Department for
Business, Energy
& Industrial Strategy

Enabling or requiring hydrogen-ready industrial boiler equipment

Call for evidence

Closing date: 14 March 2022

December 2021

Any enquiries regarding this publication should be sent to us at: hydrogen.industry@beis.gov.uk

Executive summary

For the UK to meet its Sixth Carbon Budget (CB6) on the pathway to Net Zero, rapid and deep decarbonisation is required across every industrial sector. In 2019 industry produced 15% of UK CO_2 emissions (78 $MtCO_2e$) and Government expects industrial CO_2 emissions will need to reduce by around two-thirds by 2035. Replacing fossil fuels with low carbon alternatives, such as hydrogen, electrification, or biofuels, will play a significant role in achieving this. The recently published *Net Zero Strategy* indicated that to stay on track for our CB6 delivery pathway, demand for low carbon hydrogen to decarbonise industry may need to increase to 50 TWh by 2035, from virtually nothing today.[1]

The *UK Hydrogen Strategy* set out in further detail the role that low carbon hydrogen could play in ensuring the UK meets CB6 and achieving our trajectory towards Net Zero.[2] Industry is likely be an early source of hydrogen demand in the 2020s, with demand from industrial fuel switching picking up from the middle of this decade. In particular, the Strategy highlighted analysis indicating that industrial boilers and combined heat and power units (CHPs) could make up around two thirds of demand for industrial fuel switching to hydrogen by 2030. We therefore committed in the Hydrogen Strategy to explore policies to unlock the potential demand from these technologies and publish this call for evidence on hydrogen-ready industrial equipment.

BEIS recently published a call for evidence on decarbonising CHPs, which included the role of hydrogen, so we are focusing this call for evidence on boiler equipment.[3] Industrial boilers are used across a range of sectors and our analysis indicates that by 2030, they could make up around 40-50% of hydrogen demand for industrial fuel switching. 'Hydrogen-ready' boiler equipment, that runs on fossil fuels today but is designed for subsequent conversion to hydrogen, could act as an important bridge to enable industry's transition to a low carbon future.

Today, however, few industrial sites are taking the preparatory steps needed to enable hydrogen fuel switching in the future, in part because they do not know if or when they will have access to low carbon hydrogen. Government could potentially help overcome this barrier by enabling or requiring industrial boiler equipment to be hydrogen-ready. This would not be to discourage industrial sites from installing other low carbon technologies such as electrification or carbon capture, usage and storage (CCUS), consistent with the government's approach of encouraging the most cost-effective ways to decarbonise. Instead, the aim would be to enable cheaper and faster fuel switching to hydrogen when and where it becomes available and avoid the installation of new industrial boiler equipment without a credible pathway to decarbonise.

There is currently no standardised definition of hydrogen-ready for industrial boiler equipment. In this call for evidence, we are seeking views on how hydrogen-ready might best be defined, whether hydrogen-ready boiler equipment can enable

[1] HM Government, Net Zero Strategy, 2021, 121-125
[2] HM Government, UK Hydrogen Strategy, 2021
[3] HM Government, Combined Heat and Power: pathway to decarbonisation, 2021

cheaper and faster fuel switching, and if government should act to encourage its use in industry. This call for evidence will also help us to understand how to stimulate from the outset an innovative and internationally competitive UK supply chain for hydrogen-ready industrial boilers that can support both domestic and global markets.

The call for evidence is split into four sections, with subsections followed by a series of questions. Section 1 introduces the topic and sets out who we would like to hear from. Sections 2 - 4 then cover:

- The benefits, challenges, and risks of defining hydrogen-ready industrial boiler equipment. We are also asking for respondents to provide information on other solutions or technologies that could be used to decarbonise industrial boilers. An important question we are seeking to address is whether the cost premium associated with hydrogen-ready industrial boilers would be justified, considering other ways to fuel switch and different scenarios for future uptake of hydrogen.
- The role government could play to enable or require the adoption of hydrogen-ready equipment. We identify different ways regulation could work, consider what exemptions might be justified, and suggest potential criteria for assessing the merits of a regulatory approach. Questions ask for evidence and views on what governments' role should be and the implications of this.
- Whether the supply chain would be able to support deployment of hydrogen-ready equipment, the date by which the supply chain could accommodate regulation for this and what the wider economic opportunities and implications of a regulatory approach might be.

Responses to the call for evidence will be accepted from 20 December through to 14 March 2022. A summary of responses will be published once the Government has analysed all the responses. Feedback from this call for evidence may form the basis for further consultations on proposals for changes to policy for industrial equipment.

Contents

General information

Why we are consulting

This call for evidence is an important opportunity to gather stakeholder views on the potential for 'hydrogen-ready' industrial boiler equipment to help industry decarbonise and kickstart the UK hydrogen economy.

Stakeholder Engagement details

Issued: 20 December 2021

Closed: 14 March 2022

Enquiries to:

Hydrogen Economy Team
Department for Business, Energy & Industrial Strategy
2nd Floor, Orchard 3
1 Victoria Street
London, SW1H 0ET

Email: hydrogen.industry@beis.gov.uk

Consultation reference: Hydrogen-ready industrial boiler equipment

Audiences:

- Industrial sites
- Original equipment manufacturers for industrial boiler equipment
- Other participants in the supply chain for industrial boiler equipment
- Energy Service Companies with an interest in hydrogen
- Gas suppliers, and other companies with an interest in hydrogen
- Non-Governmental Organisations, academics, and members of the public with an interest in this area.

Territorial extent:

The scope of this call for evidence is UK-wide. We will continue to work with the devolved administrations as we gather evidence and develop any policy proposals.

Confidentiality and data protection

Information you provide in response to this consultation, including personal information, may be disclosed in accordance with UK legislation (the Freedom of Information Act 2000, the Data Protection Act 2018 and the Environmental Information Regulations 2004).

If you want the information that you provide to be treated as confidential, please tell us, but be aware that we cannot guarantee confidentiality in all circumstances. An automatic confidentiality disclaimer generated by your IT system will not be regarded by us as a confidentiality request.

We will process your personal data in accordance with all applicable data protection laws. See our privacy policy.

We will summarise all responses and publish this summary on GOV.UK. The summary will include a list of names or organisations that responded, but not people's personal names, addresses or other contact details.

Quality assurance

This call for evidence was carried out in accordance with the Government's consultation principles.

If you have any complaints about the way this call for evidence was conducted, please email: beis.bru@beis.gov.uk.

1. Introduction

1.1 Background to this call for evidence

In August 2021 BEIS published the *UK Hydrogen Strategy* setting out the government's approach for developing a thriving hydrogen economy.[4] This built on the Prime Minister's *Ten Point Plan for a Green Industrial Revolution*, and specifically the UK's ambition to deploy 5GW of low carbon hydrogen by 2030.[5]

The Strategy described the role hydrogen could play in ensuring the UK meets its Sixth Carbon Budget (CB6) and achieving our trajectory towards Net Zero.[6] To do so, it covered the full extent of the hydrogen value chain, encompassing production, distribution, storage, and end uses. Guided by clear goals and principles, and a roadmap showing how we expect the hydrogen economy to develop over time, the Strategy sets out near term commitments, along with long-term direction to unlock the innovation and investment needed.[7] One of those commitments was to publish this call for evidence on hydrogen-ready industrial equipment, to help determine the potential for this technology to decarbonise industry.

In 2019 industry produced 78 $MtCO_2e$, representing 15% of UK CO_2 emissions. To meet CB6, rapid and deep decarbonisation is required across every industrial sector, and government expects industrial CO_2 emissions to decrease by around 63-76% by 2035. To achieve this, the Net Zero Strategy indicated that industry could need up to 50 TWh of hydrogen per annum by 2035. [8] Hydrogen-ready equipment, that runs on fossil fuels today but is designed for subsequent conversion to hydrogen, could act as a bridge for industry to make this transition.

Today, a standardised definition for 'hydrogen-ready' industrial equipment does not exist. For the purpose of this call for evidence, 'hydrogen-ready' refers to either equipment or whole plants designed for easier, cheaper, and faster conversion to hydrogen than would otherwise be the case.

We are focusing this call for evidence on industrial boiler equipment. This is because boilers are used across a range of sectors and our analysis indicates a significant proportion of the demand for hydrogen will come from this equipment category. Furthermore, the technology required for hydrogen boilers is relatively advanced and more standardised than for other types of industrial equipment. For these reasons, testing our analysis and assessing the case for enabling or requiring industrial boilers to be hydrogen-ready is a good starting point to review the potential of hydrogen-ready equipment more broadly.

[4] HM Government, UK Hydrogen Strategy, 2021
[5] HM Government, The Ten Point Plan for a Green Industrial Revolution, 2020
[6] HM Government, Carbon Budget 6 Impact Assessment, 2021
[7] HM Government, UK Hydrogen Strategy, 2021, 24 - 25
[8] HM Government, Net Zero Strategy, 2021, 121-125

1.2 Who we want to hear from

We want to hear from a broad range of stakeholders, including but not limited to:

- Industrial sites, particularly those that use boilers for industrial processes or plan to in the future.
- Original equipment manufacturers for industrial boilers.
- Energy Service Companies with an interest in hydrogen.
- Other participants in the supply chain for industrial boilers, who provide services for training, installation, operation, maintenance, financing, and decommissioning of equipment.
- Gas suppliers, and other companies with an interest in the production, transmission, distribution, and storage of hydrogen.
- Non-Governmental Organisations, academics, and members of the public with an interest in this area.

We are seeking views on topics in the following main areas:

- How hydrogen-ready should be defined.
- Whether hydrogen-ready industrial boiler equipment would enable cheaper and faster fuel switching.
- Whether government should take action to enable or require hydrogen-ready industrial boiler equipment.
- The role of the supply chain and how best to maximise the economic opportunities for the UK.

All questions are optional and there is no specified wordcount. We encourage as great or little detail as is available and welcome any supporting evidence. A summary of responses will be published where we will ensure that any personal data is anonymised.

1.3 Structure for this call for evidence

The call for evidence is organised into four parts:

Section 1: Introduction

This section introduces the call for evidence, its structure and who we want to hear from.

Section 2: The opportunity for hydrogen-ready industrial boilers

This section describes the potential for low carbon hydrogen to decarbonise industrial boilers and seeks views on other low carbon solutions. It then explores how hydrogen-ready should be defined and the rationale for this technology. Questions ask for views on defining hydrogen-ready and for views and evidence on the costs and complexity of installing and converting hydrogen-ready boiler equipment to use hydrogen.

Section 3: The role for government to support hydrogen-ready industrial boiler equipment

This section considers if government should encourage the adoption of hydrogen-ready industrial boiler equipment, the benefits and risks of doing so, and considers potential approaches to implementation. Questions ask whether government should encourage hydrogen-ready equipment, and if so, how this could work in practice and in what timescales. Questions also seek views on a proposed criteria to assess the merits of a regulatory approach.

Section 4: The role of the supply chain and economic opportunities for the UK

This section examines the roles that relevant supply chain participants would play in supporting the deployment of hydrogen-ready industrial boiler equipment. Questions ask how the supply chain may need to support industry to deploy hydrogen-ready equipment, and what the wider economic implications of hydrogen-ready equipment could be.

Section 1 - Questions

1. **If you are responding on behalf of an organisation, please confirm the name and type of organisation you represent?** (e.g., industrial site, original equipment manufacturer, academic, member of the public)

2. **What is your main interest in relation to this call for evidence?**

2. The opportunity for hydrogen-ready industrial boilers

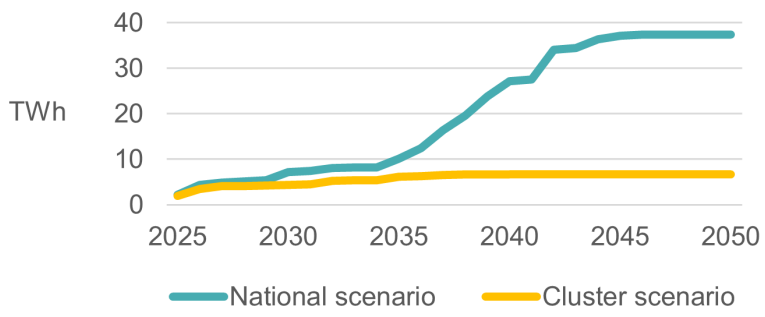
2.1 Hydrogen fuel switching as a way to decarbonise industrial boilers

Low carbon hydrogen is a good option to decarbonise industrial processes that are harder or more expensive to electrify, given its similarities with natural gas. Analysis for the *UK Hydrogen Strategy* assessed potential hydrogen demand for industrial fuel switching. By 2030 demand could range between 10 TWh and 21 TWh per annum, depending on whether hydrogen supply is limited to industrial clusters or increasingly available nationwide. By 2050, if hydrogen is available extensively nationwide, hydrogen demand for fuel switching could reach 105 TWh per annum.[9] For context, the Net Zero Strategy indicates that by 2050 demand for hydrogen across the whole economy could range between 240 – 500 TWh per annum.[10]

Our analysis uses the Net Zero Industrial Pathways (NZIP) model, which calculates hydrogen demand for different equipment categories. Industrial boilers make up a significant proportion of this demand, in part because they are used in a wide range of sectors. In this call for evidence, an industrial boiler refers to equipment used to produce hot water or steam, primarily for an industrial or manufacturing process, rather than for heating buildings. BEIS' Hy4heat programme estimated the quantity and size of industrial boiler stock in the UK connected to the below 7 bar gas network. The study estimated that in the UK there are around 9500 boilers with a capacity less than 1MW, and around 2000 boilers with a capacity between 1 MW - 50 MW.[11]

Figure 1 sets out NZIP modelling for potential hydrogen demand from boilers in two scenarios. The orange line represents a cluster scenario where the availability of hydrogen for fuel switching is limited to a series of industrial clusters across the UK. The teal line represents a national scenario, where hydrogen for fuel switching is initially accessible within those industrial clusters and then becomes increasingly available nationwide.[12]

Fig 1: Potential hydrogen demand for industrial boiler fuel switching



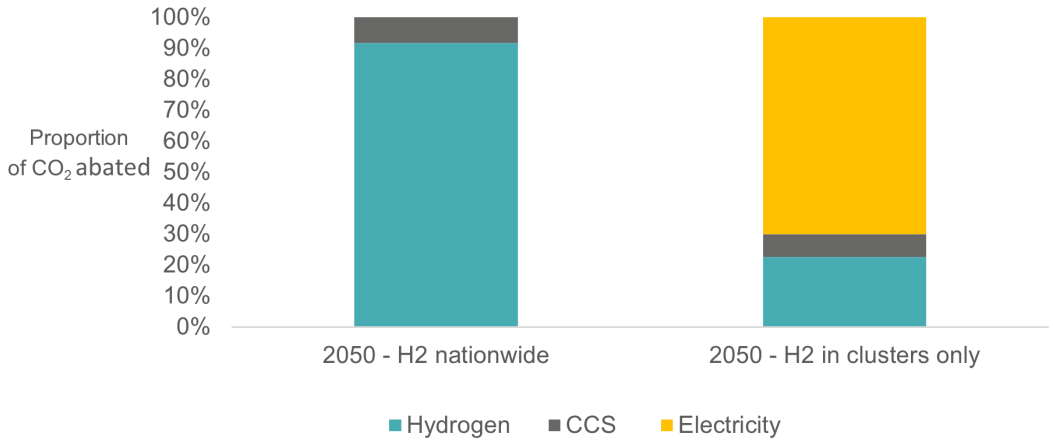
[9] HM Government, UK Hydrogen Strategy, 2021, 54
[10] HM Government, Net Zero Strategy, 2021, 319
[11] Element Energy, Hy4Heat Work Package 6, 2020, 113
[12] NZIP model details see, HM Government, Industrial Decarbonisation Strategy, 2021, 132-135.

In the cluster scenario, demand for hydrogen rises to 5 TWh by 2030, before plateauing around 7 TWh per annum in the late 2030s. In the national scenario, early demand is realised through the clusters, reaching 8 TWh by 2030, and then continues to rise as sites outside of clusters begin to receive hydrogen, plateauing at 37 TWh per annum in the mid-2040s. This fuel switching to hydrogen has significant potential to abate industrial CO_2 emissions, resulting in 1.3 $MtCO_2e$ savings per annum in the cluster scenario, rising to around 7.3 $MtCO_2e$ per annum in the national scenario by 2050.

To determine hydrogen demand for industrial boiler fuel switching, the NZIP model runs a least cost assessment to compare hydrogen with other low carbon technologies such as electrification, biofuels, and CCUS. To make this assessment, the projected fuel prices for different low carbon fuels, along with assumptions for the cost of conversion to different technologies to decarbonise are considered. Further factors accounted for by the model include the technology readiness of associated equipment and assumptions for when and where hydrogen and CCUS infrastructure would be deployed.

Figure 2 shows which technologies the model selects to abate CO_2 emissions from methane-fired boilers. This indicates that low carbon hydrogen is the cheapest way to decarbonise industrial boilers where it is available, aside from 7-8% of boilers opting for CCUS. If the supply of hydrogen is limited to industrial clusters, boiler processes outside of those clusters choose electrification instead. In the cluster scenario, electrification represents 70% of the abated methane emissions.

Figure 2: Least cost way to decarbonise natural gas industrial boilers by 2050



These results are not a prediction, but a pathway driven by assumptions, in particular BEIS' expectations for future energy prices.[13] The model does not account for policy decisions BEIS could take to help reduce the costs to industry of using low carbon fuels such as electricity or hydrogen. Nor does the model account for options to use regulation to encourage fuel switching, such as for hydrogen-ready equipment.

[13] HM Government, Industrial Decarbonisation Strategy, 2021, 133-134

Finally, the model does not reflect air quality impacts, which are more significant for combustion technologies than electrification. Nevertheless, the modelling highlights that fuel switching industrial boilers to hydrogen could represent a significant source of demand for hydrogen, which in turn would help decarbonise a significant proportion of industrial CO_2 emissions. However, to achieve this the following challenges must be overcome:

- Low carbon hydrogen must be a competitive fuel choice compared with alternatives.
- Low carbon hydrogen must be readily available through resilient and cost-effective distribution.
- Fuel switching industrial equipment to low carbon hydrogen must be fast and cost-effective, whilst meeting safety and environmental requirements.

Government is providing financial support across the hydrogen value chain to ensure hydrogen is a competitive fuel choice. Furthermore, the *UK Hydrogen Strategy* committed to review hydrogen network and storage requirements, including the need for economic regulation and funding, with the intention to update on this in early 2022.

This call for evidence focuses on the third challenge: exploring if hydrogen-ready boiler equipment could help enable a fast and cost-effective transition for industry to use hydrogen.

Section 2.1 - Questions

3. What factors would impact the way an industrial site would decarbonise boiler processes?

4. Do you think that low carbon hydrogen is a good way to decarbonise industrial boilers? Please give details to explain your view.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

5. Would other low carbon alternatives, including electrification, biofuels or CCUS, also offer a suitable way to decarbonise boiler processes? To what extent would changing energy prices influence your view?

2.2 Defining hydrogen-ready

There is currently no standardised definition for 'hydrogen-ready', so equipment manufacturers use the term to mean different things. At times it is used to refer to equipment that can already fire 100% hydrogen, while in other instances it refers to firing a blend of hydrogen and methane. An established definition of hydrogen-ready could help sites take informed decisions about whether this technology is suitable for them. We propose that for industrial boilers 'hydrogen-ready' should be understood in all the ways set out below. Questions for this section welcome views on this.

- Hydrogen-ready should refer to equipment that has been designed for faster and cheaper conversion to use 100% hydrogen. It is therefore distinct from conventional equipment that could be retrofitted for conversion to hydrogen but has not been specifically designed for efficient conversion.
- Hydrogen-ready should refer to equipment that can fire natural gas when installed and can be converted to use 100% hydrogen. It may be that hydrogen-ready equipment cannot initially use 100% hydrogen.
- Hydrogen-ready should refer to equipment designed for conversion to use 100% hydrogen. Hydrogen-ready equipment might be able to fire a blend of hydrogen and methane, but equipment designed *solely* to fire a blend would not be considered hydrogen-ready.[14]
- Hydrogen-ready should refer to new boiler equipment (including relevant subcomponents). If existing equipment is retrofitted to fire hydrogen it would be most cost-effective for this conversion to happen when the hydrogen becomes available. This avoids the need for two conversions, first from conventional to hydrogen-ready equipment and then from hydrogen-ready to use hydrogen.
- Hydrogen-ready equipment must meet safety and performance standards, such as limits for nitrogen oxides (NO_x), both before and after conversion to use hydrogen.
- Hydrogen-ready equipment could refer to equipment that can fire hydrogen as well as natural gas at the point of installation, often referred to as 'multi-fuel' equipment. Similarly, hydrogen-ready could refer to equipment that once converted to hydrogen, can still fire natural gas. The capabilities to switch between fuels would not be essential, but equipment that could do so would be deemed hydrogen-ready.

Hydrogen-ready subcomponents for industrial boilers

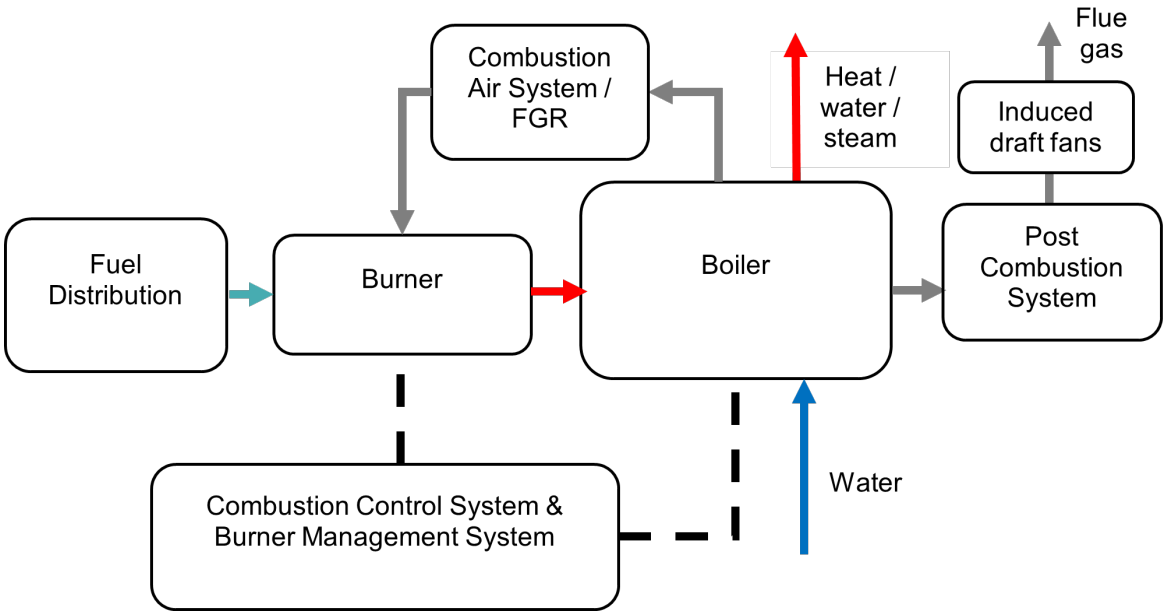
Industrial boiler systems are made up of subcomponents, often on different replacement cycles. Work Package 6 of the Hy4Heat programme developed a framework to help determine the subcomponents for hot water, and high and low pressure steam boilers that would require modification to use hydrogen.[15]

[14] Current trials indicate that hydrogen blending is not expected to impact the safety or performance of a range of industrial appliances. Government is working with industry to continue to build this evidence-base and anticipates a likely policy decision on blending in 2023, subject to the completion of both the economic and safety case. For more information see HM Government, UK Hydrogen Strategy, 2021, 76

[15] Element Energy, Hy4Heat Work Package 6, 2020, 31-32

For all subcomponents, the application of health and safety legislation and product safety legislation would need to be considered in relation to how hydrogen-ready boiler equipment is installed and operated, including both before and after conversion to hydrogen.[16] Figure 3 provides a schematic for the subcomponents that make up a typical boiler system. This is followed by a description of adaptations required to fire hydrogen for each subcomponent. Understanding these adaptations is a necessary first step in considering their potential hydrogen-ready requirements.

Fig. 3 - Schematic of an industrial boiler system



- **Boilers** can have 30 to 40 year replacement cycles, often double that of other components. Initial evidence suggests that existing boilers would be compatible with hydrogen, though energy output may reduce by around 10% due to hydrogen's distinct combustion characteristics.[17] Heat exchange materials may also require optimising for hydrogen.
- **Burner Systems** have replacement cycles of around 15 years and need to be specifically designed to accommodate the combustion characteristics of hydrogen. For instance, requirements could include ultraviolet flame detection and increased thermal loading on burner tips.
- **Electrical Controls and Instrumentation** such as for the combustion control and burner management system would need software compatible with hydrogen-firing.

[16] For health and safety legislation see the Dangerous Substances and Explosive Atmospheres Regulations 2002. For product safety legislation see the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016.
[17] For more information regarding hydrogen's combustion characteristics see Element Energy, Hy4Heat Work Package 6, 2020, 23-26

- **Fuel Distribution** including pipework may require upgrading because hydrogen's characteristics could otherwise lead to leakages, pipe embrittlement or insufficient pipe diameters for equivalent energy volumes.
- **Combustion Air System and Flue Gas Recirculation (FGR)** equipment may need to be installed or upgraded to mitigate the higher levels of NOx emissions typically associated with combusting hydrogen.
- **Post and Flue Gas Treatment** may be required where FGR equipment or other means to reduce NO_X levels are not sufficient.
- **Induced Draft Fans** may need to be upgraded or redesigned to meet the health and safety and product safety requirements associated with the use of hydrogen.

Other types of 'hydrogen-ready' equipment

Industrial boilers are not the only types of combustion equipment that could be hydrogen-ready. Industrial kilns, ovens and furnaces could also be hydrogen-ready, as could boilers used for commercial and domestic heating. BEIS will be consulting shortly on the case for enabling or requiring new domestic gas boilers to be hydrogen-ready by 2026.[18] Similarly, electricity generation equipment could be hydrogen-ready and BEIS recently ran a call for evidence on this, which is discussed further at section 3.2 below.[19] Definitions for hydrogen-ready equipment for one application could impact others, and we are seeking to understand any interdependencies. Questions for this section welcome views on how to best align hydrogen-ready definitions across equipment categories.

Section 2.2 – Questions

6. **How should hydrogen-ready be defined for industrial boilers? Do you have any views on the ways we have described hydrogen-ready for industrial boilers?**

7. **Do you agree it would be possible for equipment manufacturers to produce hydrogen-ready boiler equipment at scale and in the ways described above?** Please give details to explain your view.
    - Strongly agree
    - Agree
    - Neither agree nor disagree
    - Disagree
    - Strongly disagree

8. **Is the schematic of a typical industrial boiler system accurate? Are there additional subcomponents that should be considered?**

[18] HM Government, Net Zero Strategy, 2021, 146
[19] HM Government, Decarbonisation Readiness: Call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements, 2021

9. **Are the descriptions of how subcomponents would need to differ to fire hydrogen accurate?**

10. **How would industrial boiler subcomponents need to be modified to be hydrogen-ready? Would this differ for the various types of industrial boilers, such as high pressure steam boilers, low pressure steam boilers, and hot water boilers?**

11. **Do you have any views on how a hydrogen-ready definition for industrial boilers should relate to definitions for other types of equipment, including for other industrial processes, domestic and commercial heating, or electricity generation?**

2.3 The cost and conversion benefits of hydrogen-ready industrial boiler equipment

There are two broad options for how an industrial site could fuel switch to hydrogen:

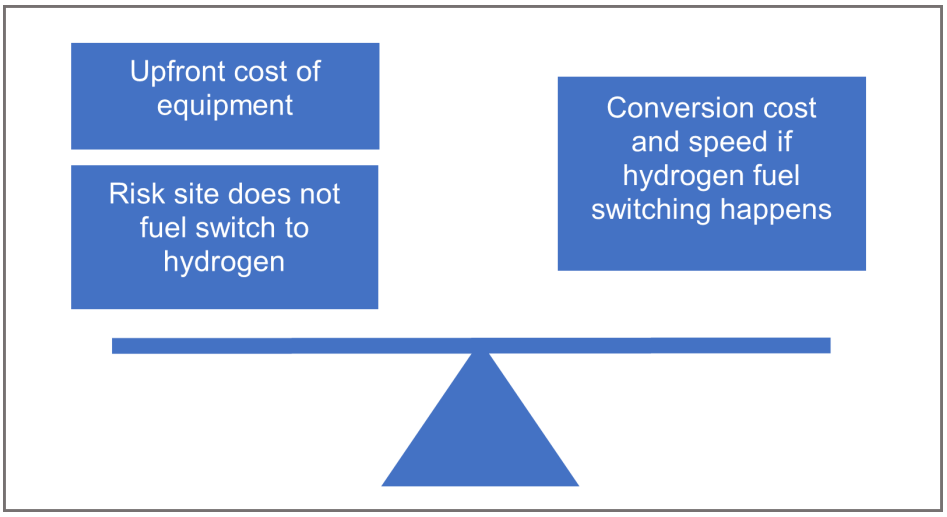
- **Waiting until the site has access to hydrogen and then fuel switch** by retrofitting existing fossil fuel boiler equipment to run on hydrogen.
- **Taking preparatory steps in advance of accessing hydrogen** by installing new hydrogen-ready boiler equipment in line with natural replacement cycles that make later conversion to hydrogen faster and cheaper when compared with retrofitting conventional fossil fuel boiler equipment.

To determine which of these approaches is most cost effective, it will be necessary to establish the upfront cost premium of hydrogen-ready industrial boiler equipment at the point of installation compared to equivalent conventional equipment. It will also be necessary to determine what cost savings hydrogen-ready equipment might offer at the point of conversion, when compared with options to retrofit conventional equipment, such as through replacement or upgrade.

Also significant is the different speed and ease at which conventional or hydrogen-ready boiler equipment can be converted to hydrogen. Hydrogen-ready equipment may enable faster, less complex conversion. If so, this could help both lower costs and enable the supply chain to convert UK boiler stock to run on hydrogen sooner, which in turn would deliver greater carbon savings.

However, taking preparatory steps in advance of accessing hydrogen entails a risk that a site will pay a premium for hydrogen-ready boiler equipment but then not switch to hydrogen, and so would not realise the conversion benefits of cost and speed described above. A third factor, therefore, alongside cost and speed, that would impact a site's decision on whether to install hydrogen-ready equipment is the likelihood of accessing a supply of hydrogen within equipment replacement cycles. Figure 4 provides a simple illustration of the trade-offs involved in this decision.

Fig 4: Illustration of hydrogen fuel switching decision process



At present we have some limited data on the costs and speed of different ways to fuel switch to hydrogen. BEIS's Industrial Fuel Switching study determined that a new 50 MW hydrogen boiler could cost £9.95m, equating to a 20% capex premium compared with a natural gas equivalent.[20] Work Package 6 of the Hy4Heat programme provides data on costs to retrofit natural gas boilers to fire hydrogen. It estimates, for instance, that to retrofit a 20 MW steam boiler in the food and drink sector could cost £1m, and £780,000 in sectors such as chemicals where some boiler subcomponents are more likely to already be compatible with hydrogen.[21]

We do not have data on the costs of hydrogen-ready boiler equipment, or how this might make conversion to hydrogen faster. Questions for this section welcome views and evidence on this and we also intend to run a study to further understand the costs and conversion benefits for hydrogen-ready boiler equipment. This data will be vital in determining whether hydrogen-ready boilers are a good way to help industry decarbonise and whether government should take action to encourage deployment.

Section 2.3 - Questions

12. Do you have views or evidence on what the costs of installing hydrogen-ready boiler equipment would be in contrast with equivalent costs for conventional equipment?

13. Do you have views or evidence on what the costs of converting hydrogen-ready boiler equipment to use hydrogen would be in contrast with equivalent costs for converting conventional equipment?

14. Do you have any views or evidence on the time and complexity of installing hydrogen-ready boiler equipment, when compared to installing conventional equipment?

15. Do you have any views or evidence on the time and complexity of converting hydrogen-ready boiler equipment to use hydrogen, when compared to converting conventional equipment to use hydrogen?

For questions 12 - 15, where possible please provide:

- Details of any assumptions you have made when estimating costs and speed, including how you are using the term hydrogen-ready.
- All associated costs, including for how installation or conversion speeds might entail additional costs associated with plant shutdowns that impact production capacity.
- Data on costs and installation/conversion speeds for 1MW, 10MW and 50MW boilers. Where possible please break down costs and installation/conversion speeds by the subcomponents described at Section 2.1.
- Whether data would vary for the type of boiler including hot water, low and high pressure steam boilers.

[20] HM Government, Industrial Fuel Switching Market Engagement Study, 2018, 66
[21] Element Energy, Hy4Heat Work Package 6, 2020, 37

16. **How might the risk of not accessing hydrogen impact whether an industrial site decides to deploy hydrogen-ready boiler equipment?**

17. **Are there any other commercial, operational, or environmental factors that might affect whether a site deploys hydrogen-ready boiler equipment?**

18. **Overall, do you agree it could be beneficial for industrial sites to deploy new boiler equipment that is hydrogen-ready? Please give details to explain your view.**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

3. The role for government to support hydrogen-ready industrial boiler equipment

3.1 Enabling or requiring hydrogen-ready boiler equipment

Today, few industrial sites are taking the preparatory steps needed to enable hydrogen fuel switching in the future. One reason for this is because of the risk, highlighted in section 2.3, that sites do not know if or when they will have access to hydrogen. As a result, sites cannot adequately assess the benefits of making upfront investments in hydrogen-ready equipment or other preparations which could realise savings when converting to hydrogen at a later date. This could be understood as a market failure caused by the 'missing information' of hydrogen availability.

Government could use the following levers to address this market failure, used in combination with one another and potentially staggered over time:

1. Provide timely information about the future cost and availability of hydrogen, and comparable information for other ways to decarbonise.
2. Fund some or all of the costs of hydrogen-ready industrial boiler equipment, thereby de-risking the initial investment.
3. Develop a standardised definition for what constitutes a hydrogen-ready industrial boiler.
4. Require new industrial boiler equipment to be hydrogen-ready, subject to potential exemptions (discussed at section 3.2).

Enabling hydrogen-ready boiler equipment

Government is already using the first lever and providing information for the decarbonisation of industrial clusters, announcing that the HyNet and East Coast clusters will be taken to the negotiation stage, with the Scottish Cluster selected in reserve.[22] Similarly, the Net Zero Hydrogen Fund will provide up to £240m of support to new hydrogen production projects and the Industrial Decarbonisation and Hydrogen Support scheme will allocate an initial £100m to electrolytic projects in 2022, with a further round of allocations in 2024.[23]

Decisions on whether to transition parts or all of the existing gas grid to hydrogen will also have significant implications, and the government has set a strategic decision point on this for 2026.[24] This could have a particular impact on dispersed sites, where access to hydrogen, if not through the grid, may be more challenging. That said, gas grid conversion is not the only way that dispersed sites could access

[22] HM Government, 2021, Guidance for Cluster sequencing for carbon capture, usage and storage (CCUS) deployment: Phase-1
[23] HM Government, Net Zero Strategy, 2021, 107
[24] UK Hydrogen Strategy, 2021, 63

hydrogen, with viable alternatives including bespoke hydrogen pipelines, co-location with electrolytic hydrogen, and non-pipeline options such as trucked hydrogen.

Despite the information that government and the market will aim to provide as the hydrogen economy develops, full knowledge of when and where hydrogen will become available will remain uncertain for many sites. This could discourage sites from making the necessary upfront investments to prepare for the transition, resulting in the continued deployment of fossil-fuel only equipment that could be slower and more expensive to convert to hydrogen in the future.

Government could use the second lever offering grants or loans to help sites with the costs of hydrogen-ready industrial boiler equipment. At present, the £315m Industrial Energy Transformation Fund is able to provide capital support to first movers seeking to deploy hydrogen-ready equipment if they can demonstrate a realistic plan to access hydrogen within 5 years, or if the new equipment would also reduce their energy consumption.[25] Funding could be a useful way for early adopters to demonstrate the commercial and technical case for hydrogen-ready boilers. However, direct funding is limited by budget constraints and uneven uptake of support. Furthermore, this may not be the fairest way to share costs between taxpayers and industry.

The third lever government could use would be to formally define what constitutes hydrogen-ready industrial boiler equipment and promote sites to deploy this on a voluntary basis. This could involve assessment through a government scheme, such as the Energy Technology List (ETL) that develops performance criteria for highly energy efficient plant and machinery, including industrial boilers, and allows manufacturers to 'list' eligible products.[26] Accrediting or certificating equipment could encourage sites to deploy hydrogen-ready boilers by giving reassurances for the suitability of different products. This could also help to standardise what constitutes 'hydrogen-ready', helping ensure Original Equipment Manufacturers (OEMs) and other supply chain participants develop the right products and services.

Requiring hydrogen-ready industrial boiler equipment

Regulation could help mitigate the 'missing information' market failure, by requiring sites to prepare for a transition to hydrogen. This would not prohibit sites from opting for other low carbon technologies such as electrification or CCUS. Instead, the aim would be to prevent the installation of new industrial boiler equipment without a credible pathway to decarbonise. The benefits and risks of a regulatory approach are outlined below, and we welcome stakeholder views on this.

Benefits of requiring boiler equipment to be hydrogen-ready:

- Hydrogen-ready equipment has the potential to reduce overall costs of fuel switching, when accounting for upfront costs and the costs converting to hydrogen, compared with fuel switching conventional equipment.

[25] HM Government, IETF guidance, 2021, 87. Applicants to funding are required to demonstrate how their site is hydrogen-ready and decisions are made on a case-by-case basis. Funding is split into the £289 million for England, Wales, and Northern Ireland, and £26 million for Scotland.
[26] HM Government, Guidance Energy Technology List (ETL), 2020

- Hydrogen-ready equipment has the potential to accelerate the transition to hydrogen and increase cumulative carbon savings. Sites undertaking preparatory work in line with a regulatory framework could de-risk their conversion to hydrogen and enable the supply chain to convert boiler stock at a faster rate.
- Requiring sites to invest in hydrogen-ready equipment could encourage them to consider, sooner than they might otherwise have done so, whether hydrogen or another option such as electrification is the right way to decarbonise.
- Requiring sites to install hydrogen-ready equipment could encourage forward-leaning sites to deploy equipment more quickly. Early adopters may be more confident that the supply chain would adapt to provide services for this equipment.
- Regulation could signal to OEMs and other supply chain participants that there is a business case to invest in the necessary products and services. This could encourage investment and help create economies of scale, which could lower costs for hydrogen-ready equipment and for subsequent conversion to hydrogen.
- Signalling to the wider hydrogen value chain that industrial boilers could represent significant demand for hydrogen end use. This could build confidence in the market and help lower the overall costs of using hydrogen.

Risks of requiring industrial boiler equipment to be hydrogen-ready:

- If hydrogen does not become available at a site within equipment replacement cycles, then that site would be required to make initial investments without subsequently realising conversion benefits. This has the potential for the greatest impact on sites that are less likely to receive hydrogen, although this could be partially mitigated through exemptions to any regulation. See section 3.2 for a discussion of possible exemptions.
- Hydrogen might become available, but for some sites hydrogen-firing may not turn out to be the best way to decarbonise boiler processes. These sites could pay more for hydrogen-ready equipment but then not realise the benefits because they do not ultimately convert to hydrogen.
- There may be a risk that the option to install hydrogen-ready boiler equipment could encourage sites to install fossil fuel equipment (albeit hydrogen-ready). These sites might have opted for electrification, which would also be future proofed against possible changes to air quality regulations. If a site subsequently does not hydrogen fuel switch, this could result in stranded fossil fuel assets and potentially delay the pace at which boilers are decarbonised.
- If regulation were implemented too soon, supply chains might find it challenging to support sites to deploy hydrogen-ready boiler equipment. For instance, OEMs may not be able to develop commercially viable hydrogen-ready versions that maintain performance and safety levels.
- A regulatory approach could have other unintended consequences. For instance, regulation might encourage sites to install non-hydrogen-ready boiler equipment in advance of normal replacement cycles, so to avoid having to comply with incoming regulation.

Section 3.1 – Questions

19. Considering the possible levers available, do you have any views on whether government should enable and/or require industrial boiler equipment to be hydrogen-ready?

20. How do you think the market for hydrogen-ready boiler equipment would develop without regulation?

21. Do you agree with the benefits and risks presented of requiring boiler equipment to be hydrogen-ready? Are there any other factors to consider?

22. Overall, do you agree that it would be beneficial for government to require boiler equipment to be hydrogen-ready? Please provide details for your views.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

23. If government required industrial boilers to be hydrogen-ready, what would be the implications for other types of equipment used for combustion of fossil fuels? (e.g. domestic and commercial boilers, industrial kilns, furnaces, ovens, dryers, and electricity generating equipment.)

3.2 How hydrogen-ready regulation could work in practice

If regulation for hydrogen-ready boilers were to prove necessary or desirable to help industry decarbonise, government would need to consider how this would work in practice. Our assessment of this is at an early stage and we welcome stakeholder views.

We have identified two broad ways that regulation might work. These options could be combined and there may be other ways requirements could work in practice. One approach could be to use a product standard requiring specific subcomponents to be hydrogen-ready. Equipment manufacturers would be obliged to ensure that sub-components placed on the UK market met a hydrogen-ready standard and industrial sites would need to ensure only accredited sub-components were installed.

A second approach could be to use the environmental permitting regime to create a new requirement for new industrial boiler plants. Rather than targeting specific components, this would create a requirement for plants, possibly within a certain capacity range, to be hydrogen-ready. While this obligation would be placed on sites, we expect that equipment manufacturers would develop the equipment to enable sites to fulfil it.

We would need to work through the devolution consequences of any regulatory approach. We will continue to work closely with the devolved administrations as we gather evidence and develop our thinking on how any potential requirements might work in practice.

Product Standards

Ecodesign and Energy Labelling regulation, that provides a framework for setting minimum environmental performance standards and energy efficiency labels for energy related products, is one example of a product standard led approach.[27] Targeting a product standard at the whole boiler system could be challenging, given that industrial boilers are made up of distinct subcomponents often with different replacement cycles. As a result, separate standards for different sub-components might be required. Given the bespoke way that boiler systems are often configured, developing comprehensive product standards that ensured sites were sufficiently hydrogen-ready would likely be complex.

Environmental Permitting

An example of the use of environmental permitting would be the 2013 CHP Ready requirements.[28] This requires developers of new combustion power plants and Energy from Waste plants to demonstrate Best Available Techniques (BAT) with regards to CHP deployment. These stipulate that plants with 50 MW thermal capacity should install CHP where it is economically and technically viable to do so. In instances where this is not the case, sites should install equipment that can be

[27] HM Government, Regulations: ecodesign of energy-consuming products, 2021
[28] HM Government, Environment Agency, CHP Ready Guidance for Combustion and Energy from Waste Power Plants, 2013

converted to CHP with 'minimum modification' and should undertake periodic reviews to determine if opportunities to supply heat emerge.

BEIS and the Welsh Government recently published a call for evidence on *Decarbonisation Readiness* to assess if environmental permitting could be used to require carbon capture or hydrogen readiness for electricity generation.[29] This considered an expansion of the 2009 Carbon Capture Readiness requirements for new build electricity generation plants, sized 300 MW or greater, to demonstrate the technical and economic feasibility of carbon capture retrofit within the plant's lifetime.

The call for evidence proposes to remove 300 MW minimum capacity threshold, to move requirements from the planning consent process to the environmental permitting process, and for plants to be able to comply either through carbon capture readiness or hydrogen readiness. The call for evidence proposes hydrogen readiness could entail:

- that sufficient space is available on or near the site to accommodate any equipment necessary to facilitate hydrogen conversion
- the technical feasibility of conversion to 100% hydrogen-firing
- that the site's location enables the transport of hydrogen to the site and/or that hydrogen can be produced and potentially stored at the site
- that it is likely to be economically feasible, within the power station's lifetime, to convert to hydrogen combustion.

A further potential expansion could be for these requirements to cover combustion plants for industrial heat, as well as for electricity generation. Environmental permitting treats combustion plants as equivalent, albeit with some deviation, regardless of the purpose of that combustion. There may be some value in aligning requirements for industrial heat and electricity generation. However, we also consider there is merit evaluating the potential for hydrogen-ready regulation for heat and power equipment separately. Focussing on specific equipment categories to begin with could result in better targeted actions to enable or require hydrogen-ready equipment. The questions for this section welcome views on this.

Potential exemptions

Exemptions might be a useful way to prevent sites that are never likely to use hydrogen from incurring avoidable costs. Exemptions could be applied under either a product standard or an environmental permitting-led approach, though either option could impact on the feasibility of certain exemptions. Our assessment of the exemptions that might be warranted is at an early stage and we welcome views on the following possibilities:

- Sites that opt to install non-fossil fuel technology, such as electric or biofuel boilers.

[29] HM Government, Decarbonisation Readiness: Call for evidence on the expansion of the 2009 Carbon Capture Readiness requirements, 2021

- Sites that can credibly demonstrate how they would decarbonise new natural gas boilers that are not hydrogen-ready, for instance via CCUS.
- Sites that can demonstrate why their circumstance prohibits hydrogen-firing because of, for example, safety reasons.
- Equipment which has a particularly short lifecycle so is unlikely to receive hydrogen before the equipment is decommissioned.
- Equipment that is used very occasionally on sites unlikely to receive hydrogen.

Alongside site specific exemptions, a location-based approach to exemptions or the timing of regulations coming into force might be appropriate. This could account for varying decarbonisation options and the likelihood of hydrogen becoming available in different parts of the UK, while still ensuring fair and open competition.

Potential timing

The timing of any regulation would be significant as it would determine the proportion of boiler stock that would become hydrogen-ready. If regulation happened sooner, possibly in the mid-2020s, fuel switching could happen faster, and more sites could realise potential cost savings when converting to hydrogen. On the other hand, more sites would incur the risk of installing equipment that is potentially more expensive but without any of the benefits, if they do not subsequently fuel switch to hydrogen.

If regulation happened later, possibly in the late 2020s, sites would have more information regarding the cost and availability of hydrogen. This would help sites take a more informed decision about whether hydrogen or another way to decarbonise is best for their circumstances. Waiting until later could also enable government to align decisions on whether to regulate with wider decisions regarding the gas network and hydrogen distribution.

However, regulating much later could undermine the rationale for requiring boiler equipment to be hydrogen-ready in the first place. Hydrogen-ready equipment would be installed in line with natural equipment replacement cycles in advance of fuel switching happening. Over time, an increasing proportion of sites will have access to hydrogen, in which case they will not need to undertake preparatory work such as installing hydrogen-ready equipment and will instead be able to fuel switch immediately.

Furthermore, in the longer term, as switching to hydrogen and other ways to decarbonise boilers becomes increasingly possible, hydrogen-ready requirements might not be the best way to support industrial decarbonisation. Instead, in order to achieve the carbon savings needed for Net Zero, it might be necessary to require new equipment to be low carbon at the point of installation or indeed for such requirements to also cover existing equipment.

Section 3.2 – Questions

24. Do you have any views on what kind of regulatory approach might be suitable for requiring the deployment of hydrogen-ready industrial boiler equipment?

25. Do you have any views on whether we should consider the potential for regulating hydrogen-ready industrial boiler equipment separately from hydrogen-ready requirements for power generation?

26. Do you have any views on the possible exemptions presented? Are there other factors that should be considered when assessing potential exemptions?

27. Do you have any views on the potential timing for introducing any regulation requiring industrial boiler equipment to be hydrogen-ready?

28. Do you have any views on how potential requirements for industrial boiler equipment might need to evolve, as options for industrial sites to decarbonise change over time?

3.3 Criteria to evaluate whether to take a regulatory approach

As described in section 2, hydrogen-ready regulation for industrial boilers has the potential to support faster and cheaper fuel switching from fossil fuels to hydrogen. The table at Figure 5 sets out the criteria we propose to use in assessing the merits of a regulatory approach. The criteria are not ranked in order of importance and questions for this section welcome respondents' views on these.

Fig 5: Possible criteria to determine the merit hydrogen-ready boiler regulation

Criterion	Description	Approach
1) Fast and cost-effective emissions abatement	Regulation should offer a rapid way to decarbonise industrial boilers, whilst not putting undue costs/burdens on industry.	This criterion will require determining upfront and conversion cost differentials for hydrogen-ready boiler equipment compared with options to retrofit. We will also compare retrofit and hydrogen-ready approaches in terms of the speed at which fuel switching can happen and the carbon savings this could enable. We will assess options to fuel switch for a range of scenarios for hydrogen uptake.
2) Technical viability	It must be technically viable for industrial sites, equipment manufacturers and other supply chain participants to meet any new regulation.	This criterion assesses whether equipment manufacturers could develop and produce hydrogen-ready sub-components, and whether sites could deploy these components. It would need to be technically viable for hydrogen-ready equipment to meet requirements for performance and safety, both before and after conversion to hydrogen.
3) Deliverability	The supply chain must be able to provide the products and services industrial sites require to meet the requirements and timescales of any new regulation.	This criterion will assess the capability of relevant supply chains, in order to determine if and when regulation could come into force. We will consider how various options to define hydrogen-ready for industrial boilers could affect deployment trajectories for relevant equipment and what the impact would be on UK supply chains.

Criterion 1: Fast and cost-effective emissions abatement

This criterion focuses on the potential of regulation to lower costs and increase the rate of decarbonisation for industrial boilers. We will assess whether hydrogen-ready boiler equipment represents a fast and cost-effective way to fuel switch industrial boilers, when compared with retrofitting existing equipment.

This will support analysis against a range of scenarios for hydrogen uptake, to determine whether hydrogen-ready regulation presents a fast and cost-effective way to decarbonise boilers, and if so, the best timing for any regulation to come into force.

This criterion would not compare hydrogen fuel switching options with other low carbon technologies such as electrification, CCUS and biofuels. This is because, as noted in section 3.1, we anticipate the scope for hydrogen-ready regulation to be focused on fossil-fuel only equipment. Sites would be able to opt for their preferred low carbon technology, with any regulation aiming to prevent expensive retrofit or asset stranding of fossil fuel equipment.

Criterion 1 will aim to consider the industry-wide costs and benefits of regulation and the implications regulation might have on specific sites, where the likelihood of receiving hydrogen will vary. This will help us to assess the distributional impacts of any costs and benefits, for instance to determine if the benefits of a regulatory approach would be unreasonably weighted to certain locations or sectors.

Criterion 2: Technical viability

This criterion aims to assess whether a definition for hydrogen-ready industrial boiler equipment can be developed that would be technically viable. This would consider whether equipment manufacturers could develop and produce hydrogen-ready sub-components, and whether sites could deploy these components.

There are examples of industrial sites using hydrogen boilers, demonstrating the viability of hydrogen-firing. Furthermore, BEIS' Hy4Heat programme reported 'no-showstopping barriers' to the technical viability of retrofitting existing industrial equipment, including boilers, to fire hydrogen.[30] We have limited evidence of the technical viability of hydrogen-ready equipment designed for conversion at a later stage.

To be deemed technically viable, equipment would need to maintain performance and safety both before and after conversion to hydrogen, and we anticipate this assessment would cover:

- Energy efficiency and performance
- Product safety and health and safety requirements
- National and local air quality requirements, (in particular for NO_x emissions)

[30] Element Energy, Hy4Heat Work Package 6, 2020, 49

Criterion 3: Deliverability

This criterion aims to determine how different approaches to defining and regulating hydrogen-ready industrial boilers would impact the ability of supply chains to help industry fuel switch. This will need to account for how much time the supply chain would need to adapt to any new requirements and assess the potential opportunities and impacts of regulation, both in the nearer and longer term. We anticipate that this will help us to understand potential market behaviours in response to any regulation and could inform what exemptions and mitigations might be appropriate.

We also intend to use this criterion to assess the impact that different approaches to defining hydrogen-ready would have on UK participants in relevant supply chains. This will aim to ensure that any new regulation would foster a sustainable supply chain both for domestic and international markets.

Section 4 goes into further detail on the role of supply chain participants for hydrogen-ready industrial boiler equipment, the date the supply chain could deliver new hydrogen-ready regulation, and the wider economic opportunities and implications that regulation could have.

Section 3.3 – Questions

29. Do you think these three criteria provide the right framework to assess the merits of hydrogen-ready regulation? Please provide details.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

30. Are there other factors or criteria that should be accounted for?

4. The role of the supply chain and economic opportunities for the UK

4.1 The role for supply chains in enabling deployment of hydrogen-ready boiler equipment

For industry to fuel switch successfully to low carbon hydrogen, the support of world-class, sustainable supply chains is vital. The UK is well positioned to grow and develop the supply chains needed, and the *UK Hydrogen Strategy* sets out that we aim to capitalise on opportunities such as regional growth and jobs and the export potential for UK products and services.[31]

Today, the supply chain to enable fuel switching to hydrogen is at an early stage of development. Industrial fuel switching at scale will require the development of new capabilities across the supply chain. This could open up opportunities for new participants in the supply chain and give existing participants the chance to expand and adapt the products and service they provide.

For this call for evidence, 'supply chain' refers to the capabilities of businesses to provide the resources, products, and expertise to develop and deploy hydrogen-ready industrial boiler equipment. This covers the supply of manufactured components, the supply of finance to fund deployment, and the supply of personnel with the skills and expertise to install, operate, service and decommission the boilers. Below are the types of services that supply chain participants provide across the lifecycle of an industrial boiler.

- **Manufacturing** of boiler subcomponents, as listed at section 2.2, including:
    - Boiler, including heat transfer elements
    - Burner system
    - Electrical controls and instrumentation
    - Fuel distribution, including pipework
    - Combustion air system and flue gas recovery systems
    - Post combustion and flue gas treatment
    - Forced or induced draft fans

- **Installation**: Businesses that install and commission the subcomponents that make up the boiler system. Often this is carried out by subcomponent manufacturers.
- **Finance and insurance:** Companies offering financial services to help fund or insure equipment
- **Operation:** Industrial operators must have the adequate skills required to operate the boiler. Specialist training companies often provide training to ensure staff have the capability to operate equipment safely and effectively.

[31] HM Government, UK Hydrogen Strategy, 2021, 85

- **Inspection, maintenance, and modification:** For servicing, maintenance and repairs it is likely that the relevant OEM will be contracted. Similarly, equipment manufacturers, or specialist companies may be contracted to inspect and/or modify equipment, for instance to achieve higher levels of performance or to adapt the fuel type used.
- **Decommissioning, disposal, and resale:** Specialist companies that provide end of use services, including recycling or reuse of subcomponents.

To facilitate industry to deploy hydrogen-ready industrial boiler equipment, companies providing these products and services may need to adapt, opening up new business opportunities. This could involve developing new product lines or reskilling staff. Regulation could potentially give supply chain participants clarity about what products and services would be required in the future. This could create the confidence needed to encourage investment and help companies to design their business strategies in preparation for regulation coming into effect.

In the longer term, if hydrogen fuel switching happens at scale, regulation could enable the supply chain to support this transition because hydrogen-ready equipment involves preparing for conversion to hydrogen to make it fast and cost-effective. Installing this equipment prior to conversion, as part of natural replacement cycles, could de-risk the transition and enable the supply chain to convert industrial sites at a faster rate, leading to greater carbon savings.

Adapting to meet new hydrogen-ready regulation could be challenging for some supply chain participants. This may be particularly true if regulation were to come into force sooner, giving companies less time to adapt. Given the critical function supply chains will play in enabling fuel switching we recognise that details of any potential regulation will need to be clear and provided in advance. Similarly, if regulation proved to be the right approach, the date requirements came into effect would need to give sufficient time for businesses to prepare.

Questions for this section welcome views on what supply chains would need to do in preparation for regulation, what government could do to support this and by when supply chains would be able to support the deployment of hydrogen-ready boiler equipment at scale.

Section 4.1 Questions

31. Are the listed services the supply chain provides for the industrial boiler market accurate?

32. Do you agree that the existing supply chain would be able to adapt to meet potential regulation requiring industrial boiler equipment to be hydrogen-ready? Please give details for your views.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

33. How could the government help supply chain participants to support the deployment of hydrogen-ready boiler equipment?

34. How much time would be needed between the details of regulation being provided and any new requirements coming into effect?

35. By what date could supply chains enable industrial sites to meet potential new requirements for boiler equipment to be hydrogen-ready? Please give details for your views.

4.2 Wider economic opportunities and implications of hydrogen-ready regulation for the UK

The *UK Hydrogen Strategy* set our ambition for UK businesses to position themselves at the forefront of the growing global hydrogen market. This means securing investment for a pipeline of British projects, creating good quality green jobs in regions across the UK, and fostering our export strengths to get ahead in a global market. The benefits could be substantial, and our analysis indicates in 2030 the UK hydrogen economy could be worth £900m and support over 9,000 jobs. By 2050, under a high hydrogen scenario, the hydrogen economy could be worth up to £13 billion and support up to 100,000 jobs.[32]

Alongside the aim to support industrial decarbonisation, well-designed regulation could help the UK capitalise on the opportunities the transition to hydrogen presents. It could help lower industrial decarbonisation costs, making the UK an attractive place to manufacture green products. We expect that regulation would give UK-based supply chain participants the confidence to invest in hydrogen-ready products and services for the UK market and for export. It could help demonstrate that industry is ready to switch to hydrogen, boosting the investment case across the hydrogen value chain, including for production, distribution, and storage.

That said, regulation could entail economic risks, particularly if it places excessive or unnecessary burdens on industry. We are keen to understand the opportunities and risks presented by an enabling or requiring hydrogen-ready boilers. Below is an initial assessment of the factors to consider and the questions for this section welcome views on this.

Jobs and investment

Industry is a crucial aspect of the UK economy and in 2018 manufacturing accounted 2.7m jobs.[33] Fuel switching industry to hydrogen is likely to require sites and the supply chain to reskill staff and has the potential to create new green jobs across the UK. Regulation for boilers could foster our hydrogen skills base, that would help grow the hydrogen economy more broadly. Private sector investment will be required to enable this transition, and regulation could stimulate this by helping make clear the products and services required in the future.

Export opportunities

Our analysis indicates that by 2030 around a quarter of UK jobs in the UK hydrogen sector and around 30% of economic opportunity could be driven by exports, with these growing in relative importance by 2050.[34] The market for industrial boilers and associated services is global, and a transition to hydrogen-ready equipment in the UK, through regulation or otherwise, could help position UK-based manufacturers to export this technology abroad.

[32] HM Government, UK Hydrogen Strategy, 2021, 86
[33] House of Commons Library, Research Briefing, Manufacturing: statistics and policy, 2020
[34] HM Government, UK Hydrogen Strategy, 2021, 96

Innovation, knowledge, and technology transfer

The UK's existing hydrogen research base is strong with leadership in fuel cell and electrolyser technology. Regulation could help kick start UK innovation to develop industrial equipment able to fire hydrogen. The technology needed for hydrogen-ready industrial boilers has the potential for knowledge transfer in relation to other equipment categories, such as kilns, furnaces, and ovens, and also to non-industrial sectors such as building heating and electricity generation.

Leadership for standards and regulation

Widespread deployment of industrial equipment capable of using hydrogen will require new and updated regulations. Being an early mover for hydrogen-ready regulation could help the UK influence the development of standards and regulations for hydrogen equipment around the world. This could enable the UK to take a leading role in encouraging industrial decarbonisation globally and help ensure the products and services developed abroad meet the needs of British industry and UK-based supply chain participants. Questions for this section welcome information on work happening in other countries to develop standards or regulation for hydrogen-ready equipment.

Section 4.2 Questions

36. How could hydrogen-ready requirements for industrial boiler equipment support the following objectives and maximise benefits to the UK economy:

- **Jobs and investment**
- **Export opportunities**
- **Innovation, knowledge, and technology transfer**
- **Leadership for standards and regulation**

37. Do you have any views or evidence regarding work to develop standards or regulation in other countries which would be relevant if the UK were to require industrial boiler equipment to be hydrogen-ready?

38. Are there any other final comments you wish to make regarding this call for evidence?

5. Next steps

A summary of responses will be published once the Government has analysed all of the data collected in this call for evidence.

The feedback from this call for evidence will be analysed and may form the basis for further consultations on proposals for changes to policy for industrial boiler equipment.

6. Full list of questions

Section 1 - Questions

1. **If you are responding on behalf of an organisation, please confirm the name and type of organisation you represent?** (e.g., industrial site, original equipment manufacturer, academic, member of the public)

2. **What is your main interest in relation to this call for evidence?**

Section 2.1 - Questions

3. **What factors would impact the way an industrial site would decarbonise boiler processes?**

4. **Do you think that low carbon hydrogen is a good way to decarbonise industrial boilers? Please give details to explain your view.**

    - Strongly agree
    - Agree
    - Neither agree nor disagree
    - Disagree
    - Strongly disagree

5. **Would other low carbon alternatives, including electrification, biofuels or CCUS, also offer a suitable way to decarbonise boiler processes? To what extent would changing energy prices influence your view?**

Section 2.2 - Questions

6. **How should hydrogen-ready be defined for industrial boilers? Do you have any views on the ways we have described hydrogen-ready for industrial boilers?**

7. **Do you agree it would be possible for equipment manufacturers to produce hydrogen-ready boiler equipment at scale and in the ways described above?** Please give details to explain your view.

    - Strongly agree
    - Agree
    - Neither agree nor disagree
    - Disagree
    - Strongly disagree

8. **Is the schematic of a typical industrial boiler system accurate? Are there additional subcomponents that should be considered?**

9. **Are the descriptions of how subcomponents would need to differ to fire hydrogen accurate?**

10. **How would industrial boiler subcomponents need to be modified to be hydrogen-ready? Would this differ for the various types of industrial boilers, such as high pressure steam boilers, low pressure steam boilers, and hot water boilers?**

11. **Do you have any views on how a hydrogen-ready definition for industrial boilers should relate to definitions for other types of equipment, including for other industrial processes, domestic and commercial heating, or electricity generation?**

Section 2.3 - Questions

12. **Do you have views or evidence on what the costs of installing hydrogen-ready boiler equipment would be in contrast with equivalent costs for conventional equipment?**

13. **Do you have views or evidence on what the costs of converting hydrogen-ready boiler equipment to use hydrogen would be in contrast with equivalent costs for converting conventional equipment?**

14. **Do you have any views or evidence on the time and complexity of installing hydrogen-ready boiler equipment, when compared to installing conventional equipment?**

15. **Do you have any views or evidence on the time and complexity of converting hydrogen-ready boiler equipment to use hydrogen, when compared to converting conventional equipment?**

For questions 12 - 15, where possible please provide:

- Details of any assumptions you have made when estimating costs and speed, including how you are using the term hydrogen-ready.
- All associated costs, including for how installation or conversion speeds might entail additional costs associated with plant shutdowns that impact production capacity.
- Data on costs and installation/conversion speeds for 1MW, 10MW and 50MW boilers.
- Data on costs and installation/conversion speeds for the subcomponents described at Section 2.1.
- Whether data would vary for the type of boiler including hot water, low and high pressure steam boilers.

16. **How might the risk of not accessing hydrogen impact decisions to deploy hydrogen-ready boiler equipment?**

17. **Are there any other commercial, operational, or environmental factors that might affect whether a site installs hydrogen-ready boiler equipment?**

18. **Overall, do you agree it could be beneficial for industrial sites to deploy new boiler equipment that is hydrogen-ready? Please give details to explain your view.**

    - Strongly agree
    - Agree
    - Neither agree nor disagree
    - Disagree
    - Strongly disagree

Section 3.1 - Questions

19. **Considering the possible levers available, do you have any views on whether government should enable and/or require industrial boiler equipment to be hydrogen-ready?**

20. **How do you think the market for hydrogen-ready boiler equipment would develop without regulation?**

21. **Do you agree with the benefits and risks presented of requiring boiler equipment to be hydrogen-ready? Are there any other factors to consider?**

22. **Overall, do you agree that it would be beneficial for government to require boiler equipment to be hydrogen-ready? Please provide details for your views.**

    - Strongly agree
    - Agree
    - Neither agree nor disagree
    - Disagree
    - Strongly disagree

23. **If government required industrial boilers to be hydrogen-ready, what would be the implications for other types of equipment used for combustion of fossil fuels? (e.g. domestic and commercial boilers, industrial kilns, furnaces, ovens, dryers, and electricity generating equipment.)**

Section 3.2 - Questions

24. Do you have any views on what kind of regulatory approach might be suitable for requiring the deployment of hydrogen-ready industrial boiler equipment?

25. Do you have any views on whether we should consider the potential for regulating hydrogen-ready industrial boiler equipment separately from hydrogen-ready requirements for power generation?

26. Do you have any views on the possible exemptions presented? Are there other factors that should be considered when assessing potential exemptions?

27. Do you have any views on the potential timing for introducing any regulation requiring industrial boiler equipment to be hydrogen-ready?

28. Do you have any views on how potential requirements for boiler equipment might need to evolve, as options for industrial sites to decarbonise change over time?

Section 3.3 - Questions

29. Do you think these three criteria provide the right framework to assess the merits of hydrogen-ready regulation? Please provide details.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

30. Are there other factors or criteria that should be accounted for?

Section 4.1 - Questions

31. Are the listed services the supply chain provides for the industrial boiler market accurate?

32. Do you agree that the existing supply chain would be able to adapt to meet potential regulation requiring industrial boiler equipment to be hydrogen-ready? Please give details for your views.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

33. **How could the government help supply chain participants to support the deployment of hydrogen-ready boiler equipment?**

34. **How much time would be needed between the details of regulation being provided and any new requirements coming into effect?**

35. **By what date could supply chains enable industrial sites to meet potential new requirements for boiler equipment to be hydrogen-ready? Please give details for your views.**

Section 4.2 - Questions

36. **How could hydrogen-ready requirements for industrial boiler equipment support the following objectives and maximise benefits to the UK economy:**

- Jobs and investment
- Export opportunities
- Innovation, knowledge, and technology transfer
- Leadership for standards and regulation

37. **Do you have any views or evidence regarding work to develop standards or regulation in other countries which would be relevant if the UK were to require industrial boiler equipment to be hydrogen-ready?**

38. **Are there any other final comments you wish to make regarding this call for evidence?**

This consultation is available from: www.gov.uk/government/consultations/enabling-or-requiring-hydrogen-ready-industrial-boiler-equipment-call-for-evidence

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