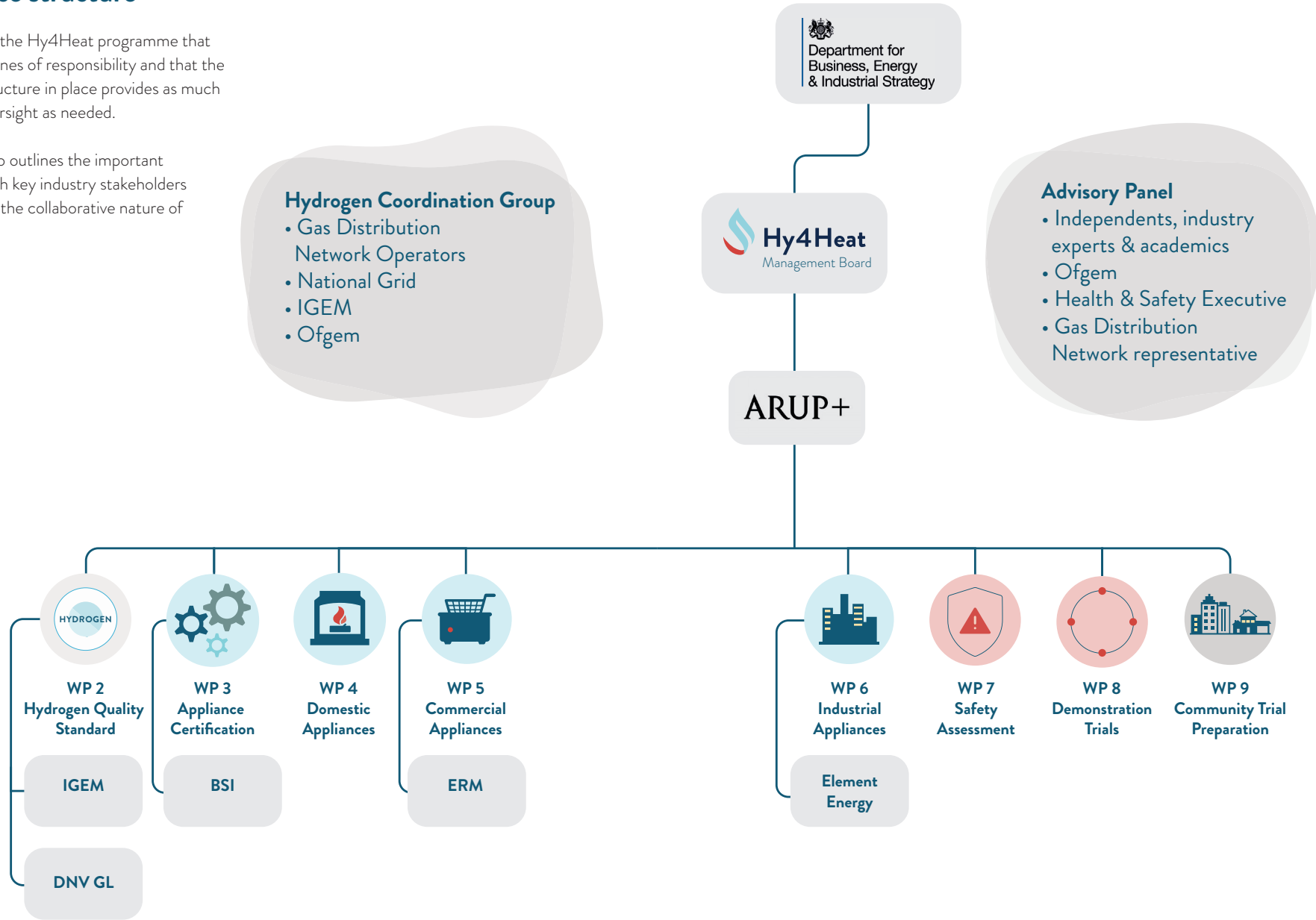
Over the past year we have issued three stakeholder newsletters and established a website www.hy4heat.info and social media account, to chart the programme's progress and provide access to information on the various work packages. We have also created a simple, infographic of the programme that is available for any organisation to use that may find it useful.

If you'd like us to present at your conference or event, then contact us with your details and we'll do our best to attend.

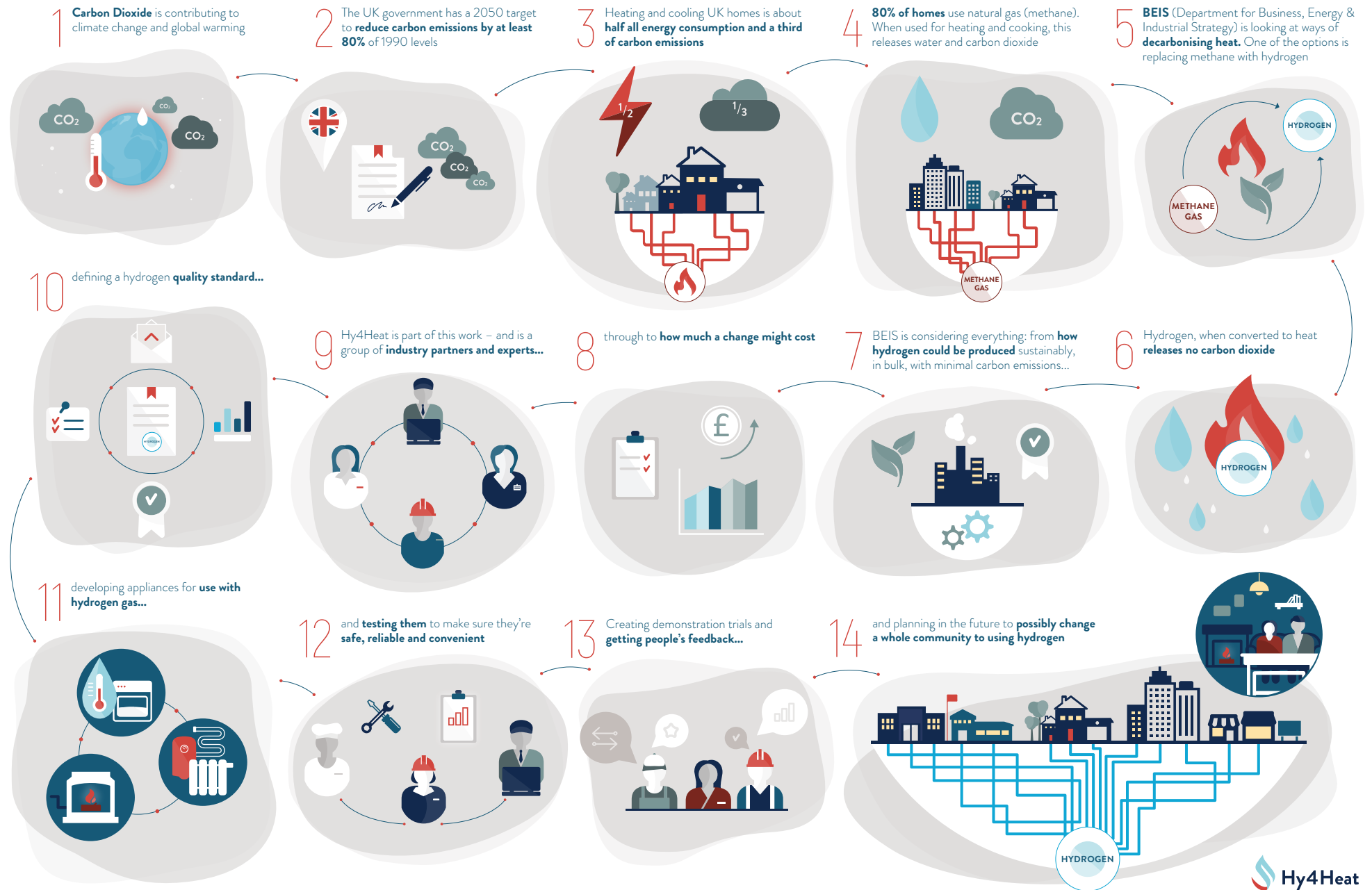
Hy4Heat programme governance structure

It's essential for the Hy4Heat programme that there are clear lines of responsibility and that the organisation structure in place provides as much support and oversight as needed.

This diagram also outlines the important relationships with key industry stakeholders and emphasises the collaborative nature of the programme.



The Hy4Heat Programme



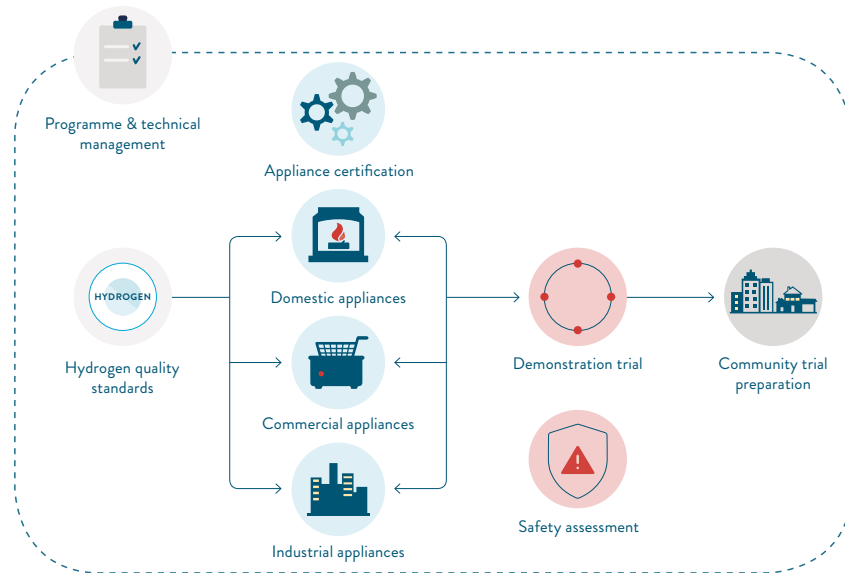
Work package overview

The Hy4Heat team designs and oversees the programme and technical management of all other various, interdependent, work packages.

The majority of the work packages are delivered through contracts appointed by BEIS. In October 2018 BEIS confirmed the programme would be expanded to include the development of hydrogen gas meters. This will become work package 10.

WORK PACKAGE 1

Work package 1 is the programme management and oversight of all the other workstreams.



WORK PACKAGE 2

Hydrogen gas standards; defining the purity of the gas and the colourant and odorant to be added.



WORK PACKAGE 3

Hydrogen appliance certification of a new generation of appliances.



WORK PACKAGE 4

Development of community trial-ready domestic hydrogen appliances: including gas fires, cookers, boilers and innovative hydrogen appliances.



WORK PACKAGE 5

Market research study into the variety of commercial appliances and the issues to be addressed in their conversion or replacement with hydrogen appliances.



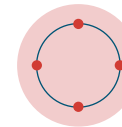
WORK PACKAGE 6

Market research study into the variety of industrial appliances and the issues to be addressed in their conversion or replacement with hydrogen appliances.



WORK PACKAGE 7

Safety issues related to hydrogen in properties, such as ventilation and leakage detection.



WORK PACKAGE 8

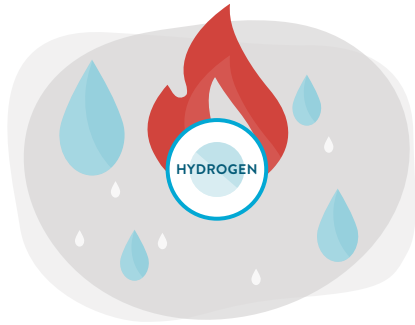
Establishing unoccupied trials to demonstrate the domestic hydrogen appliances developed in work package 4.



WORK PACKAGE 9

Planning and preparation for a potential community trials using hydrogen, in the event BEIS decides to proceed to this stage.

Work package 2



HYDROGEN QUALITY STANDARDS

- 12 March 2018 Prior Information Notice published
- 5 June 2018 Invitation to Tender published
- 8 October 2018 IGEM appointed to develop new hydrogen standards
- 20 October 2019 DNV GL appointed to conduct studies into purity and colourant of hydrogen gas

IGEM (The Institution of Gas Engineers & Managers) is reviewing the relevant gas standards for hydrogen. Purity and colourant are being considered by DNV GL.

IGEM has been appointed to develop hydrogen standards for the Hy4Heat programme. It will be reviewing all relevant existing standards and bringing together a group of technical specialists to identify knowledge gaps, both in the UK and internationally.

Three IGEM working groups will look at a range of areas including:

- DSEAR (dangerous substances and explosive atmospheres regulations)
- materials
- leakage rate and ventilation
- appliance location
- fluing, installation and air supply
- installation

The work will be peer reviewed by industry experts such as, the Health & Safety Laboratory, DNV GL, and IGEM's own Technical Coordinating Committee and Gas Utilisation Committee.

Work package 3



HYDROGEN APPLIANCE CERTIFICATION

- 30 April 2018, Notified Bodies and Test Labs surveyed
- 7 August 2018, Domestic appliance certification engagement event
- 30 November 2018 BSI appointed

Hydrogen appliances are to be certified under GAR (Gas Appliance Regulation). These regulations will be aimed at providing guidance on the testing and certification of hydrogen gas appliances for notified bodies and appliance manufacturers.

BSI has been appointed to undertake the work of developing some standardised guidance (PAS: publicly available specification) on how to apply current standards to ensure consistency across the industry.

The PAS will give guidance for notified testing and certification bodies to use when testing and certifying those appliances developed in work package 4 of the Hy4Heat programme and for manufacturers to use when developing manufacturer's instructions. It will provide guidance on good practice for the safe use, commissioning and installation of hydrogen fuelled appliances, including domestic boilers, fires and ovens.

Hy4Heat conducted a survey of a number of Notified Bodies and Test Labs in the UK and Europe which indicated that hydrogen appliances could be certified under the current GARs and that the majority of Notified Bodies have the ability and capability to certify appliances. All those surveyed identified that there were risks specifically relating to the testing of hydrogen appliances, this included:

- Leakages will be harder to identify
- Some design limits and choices may no longer be appropriate as hydrogen is more volatile
- Potential higher explosion risk
- Additional laboratory safety devices would need to be added for hydrogen testing
- Engineering practices may need to be adjusted; eg minimising voids, number of compression joints, etc
- Flame monitoring solutions may require investigations for efficacy and reliability
- There's a need for holistic assessment for risk, similar to natural gas or liquid petrol gas

In conclusion, there will be differences in how hydrogen appliances need be tested – something this work package looks to address.

Work package 4



DOMESTIC HYDROGEN GAS APPLIANCE DEVELOPMENT

- 15 June 2018 hydrogen appliance stakeholder engagement event
- 31 August 2018 Invitation to Tender for SBRI competition published
- 31 August 2018 online webinar supporting applications
- 9 November 2018 successful applicants notified

The aim of this work package is the delivery of prototype appliances which can demonstrate the safe use of hydrogen as a fuel in providing domestic heating, hot water and cooking requirements. It will oversee the development and certification of community trial-ready domestic hydrogen appliances: gas fires, cookers, boilers and innovative hydrogen gas appliances.

The focus is to demonstrate the safe use of hydrogen as a fuel

This will provide critical evidence of end use application, safety, in-use emissions, and functionality. The appliance types to be developed are boilers (combination and regular/system), cookers (stand-alone hobs, stand-alone ovens with grills and integrated freestanding cookers), fires (standard and mid-range) and innovative domestic hydrogen appliances.

As there isn't an existing commercial market for domestic hydrogen gas appliances, the approach that's being adopted for this work package is pre-commercial procurement (PCP), an SBRI (Small Business Research Initiative) competition. This is a well-established process that enables the development of innovative products and services in response to specific challenges faced by government departments and public sector bodies. Successful business partners receive finance to develop their ideas, generating new business opportunities and routes to market. This PCP approach is to facilitate innovation with the aim of providing the opportunity for the best solutions to be delivered, which have greater chance of commercial success after the competition ends.

The objectives of the competition are to:

- Deliver prototype appliances which can demonstrate safe use of hydrogen as a fuel in providing domestic heating, hot water and cooking requirements
- Contribute to positive stakeholder engagement through use of the prototype appliances in the unoccupied demonstrations
- Understand and where feasible address, the challenges and risks associated with progressing the appliances to a volume manufacturing stage
- And understand the challenges and potential solutions for a transition to hydrogen including products that simplify the switch-over process, for example dual-fuel, hydrogen-ready, or adaptable.

Intellectual property is always an important consideration for commercial manufacturers, so using this procurement approach suppliers receive financial support and retain intellectual property generated, with certain rights of use retained by BEIS.

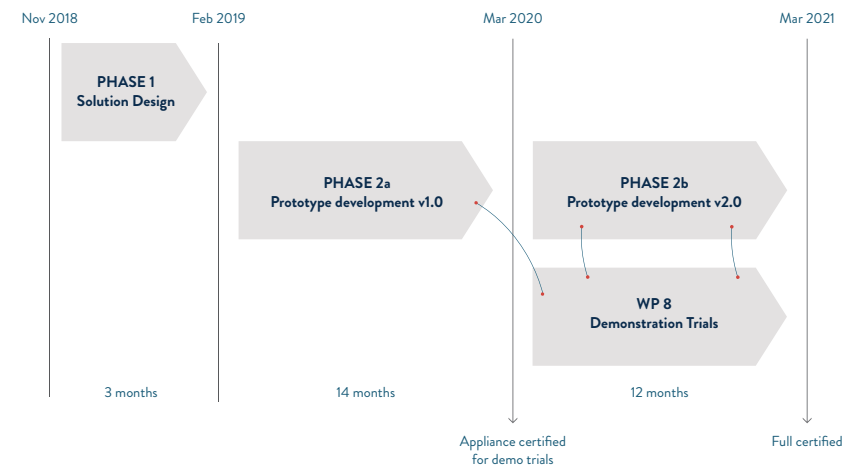
The competition takes place over three phases:

Phase 1 focuses on developing solution design documents covering the detail of the prototype development. These should demonstrate the concept hydrogen appliance is viable, detailing the necessary development and testing required to create the first prototype, including an understanding of any issues to be overcome and ways this would be done.

Phase 2a is prototype development and focuses on the physical development of the first prototype which will be tested for functionality and safety. The prototype from phase 2a will be used in work package 8 (demonstration trials).

Phase 2b is the development of prototype 2.0. Projects within this phase are funded to further develop the prototype appliance to be community-trial-ready and certified for use in an occupied home. Among the deliverables of this phase is likely to be a business plan for scaling-up the manufacture of appliances and training of installers, etc, in preparation for a potential future community trial.

Phased competition structure



Work packages 5 & 6



COMMERCIAL AND INDUSTRIAL APPLIANCES

- 25 May 2018 Prior Information Notice published for understanding commercial and industrial appliances
- 26 July 2018 Invitation to Tender published for understanding commercial and industrial appliances
- 24 October 2018, Element Energy awarded contract to write a research report on understanding industrial appliances
- 24 October 2018 ERM (Environmental Resources Management) appointed to produce a research report on commercial sector appliances

The reports will consider the existing market and identify any knowledge gaps and barriers to conversion that may need to be addressed. They will also inform consideration of whether further evidence, potentially in the form of practical testing, will be needed to demonstrate that these sectors can be successfully converted as part of demonstrating and de-risking the use of hydrogen for heat in UK homes and businesses.

These work packages are comprehensive research reports on the feasibility of converting commercial sector appliances and industrial heat generation from natural gas to hydrogen.

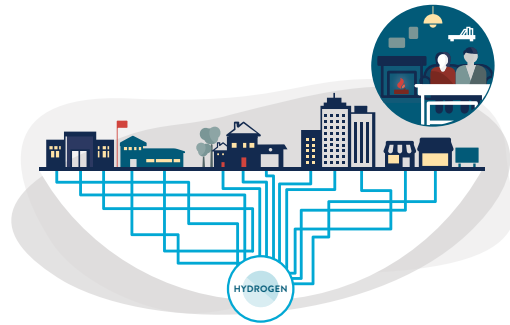
Work package 7



SAFETY

This work package focuses on safety issues in relation to hydrogen in properties - looking at issues such as ventilation and leakage detection. A co-ordination group has been established with Gas Distribution Network Operators. We are also working on aligning the Hy4Heat programme with other hydrogen programmes and initiatives with an agreed approach.

Work packages 8 & 9



DEMONSTRATION TRIALS

- 14 August 2018 appliance manufacturers surveyed about access to testing facilities

The hydrogen appliances developed in work package 4 are to be demonstrated for stakeholders to view. These demonstrations, in unoccupied buildings and locations, are expected to take place from approximately April 2020 through to March 2021. This is envisaged to be an essential stepping stone in preparations for a potential community trials.

POTENTIAL COMMUNITY TRIALS

Preliminary work has been undertaken in relation to planning and preparing for potential community trials, should the government make a decision to proceed to this stage. Activity in this work package will increase in the next phase of the Hy4Heat programme.

Hy4Heat key dates so far

- 3 November 2017 Hy4Heat contract awarded by BEIS
- 30 January Prior Information Notice for all work packages
- 2 March 2018 Prior Information Notice for definition of a hydrogen quality standard (WP2)
- 16 March 2018 stakeholder engagement event
- 2 April 2018 Hydrogen quality standard event (WP2)
- 30 April Notified Bodies and Test Labs surveyed (WP3)
- 4 June 2018 Stakeholder newsletter published
- 15 June 2018 Invitation to Tender issued for hydrogen quality gas standards (WP2)
- 15 June 2018 Hydrogen gas appliances event (WP4)
- 29 June 2018 Prior Information Notice for understanding commercial and industrial appliances (WP5 & WP6)
- 26 July 2018 Invitation to Tender issued for understanding commercial and industrial appliances (WP5 & WP6)
- 7 August 2018 Hydrogen domestic appliance certification (WP3) stakeholder engagement event
- 14 August 2018 appliance manufacturers surveyed about access to testing facilities (WP8)
- 31 August 2018 Invitation to Tender for domestic hydrogen appliance development (WP4)
- 31 August 2018 Stakeholder newsletter published
- 8 October 2018 IGEM appointed to develop hydrogen standards (WP2)
- 11 October 2018 Website published
- 20 October 2018 DNV GL contract award notice (WP2)
- 24 October 2018 Environmental Resources Management (ERM) appointed to produce a research report on converting commercial sector appliances to hydrogen (WP5)
- 24 October 2018 Element Energy Ltd appointed to produce a research report on understanding industrial appliances (WP6)
- October 2018 programme expanded to include hydrogen gas meters (WP10)
- 9 November successful SBRI competition applicants to manufacture domestic hydrogen appliances notified (WP4)
- 23 November 2018 Stakeholder newsletter published
- 30 November 2018 BSI appointed to develop standardised guidance



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