Title: Improving boiler standards and efficiency: boiler efficiency, hydrogen-ready boilers, and the role of hybrid systems

IA No: BEIS067(C)-22-CHD

Lead department or agency: Department for Business, Energy and Industrial Strategy

Other departments or agencies: None

Impact Assessment (IA)

Date: 13/12/22

Stage: Development/Options

Source of intervention: Domestic

Type of measure: Secondary legislation

Contact for enquiries: domesticboilersconsultation@beis.gov.uk

Summary: Intervention and Options

RPC Opinion: Not required

Cost of Preferred (or more likely) Option (in 2019 prices, 2020 present value)

Total Net Present Social Value	Business Net Present Value	Net cost to business per year	Business Impact Target Status
£6,580m	-£570m	£33m	n/a

What is the problem under consideration? Why is Government action or intervention necessary?

There are several strategic pathways to full decarbonisation of heat by 2050; however, in all of them we expect there to be at least 10 million gas boiler installations between 2025 and 2035. In a scenario where a decision is taken to roll-out hydrogen for use in domestic heating, this figure is likely to be higher as hydrogen-ready boilers (initially fitted to burn natural gas) will continue to be deployed widely throughout the period. This represents a significant target population for further improvements to in-home boiler performance. New heating installations can also present opportunities to take steps to prepare homes for the future transition to low-carbon heating. The full societal costs of fossil fuel combustion are not reflected in boiler market prices and imperfect information makes it difficult for households to make decisions consistent with our decarbonisation pathways. In the absence of an effective policy framework, including regulatory policies, new boiler installations will not consistently achieve the highest possible levels of efficiency nor prepare homes for the low-carbon heating transition. This would result in lower greenhouse gas emissions reductions from buildings than targeted in near-term carbon budgets and higher costs associated with future Net Zero pathways. Furthermore, without regulation, hybrids are likely to be a premium product, which are likely to cost consumers more and hinder widespread deployment.

What are the policy objectives of the action or intervention and the intended effects?

There are two overall policy objectives of this policy intervention:

a) To increase the efficiency of newly installed domestic-scale gas boilers from 2025, to reduce gas consumption in the short term thereby increasing the UK energy security, contributing to meeting carbon budgets and reducing consumer bills.

b) To reduce the costs and disruption associated with a potential transition to the use of hydrogen for domestic heating, by considering the option of requiring that from 2026 all new domestic-scale gas boilers be 'hydrogen-ready'.

This Impact Assessment therefore appraises the impact of enhancing boiler efficiency standards and mandating hydrogen-ready boilers. It also explores the potential role of hybrid heating systems as a means of delivering carbon savings and providing consumers with a steppingstone between their existing systems and full low-carbon alternatives.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base)

The policy options considered in this Impact Assessment are:

- Option 0 (counterfactual): Do nothing
- Option 1: Introduce a new set of requirements from 2025 to increase the in-home performance of newly installed domestic-scale gas boilers which looks to expand and build on the existing Boiler Plus Standards which apply in England
- Option 2: Mandate that from 2026 all newly installed domestic-scale gas boilers are hydrogen-ready, thereby preparing homes for a potential future hydrogen conversion
- Option 3 (preferred option): Implement options 1 and 2 in tandem
- Option 4: Implement Option 3 and require that from 2028 all newly installed natural gas boiler installations must be accompanied by an electrical heat generation element or other renewable/low-carbon system, supporting increased deployment of hybrid heating systems alongside standalone heat pumps.

Barriers such as carbon externality, imperfect information, and misaligned incentives mean that, without Government regulation, the domestic gas boiler market will fail to deliver its carbon saving potential and limit the potential to reduce consumer bills and mean boiler deployment does not contribute to the wider decarbonisation transition. Regulatory approaches are most likely to deliver the large scale take up needed to meet carbon budgets and provide certainty to support investment in supply chains. Option 3 is preferred to Option 4 as, while hybrid heating systems would significantly contribute to meeting carbon budgets, the high equipment costs and uncertainty around the technology mean that it's too soon to take any decision on a market-wide deployment.

Will the policy be reviewed? It will be reviewed. **If applicable, set review date:** N/A

Is this measure likely to impact on international trade and investment?		Yes		
Are any of these organisations in scope?	**Micro** Yes	**Small** Yes	**Medium** Yes	**Large** Yes
What is the CO_2 equivalent change in greenhouse gas emissions? (Million tonnes CO_2 equivalent)		**Traded:** 1	**Non-traded:** 20	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister Matthew Pennycook Date: 09/12/22

Summary: Analysis & Evidence

Policy Option 3

Description: Preferred option - introduce new requirements to improve in-home boilers from 2025 and mandate hydrogen-ready boilers from 2026 so that all domestic-scale gas boilers sold in the domestic market are hydrogen-ready.

FULL ECONOMIC ASSESSMENT

Price Base	PV Base	Time Period	Net Benefit (Present Value (PV)) (£m)		
2020	2025	26 years	**Low:** n/a	**High:** n/a	**Best Estimate: £8,250m**

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	n/a		n/a	**n/a**
High	n/a		n/a	**n/a**
Best Estimate	n/a		n/a	**£710m**

Description and scale of key monetised costs by 'main affected groups'

The largest societal costs are the capital costs associated with installing new technologies to prepare homes for the future transition to low-carbon heating.

Other key non-monetised costs by 'main affected groups'

None identified.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	n/a		n/a	**n/a**
High	n/a		n/a	**n/a**
Best Estimate	n/a		n/a	**£8,960m**

Description and scale of key monetised benefits by 'main affected groups'

The largest monetised benefits are the carbon emissions savings, followed by reduced long variable running costs and air quality improvements.

Other key non-monetised benefits by 'main affected groups'

Innovation benefits, reduced technology costs due to learning from wider deployment leading to future decarbonisation being more cost effective. Policy framework stability, with market-wide application, enabling strategic confidence to invest in supply chains, training, etc. Development of competitiveness in UK's clean goods and services related to heat. Alignment with Net Zero strategy. Reduced disruption in the High Hydrogen pathway due to lower number of boiler replacements required. Increased UK energy security.

Key assumptions/sensitivities/risks	Discount rate	3.5

Costs of heating systems, costs of heating conversion, efficiency improvements, future fuel costs, future technology costs, sensitivity on strategic pathways, space heating split and carbon values. This Impact Assessment presents the uncertainty through sensitivity analysis in the Risks and uncertainties section of this report.

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: £33m	**Benefits: £0m**	**Net: £33m**	163

Problem under consideration

1. The UK was the first major economy in the world to set a legally binding target to achieve Net Zero greenhouse gas emissions by 2050. To ensure continued progress, we have set a series of legally binding 'carbon budgets', covering interim periods, which are among the most stringent climate targets in the world. The most ambitious is the recently set target to cut emissions by 78% by 2035, compared to 1990 levels.

2. There are around 30 million buildings in the UK[1] responsible for approximately 30% of our emissions[2]. The vast majority (79%) of these emissions result from heating, making up 23% of all UK emissions[3]. As such, meeting Net Zero will require almost all buildings to fully decarbonise. The decarbonisation of heat is recognised as one of the biggest challenges we face in meeting our climate targets.

3. There are several strategic pathways to full decarbonisation of heat by 2050 with a range of low-carbon technologies and systems that may have an important role to play, including heat pumps and a large potential role for hydrogen boilers.

4. Despite a range of policies that are expected to combine to grow the heat pump market to 600,000 installations a year by 2028, we still expect there to be at least 10 million boiler installations between 2025 and 2035. This represents a significant target population for further improvements to in-home boiler performance. New heating installations can also present opportunities to take measures to prepare homes for future transition to low-carbon heating. This includes measures to support the low-temperature operation of systems, saving consumers money, and preparing homes for a potential hydrogen transition.

5. Previous changes to boiler standards through amendments to Approved Document L, the statutory guidance to Part L of the Building Regulations have sought to improve efficiency and thereby lower consumer bills and carbon emissions. Most recently, the Boiler Plus Standards[4] sought to raise standards for boiler heating systems in England. Previous changes to minimum boiler efficiency have focused on raising minimum tested performance standards, however in the past, there have been shown to be differences between tested and in-home boiler performance.[5]

6. A first goal of the consultation is to consider measures that would ensure newly installed natural gas boilers are performing as efficiently as possible in the home. These measures will not only help to reduce emissions and bills now but also support moves towards optimal low temperature heating, which is likely to be the future of low-carbon heat, given it maximises the efficiency of all hydronic space-heating appliances.

7. The second aim of the consultation is to test the case for requiring that from 2026 all newly installed domestic-scale gas boilers are 'hydrogen-ready', meaning they can be easily converted to operate on hydrogen in future. The deployment of hydrogen-ready boilers from the mid-2020s is expected to deliver significant benefits should hydrogen later be rolled-out across the gas grid, even partially, by reducing the costs associated with scrapping natural gas-only boilers before the end of their useful life. Mandating hydrogen-ready boilers will allow industry to prepare supply chains and make the investments required, keeping costs down.

8. Finally, this consultation will also consider the role of hybrid heating systems in the 2020s and 2030s, specifically hybrid systems consisting of a gas boiler (natural gas and hydrogen-ready) and a heat

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[1] Office for National Statistics (2020), 'Households projections for England', Table 401 (https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/householdprojectionsforenglandd), and
BEIS (2020), 'Non-domestic National Energy Efficiency Data-Framework' (https://www.gov.uk/government/statistics/non-domestic-national-energy-efficiency-data-framework-nd-need-2020), based on 2018 data.

[2] BEIS (2021), 'Final UK greenhouse gas emissions national statistics: 1990 to 2019' (https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019), and National statistics Energy Consumption in the UK (ECUK) (https://www.gov.uk/government/statistics/energy-consumption-in-the-uk), last updated 2021.

[3] BEIS (2021), 'Final UK greenhouse gas emissions national statistics: 1990 to 2019' https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2019, last updated 2021.

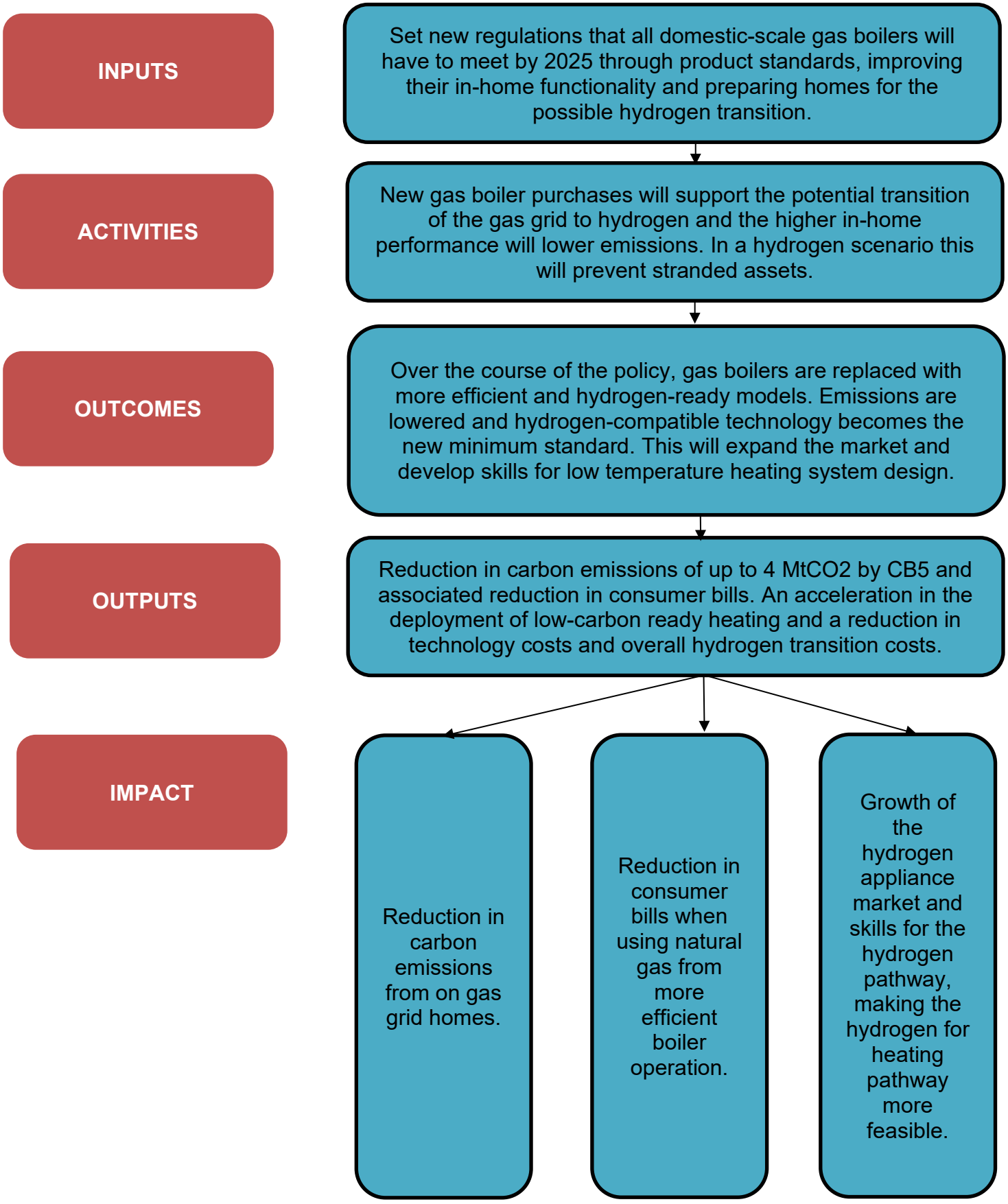
[4] BEIS (2017), 'Boiler Plus Standards' https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/651853/Boiler_Plus_final_policy_and_consultation_response.pdf.

[5] GASTEC for the Energy Saving Trust (2009), 'In-situ monitoring of efficiencies of condensing boilers and use of secondary heating', (https://www.gov.uk/government/publications/in-situ-monitoring-of-efficiencies-of-condensing-boilers-and-use-of-secondary-heating-trial-final-report-2009) and VHK for the European Commission (2019), 'Boilers, Review study Task 4 - Technical analysis, Final report', (https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%204%20final%20report%20July%202019.pdf)

pump. Hybrids may represent a next-generation technology, combining the combustion technologies familiar to consumers with efficiency improving heat pump elements, and may act as a stepping-stone to low-carbon heating options. In this Impact Assessment (IA), we estimate costs and benefits of the policy proposals following the approach set out in the Green Book.

Policy objective

9. There are two overall policy objectives of this policy intervention:
    a. To increase the efficiency of newly installed domestic-scale gas boilers from 2025, to reduce gas consumption in the short term thereby increasing UK energy security, contributing to meeting carbon budgets, and reducing consumer bills.
    b. To reduce the costs and disruption associated with a potential transition to the use of hydrogen for domestic heating, by considering the option of requiring that from 2026 all new domestic-scale gas boilers be 'hydrogen-ready'.
10. Historically, progress in the gas boiler market has been driven by innovation and technological development supporting efficiency gains, the widespread adoption of which have then been supported by regulatory changes. The standards set have in turn driven further innovation and optimisation of the appliances. Minimum gas boiler standards set in 2005 required newly installed gas boilers to be more efficient condensing models. In 2018, new Standards applying in England, known as Boiler Plus, were set through an amendment to Approved Document L, the statutory guidance to Part L of the Building Regulations with the intention of incorporating additional energy saving technology to enhance boiler performance.
11. As set out in the consultation, it has been suggested there is further scope to improve in-home boiler performance, which is the focus of the first set of proposals (Option 1), through a combination of existing technologies, installation practice and raising the minimum capabilities of individual boilers. In addition to the expected carbon reduction, there are other expected benefits:
    a. Reducing bills through lower gas consumption
    b. Providing installers and consumers with tools to optimise a boiler’s performance through low temperature operation, which may support the transition to heat pumps by supporting installers through low temperature training
12. The other objective of the consultation is to prepare homes for low-carbon heating. Our proposal to mandate domestic-scale hydrogen-ready boilers from 2026, if the assumptions set out in the consultation are met (set out in Option 2), will support the possible hydrogen Net Zero pathway by preparing homes for a future grid conversion and therefore reducing the unnecessary scrappage of natural gas-only boilers. This is expected to reduce the total cost of a potential transition to hydrogen as well as consumer costs and disruption by preventing stranded assets.
13. The third set of proposals (Option 4) explores the potential widespread deployment of hybrid heating systems from 2028 onwards, as a means of delivering early carbon savings and providing consumers with a stepping-stone between their existing systems and full low-carbon alternatives. Hybrid heating systems provide an opportunity for consumers to become familiar with a new technology, whilst having confidence that it is supported by a system they are accustomed to. This could be delivered through a number of policy levers, including by raising the minimum efficiency performance standard for space heating appliances through product standards, effectively making hybrid systems the new minimum standard. The consultation assesses the potential risks and benefits of such a policy and concludes that further evidence, particularly on the interaction between hybrids and hydrogen for heating, is needed before a wider strategic decision can be made on the role of hybrids beyond 2028. The consultation proposes that the role of hybrid systems beyond 2028 should be considered as part of wider strategic decisions on heat decarbonisation in 2026.
14. Below is a light-touch logic model, giving a visual representation of the intended relationships between the proposals of enhancing boiler efficiency standards and mandating hydrogen-ready boilers with the objectives stated above. Given the uncertainty regarding the role of hybrid heating systems, we haven’t considered them in this logic model.


INPUTS
Set new regulations that all domestic-scale gas boilers will have to meet by 2025 through product standards, improving their in-home functionality and preparing homes for the possible hydrogen transition.
ACTIVITIES
New gas boiler purchases will support the potential transition of the gas grid to hydrogen and the higher in-home performance will lower emissions. In a hydrogen scenario this will prevent stranded assets.
OUTCOMES
Over the course of the policy, gas boilers are replaced with more efficient and hydrogen-ready models. Emissions are lowered and hydrogen-compatible technology becomes the new minimum standard. This will expand the market and develop skills for low temperature heating system design.
OUTPUTS
Reduction in carbon emissions of up to 4 MtCO2 by CB5 and associated reduction in consumer bills. An acceleration in the deployment of low-carbon ready heating and a reduction in technology costs and overall hydrogen transition costs.
IMPACT
Reduction in carbon emissions from on gas grid homes.
Reduction in consumer bills when using natural gas from more efficient boiler operation.
Growth of the hydrogen appliance market and skills for the hydrogen pathway, making the hydrogen for heating pathway more feasible.

Rationale for intervention

15. This section lays out the key factors in the UK heating market which have prevented boiler and general heating systems from operating more efficiently and limited the uptake of low-carbon heating systems and transitional technology. We have included the main barriers and market failures which justify Government intervention.

    a. **Carbon Externality:** A key element of the rationale for this intervention is the market failure with respect to the uncaptured negative externalities associated with the use of conventional heating technologies. The full societal costs of heating based on fossil fuel combustion should consider the emission of greenhouse gases and the impacts on health. The Boiler Plus Review[6] suggested that the upfront cost of the boiler, the ability to site the boiler in a particular space and ensuring that the boiler was powerful enough for the home all took priority over whether a new boiler would be more energy efficient. The need to deliver advancements in the decarbonisation of heating requires more urgent Government action to correct the effects of this market failure within the UK heating system.

    b. **Imperfect information:** Consumers may be unaware of the potential benefits of higher-performing boilers and the disparity between lab and in-home efficiency, making it difficult for consumers to accurately value the benefits of higher efficiency. This information asymmetry reduces the consumer's ability to choose the heating appliance based on merit, and thus constraining the technology's ability to compete in the market. Likewise, consumers may be unaware of the changes to heating systems required in the different decarbonisation pathways. This uncertainty makes it difficult for households to prepare for transition. Government intervention would allow consumers to choose among only higher-performing boilers compatible with the decarbonisation pathway, addressing this market failure.

    c. **System lock-in:** The Government's ambition is to phase out the installation of natural gas-only boilers beyond 2035. This would mean that all fossil fuel heating systems from this point could only be replaced either by a low-carbon appliance (such as a heat pump) or a low-carbon-ready heating system (such as a hydrogen-ready boiler if an area has access to a supply of low-carbon hydrogen in the future). While the strategic decisions on the role of hydrogen for heating are not planned until 2026, we are conscious that conventional heating systems typically have a lifetime of about 15 years. If hydrogen-ready boilers were deployed at a later date in the hydrogen heating scenario, it would lead to higher disruption and increased Net Zero transition costs from the premature scrappage of still functioning heating systems. Hydrogen-ready boilers offer the opportunity to prevent this by ensuring boilers are not scrapped early if a hydrogen conversion takes place.

    d. **Misaligned Incentives:** In rented properties, where the costs of upgrading a property falls to landlords, the benefits of lower energy costs and/or a warmer home accrue to tenants. These misaligned incentives make it less likely for landlords to include the appliance efficiency in their decision process when purchasing a boiler. Therefore, without Government intervention landlords might continue to purchase less efficient boilers, which carry a higher societal cost.

    e. **Economies of scale:** New boiler standards will create a large market for the best types of products, which can lead to economies of scale through supply chain optimisation, including for hydrogen-ready boilers that meet the new efficiency standards. Without Government intervention hydrogen-ready boilers and the most efficient boiler models are likely to be a premium product, which are likely to cost consumers more and hinder widespread deployment. Research conducted into the switch from non-condensing to condensing boilers concluded that without Government intervention, the significant market changes and extensive deployment of condensing boilers across the UK housing stock would not have occurred nor the added benefit economies of scale, which occurred through higher numbers of condensing boiler sales.[7]

[6] BEIS (2021), 'Boiler Plus: initial policy review' https://www.gov.uk/government/publications/boiler-plus-initial-policy-review.

[7] N.Eyre (2020), 'The story of condensing boiler market transformation – a briefing note for BEIS'.

16. These barriers mean that, without Government regulation, the domestic gas boiler market will fail to deliver its carbon saving potential and will not make the fullest contribution to legally binding carbon budgets. Without intervention, there will also be less opportunity to reduce consumer bills. This Initial Stage IA considers ways to build on the previous boiler standards changes, including Boiler Plus, to implement these improvements.

Description of options considered

17. The policy options considered in this impact assessment are compared against the do-nothing scenario:

    a. **Option 0:** Do nothing - under the counterfactual no further regulations are applied to new gas boilers

    b. **Option 1:** Introduce a new set of requirements from 2025 to increase the in-home performance of newly installed domestic-scale gas boilers which looks to expand and build on the existing Boiler Plus Standards which apply in England

    c. **Option 2:** Mandate that from 2026 all newly installed domestic-scale gas boilers are hydrogen-ready, thereby preparing homes for a potential future hydrogen conversion

    d. **Option 3 (preferred option):** Implement options 1 and 2 in tandem

    e. **Option 4**: Implement Option 3 and require that from 2028 all newly installed natural gas boiler installations must be accompanied by an electrical heat generation element or other renewable/ low-carbon system, supporting increased deployment of hybrid heating systems alongside standalone heat pumps

18. There are a range of implementation approaches that these policy options could take. In this IA, we estimated only the quantifiable costs and benefits in illustrative scenarios. The following paragraphs describe alternative options (to options 0-4) that have been considered but discarded as unlikely to meet our objectives.

19. The condensing boiler market is very mature therefore the alternatives to regulating to enhance in-home boiler efficiency are quite limited and anticipated to inhibit the benefits, leading to little or no change in the market without supporting regulation. Despite market maturity, due to a combination of factors, boilers are still not able to operate as efficiently in the home compared to tested minimum performance standards. Since the introduction of new boiler standards in 2005, the market has been allowed nearly 20 years to make these improvements to in-home performance on its own and has so far not been able to. The first option considered includes enhanced marketing for households looking to improve real-world efficiency. This is unlikely to lead to a significant impact because of the market barriers described above and has therefore been discarded. Another option considered is providing Government support to install boilers complying to the new standards. This has been discounted as most boilers are distress purchases and previous schemes to support boiler replacements across all households have been shown to have poor value for money.[8] However, the Government is supporting the installation of measures for those in fuel poverty, including through the new ECO4 scheme.[9]

20. Turning to hydrogen-ready boilers, alternative policies (such as localised deployment and Government financial support) have been considered but discounted as we don't expect them to have a significant impact. Similar changes in the heat market, such as the switch to condensing boilers, were only achieved through Government regulation. Despite being a mature technology, widespread deployment was only achieved following setting standards in the associated guidance to Building Regulations at a level that effectively made the technology mandatory from replacement installations, in nearly all cases.

21. Localised deployment, rather than setting standards that apply across the country, was discounted due to uncertainty about where hydrogen is likely to be deployed and the negative impacts on costs/compliance that could be caused by allowing two different standards of boilers to be sold simultaneously.

[8] Energy Saving Trust Sa (2011), 'English Boiler Scrappage Scheme 2010 Evaluation Report'.

[9] BEIS (2022), 'Energy Company Obligation, ECO4: 2022 – 2026, Government Response' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1065823/eco4-government-response.pdf).

22. Finally, the key reason for discounting these options is the reduced impact they are likely to have on the potential costs, especially in the case of hydrogen-ready boilers. BEIS research indicates that hydrogen-ready boilers will be significantly more expensive than gas boilers until sales tend towards current levels.[10] The research concluded that hydrogen-ready boilers could reach cost parity with natural gas boilers when produced at scale, but that they could cost up to 20% more otherwise. Mandating all domestic boilers to be hydrogen-ready will prevent them from becoming a niche product sold at a premium. Through the consultation, the Government is seeking evidence on the future cost of hydrogen-ready boilers, to ensure that consumers will not face additional costs when these products are mandated through the consultation.

23. Hybrid heating systems currently make up only a small proportion of the UK's domestic heating market, with only 1,400 being sold in the UK in 2021 – primarily driven by the installation of hybrid heating systems in new-build homes in Scotland.[11] The Government has incentivised the uptake of low-carbon heating technologies, including hybrid heating systems, through the Renewable Heat Incentive, the Green Homes Grant Local Authority Delivery scheme, and the Energy Company Obligation for retrofit homes. However, there has been limited uptake of hybrid heating systems through these schemes. Without regulation, there is expected to be limited growth for hybrid heating systems in the UK. The Government expects standalone heat pumps to remain the primary low-carbon heating source for new buildings for the foreseeable future and we also expect low-carbon heat networks to play an important role here. However, the Government acknowledges there is a potential role for hybrids, on the gas grid in retrofit properties, provided assurances can be gained that consumers will benefit from high performing and low-carbon installations in suitable homes.

Summary and preferred option with description of implementation plan

24. The original Boiler Plus Standards were implemented using an amendment to Approved Document L, the statutory guidance to Part L of the Building Regulations and applied in England only. The Government's intention is to use product standards to implement the boiler efficiency and hydrogen-ready proposals set out above, through updating Ecodesign legislation. This is intended to achieve the policy objective by setting standards that products would have to meet to be sold in the market.

25. Product standards were previously set by the European Union (EU). Following the UK's exit from the EU, Ecodesign and Energy Labelling legislation was retained in domestic law and will therefore continue to apply in Great Britain (GB) until any further changes are made. The powers formerly placed on the European Commission to introduce and to update Ecodesign and Energy Labelling requirements were transferred to the Secretary of State, allowing Great Britain to maintain its own requirements for energy-related products. In accordance with the Northern Ireland protocol, EU Ecodesign and Energy Labelling requirements continue to apply in Northern Ireland. However, the Northern Ireland Protocol Bill was introduced by HMG in Parliament on 13 June 2022. The Bill proposes the creation of a dual regulatory regime in Northern Ireland, which will allow businesses selling products in Northern Ireland to choose between meeting UK or EU rules (or both). Once the NIP Bill has passed through the Parliamentary process and is in force, proposals on energy-related products could encompass the whole UK. This may, however, require amending Ecodesign legislation to extend regulation making powers to Northern Ireland.

26. The Office for Product Safety and Standards (OPSS), part of the Department for Business, Energy and Industrial Strategy, is the appointed Market Surveillance Authority for Ecodesign Regulations in Great Britain and will provide oversight for implemented proposals.

27. The expectation is to implement from 2025. This timing would allow industry the time to respond to the multiple changes proposed and provide for a smooth transition. However, given the recent increase in the cost of natural gas and increased volatility in the market, a faster implementation timeline for some or all proposals will be considered through the consultation.

[10] Element Energy on behalf of BEIS (2018), 'Hydrogen Supply Chain Evidence Base' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760479/H2_supply_chain_evidence_-_publication_version.pdf).

[11] Delta EE (2021), 'UK Heating market report 2021'.

Analytical approach

28. This section outlines the evidence base on which impacts of the policy proposals have been modelled and the overall analytical approach taken to assess the costs and benefits of the policy options.

29. The IA presents the evidence of the impacts of the proposals for households, the business sector and wider society. It follows the principles of the Green Book guidance in identifying the key direct costs and benefits for these groups. The changes are compared with counterfactual scenarios and then monetised. Net present values are derived by comparing the aggregate costs and benefits which are discounted by the social discount rate.

30. Assumptions are varied to produce a sensitivity analysis to show the sensitivity of Social Net Present Value (SNPV) with respect to changes in the assumptions used and the pathways considered.

31. Non-monetised costs and benefits are not included in the SNPV calculation, but are important to consider as part of a comprehensive assessment of the proposals presented in this IA. Hence, the IA is supplemented by a qualitative discussion on non-monetised costs and benefits which sets out the relevant evidence on wider strategic considerations.

Decarbonisation Pathways

32. There are several strategic pathways to full decarbonisation of heat by 2050; costs and benefits of the policy options in this IA will depend on the pathway used. To account for this uncertainty, we assess the policy options and the do-nothing option in two illustrative scenarios, High Electrification and High Hydrogen, which reflect different technology mixes at the two ends of the spectrum. Many other pathways to decarbonise heating are possible, however, by modelling the two extremes we can show the range of possible outcomes. These scenarios are an updated version of the scenarios presented in the Net Zero Strategy[12] and are weighted 50:50 when calculating the central SNPV of each policy option, reflecting the uncertainty over the decarbonisation of heat.

33. In both scenarios we assume that heat pump deployment will ramp-up quickly, reaching 600,000 installations by 2028, reflecting the commitment in the Prime Minister's 10 Point Plan for a Green Industrial Revolution.[13] Energy efficiency is assumed to be the same in both the High Electrification and the High Hydrogen scenarios.

34. In the High Electrification scenario, we assume there is no use of hydrogen for heating in buildings and that the heat pump market will continue its rapid growth after 2028, reaching almost 2 million installations per year from 2035. No gas boilers are installed in households from 2035, with the last installations taking place in 2034.

35. In the High Hydrogen scenario, hydrogen has proven feasible and preferable as a solution for heating most UK buildings and we assume its rollout will start in pilots by the end of the 2020s and accelerate in the early 2030s. In this scenario, boilers can still be installed after 2035 in areas that haven't converted to hydrogen yet, provided that they can switch from burning natural gas to burning hydrogen when the area is converted.

36. Under Option 4, hybrid systems (with efficiency higher than 100%) are assumed to be installed instead of gas boilers in both the High Electrification and the High Hydrogen scenarios.

Evidence base

37. The appraisal values used in the analysis include:

    a. Carbon values – HMT Green Book supplementary guidance on valuation of energy use and greenhouse gas (GHG) emissions is used to value greenhouse gas savings.

[12] BEIS (2021), 'Net Zero Strategy: Build Back Greener' (https://www.gov.uk/government/publications/net-zero-strategy).

[13] Prime Minister's Office, 10 Downing Street (2020), 'Ten Point Plan for a Green Industrial Revolution for 250,000 jobs', https://www.gov.uk/government/news/pm-outlines-his-ten-point-plan-for-a-green-industrial-revolution-for-250000-jobs

b. Electricity and fossil fuel air quality damage costs – Values from Department for Environment, Food and Rural Affairs (DEFRA) are used to measure air quality damage costs. Air quality impact of hydrogen combustion has not been quantified.

c. Electricity and fossil fuel carbon emissions factors – HMT Green Book supplementary guidance is used to measure carbon emissions from electricity and fossil fuels. Emissions factors for hydrogen production are calculated from the "Options for a UK low carbon hydrogen standard" report;[14] linear interpolation has been used for intermediate years.

d. Long-run variable costs of energy supply – HMT Green Book supplementary guidance is used to value the long-run variable costs of energy supply (LRVCs). Levelised cost of hydrogen production has been used as a proxy for hydrogen LRVCs. The figures are taken from the Hydrogen Production Costs report,[15] with linear interpolation used to fill in intermediate years.

38. All prices in this analysis have been converted into 2020 prices using the GDP deflator. The Green Book social time preference rate ('discount rate') of 3.5% has been applied for social present values.

Monetised costs and benefits

39. We estimate the costs and benefits associated to the policy proposals, relative to their counterfactuals.

a. **Capital costs of the heating technologies installed:** The total cost of purchasing and installing heating technologies under the different options. This cost implicitly includes any costs borne by manufacturers to comply with the regulation, as we assume they will eventually pass them to consumers. Total cost will vary depending on the assumed capex for the different technologies (e.g., boilers complying with the standards proposed in Options 1 and 3 and hybrids installed under Option 4 are assumed to be more expensive than boilers in the counterfactual Option 0) and the total number of heating technologies deployed (e.g., the hydrogen-ready mandate reduces the scrappage of boilers in the hydrogen pathway, therefore changing the overall numbers of boilers installed). This total cost includes, when evaluating the impact of the hydrogen-ready mandate, the costs of replacing some components when a hydrogen-ready boiler is required to switch from natural gas to hydrogen.

b. **Generation costs and benefits:** The estimated value of the change in energy demand. Enhancing boiler standards increases boiler efficiency, reducing gas demand needed to fulfil an equivalent heat demand. Hybrids installed under Option 4 displace part of the gas (both natural gas and hydrogen) counterfactual demand with electricity.

c. **Carbon savings:** The estimated value of the carbon emitted in all scenarios.

d. **Air quality impacts:** The estimated value of the public health impacts of changes to emissions of nitrogen oxides and particulate matter.

e. **Maintenance:** The difference between the annual costs to maintain the different heating system. These costs are assumed to be the same in all options, so the difference of zero is not shown in the result tables.

f. **Familiarisation cost:** This is the cost to business associated with the time spent understanding the new regulations.

Non-monetised costs and benefits

a. **Supply chain**: By mandating hydrogen-ready boilers, the regulation will support the development of supply chains. In our appraisal we include the capital costs avoided

[14] E4Tech and Ludwig-Bölkow-Systemtechnik GmbH for BEIS (2021), 'Options for a UK low carbon hydrogen standard: Final report', (https://www.gov.uk/government/publications/options-for-a-uk-low-carbon-hydrogen-standard-report). The time series used assumes a hydrogen production mix consistent with the Net Zero Strategy. This includes electrolysis, methane reformation with carbon capture and storage and bioenergy with carbon capture and storage (BECCS). Upstream emissions from natural gas and possible negative emissions associated with BECCS have not been taken into account. The hydrogen supply mix is highly uncertain, and depends on a range of factors including: cost and performance of production technologies; performance of Carbon Capture Usage and Storage; availability and cost of low carbon electricity; availability of sustainable biomass; scale of hydrogen demand; and technology availability

[15] BEIS (2021), 'Hydrogen Production Costs 2021',https://www.gov.uk/government/publications/hydrogen-production-costs-2021. The figures do not include any potential income from negative emissions from BECCS.

because of the reduced scrappage but we don't quantify the benefits to industry. The mandate will provide certainty to the low-carbon heating sector, allowing businesses to align strategies, investment plans and training, and drive forward innovation in technologies and business models. It will also help create green jobs (see below) and create opportunities for UK manufacturers. The development of the supply chain will be the base for the mass roll-out of low-carbon heating in the 2020s and subsequent decades, which will be needed to achieve the Government's target of Net Zero carbon emissions by 2050. If monetised, this would have a positive impact on the SNPV.

b. **Reduced disruption:** Hydrogen-ready boilers might reduce the disruption to consumers as they would reduce the total number of boiler installations required in the High Hydrogen pathway. Furthermore, by spreading installations out, the policy will make it easier for households to find installers, making the transition to Net Zero smoother. These benefits have not been quantified in this IA.

c. **Innovation and cost reductions:** BEIS expects that by mandating hydrogen-ready boilers now, the scaling up of supply chains will present significant opportunities for manufacturers and installers to identify improvements through learning by doing. This has the potential to reduce costs and consumer barriers and potentially increase performance over time.

d. **Jobs:** Most UK-installed boilers are manufactured in the UK. Any move in regulatory standards is likely to support this domestic market, as GB standards are likely to be higher than or divergent from other country standards. There may potentially be trade advantages if UK products continue to access other country markets as a premium product. In addition, if a hydrogen-ready mandate is pursued, the UK is likely to be moving quicker than other countries so again could lead to the growth of UK manufacturing jobs and more inward investment. These effects haven't been quantified in this IA.

e. **Behaviour:** The policy will help householders to become more familiar with heating systems operating as efficiently as possible through low flow temperatures. This supports the transition to low-carbon heating as most heat pumps will also operate using low flow temperatures. Additionally, the proposed boiler heating controls policy requires controls that will be needed to optimise heat pumps, so the policy provides consistency of controls across the different heating technologies. Similarly, mandating hydrogen-ready boilers will allow householders to familiarise themselves with the idea of using an alternative gas.

f. **Consistency with strategic objectives:** As set out in the Heat and Buildings Strategy, given the diversity of buildings and building use, no single solution can provide the best option for everyone. The future is likely to see a mix of low-carbon technologies used for heating: electrification of heat for buildings using heat pumps, heat networks, and potentially switching the natural gas in the grid to low-carbon hydrogen. While there is work to be done to identify the best solutions for different buildings and regions, there are also areas where the solution is clear. Our policy design is focused on taking low regret actions to reduce emissions in the interim while many households continue to install gas boilers.

g. **Comfort taking:** Improving boiler efficiency reduces the amount of fuel required to deliver a given level of energy service, meaning that some households will heat their homes to a higher temperature, for a longer period, or heat more rooms in their homes, at the same cost.

h. **Health benefits:** Heating homes to a higher temperature can lead to improved health. If monetised, this would have a positive impact on the SNPV.

i. **Electricity generation and grid reinforcement:** Option 4 will change the demand for electricity through the deployment of hybrid systems. Hybrid systems could provide significant flexibility benefits to the power sector and the electricity network when compared with commensurate growth in deployment of standalone heat pumps. However, this needs to be balanced against the risk that mass deployment of hybrids could also significantly increase the demand on the electricity grid – creating additional costs associated with electricity generation and distribution. This risk would be heightened if the

hybrids, and in turn heat pump deployment, was pursued at a faster rate than expected under the High Electrification pathway. We have not quantified the impact this could have on grid reinforcement or generation costs.

Assumptions and results

40. The following assumptions have been used to model the four policy scenarios and the do-nothing option:

    a. The proposals outlined in the consultation are focused on domestic-scale gas boilers up to 45kW capacity; we assume that all boiler installations from 2025 will occur in households currently using gas boilers for heating.

    b. We assume the average lifetime of gas boilers and hybrids to be 15 years. For simplicity, in our model we assumed that all gas boilers are replaced exactly every 15 years, unless where scrappage is required for the conversion to hydrogen.

    c. We assume at least 1.5 million replacement gas boilers will be installed in 2025; gas boiler installations reduce over time as some households switch to different heating technologies (e.g., heat pumps or heat networks). Heat pump deployment depends on the decarbonisation pathway, as described in the Decarbonisation Pathways section, but we assume it is not affected by the policy proposals (i.e., the same number of heat pumps are assumed to be installed under all scenarios, within the same pathway). Therefore, in our analysis, we have only included the costs associated with boilers as the costs associated with other technologies are the same in the counterfactuals and policy options.

    d. We used the average heat demand for households on the gas grid and assumed that it will vary over time because of the impact of energy efficiency measures, consistent with current policy proposals, and long-term energy trends.

    e. The proposals are appraised over the timeframe between the assumed start dates and 2050. The residual value of appliances in use in 2050 is included in the results – capital costs for heating systems are pro-rata-ed by their design lifetime to reflect the relevant costs and benefits within the appraisal period.

    f. We assume that complying with the boiler standards in Options 1-4 will not increase the maintenance cost. Therefore, the difference in maintenance cost between the policy options and their counterfactuals is zero and, for simplicity, is not reported in the results.

    g. The Boiler Plus Review found that the available data and the views of industry suggest that compliant installations are common, but there may also be non-compliance. Because of this, we have assumed 10% optimism bias for Option 1. For the hydrogen-mandate and hybrids, we haven't modelled optimism bias as such and have assumed 100% compliance. This is because any manufacturer's boilers sold as hydrogen-ready which cannot operate using 100% hydrogen may face enforcement action from the OPSS. Furthermore, the choice of conservative assumptions should reduce the risk of overestimating the policy impact. The Uncertainty and Risk section shows even more conservative scenarios which can be used to assess the policy options under less favourable conditions.

    h. The Boiler Plus Review aimed to assess compliance with the current set of Standards introduced in England as an amendment to the guidance of Part L of Building Regulations. While the review found that compliance within minimum tested standards of 92% Energy-related Products (ErP) efficiency was at or close to 100% and the vast majority of all boiler installation are likely to be accompanied by a newly installed or existing time temperature control, it concluded that it was not possible to estimate the level of compliance with the additional efficiency measures requirement on the basis of the market data available. We are unable to say compliance with the current standards is close to 100%. Potentially we should view this as likely to mean that compliance is lower than 100% due to the lack of information collected about these measures held in a central place of installer self-certification.

41. Assumptions specific to each option are presented in the following sections.

Option 1

42. The consultation document describes the proposed changes to Boiler Plus Standards, which we expect will improve the efficiency of boilers installed (Option 1). These include refining the definition of heating controls, introducing a modulation range requirement, and extending the scope of the requirements beyond combination boilers to include system and heat-only boilers.

43. Previous Government publications[16] have acknowledged a gap between lab and in-home performance of gas boilers. As described in the consultation document, the proposals in this policy seek to improve in-home efficiency rather than focussing only on tested efficiency. In the counterfactual we have assumed gas boilers to have an in-situ efficiency of 84%,[17] in Option 1 all newly installed boilers from 2025 are assumed to have, on average, an in-situ efficiency of 90% (6% points higher than in the counterfactual).

44. We assume the efficiency improvement will apply to all boilers, regardless of the fuel they use (natural gas or hydrogen). We also assume a 15% rebound effect[18] and a 10% optimism bias, meaning that the estimated reduction in fuel demand is around 5%.

45. We assume the cost of complying with the new regulations to be £50[19] more than the counterfactual gas boiler cost, to be paid at the point of installation. We discuss the uncertainty on the costs and efficiency assumptions in the Risks and uncertainties section of this IA.

46. Table 1 shows the SNPV of Option 1. This is calculated as the difference in costs between the policy option and the counterfactual in both the High Hydrogen and the High Electrification pathways.

Table 1: Option 1 SNPV and carbon savings

2020 prices, 2025 PV	**High electrification pathway**	**High hydrogen pathway**
Difference between Option 1 and do nothing		
Carbon Costs (£b)	3.8	4.8
Long run variable cost (£b)	1.6	5.4
Air quality (£b)	0.1	0.2
Technology cost (£b)	-0.5	-1.0
Total (£b)	**5.1**	**9.5**
Combined SNPV (50%) (£b)	**7.3**	
Carbon savings in CB5 (MtCO2)	4.2	4.5
Carbon savings in CB6 (MtCO2)	5.4	6.9

47. In both pathways, the higher boiler efficiency leads to a reduction in fuel demand, which brings benefits in terms of carbon, LRVCs and air quality. In the table we only show the difference between Option 1 and the counterfactual *within the same decarbonisation pathway*, which means that the impact of heat pump deployment is not quantified (as it's assumed not to be affected by the policy). Therefore, the policy impact is higher in the High Hydrogen pathway where more boilers are installed, driving additional fuel demand reductions. The technology cost is higher in Option 1 as boilers are assumed to cost £50 more than in the counterfactual.

[16] BEIS (2017), 'Heat in Buildings: Boiler Plus Final Policy and Consultation Response', https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651853/Boiler_Plus_final_policy_and_consultation_response.pdf

[17] From Energy Saving Trust (EST) field trials.
GASTEC for the Energy Saving Trust (2009), 'In-situ monitoring of efficiencies of condensing boilers and use of secondary heating' (https://www.gov.uk/government/publications/in-situ-monitoring-of-efficiencies-of-condensing-boilers-and-use-of-secondary-heating-trial-final-report-2009) and
VHK for the European Commission (2019), 'Boilers, Review study Task 4 - Technical analysis, Final report' (https://www.vhk.nl/downloads/Reports/2019/VHK%20569%20Boilers%20Task%204%20final%20report%20July%202019.pdf).

[18] Illustrative assumption, based on: Glasgow Caledonian University (2008), 'An Analysis of the Difference between Measured and Predicted Energy Savings when Houses are Insulated' (https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.510.6384&rep=rep1&type=pdf).

[19] Illustrative data point, based on knowledge of new modulation and controls costs.

Option 2

48. Hydrogen-ready boilers are heating systems that can operate with a natural gas supply or a hydrogen supply. They can be installed and used prior to conversion to a low-carbon hydrogen supply, thereby reducing disruption to consumers in comparison to scrapping a natural gas-only boiler and replacing with a hydrogen-only boiler. The process of converting a hydrogen-ready boiler from burning natural gas to hydrogen would be performed by a trained engineer and would involve changing a small number of components including the burner.

49. There is currently not an agreed standardised definition for domestic hydrogen-ready boilers in the UK. Currently available boilers that are able to operate using a blend of 20% hydrogen and natural gas are sometimes referred to as hydrogen-ready. In our analysis, we consider a boiler to be hydrogen-ready if it has been designed specifically to facilitate a simple and quick conversion to 100% hydrogen by certified gas engineer. The Hy4Heat programme has delivered prototypes of such systems, which can be easily converted to burn hydrogen through replacing key component parts.

50. Mandating hydrogen-ready boilers would reduce the number of boilers prematurely scrapped if the gas grid in an area is converted to hydrogen; gas boilers that are not hydrogen-ready would need to be replaced when the conversion takes place, while key components of the hydrogen-ready boilers could be replaced to allow them to switch to burning hydrogen.

51. In the High Electrification pathway, where hydrogen is assumed to have no role in heating, the proposed policy would have no impact on scrappage.

52. Table 2 summarises the key methodological assumptions used for each option and for each pathway.

Table 2: Methodological assumptions for Option 2 under each pathway

	High electrification pathway	**High hydrogen pathway**
Do nothing (counterfactual)	No hydrogen-ready boilers are deployed in this scenario.	No hydrogen-ready boilers are installed before 2030. Hydrogen roll-out starts in 2030; from that year we assume that all boilers installed will be hydrogen-ready, even in the absence of regulation. This is a conservative assumption which is likely to underestimate the benefits of the policy.
Policy option: Mandate hydrogen-ready boilers from 2026	All gas boilers sold in the domestic market are hydrogen-ready from 2026, but no impact as hydrogen is assumed to have no role in heating.	All gas boilers sold in the domestic market are hydrogen-ready from 2026.

53. We assume hydrogen-ready boilers cost the same as standard gas boilers when installed. In our central scenario, we assume a cost of £200 to replace key components when a hydrogen-ready boiler switches from natural gas to hydrogen[20] – this is compared to the much higher cost of scrapping a natural gas boiler and replacing it with a hydrogen boiler, in households without hydrogen-ready boilers. The consultation document outlines the enabling work which might be required in some cases ahead of the boiler's conversion to hydrogen – in this analysis we haven't included the costs associated to this possible further work.

54. The model uses assumptions which draw on evidence discussed in Annex I. Sensitivity tests, including testing the assumption on heat pumps suitability, are discussed in the Risks and uncertainties section.

55. In Table 3, we highlight the key results in the two modelled decarbonisation pathways. The SNPV is calculated by estimating the difference in costs between the policy option and the counterfactual in

[20] An approximate cost, based on BEIS analysis of research conducted under work package 4b of the Hy4Heat programme (https://www.hy4heat.info/wp4).

both the High Hydrogen and High Electrification pathways. The proposal is assumed to have no impact on fuel demand or carbon emissions: the LRVCs, carbon and air quality costs are the same in Option 2 and the counterfactual and therefore are not shown.

56. In the High Hydrogen Pathway, mandating hydrogen-ready boilers will reduce the overall technology cost (despite the cost of conversion parts) as fewer gas boilers are scrapped prematurely. This will reduce disruption for householders, but this additional benefit has not been monetised. In the High Electrification Pathway, the benefits of hydrogen-ready boilers are not realised as there is no transition to hydrogen for heating; as hydrogen-ready boilers as assumed to cost the same as standard gas boilers, the analysis shows no monetised impact of the policy under that pathway.

Table 3: Option 2 SNPV

2020 prices, 2025 PV	**High electrification pathway**	**High hydrogen pathway**
Difference between Option 2 and do nothing		
Capex costs of boilers (£m)	0	2,321
Capex costs of hydrogen-ready conversion (£m)	0	-430
Total SNPV (£m)	**0**	**1,891**
Combined SNPV (50%) (£m)	**946**	

Table 4: Option 2 boiler scrappage impact

	Do nothing (counterfactual)	**Option 2: Mandate hydrogen-ready boilers from 2026**
No. of natural gas boilers scrapped prematurely (under 15 years old) (million)	5.6	2.6
No. of natural boilers scrapped under 5 years old	224,000	0
No. of boiler-years scrapped (million)	26.4	8.7
Average lifetime of scrapped boilers (years)	10	12

57. We calculate ‘boiler-years’ as the total number of years a set of boilers is used. For example, using 10 boilers for their whole assumed lifetime (15 years) is equivalent to 150 boiler-years. When boilers are scrapped there is a loss of boiler-years which depend on the number of boilers scrapped and their age at the time of scrappage. When compared with the do-nothing scenario, implementing the policy will save 3 million gas boilers from being scrapped prematurely, and save 17.7 million boiler-years (as shown in Table 4). The policy also increases the average scrapped gas boiler’s lifetime by around 2 years, reducing the overall cost paid by consumers.

Option 3

58. In Option 3 (our preferred option), in addition to expanding and amending boiler standards in 2025, we assume that hydrogen-ready boilers are mandated from 2026. This proposal is a **combination of** options 1 and 2. For simplicity, we assume that there are no interactions between these two measures and that hydrogen-ready boilers will have the same efficiency as non-hydrogen-ready boilers. Therefore, the resulting SNPV is simply the sum of the SNPVs of Option 1 and Option 2, as shown in Table 5.

Table 5: Option 3 SNPV and carbon savings

2020 prices, 2025 PV	**High electrification pathway**	**High hydrogen pathway**
Difference between Option 3 and do nothing		
Carbon Costs (£b)	3.8	4.8
Long run variable cost (£b)	1.6	5.4
Air quality (£b)	0.1	0.2
Technology cost (£b)	-0.5	-1.0
Capex costs (£b)	0	1.9
Total (£b)	**5.1**	**11.4**
Combined SNPV (50%) (£b)	**8.2**	
Carbon savings in CB5 (MtCO2)	4.2	4.5
Carbon savings in CB6 (MtCO2)	5.4	6.9

Option 4

59. Hybrid heat pumps, as described for the purposes of the consultation, combine a natural gas boiler with an electrical heat pump. They achieve higher levels of efficiency and lower carbon emissions than traditional fossil fuel heating systems but achieve lower carbon abatement than 'standalone' heat pumps. If hydrogen-ready boilers are mandated from 2026, we assume any hybrid heat pumps will also be hydrogen-ready.

60. The Government is keen to explore the potential benefits and limitations widespread roll-out of hybrids from 2028 onwards, as a means of delivering carbon savings and providing more consumers with a steppingstone between their existing systems and full low-carbon alternatives. The recently published Energy-related products Policy Framework proposed using product legislation to raise the minimum efficiency performance standards of heating appliances to above 100%, which would be one way to achieve this outcome. Such a minimum standard could be met by the widespread adoption of hybrid heat pumps, with the incorporation of heat pumps within or alongside boiler appliances. In this IA, we assume that the hydrogen boilers installed in the High Hydrogen pathway are not in scope of the regulation, which therefore only applies to the natural gas boilers (including hydrogen-ready boilers using natural gas as fuel) installed before the transition to hydrogen.

61. As set out in the Heat and Buildings Strategy, from the mid-2030s all new heating systems will need to be low-carbon, or systems that can be easily converted to operate on a low-carbon fuel, such as hydrogen-ready boilers. Therefore, in the High Electrification scenario we assume that all the hybrids installed from 2028 are replaced before 2050 by standalone heat pumps. We assume that hybrids will be installed up until 2035 which will ensure that they are only replaced at the end of their useful life. In the High Hydrogen scenario, we assume that all the hybrids installed will be hydrogen-ready so that they can still be used after the transition from natural gas to hydrogen.

62. The market for hybrid heating systems continues to develop and a range of product choices are now available to consumers in the UK. For purely illustrative purposes, in our analysis we considered only two different archetypes of hybrid systems and we assumed that the market would be equally split between them.

    a. A "standard" hybrid system, where a heat pump is installed alongside a natural gas boiler. We assume that this configuration allows the heat pump component to meet 80% of the space heating demand.

    b. A "compact" hybrid, consisting of a heat pump and natural gas boiler integrated within a single unit. In this configuration, we assume that the heat pump component meets 50% of the space heating demand.

63. For both hybrid types, we assume the gas boiler component to meet 100% of the hot water demand. Other key assumptions for hybrids are shown in Annex I.

64. We assume that Option 4 will build on Option 3 (i.e., that under this option boilers will be hydrogen-ready and comply with enhanced performance standards). Therefore, Table 6 shows the impact of Option 4 compared to Option 3, its counterfactual, rather than to the do-nothing option.

Table 6: Option 4 SNPV and carbon savings

2020 prices, 2025 PV	**High electrification pathway**	**High hydrogen pathway**
Difference between Option 4 and Option 3		
Carbon Costs (£b)	13.3	18.7
Long run variable cost (£b)	-6.7	-7.7
Air quality (£b)	0.3	0.2
Technology cost (£b)	-18.2	-36.6
Total (£b)	**-11.3**	**-25.5**
Combined SNPV (50%) (£b)	**-18.4**	
Carbon savings in CB5 (MtCO2)	10.1	11.4
Carbon savings in CB6 (MtCO2)	22.1	30.4

65. In both pathways, the SNPVs of the monetised costs and benefits show that the impacts of mandating hybrids from 2028 would lead to a net cost overall. The main driver for this is the capital costs of hybrid heat pumps which outweigh the capital costs of boilers. This is followed by long-run variable costs: households switching to hybrid heating systems experience higher long-run variable costs because although hybrid heat pumps use less energy to heat homes compared to a gas boiler, the ratio of electricity and gas LRVCs is not offset by the assumed increased efficiency of the heat pump.

66. The net benefits include the carbon savings and air quality benefits. As hybrid heat pumps are more efficient than gas boilers and use less energy, overall switching from a lower-efficiency technology to a more efficient technology results in a net carbon saving and air quality benefit.

67. This analysis uses extremely uncertain assumptions and should therefore be considered as purely illustrative. The consultation document includes wider consideration on the strategic role of this technology and concludes that it is too soon to take any decision on moving to a market-wide deployment of hybrids in existing on-grid homes from 2028 onwards. Given this uncertainty and the fact that we aren't recommending this option, we haven't estimated fuel poverty impact, equality impact, or Equivalent Annualised Net Direct Cost to Business (EANDCB) for this option.

Risks and uncertainties

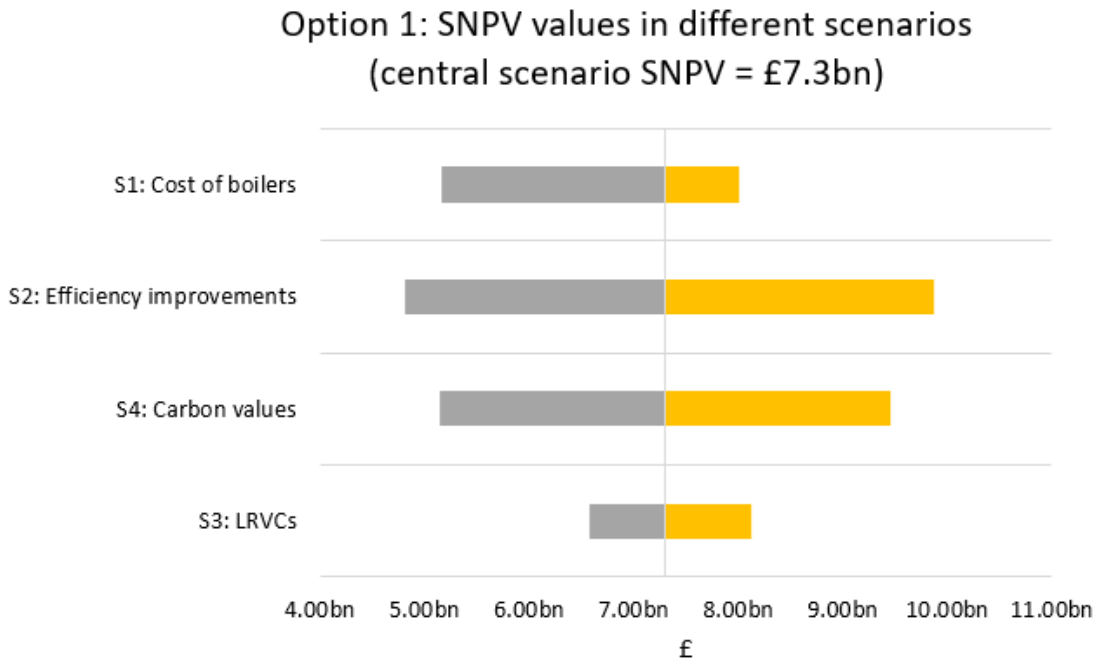
68. The quantified impacts are sensitive to changes in the underlying assumptions. Sensitivities around the scenarios are conducted on the key variables, discussed here. The full list of sensitivity assumptions is included in Annex I.

69. For Option 1, we considered sensitivities around the cost of boiler upgrades (S1), the level of efficiency improvements (S2), the LRVCs (S3), and the carbon values (S4).

Table 7: Sensitivity results – Option 1

Option 1	**SNPV (£bn)**
Central scenario	7.30
S1: Costs of gas boiler upgrades – higher	5.16
S1: Costs of gas boiler upgrades – lower	8.01
S2: Efficiency improvements – higher	9.79
S2: Efficiency improvements – lower	4.72
S3: LRVCs – higher	8.13
S3: LRVCs – lower	6.58
S4: Carbon values – higher	9.46
S4: Carbon values – lower	5.14

Figure 1: Sensitivities in SNPV estimates in Option 1



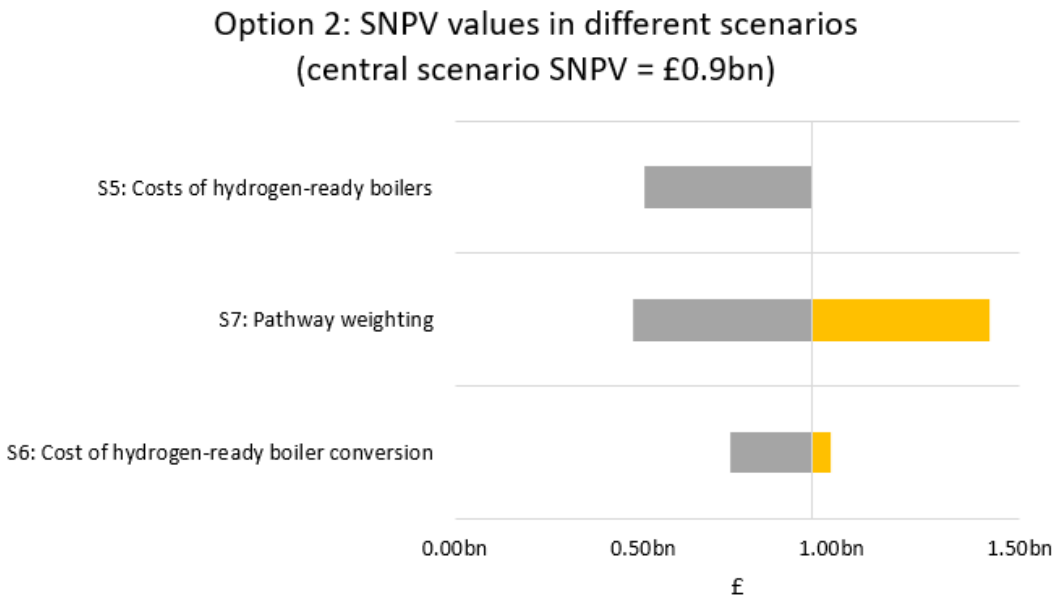
70. In all sensitivity scenarios, the policy impacts lead to a monetised net benefit. The SNPV estimate is most sensitive to the uncertainty around the costs of more efficient gas boilers (S1), followed by uncertainty around efficiency improvements (S2) and carbon values (S4). The SNPV estimate is least sensitive to the uncertainty of LRVCs (S3).

71. For Option 2, we considered sensitivities around the cost of hydrogen-ready boilers (S5), the costs of hydrogen-ready boiler conversion (S6), and the pathway weighting (S7).

Table 8: Sensitivity results – Option 2

Option 2	**SNPV (£bn)**
Central scenario	0.95
S5: Costs of hydrogen-ready boilers – higher	0.50
S6: Cost of hydrogen-ready boiler conversion – higher	0.73
S6: Cost of hydrogen-ready boiler conversion – lower	1.00
S7: Pathway weighting 75/25 hydrogen/electrification	1.42
S7: Pathway weighting 25/75 hydrogen/electrification	0.47

Figure 2: Sensitivities from SNPV in Option 2



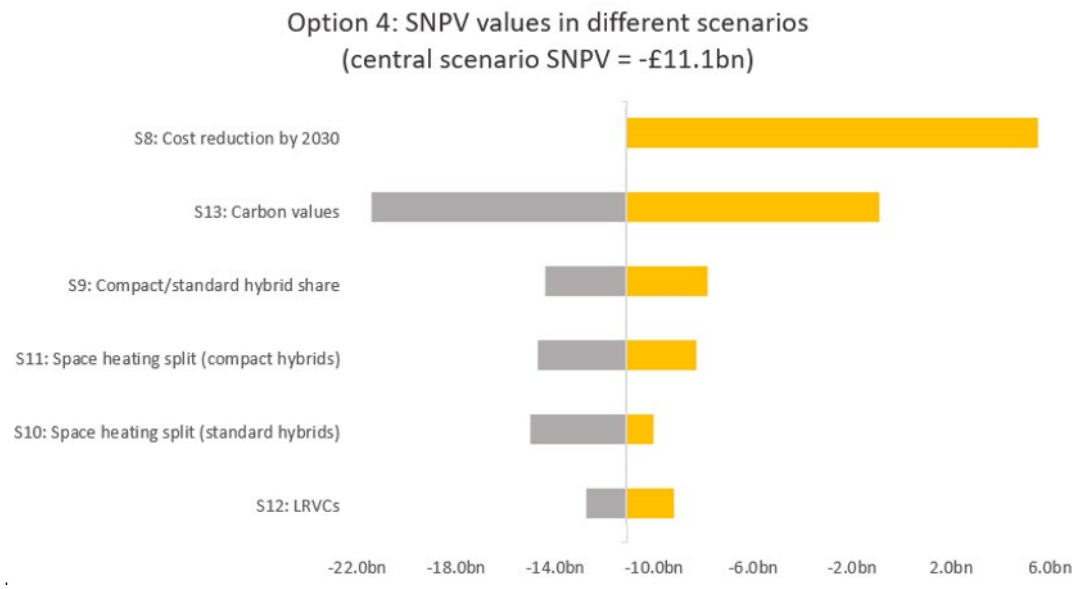
72. In all sensitivity scenarios, the policy impacts lead to a monetised net benefit. Costs of installing a hydrogen-ready boiler and pathway weighting, as shown in sensitivities S5 and S7, have a small to moderate impact on the SNPV for Option 2. Uncertainty around hydrogen-ready conversion costs has a small impact on the SNPV (S6).

73. For Option 4, we considered sensitivities around the hybrids cost reduction by 2030 (S8), the share of compact and standard hybrids (S9), and the space heating split (S10 and S11). Sensitivities S3 and S4 will also apply to Option 4.

Table 9: Sensitivity results – Option 4

Option 4	**SNPV (£bn)**
Central scenario	-11.10
S8: Cost reduction by 2030 – high	5.38
S9: Compact/standard hybrid share 100/0	-7.86
S9: Compact/standard hybrid share 0/100	-14.34
S10: Space heating split (standard hybrids) – high	-10.02
S10: Space heating split (standard hybrids) – low	-14.93
S11: Space heating split (compact hybrids) – high	-8.28
S11: Space heating split (compact hybrids) – low	-14.62
S12: LRVCs – higher	-9.19
S12: LRVCs – lower	-12.65
S13: Carbon values – higher	-0.94
S13: Carbon values – lower	-21.25

Figure 3: Sensitivities from SNPV in Option 4



74. The SNPV estimate is very sensitive to the uncertainty around the cost reduction of hybrids by 2030 (S8), followed by uncertainty around carbon values (S13). Uncertainty around the share of compact and standard hybrids (S9), space heating splits (S10 and S11), and LRVCs (S12), all have a moderate impact on the SNPV.

Fuel poverty impact

75. We estimate that most boiler installations from 2025 will occur in households currently using gas boilers for heating. Approximately 86% of households in England currently use a gas boiler, therefore the characteristics of the households affected by the policy proposals are not dissimilar to the characteristics of the overall population.

76. Under the current Low Income Low Energy Efficiency measure of fuel poverty, in 2020 13.2% of all households in England were fuel poor, compared to 11.2% for households using gas boilers as their main heating systems.[21]

[21] BEIS (2022), 'Fuel Poverty Statistics England' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1056764/2020_fuel_poverty_detailed_tables_under_the_Low_Income_Low_Energy_Efficiency__LILEE__indicator__Excel_.xlsx).

77. We anticipate that enhancing boiler standards will have a small impact on fuel poverty. The efficiency improvement can save households money by reducing a proportion of their annual heating bills, and where heating bills are above average, the savings will be correspondingly higher than average. We estimate bill savings of around £30 per year in the typical household using a natural gas boiler. This figure is based on Green Book gas prices (June 2021), which do not take into account the current energy price rises. Using the energy prices from the Energy Price Guarantee (from 1 October 2022), we estimate the policy would lead to the equivalent annual savings of around £60 for a typical household.[22] We also expect the policy to increase the thermal comfort of the households, although this benefit has not been quantified. These impacts will be beneficial for all households, but in particular, will benefit those with the lowest available funds and the lowest thermal comfort.

78. Mandating hydrogen-ready boilers is assumed to have no impact on fuel poverty. The expected benefit of the policy is that the number of homes with natural gas-only boilers would be significantly reduced prior to any conversion of the gas network from natural gas to hydrogen. This in turn would reduce the overall costs and disruption involved in converting to hydrogen and will not affect fuel demand.

79. The Government is committed to ensuring the costs of decarbonising the energy system are fair and affordable for all energy users. We are considering both the benefits and the costs of different pathways holistically across the Government and we remain committed to working with industry and consumers to keep costs down and identify how costs can be allocated in a way that incentivises user behaviour that drives decarbonisation.

Equality impact

80. Under the Public Sector Equality Duty, the Government must have due regard to the potential impact of new boiler regulations on people with protected characteristics as set out in s.149 of the Equality Act 2010 (age, disability, gender reassignment, marriage or civil partnership, pregnancy and maternity, race, religion or belief, sex, sexual orientation). This requires BEIS to pay due regard to the need to:

    a. eliminate unlawful discrimination, harassment and victimisation and other conduct prohibited by the Act;

    b. advance equality of opportunity between people who share a protected characteristic and those who do not;

    c. foster good relations between people who share a protected characteristic and those who do not.

81. The main groups that will be affected by the policy are:

- Households installing boilers from 2025
- Boiler installers
- Manufacturers

82. In this IA we have analysed only the impact on households. Furthermore, equality analysis is limited to those characteristics captured by the English Housing Survey[23]. These are age (Table 10), ethnic minorities (Table 11), and disabilities (

83. Table 12).

Table 10: Age demographic of households with gas boilers

Age of household reference person	**16-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65 of over**
Households with gas boilers	2%	14%	18%	20%	18%	28%

[22] These savings will vary overtime as gas unit prices change.

[23] Based on DLUHC 'English Housing Survey' (https://www.gov.uk/government/collections/english-housing-survey) and BEIS 'Fuel Poverty statistics' (https://www.gov.uk/government/collections/fuel-poverty-statistics).

All households	3%	14%	17%	19%	18%	30%

Table 11: Ethnicity demographic of households with gas boilers

Ethnicity of household reference person	**White**	**Others**
Households with gas boilers	89%	11%
All households	89%	11%

Table 12: Disability/long-term illness demographic of households with gas boilers

Member of the household with a long-term illness or disability	**Yes**	**No**
Households with gas boilers	36%	64%
All households	36%	64%

84. We don't expect our recommended option to have any negative impact on people with protected characteristics. We also don't expect our recommended option to impact equality of opportunity between people with protected characteristics and those without.

85. Revising the boiler efficiency standards through amendments to product standards legislation is not expected to have a negative impact on equality, as any improvement in regulation would have a positive benefit for all consumers and likely impact industry. We estimate the boiler cost to increase by £50 in our central scenario, but efficiency improvements will offset this extra cost because of fuel bills reductions, with a payback period of around 2 years.[24] Additionally, some low income and vulnerable households may not be directly liable for the upfront cost of the boiler (for example social housing and private-rented tenants) and others may be eligible for financial support for energy efficiency improvements and heating system installations and therefore unaffected by upfront costs, but reap the benefits of bill savings. Additionally, while the Government may potentially specify certain product characteristics, it is intended to allow space also for consumer choice, so those less confident with smart technologies are not required to adopt such technologies, and ancillary technologies, such as a smart phone, in order to comply.

86. We assume that mandating hydrogen-ready boilers will not increase the installation cost but will reduce potential replacement costs for some households through the reduction of unnecessary gas boiler scrappage (which comes at a much higher cost than the £200 conversion cost).

87. Across all the various products, the Government expects the impact of product standards to be neutral. Requirements are technology neutral and allow the manufacturer to decide how best to design a product to meet the requirements as well as the needs of consumers. This helps to limit impacts on consumer choice and consumer needs. There may be instances for some products where more attention needs to be given, for example, if certain product types and technologies are used predominantly by certain sections of society. In these instances, there may need to be exemptions, allowances or longer lead in periods included in product regulation.

Equivalent Annualised Net Direct Cost to Business (EANDCB)

88. This section of the IA considers the direct costs and benefits to businesses to assess the net regulatory impact of the recommended option. The impact of the consultation on businesses, both in the heating appliance sector and more broadly, will depend in large part upon the wider policy framework for heat decarbonisation of which it is part, which will be continuing to develop in parallel

[24] Based on Green Book gas prices.

to development of these policies. Therefore, the assessment in this section should be considered only as illustrative and indicative.

89. Under the implementation model anticipated in this IA, the regulations will apply to the manufacturers of fossil fuel heating appliances sold in the UK. This is a relatively concentrated market sector, with four companies responsible for around 90% of annual gas boiler sales (ca. 1.7 million sales per year), and five companies responsible for around a further 7.5% of sales.[25]

90. These manufacturers will face additional technology capital costs (which include the cost of any changes they need to make to comply with the regulation and familiarisation costs associated with compliance). The technology cost associated with boiler efficiency upgrades (£50 in the central scenario for Option 1) has been attributed as a direct business cost. 20 hours[26] of familiarisation time is assumed to be required for each manufacturer to understand the regulations (for Options 1-3), as a one-off cost. This is estimated at around £58,000.[27] We also anticipate there to be some reporting costs for manufacturers, which we will work with stakeholders in future consultations to quantify.

91. The Department for Business, Energy and Industrial Strategy's Impact Assessment Calculator[28] has been used to generate the headline EANDCB metrics below for policy options 1-3, alongside the estimated Business Impact Target (BIT) score (Table 13). The direct costs to business are the sum of the costs over the appraisal period of the policy options. The BIT score is designed to estimate the impact of a measure across a parliament.[29]

Table 13: EANDCB results

EANDCB and Business Net Present Value (£m)	**Option 1**	**Option 2**	**Option 3 (preferred)**
Total Net Present Social Value (2019 prices, 2020 PV)	5,820	750	6,580
Business Net Present Value (2019 prices, 2020 PV)	-570	<0.1	-570
Net direct cost to business per year	33	<0.1	33
Score against the Business Impact Test	163	<0.1	163

92. Installers will likely face some one-off familiarisation and training costs to comply with the new technical standards, but this hasn't been quantified in this IA as it's not a direct impact of the policy. They will likely also benefit from additional trade, although this is considered an indirect benefit.

93. Given that the regulation will affect all boilers available in the market, private sector landlords won't require any familiarisation costs, but will face additional technology costs associated with boiler efficiency upgrades (£50 in the central scenario for Option 1).

Impact on small and micro businesses

94. The UK boiler market is dominated by 4 large manufacturers responsible for around 90% of annual gas boiler sales (ca. 1.7 million sales per year), [30] with the rest made up by several other businesses

[25] BSRIA (2020), 'Domestic Boilers Market Analysis' (https://www.bsria.com/uk/product/n7Wq6n/domestic_boilers_world_market_for_heating_boilers_2021r2020_8a707622/).

[26] Illustrative assumption.

[27] Based on the illustrative estimate of 20 hours needed for familiarisation, and using the hourly wage for management consultants and business analysts (~£24/hr) from the 'ONS – Annual Survey of Household Earnings, 2020 Provisional Dataset', uplifted with the non-wage cost uplift from RPC / Eurostat 2019 (21.78%).

[28] BEIS (2013), 'Impact assessment calculator, https://www.gov.uk/government/publications/impact-assessment-calculator--3.

[29] The Dissolution and Calling of Parliament Act (2022) ensures that Parliament will automatically dissolve 5 years after it has first met, if it has not been dissolved sooner. Therefore, we take the net direct cost to business per year and multiply by 5.

[30] BSRIA (2020), 'Domestic Boilers Market Analysis' (https://www.bsria.com/uk/product/n7Wq6n/domestic_boilers_world_market_for_heating_boilers_2021r2020_8a707622/).

of varying sizes. The majority are UK based branches/companies of larger holding companies. Therefore, it is anticipated that the majority of the impact will be on these organisations.

95. However, there are some notable smaller market players that supply boilers. Through the consultation process we will look to gather evidence on the direct impacts of the proposals on smaller manufacturing businesses.

96. The boiler installation sector is dominated by small businesses; there are over 76,000 registered Gas Safe businesses, comprising of over 130,000 registered Gas Safe installers in the UK.[31] These businesses will only be indirectly affected by the regulation through potential one-off familiarisation and training costs.

97. Training can be accessed at relatively low cost, and at times outside the peak boiler installation periods, so installers can be flexible as to how and when they choose to undertake training within the coming into force period.

98. Table 14 sets out an estimate of the portfolio size for domestic landlords, drawing on data from the Department for Levelling Up, Housing and Communities' Private Landlord Survey.[32] This shows that, in 2018, almost half (45%) of domestic landlords owned a single property and around 1% of landlords owned 25 or more properties. As per the Final IA for the Private Rental Sector (PRS) Regulations published in 2015,[33] all landlords are assumed to be small or micro businesses.

Table 14: Landlords by portfolio size

Portfolio size	Landlords (%)	Tenancies (%)
1	45.0	21.1
2 to 4	38.3	31.0
5 to 9	10.4	17.7
10 to 24	4.9	15.4
25 to 100	1.3	11.8
More than 100	0.1	3.1

99. Approximately 40% of households living in PRS properties with an Energy Performance Certificate (EPC) rating of F or G are in fuel poverty[34], which is much higher than in other tenures. This means the PRS includes some of the highest priority dwellings for this policy to target and many of the households that stand to benefit the most.

100. The costs incurred by landlords as a result of the regulations are likely to be on a per-property basis meaning landlords with small property portfolios will not be disproportionately burdened by the new standards.

A summary of the potential trade implications of measure

101. The policy is expected to apply equally to boiler manufacturers who import to the domestic market as to those manufactured in the UK, with potential impact on international trade and inward investment. Our assessment at this stage is that the policy is unlikely to have significant negative effects on trade or inward investment and may in fact have positive effects. On the one hand, the policy could in principle lead to gas boiler manufacturers who were otherwise considering commencing trade of their products into the UK choosing not to do so. In practice, however, the UK

[31] Gas Safe Register (2021), 'Gas Safe Register: At a glance 2020-21' (https://www.gassaferegister.co.uk/media/3176/2020-21-gas-safe-register-at-a-glance-report.pdf).

[32] Ministry of Housing, Communities & Local Government (2019), 'English Private Landlord Survey 2018' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/775004/Chapter_1_Figures_and_Annex_Tables.xlsx), Figure 1.2.

[33] DECC (2015), 'Final Stage Impact Assessment for the Private Rented Sector' (https://www.legislation.gov.uk/ukia/2015/217/pdfs/ukia_20150217_en.pdf).

[34] BEIS (2019), 'Consultation on fuel poverty strategy for England' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819606/fuel-poverty-strategy-england-consultation.pdf).

gas boiler market is highly mature and significant new fossil fuel entrants in the absence of this policy, while not impossible, would perhaps therefore be unlikely. As with broader market competitiveness above, we will continue to assess this during further policy development and in further consultation with market actors.

Monitoring and Evaluation

102. We aim to implement a robust monitoring and evaluation strategy to investigate and demonstrate the impact and outcomes of the proposed regulation. A thorough evaluation plan will be developed in advance of the implementation of the regulations and will be integral into the delivery of the policy. The plan will aim to monitor the effects of the proposed regulations in terms of carbon savings, costs to the consumer and industry and installer jobs/skills and to provide a cost-effectiveness assessment of the proposed regulation. It is expected that the evaluation will seek to answer questions such as:

    a. To what extent has the regulation achieved its aims?

    b. How has the design of the regulation influenced the impacts that were achieved?

    c. To what extent has the regulation been complied with by the sector?

    d. What is the quality of installations?

103. More information on our monitoring and evaluation strategy will be provided in the final impact assessment.

Annex I – full list of sensitivity and modelling assumptions

Modelling assumptions

Table 15: Option 1 assumptions in the central scenario

	Lifetime	Additional cost	In-situ efficiency	Rebound effect	Optimism bias
Gas boiler in the counterfactual (Option 0)	15 years	-	84%		
Gas boiler under policy Option 1	15 years	£50 more than the counterfactual	90%[35]	15%[36]	10%

Table 16: Option 2 assumptions in the central scenario

	Lifetime	Additional cost	Gas to H2 conversion cost
Hydrogen-ready boiler	15 years	£0 more than the counterfactual (no increase in equipment and labour costs compared to natural gas boiler equivalent)	£200

Table 17: Option 4 assumptions in the central scenario

	Standard hybrids	Compact hybrids
Average capex	£9,000	£7,000
Lifetime	15 years	15 years
Boiler in-situ efficiency	90% as set by policy Option 1	90% as set by policy Option 1
Gas/electric split for space heating[37]	35% gas, 65% electric (20/80 space heating split)	60% gas, 40% electric (50/50 space heating split)
Heat pump efficiency	260%	290%
Capex reduction	20% by 2030 30% by 2050	20% by 2030 30% by 2050
Share of installations	50%	50%

Sensitivity assumptions

S1: Costs of gas boiler upgrades *(Option 1)*

The central scenario assumes an additional cost of £50 for gas boilers that meet the proposed standards set out in Option 1. As a sensitivity, the low and high end of the assumption range is tested here (S1). We assume a cost of £0 at the low end and £200 at the high end.

S2: Efficiency improvements *(Option 1)*

[35] We assume the efficiency improvement will apply to all boilers, regardless of the fuel they use (natural gas or hydrogen).

[36] Illustrative assumption, based on: Glasgow Caledonian University (2008), 'An Analysis of the Difference between Measured and Predicted Energy Savings when Houses are Insulated' (https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.510.6384&rep=rep1&type=pdf).

[37] Assuming that hot water demand is 20%, and that hot water demand is met by the boiler component.

In the central scenario, we assume that the policy discussed in Option 1 will improve boiler efficiency by 6%. The sensitivity test (S2) will estimate the impact if the efficiency improvements were 4% (lower scenario) and 8% (higher scenario).[38]

S3: LRVCs *(Option 1)*

The low and high long run variable costs projections, from the HMT Green Book supplementary guidance,[39] are used to test the sensitivity on energy prices, which are inherently hard to project with any certainty. This sensitivity test also applies to Option 4.

S4: Carbon values *(Option 1)*

HMT Green Book supplementary guidance on valuation of energy use and greenhouse gas (GHG) emissions is used to value greenhouse gas savings. To reflect the uncertainty of carbon values, low and high carbon values are tested to assess the impact on the NPV. This sensitivity test also applies to Option 4.

S5: Equipment costs of hydrogen-ready boilers *(Option 2)*

In the central scenario, we assume that initial installation equipment costs of a hydrogen-ready boiler will be the same as their natural gas boiler equivalent.[40] However, there is also evidence to suggest that hydrogen-ready boilers are likely to be up to 15% more expensive to manufacture than natural gas boilers.[41] The sensitivity test will estimate the impact if equipment costs were 15% higher and the same as a gas boiler. This is to reflect the uncertainties of future equipment costs of hydrogen-ready boilers in the future. The central scenario also assumes that labour costs of installing a hydrogen-ready boiler will be the same as their natural gas boiler equivalent. We don't test sensitivities of labour costs because we don't expect hydrogen-ready boilers to take longer to install, so any increase in cost is more likely to affect only the appliance.

S6: Costs of hydrogen-ready boiler conversion *(Option 2)*

The central scenario assumes a cost of £200 for converting hydrogen-ready boilers to burning hydrogen. As a sensitivity, the low and high end of the assumption range is tested here (S6). We assume a cost of £150 at the low end and £400 on the high end of the assumption range.[42]

S7: Pathway weighting (75/25 and 25/75) *(Option 2)*

In the central scenario, the High Hydrogen and High Electrification pathways have been weighted equally (50/50) to reflect the uncertainty in the future technology mix in households on the gas grid. As a sensitivity, we have tested different weightings (such as 75/25 and 25/75) which would represent a higher or lower probability associated to the two pathways considered.

S8: Cost reduction by 2030 *(Option 4)*

[38] Illustrative assumption.
[39] Based on HMT Green Book supplementary guidance, available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.
[40] Element Energy (2018), 'Hydrogen supply chain evidence base' (https://eur02.safelinks.protection.outlook.com/?url=https%3A%2F%2Fassets.publishing.service.gov.uk%2Fgovernment%2Fuploads%2Fsystem%2Fuploads%2Fattachment_data%2Ffile%2F760479%2FH2_supply_chain_evidence_-_publication_version.pdf&data=04%7C01%7CConall.Halton3%40beis.gov.uk%7C7ee1a8f9a0a547628a6908d9fc84cb0d%7Ccbac700502c143ebb497e6492d1b2dd8%7C0%7C0%7C637818469532483178%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C3000&sdata=BDY0l%2Brb6O3DCRX6mrt%2FE%2F7XFV7RXO8sH0oPM3HO%2BrM%3D&reserved=0).
[41] Frazer-Nash Consultancy, prepared for BEIS (2018), 'Logistics of Domestic Hydrogen Conversion' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/760508/hydrogen-logistics.pdf).
[42] Boiler guide (2021), 'How Much Does a Boiler Service Cost?' (https://www.boilerguide.co.uk/articles/much-boiler-service-cost).

The central scenario assumes a cost-reduction of 20% by 2030 for both hybrid types (standard and compact). As a sensitivity, the high end of the assumption range is tested here (S8), assuming a cost reduction of 50% by 2030.[43] We also assume the same cost reduction by 2050 in the high scenario.

S9: Compact/standard hybrid share (100/0 and 0/100) *(Option 4)*

In the central scenario, the share of compact and standard hybrids is split equally due to the uncertainty of the technology mix we will have in 2050 households. As a sensitivity, we have tested different splits such as 100% compact hybrids and 0% standard hybrids and vice versa.[44]

S10: Space heating split (standard hybrids) *(Option 4)*

For standard hybrids, we assume that the heat pump component will meet 80% of the space heating demand in the central scenario. This sensitivity test will estimate the impact if the heat pump component met 50% (low end) and 90% (high end) of the space heating demand.

S11: Space heating split (compact hybrids) *(Option 4)*

For compact hybrids, we assume that the heat pump component will meet 50% of the space heating demand in the central scenario. This sensitivity test will estimate the impact if the heat pump component met 25% (low end) and 70% (high end) of the space heating demand.

[43] Element Energy (2017), 'Hybrid Heat Pumps: Final report' (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf).

[44] Illustrative assumption.