Title: Future Support for Low Carbon Heat: Boiler Upgrade Scheme (BUS) IA number: BEIS014(F)-21-CLH Lead department or agency: Department for Business, Energy and Industrial Strategy (BEIS) Other departments or agencies: N/A	Impact Assessment (IA) Date: 16 February 2022 Stage: Final Source of intervention: Domestic Type of measure: Secondary legislation Contact for enquiries: heatconsultation@beis.gov.uk
SUMMARY: INTERVENTION AND OPTIONS	RPC Opinion: Not Applicable

Cost of Preferred (or more likely) Option (in 2020 prices)

Total Net Present Social Value	Business Net Present Value	Net cost to business per year	Business Impact Target Status
£310m	N/A	N/A	N/A

What is the problem under consideration? Why is government intervention necessary?

Significant growth of low carbon heat is needed to meet legally binding carbon budgets, move towards the 2050 Net Zero target and work towards the mass transition to low carbon heat. The current market for low carbon heat is relatively small, and these technologies are largely unable to compete on cost with conventional heating options, such as natural gas, oil and direct electric heating. The Boiler Upgrade Scheme (BUS), previously known as the Clean Heat Grant, aims to incentivise and increase the deployment of heat pumps and, in limited circumstances, biomass boilers in domestic and small non-domestic properties, in England and Wales, by providing support in the form of an upfront capital grant. This is intended to grow the supply chain prior to the planned introduction of market-based and regulatory levers from the mid-2020s to phase out fossil fuel heating in buildings. The BUS will follow the closure of the primary existing support scheme for low carbon heating, the Domestic Renewable Heat Incentive (DRHI), which will close to new applications on 31 March 2022.

What are the policy objectives and the intended effects?

The BUS scheme has three main objectives:

- Support continued deployment of low carbon heating systems in homes, and some small non-domestic buildings, following the closure of the Domestic RHI (up to 90,000 installations in total between 2022 and 2025).
- Contribute to decarbonising heating in the UK and to meeting carbon budgets by delivering up to 1.1MtCO2e of carbon savings over Carbon Budgets 4 and 5, and 2.6MtCO2e over its lifetime.
- Expand the existing low carbon heat market and supply chain to support the mass roll out of low carbon heating technology, by supporting an average of 2,100 direct FTE and 1,800 indirect FTE per year over the three job-years covering 2022/23 to 2024/25.

What policy options have been considered, including any alternatives to regulation? Please justify preferred option

Option 0 (counterfactual): There is no provision of government support for low carbon heating for able-to-pay households following the closure of the Domestic RHI (in March 2022) or small non-domestic buildings following closure of the Non-Domestic RHI (in March 2021).

Option 1a (preferred option): Provide targeted support over three years through an upfront capital grant for heat pumps and biomass boilers to follow on from the Domestic RHI at a value of £5,000 for an air source heat pump (ASHP), £6,000 for a ground source heat pump (GSHP) and £5,000 for a biomass boiler.

Option 1b (alternative option): This option is similar in design to Option 1a, but with a flat rate grant level for each technology over 3 years of £4,000 for an ASHP, GSHP or biomass boiler. These grant levels align with the April 2020 Consultation proposal.

Will the policy be reviewed? We will consider need for review

Does implementation go beyond minimum EU requirements?	N/A
Is this measure likely to impact on international trade and investment?	No

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: -0.4		Non-traded: 3.0

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:  Date: 10/02/2022

SUMMARY: ANALYSIS & EVIDENCE **POLICY OPTION 1A**

DESCRIPTION: FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period	Net Benefit (Present Value (PV)) (£m)		
2020	2020	20	Low: £155m	High: £440m	Best Estimate: £310m

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	N/A		N/A	£175m
High	N/A		N/A	£500m
Best Estimate	N/A		N/A	£350m

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

The Boiler Upgrade Scheme will see costs arising from supporting eligible low carbon technologies, with a social cost of £350m within the central scenario. Social costs include capital costs and operating costs.

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

For a certain subset of property types (typically direct electric heated properties), installing a low carbon heat technology could lead to an efficiency-driven overall lowering of fuel bills, which could lead to an increase in energy consumption, though much lower relative to the consumption pre-installation. This is known as a 'rebound effect'. Under the Boiler Upgrade Scheme this has not been quantified because of the heterogeneity in household responses and the lack of evidence for heating behaviour. If monetised, the impact on the SNPV of the BUS is uncertain, as there would be a potential reduction in carbon savings, but with increased welfare benefits.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	N/A		N/A	£330m
High	N/A		N/A	£940m
Best Estimate	N/A		N/A	£660m

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

The main monetised benefits are the reduction in carbon emissions, the improvement in air quality and long-run variable cost of energy supply savings.

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

Additional non-monetised benefits include health benefits due to improved indoor air quality as a result of switching away from fossil fuel heating. They also include the role of BUS in enabling future supply chain development and the mass rollout of low carbon heat technologies (and potential innovation, performance improvements and cost reductions associated with achieving a mass market). Additionally, as the number of heat pump installations increase over time, this should lead to an increase in awareness of and familiarity with the low carbon technologies among the public, which is essential to reaching the net zero target. These benefits have not been monetised and are not included in the Social Net Present Value (SNPV). If monetised, these benefits would have a positive impact on the SNPV.

Key assumptions/sensitivities/risks Discount 3.5%

The estimates of social costs and benefits presented are subject to significant uncertainty, both in terms of the types of installations that may come forward and the additional costs they may face. Key sensitivities include changes in assumptions surrounding deployments, additionality, and the counterfactuals.

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			Score for Business Impact Target (qualifying provisions only) £m:
Costs: N/A	Benefits: N/A	Net: N/A	N/A

Summary: Analysis & Evidence **Policy Option 1B**

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2020	2020	20	Low: £95m	High: £215m	Best Estimate: £140m

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	N/A		N/A	£60m
High	N/A		N/A	£135m
Best Estimate	N/A		N/A	£85m

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	N/A		N/A	£160m
High	N/A		N/A	£355m
Best Estimate	N/A		N/A	£225m

NB: While the costs and benefits differ for options 1a and 1b, the same description and scale of key monetised and non-monetised costs and benefits applies to both options.

Executive Summary

1. This final stage impact assessment follows the Future Support for Low Carbon Heat: Boiler Upgrade Scheme Government Response (BUS GR) published in October 2021[1]. The aim of this document is to appraise the impact of the Boiler Upgrade Scheme and illustrate the analysis that has supported policy development.

2. We set out our proposals to support low carbon heat deployment in the Future Support for Low Carbon Heat consultation[2] in April 2020 and confirmed the scheme policy in the Boiler Upgrade Scheme Government Response.

3. The scheme is planned to launch in Spring 2022, with funding committed for three years, to March 2025 at an estimated whole life capital cost of £450m (nominal, undiscounted) between 2022/23 and 2024/25 to deliver £660m of social benefits, and an overall Social Net Present Value of £310m (discounted, 2020 prices).

4. To assess the impact of the scheme, we have developed deployment scenarios, which set out potential profiles for spend, carbon savings, change in energy demand due to displacements by low carbon technologies and renewable heat supported. These estimates have been produced by drawing on a range of sources, including market intelligence, evidence from the Green Homes Grant (GHG), the National Housing Model (NHM), and social research carried out on applicants of the Domestic Renewable Heat Incentive (DRHI).

5. We anticipate that the scheme could deliver an annual generation of 0.3TWh of renewable heat on average between 2022 and 2050 and deliver 1.4MtCO2e of non-traded carbon abatement over carbon budgets 4 and 5 and 3.0MtCO2e of non-traded carbon abatement over its lifetime. There is considerable uncertainty about these impacts, which are explored in more detail in section 3.8.

6. There are also significant uncertainties in the Social Net Present Value (SNPV) of the scheme. Our central estimate of the SNPV is £310m. We have carried out sensitivity analysis to show the impact on the SNPV, when several modelling assumptions are considered. In all the sensitivity analysis scenarios tested, the SNPV remains positive.

7. It is also anticipated that the scheme will grow and develop the low carbon heat market and supply chain to support and ultimately enable the mass roll out of low carbon heating technology later this decade (and the potential innovation, performance improvements and cost reductions associated with achieving a mass market). This supply chain development is achieved by supporting an average of 2,100 direct FTE and 1,800 indirect FTE per year over the three job-years covering 2022/23 to 2024/25.

8. The key changes to the policy and analytical outputs since the consultation stage impact assessment are:

   - Length of scheme: In the consultation stage IA, it was proposed that the CHG scheme would run for two years (to 2023/24) with possibility of an extension. Under the current proposal, the BUS scheme is now planned to run over a three-year period (to 2024/25).

   - Grant levels: In the consultation stage IA, a £4,000 flat-rate grant was proposed for each technology. Our analysis now considers the preferred grant level option of a £5,000 grant for ASHPs, £6,000 grant for GSHPs and £5,000 grant for biomass. The grant levels proposed under this preferred option (1a) are based on a range of evidence sources detailed in this impact assessment.

[1] Government response to the Clean Heat Grant proposals: https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat
[2] Future Support for Low Carbon Heat Consultation: https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

- Deployment scenarios: In the consultation stage IA, the split of deployments across technologies (ASHPs, GSHPs & Biomass) was assumed to be the same as seen under the Domestic RHI. More granular, technology specific deployment estimates are now produced for the respective supported technologies. For GSHPs and Biomass boiler deployment estimates, GHG application statistics are used along with social research carried out on RHI applicants. For ASHPs, deployment scenarios are also produced using GHG application statistics, but these are combined with internal National Housing Model analysis on the number of suitable households for whom an ASHP would be 'financially attractive'. As a result of higher grant levels and subsequently higher deployment than in the Consultation Stage IA, these changes to deployment result in an increase in the SNPV.

- Counterfactual mix of technologies: The counterfactual mix of technologies used in the BUS modelling for ASHPs have been estimated using a National Housing Model[3] (NHM) data extract (combined with Delta-EE research on Capital Costs[4,5]) and the counterfactual fuel type compositions of those relevant households for whom an ASHP may be 'financially attractive'. Previously the mix of displaced technologies was assumed to reflect those in the DRHI statistics and this approach to the counterfactual mix is still used for GSHPs and Biomass boilers. It is also assumed that the small non-domestic installations supported by the BUS are akin to the DRHI installations. The assumption change resulted in a decrease in SNPV.

- Capital costs of technologies: The average capital costs of technologies have been updated based on further analysis using the NHM data extract which uses a Standard Assessment Procedure (SAP)-based energy calculator and dwelling information to estimate the size of heating system required and overall installation costs for each building archetype. The NHM information is used alongside BEIS market intelligence to model the estimated capital costs available for different segments of households (and small businesses) to best reflect anticipated market developments over the lifetime of the BUS. This assumption change has resulted in an increase in the SNPV.

- Additionality: The additionality assumption has been revised from the previous assumption in the Consultation Stage IA of 100% to 70%, following further analysis of Domestic RHI evaluation responses regarding additionality. However, the level of additionality under the BUS is uncertain. Since there is limited evidence to suggest deployment of low carbon heating technologies in the retrofit market would continue in the absence of a support mechanism, the sensitivity analysis also considers an additionality assumption of 100%. This assumption change resulted in a decrease in the SNPV.

- Air quality damage costs: The electricity and fossil fuel air quality damage costs used in the BUS modelling have been updated to use the latest values from the Department for Environment Food and Rural Affairs (Defra)[6]. These costs supersede the air quality damage costs in the data tables supporting the Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas emissions.

- Lifetime of biomass boilers: In the consultation stage IA analysis, all low carbon technologies (ASHP, GSHP and biomass) were assumed to have a lifetime of 20 years. This assumption has since been revised by BEIS engineers to a shorter lifetime of 15 years for biomass boilers, following more recent evidence on average biomass boiler lifetimes. This assumption change resulted in a decrease in the SNPV.

[3] National Housing Model (2017) - LINK
[4] Cost of Domestic Heating Measures, Delta-EE (2019). LINK
[5] This combination of Delta-EE Research and the National Housing Model is detailed in Section 3.6.
[6] Green Book supplementary guidance - Table 15: Air quality damage costs from primary fuel use, 2020 p/kWh. LINK

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1. Introduction and Background

1.1 Background

1. The government has committed in the 10-Point Plan[7] to an ambitious trajectory for heat pump deployment within this decade (600,000 heat pumps a year by 2028, across existing and new buildings) to meet our carbon budgets and make progress towards our 2050 net zero ambition. As set out in the Heat and Buildings Strategy[8], regulation will drive significant change for both the new build and retrofit market from the mid-2020s, but as recommended by the Climate Change Committee (CCC), additional financial support is required to enable the development of supply chains ahead of the introduction of new standards. The main focus is on phasing out high carbon fossil fuel heating in existing homes and small non-domestic buildings and growing demand to deliver cost reductions in low carbon heat technologies ahead of the introduction of regulations.

2. The government has committed to legally binding emissions targets in the near-term through Carbon Budgets 4 and 5 (spanning over the period 2023-32); the mid-term through Carbon Budget 6 (spanning over the period 2033-37) and in the long-term with net zero greenhouse gas emissions by 2050.

3. Heat pumps will play a substantial role in any net zero scenario and, in the near-term, the market is expected to expand through a combination of government support and signalling of planned regulatory levers. This is reflected in the ambition set out in the 10 Point Plan commitment. Under all future scenarios, heat pumps are a low-regrets option to decarbonise heat and deliver carbon savings in the 1.5 million homes not connected to the mains gas network and using fossil fuel systems for heating[9].

4. The primary current support scheme for low carbon heating, the Renewable Heat Incentive (RHI), was set up to facilitate and encourage the transition from conventional forms of heating to low carbon alternatives[10]. The scheme is an important contributor to the Government's stretching targets for both renewable heat and the carbon savings through the carbon budgets. The scheme provides financial incentives to both households and non-domestic consumers, including public bodies and charities, to help bridge the gap between the cost of low carbon heating systems and the conventional alternatives.

5. The Domestic RHI which is the primary support scheme for the deployment of low carbon heat in homes, will close to new applications on 31 March 2022 while the Non-Domestic RHI closed on 31 March 2021. The Boiler Upgrade Scheme (BUS) will follow these schemes and provide an upfront capital grant towards the cost of a heat pump and, in limited circumstances, a biomass boiler. Support will be provided to installations that do not exceed a capacity of 45kWth, in existing domestic and small non-domestic buildings.

6. There will be eligibility requirements for biomass boilers to ensure air quality is managed. Biomass boilers will only be supported in rural areas[11] and where the buildings do not have an existing connection to the mains gas grid.

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[7] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[8] https://www.gov.uk/government/publications/heat-and-buildings-strategy

[9] OFTEC, September 2020: https://committees.parliament.uk/writtenevidence/12193/html/
[10] Conventional forms of heating include natural gas, oil, coal, LPG and direct electric heating.
[11] 'Rural' is defined as meaning areas outside of settlements with a population of 10,000 people or more.

1.2 Problems under consideration

7. 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. We have already made progress towards this goal: emissions from buildings have fallen by 20% between 1990 and 2017[12]. However, to meet our net zero target, we will need to go much further.

8. Currently, heating our homes, businesses, and industry is responsible for a third of the UK's greenhouse gas emissions[13]. Decarbonisation of heat is recognised as one of the biggest challenges we face in meeting our climate targets. The Heat and Buildings Strategy sets out the immediate actions we will take for reducing emissions from buildings. These actions include the low-regrets deployment of energy efficiency measures and low carbon heating as part of an ambitious programme of work ahead of the key strategic decisions that need to be taken this decade on how we achieve the mass transition to low carbon heat.

9. The objectives of the proposed future support for low carbon heat are outlined in section 1.4.

1.3 Rationale for intervention

10. The current UK market for low carbon heat is relatively small, and these technologies are largely unable to compete on cost with conventional heating options, such as natural gas, oil and direct electric heating. This is partly due to the emerging nature of low carbon heating in the UK, which means that it does not benefit from economies of scale or from mature supply chains to the same degree as conventional technologies. Whilst the new build market for low carbon heat is expected to grow as a result of regulatory signals such as the Future Homes Standard, deployment in existing buildings requires financial support in the form of a subsidy. Existing buildings face a specific set of challenges, with installing low carbon heating tending to be more difficult and expensive than it is in new build[14]. Subsidy is required to mobilise this section of the market, to bridge the cost gap between a fossil fuel system and low carbon alternative and build supply chains in advance of the introduction of regulations and a proposed market mechanism in the mid-2020s.

11. Additionally, the full societal costs of fossil fuel combustion are not reflected in their market prices (examples include the impacts on health and climate change). By subsidising low carbon heat installations, the proposed scheme will reduce the cost differential between fossil fuel and low carbon systems, and consequently enable the transition. The main aspects of the economic rationale for subsidising low carbon heating through the BUS scheme are:

    a) Deploying low carbon heating systems can offer a cost effective and low regrets way (particularly to homes off the gas grid) to reduce carbon emissions. Given that the negative carbon externality associated with the conventional heating of buildings is not currently reflected in the cost of those systems, subsidy is currently required to make low carbon heating technologies cost competitive.

    b) The BUS scheme will promote high quality installations assured through the Microgeneration Certification Scheme (MCS) standards. It will further build supply chains that have been established through the RHI, to lead to future cost reductions and develop installer skills.

    c) This subsidy-based approach now, backed by a clear indication of the direction of travel for the heat pump market through the Heat and Buildings Strategy, will prepare the ground for a move away from a taxpayer-funded transition and towards a market-led and

[12] Defra (2019) Leading on clean growth: government response to the Committee on Climate Change 2019 progress report to Parliament - Reducing UK emissions: https://www.gov.uk/government/publications/committee-on-climate-changes-2019-progress-reports-government-responses. This only includes non-traded emissions; it does not include electricity.

[13] BEIS (2018) Heat decarbonisation: overview of current evidence base Fig.2.1: https://www.gov.uk/government/publications/heat-decarbonisation-overview-of-current-evidence-base

[14] For more details, see "New Build eligibility and Social Housing" section in the Future support for low carbon heat Government Response (October 2021). LINK

regulatory-backed transition in the future. Without state intervention, the supply chain would risk contracting following RHI closure and make subsequent measures, including regulation, less deliverable due to supply chain capacity and the current cost gap between low carbon and fossil fuel heating. This is likely to mean that taxpayers or consumers will bear a greater cost in future in financing the transition.

1.4 Policy objectives

12. The BUS scheme has three main policy objectives:

a) Increase deployment of low carbon heating systems - heat pumps and in limited circumstances biomass boilers - in homes and small non-domestic buildings.
   - This can be achieved through the BUS supporting up to 90,000 installations in total between April 2022 to March 2025.

b) Contribute to decarbonising heating in the UK and to meeting carbon budgets.
   - The BUS is estimated to deliver up to 1.1MtCO2e of carbon savings over Carbon Budgets 4 and 5, and 2.6MtCO2e over its lifetime.
   - The annual renewable heat generated by the BUS is estimated to be 0.3TWh on average between 2022 and 2050.

c) Build the low carbon heat market and supply chain to support the mass roll out of low carbon heating technology.
   - The BUS is estimated to support an average of 2,100 direct FTE and 1,800 indirect FTE per year over the three job-years covering 2022/23 to 2024/25.

2. Outline of Policy Options

13. The policy options considered in this impact assessment are:

a) Option 0 (counterfactual): There is no provision of government support for low carbon heating for able-to-pay households following the closure of the Domestic RHI (in March 2022) or small non-domestic buildings following closure of the Non-Domestic RHI (in March 2021).

b) Option 1a (preferred option): Provide targeted support over three years through an upfront capital grant for heat pumps and biomass boilers to follow on from the Domestic RHI at a value of £5,000 for an air source heat pump (ASHP), £6,000 for a ground source heat pump (GSHP) and £5,000 for a biomass boiler.

Table 2.1: Option 1a grant levels

Technology	Grant
ASHP	£5,000
GSHP	£6,000
Biomass	£5,000

c) Option 1b (alternative option): This option proposed a scheme similar to Option 1a, but with an alternative flat rate grant level of £4,000 over three years for each technology. This option is in line with the grant levels proposed in the Future Support for Low Carbon Heat Consultation and extended by a year.

Table 2.2: Option 1b grant levels

Technology	Grant
ASHP	£4,000
GSHP	£4,000
Biomass	£4,000

14. There are a range of technologies and uses that are not aligned with the primary strategic aims of these proposals and where support may be available elsewhere. The BUS GR document sets out the rationale for not supporting the following technologies through this policy package:

- Process heating
- Biogas combustion
- Solar thermal
- Fossil fuel hybrid heat pump systems

2.1 Aims of the scheme

15. The aim of the BUS is to provide capital grants to support the installation of low carbon heating systems – heat pumps and in limited circumstances, biomass boilers – in homes and small non-domestic buildings. This will build supply chains and enable the introduction of proposed regulations and market-based mechanisms in the mid-2020s, as well as helping to sustain a viable electrification-led pathway to decarbonising heat and achieving net zero. The scheme will follow on from the domestic RHI which will close to new applicants in March 2022.

16. In line with the increasing focus on strategic technologies, we intend to limit support to installations of ASHPs, GSHPs and biomass boilers (in rural areas and where emission criteria are met).

17. In all future heat scenarios - including if hydrogen is proven to be feasible and preferable to use in heating some buildings - 600,000 heat pump installations per year will be required by 2028 to be on track to deliver Net Zero. Electrification of heat via heat pumps is one of the primary routes for decarbonising heat. Looking towards 2050, heat pumps could enable us to almost decarbonise heat completely as electricity generation decarbonises. The heat pumps we propose to support are ASHPs and GSHPs. We propose to support both low and high-temperature units, but not 'hybrid heat pumps' installed alongside a fossil fuel system. Further information is available in the BUS GR[15].

18. It is necessary to ensure there are heating technologies available for a broad range of properties, including those that are not suitable for a heat pump. Although biomass has a wider strategic role to play in overall UK decarbonisation, its use in heating buildings should be limited, as recommended by the Climate Change Committee (CCC), to maximise the overall carbon abatement that is possible from sustainable biomass[16]. Under BUS, biomass boilers will not be permitted in urban areas to mitigate against the potential negative air quality impacts of biomass. Further information on eligibility criteria for biomass is available in the BUS GR.

2.2 Grant levels

[15] BEIS (2021) Government Response Boiler Upgrade Scheme https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1026446/clean-heat-grant-government-response.pdf
[16] CCC (2018) Biomass in a Low Carbon Economy: https://www.theccc.org.uk/publication/biomass-in-a-low-carbon-economy/

19. Grant levels have been set by considering evidence on consumer willingness to pay, the upfront capital cost of each technology, market intelligence, social research of RHI applicants, National Housing Model data and monitoring data from the RHI and GHG schemes. The grant setting approach prioritises increasing confidence in securing enough number of installations to achieve the scheme's objectives, over deployment of technologies at the lowest possible cost per installation – see further details on grant levels in the annex.

    Under the BUS, we will retain the right to review grant levels in response to market developments or if uptake falls substantially outside the expected range. This will be important given the relatively early stage of the market and the limited evidence on how grant amounts may affect total deployment numbers in England and Wales. However, we understand the importance of providing certainty to industry and would only expect to vary grant levels, if necessary, and following suitable notice.

20. Table 2.3 below shows the key sources of evidence used to inform the grant level proposals.

Table 2.3 Summary of evidence

Evidence source	Description of evidence
Delta EE Microgen Insight Study Owner-Occupier Stated Preference Survey (Delta EE, July 2015)[17]	Delta EE surveyed consumers on how the cost of an installation affects uptake.
Grant level experiment – Winning Moves[18]	Findings from a survey carried out on RHI applicants, exploring whether they would have proceeded with their installation if an upfront grant had been available, instead of the tariff support provided by the RHI. This experiment tested how different grant amounts could affect uptake of a grant-based scheme.
Heat Pump Association Roadmap[19]	Report on the role that heat pumps can play in decarbonising heat.
Monitoring data from the RHI and Green Homes Grant (GHG)[20]	Published statistics on applications for ASHPs, GSHPs and biomass under the DRHI and GHG.

2.3 Scope of the scheme

21. In order to target taxpayers funding most effectively to help support the installer base for existing domestic and small non-domestic buildings, we propose to introduce a 45kW thermal (th) capacity limit to focus this scheme on smaller installations.

22. For comparison, almost all domestic and non-domestic heat pump installations have a capacity less than or equal to 45kWth in the RHI, while almost half of total domestic and non-domestic biomass installations are less than or equal to 45kWth[21].

23. A 45kWth capacity limit is also consistent with that covered by the Microgeneration Certification Scheme (MCS) for a single renewable heating product. It therefore provides a framework for ensuring installation and product standards. Further information on the capacity limit can be found in the BUS GR.

[17] This report by Delta-EE is unpublished.
[18] The research carried out by Winning Moves is unpublished.
[19] A road map for the Role of Heat Pumps.
[20] Official Statistics: RHI and GHG.
[21] Domestic and non-domestic RHI deployment data on capacity shows that over 99% of ASHP, 95% of GSHP and 55% of biomass installations are less than or equal to 45kWth.

2.4 Support mechanism

24. The BUS will provide support through an upfront capital grant, rather than the current RHI tariff-based mechanism. The tariff structure of the RHI was designed to make investing in renewable heat financially attractive, as well as support a wide range of technologies and investor types. However, upfront costs are often raised as a barrier[22], particularly for consumers who do not have enough savings to pay for the extra upfront cost of a low carbon heat system compared to a fossil fuel alternative[23].

25. The proposed option is an upfront capital grant of £5,000 for ASHP, £6,000 for GSHP and £5,000 for biomass as opposed to a technology-neutral, flat-rate grant of £4,000 for all technologies. These Grant levels have been set by considering evidence on consumer willingness to pay, the upfront capital cost of each technology, market intelligence, social research of RHI applicants, National Housing Model data and monitoring data from the RHI and GHG schemes. Government retains the right to amend grant levels following scheme launch in response to unforeseen market changes or if uptake differs substantially from the expected range.

26. Further detail on the support mechanism can be found in the Future Support for Low Carbon Heat: Boiler Upgrade Scheme Government Response.

2.5 Budget management

27. The scheme has a budget of £450 million over three years [2022/23 – 2024/25]. Vouchers will be issued on a first come first served basis to applicants who meet the eligibility requirements, until the budget cap for the financial year is reached.

28. ASHP and biomass boiler vouchers will be valid for 3 months and GSHP vouchers will be valid for 6 months. In cases where they expire, their value will be added back to the available budget, if within the same financial year as issued.

29. Budget management controls will be applied to limit budget overspend and underspend. Overallocation may be applied to mitigate against the risk of funding being held up in unused vouchers. A queue may also be established to ensure returned, and newly available vouchers are allocated and used.

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[22] BEIS (forthcoming) Transforming Heat – Public Attitudes Research and unpublished RHI evaluation interview evidence.

[23]The majority of Domestic RHI applicants pay for their heating system using savings (source: Frontier economics (2017) RHI Evaluation: Synthesis: https://www.gov.uk/government/publications/rhi-evaluation-synthesis-report).

3. Analytical Approach

30. This section outlines the evidence base on which impacts of the policy proposals have been modelled, the uncertainty in our estimates, and the overall analytical approach undertaken to assess the costs and benefits of the Boiler Upgrade Scheme.

3.1 Evidence Base

31. The appraisal values used in the analysis include:

a) **Carbon values** - HMT Green Book supplementary guidance on valuation of energy use and greenhouse gas emissions are used to value greenhouse gas savings[24].

b) **Electricity and fossil fuel air quality damage costs** - The latest air quality damage costs[25] provided by the Department for Environment, Food and Rural Affairs (Defra). The updated damage costs supersede those published in HMT Green Book supplementary guidance on the valuation of energy use and greenhouse gas emissions. The updated damage costs take into account an improved understanding of health impacts, based on the latest advice from Public Health England[26] and the Committee on the Medical Effects of Air Pollution (COMEAP)[27].

c) **Biomass air quality damage costs** - The BUS will impose emissions limits on biomass boilers supported by the scheme, in line with criteria set by the RHI. As such, the national average biomass air quality damage costs provided by Defra are not appropriate to use in our analysis. Instead, biomass air quality emissions factors used in the analysis are based on research into the level of performance of biomass boilers under the RHI. See Annex A for further information.

d) **Electricity and fossil fuel carbon emissions factors** - HMT Green Book supplementary guidance is used to measure carbon emissions from electricity and fossil fuels.

e) **Biomass carbon emissions factors** - For biomass, carbon emissions factors are generated using the latest greenhouse gas conversion report[28].

f) **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).

32. All prices in this analysis have been converted into 2020 prices using the GDP deflator[29].

33. The Green Book social time preference rate ('discount rate') of 3.5% has been applied for social present values.

3.2 Counterfactual

34. Evidence from National Housing Model data combined with Delta-EE research has been used to estimate the mix of counterfactual legacy systems being replaced by ASHPs. Evidence from the RHI has been used to estimate the mix of counterfactual legacy systems being replaced by GSHPs and biomass boilers under the BUS[30]. The costs and benefits derived from a new low carbon heating technology are highly sensitive to the types of counterfactual systems they are replacing. Given the demand-led nature of the scheme, it is difficult to accurately predict where the new low carbon technologies will be deployed, and the types of systems they will replace.

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[24] The Green Book supplementary guidance can be found here: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/793632/data-tables-1-19.xlsx
[25] https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance
[26] Health matters: air pollution (2018) – LINK
[27] https://www.gov.uk/government/groups/committee-on-the-medical-effects-of-air-pollutants-comeap
[28] Greenhouse gas reporting: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019
[29] GDP deflator: https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp
[30] Counterfactual heating technologies include oil, coal, LPG, natural gas and direct electric heating.

35. Given the uncertainty around the types of systems being replaced, alternative counterfactual assumptions of 100% oil boiler displacement and 100% gas boiler displacement are shown in the sensitivity analysis in section 4.6, with both scenarios yielding a positive SNPV respectively. These alternative scenarios capture both extremes of counterfactual displacement possibilities given the inherent uncertainty of a demand-led scheme coupled with the potential for uncertain market developments in the heat pump industry. The 100% oil boiler sensitivity was chosen based on the assumption that in the event of a *'high off-grid deployment'* scenario, the majority of supported installations will likely replace oil as this is the most commonly used fossil fuel to heat off gas grid buildings. Alternatively, if heat pump market developments over the lifetime of the scheme yield a *'high gas-grid deployment'* scenario and gas boiler displacements, then the SNPV implications of this has also been accounted for.

3.3 Additionality

36. There is limited evidence to suggest deployments of low carbon heating technologies in the retrofit market would continue in the absence of a support mechanism. Additionality assumptions for low carbon heat support mechanisms are subject to change over time. Reasons for this include an increase in consumer awareness of low carbon technologies, changes in eligibility criteria and scope of support schemes, as well as changes in the number of consumers who have already installed a low carbon technology ahead of the implementation of a new scheme.

37. RHI evaluation findings suggest that around a third of applicants would have installed a low carbon heating system without support from the RHI. This is used to inform our central assumption of 70% additionality for the BUS. However, it is important to note that the level of additionality for the BUS may be different to the RHI evaluation findings, primarily because the change in support mechanism from a tariff to an upfront grant is likely to result in a greater range of applicants. We expect the grant support mechanism, which will reduce upfront costs of technologies for consumers, will widen access to the scheme and provide greater additionality. Given this uncertainty, 70% may be a conservative assumption so an alternative additionality high assumption of 100% is shown in the sensitivity analysis in section 4.6.

38. Other policy levers may be introduced that complement the BUS, which could change additionality levels. The evaluation of the BUS and other low carbon heat and energy efficiency schemes will assess additionality, taking into account potential interactions across these government support schemes.

3.4 Appraisal period

39. The appraisal period used in the BUS analysis is 20 years. This is chosen based on the expected lifetime of heat pumps[31]. Counterfactual technologies on the other hand, have an assumed lifetime of 15 years, and so counterfactual technologies displaced by heat pumps within the appraisal period, will incur a second capital cost. The second capital cost is prorated to account for the number of years remaining in the appraisal period. Biomass boilers have an assumed lifetime of 15 years, and so costs and benefits as a result of biomass installations are modelled up until appraisal year 15 only. Counterfactual technologies displaced by biomass boilers are not replaced within the appraisal period.

[31] Technology lifetimes are based on BEIS engineer judgement.

3.5 Deployment

40. For GSHP and biomass boiler deployment estimates, the GHG application statistics[32], along with social research carried out on RHI applicants were used. GHG application statistics which cover the period 30 September 2020 to 31 March 2021 were extrapolated to estimate annual demand for low carbon heat technologies with a £5,000 grant[33].

41. Despite the important differences in policy design between the BUS and GHG, which may impact applications, the GHG application statistics[34] offered an insight into how consumers may respond to the upfront grants offered by the BUS. To account for the differences in policy design, in particular the simplification of the BUS voucher application process and consumer offer compared with the GHG, a small uplift (of 10%) were made to GHG application numbers.

42. The extrapolated GHG data were adjusted using findings from social research carried out on RHI applicants to predict demands where relevant for the grant levels presented for Option 1a and 1b. For grant levels in Option 1a and 1b that were not directly tested through the experiment, estimates of take-up have been imputed by fitting trend lines to the data available.

43. For ASHPs, deployment scenarios were also produced using extrapolated GHG application statistics[35,36] with the same 10% uplift applied as for GSHPs and biomass boilers. The GHG application statistics were used in combination with a National Housing Model[37] (NHM) data extract (combined with Delta-EE research on Capital Costs[38,39]).

44. Internal BEIS analysis estimated the number of suitable households for whom an ASHP would be 'financially attractive'[40] for given conditions *(e.g., grant levels, heat pump market developments)*. Changes in this annual pool of households allowed scaling of the GHG application statistics to estimate demand. As a result of the calibration on levels of demand under the GHG, the deployment estimates are anchored empirically and account for the heterogeneous (non-financial) factors and considerations that affect the household decision process to switch their existing fossil fuel system for an ASHP.

45. Using the Option 1a approach, we expect the grant levels proposed to generate demand consistent with the £150m budget in each financial year. There is inherent uncertainty in projecting deployments. We have carried out sensitivity analysis to show the impact of a lower deployment scenario in Option 1a. However, support for the BUS cannot exceed the three-year £450m budget cap or the £150m yearly budget cap, and so the number of supported installations cannot be greater than our central deployment scenario.

46. Tables 3.1 and 3.2 below show the deployment scenarios under Options 1a and 1b and represent our modelled assumptions of installations split by technology. The data in table 3.2 (and the GSHP and biomass deployment estimates in table 3.1) were derived by applying the findings from the Winning Moves social research commissioned by BEIS to the GHG voucher applications,

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[32] The main GHG scheme offers householders an upfront grant to cover two-thirds of the cost of a range of low carbon heat and energy efficiency measures, up to a maximum contribution of £5,000. GHG applicants are also able to apply for the DRHI. Where an applicant applies for both schemes, the GHG upfront grant (£5,000) is deducted from DRHI payments.

[33] Given the design of the GHG, we expect that those 'able to pay' applicants (i.e. not low-income applicants) that applied for the GHG for ASHPs, GSHPs or biomass would have received a £5,000 grant.

[34] BEIS (2021) Green Homes Grant statistics

[35] The main GHG scheme offers householders an upfront grant to cover two-thirds of the cost of a range of low carbon heat and energy efficiency measures, up to a maximum contribution of £5,000. GHG applicants are also able to apply for the DRHI. Where an applicant applies for both schemes, the GHG upfront grant (£5,000) is deducted from DRHI payments.

[36] Covering the period 30th September to December 31st 2020, as this avoids data from the later months where GHG-specific delivery issues impacted the marketing and demand for the scheme. For sample size reasons, the full 6 months of data was used for GSHP & Biomass estimates respectively.

[37] National Housing Model (2017) - LINK

[38] Cost of Domestic Heating Measures, Delta-EE (2019). LINK

[39] This combination of Delta-EE Research and the National Housing Model is detailed in Section 3.6.

[40] This was defined as the number of relevant households (after the BUS grant) for whom both the *"Upfront CAPEX Costs"* and the *"Discounted Lifetime Costs"* of an Air Source Heat Pump are both at cost parity (or better) than replacing their existing fossil fuel system.

excluding low-income households[41]. The split across the technologies is an indication of the level of demand for each technology only, it does not represent limits on the deployments of each technology. The deployment of GSHPs may vary depending on the number of non-social housing shared ground loop systems that come forward under the scheme. Regarding Government support for GSHPs in the context of social housing, it should be noted that Wave 1 of the Social Housing Decarbonisation Fund (SHDF) provides support for social landlords installing low carbon heat installations where these are in alignment with the objectives and 'fabric first' approach of the scheme[42].

Table 3.1: Option 1a deployment scenarios

Number of installations	Technology	2022/23	2023/24	2024/25	Total
Central	ASHP	29,650	29,650	29,650	88,950
	GSHP	200	200	200	650
	Biomass	100	100	100	300
	Total	**29,950**	**29,950**	**29,950**	**89,900**
Low	ASHP	14,800	14,800	14,800	44,450
	GSHP	100	100	100	300
	Biomass	50	50	50	150
	Total	**14,950**	**14,950**	**14,950**	**44,900**

Figures may not sum due to rounding.

Table 3.2: Option 1b deployment scenarios

Number of installations	Technology	2022/23	2023/24	2024/25	Total
Central	ASHP	7,050	7,050	7,050	21,150
	GSHP	150	150	150	450
	Biomass	100	100	100	250
	Total	**7,300**	**7,300**	**7,300**	**21,850**
Low	ASHP	4,950	4,950	4,950	14,800
	GSHP	100	100	100	300
	Biomass	50	50	50	150
	Total	**5,100**	**5,100**	**5,100**	**15,250**

Figures may not sum due to rounding.

3.6 Capital and operational costs

47. Published evidence suggests that deployment and R&D could bring down the total capital cost of heat pumps, including both appliance and installations costs, by around 20% in a mass market scenario. In practice, several businesses believe that significantly higher cost reductions can be achieved significantly faster.

48. In this impact assessment, capital cost assumptions are derived from a cost study carried out by Delta-EE, and further analysis was then carried out using the National Housing Model (NHM)[43,44]. The NHM uses a Standard Assessment Procedure (SAP)-based energy calculator and dwelling information to estimate the size of heating system required and overall installation costs for each building archetype. The NHM information is used alongside BEIS market intelligence to model the

41 Low-income households were excluded due of their entitlement to higher voucher values - up to 100% of the measure's cost. Only GHG applications to the main scheme were considered since the main scheme offered a grant of two-thirds of the cost of eligible improvements, up to £5,000. Given the cost of low carbon heat installations, this is equivalent to a voucher of £5,000.

42 Wave 1 of the Social Housing Decarbonisation Fund (October 2021) - LINK

43 The NHM contains detailed information from around 20,000 household samples, taken from the English Housing Survey, Living in Wales Survey and Scottish Household Survey. The samples are extrapolated to represent the housing stock in Great Britain.

44 The Delta-EE study was carried out in 2017/18, prices have been inflated to 2020 prices for use in our analysis. BEIS (2020) Cost of installing heating measures in domestic properties.

estimated capital costs available for different segments of households (and small businesses) to best reflect anticipated market developments materialising over the lifetime of the BUS. The average capital costs of technologies deployed under the BUS scheme will ultimately be sensitive to where deployment occurs and the types of property (and existing fossil fuel system being replaced), which is subject to uncertainty under a demand-led scheme.

49. The capital cost estimates include the cost of the device, labour fee, fittings, new buffer and cylinder tanks, retrofit of radiators and new controls. GSHPs also require installation of a ground collector, where the ground collector is expected to have a lifetime of around 50 years. As this is greater than the 20-year appraisal period used in BUS cost-benefit analysis, in our modelling, the cost of this element is prorated and included in the total capital cost of a GSHP. Annual maintenance costs of low carbon and counterfactual technologies are based on assumptions made by BEIS engineers and published in the consultation stage IA[45].

3.7 Monetised costs and benefits

50. Analysis has been conducted to estimate the costs and benefits associated with low carbon heating technologies, relative to the counterfactual. The quantified costs and benefits contributing to the SNPV are:

    a) Capital costs – The estimated capital cost of installing low carbon heating technologies, relative to the counterfactual.

    b) Operational costs – The estimated annual cost of maintaining low carbon heating technologies, relative to the counterfactual.

    c) Carbon values – The estimated value of the carbon abated in both the traded and non-traded sectors due to low carbon heating technologies displacing counterfactual heating systems.

    d) Air quality damage – The estimated value of the public health impacts of changes to emissions of Nitrogen Oxides and Particulate Matter.

    e) Long-run variable costs of energy supply (LRVCs) – The estimated value of the change in energy demand due to low carbon heating technologies displacing counterfactual heating systems.

51. For the BUS scheme, low carbon buildings technologies (ASHPs and GSHPs) have an assumed lifetime of 20 years[46] , and biomass boilers 15 years. The appraisal period for the scheme therefore covers 2022/23 to 2042/43.

3.8 Uncertainty

52. There are several uncertainties around the evidence and understanding of low carbon heating technologies.

    a) Support level - There is uncertainty about the most appropriate grant levels that a new scheme should offer to incentivise consumers to install a low carbon heating system.

    b) Projecting deployments - The factors and market conditions that lead consumers to install low carbon heating systems are not consistent or predictable. This will impact the overall policy costs of the scheme.

    c) Feedback between policy design and uptake - The costs, performance and deployment of technologies are all heavily influenced by a range of factors, such as technical design, installation, and use, which are in turn influenced by individual and market wide reactions to the way policy is designed.

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[45] Consultation Stage IA: Future Support for Low Carbon Heat (April 2020) - LINK
[46] Based on RHI consultation response: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/212090/Government_Response_September_Consultation_on_Proposals_for_a_Domestic.pdf

d) Costs and benefits deriving from deployment - There are several uncertainties around the costs and benefits of any given installation, depending on how the system is used, what it is replacing and how we monetise the benefits accrued.

53. Sensitivity analysis has been conducted to assess the impact of key uncertainties on the SNPV in section 4.6.

4. Impacts Appraisal

54. This section of the impact assessment quantifies the costs and benefits of the Boiler Upgrade Scheme.

4.1 Public Expenditure Estimates – Subsidy and Administration Costs

55. Table 4.1 shows an estimate of Boiler Upgrade Scheme subsidy spend under the deployment scenarios considered.

Table 4.1: Boiler Upgrade Scheme spending profile (£m, undiscounted nominal prices)

Deployment Scenario	Technology	2022/23	2023/24	2024/25	Total
Central	Air Source Heat Pump	150	150	150	445
	Ground Source Heat Pump	<5	<5	<5	5
	Biomass	<5	<5	<5	<5
	Total	150	150	150	450
Low	Air Source Heat Pump	75	75	75	220
	Ground Source Heat Pump	<5	<5	<5	5
	Biomass	<5	<5	<5	<5
	Total	75	75	75	225

Figures are rounded to the nearest £5m and may not sum due to rounding.

56. We intend to appoint Ofgem as the administrator for the Boiler Upgrade Scheme.

57. Short term one-off costs will be incurred in 2020/21 and 2021/22 for setting up IT systems and operational processes. There will then be ongoing costs throughout the lifetime of the scheme, including handling queries, processing grant payments, and conducting the audit and compliance regime.

58. After 2024/25, the scheme will have closed to new applicants. However, administration costs will continue throughout 2025/26 as applications backlog are processed, auditing and compliance work undertaken, and the scheme closed down.

59. Table 4.2 shows our current estimate of the administration costs. The costs presented are best estimates and will change following further discussions and planning with Ofgem.

Table 4.2: Estimated administration costs (£m, 2020 prices)

	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	Total
Administration costs	0.5	5	10	10	10	5	40

Rounded to the nearest £5m; figures may not sum due to rounding.

4.2 Social net present value (SNPV)

60. Descriptions of quantified costs and benefits contributing to the SNPV are provided in sections 3.6 and 3.7. The key social cost components in the central scenario are the capital costs and operational costs of installing low carbon heat technologies relative to the counterfactual. Whilst the key social benefits are carbon savings, averted air quality damage costs and lower long-run variable costs relative to the counterfactual.

61. The SNPV, and components, for Options 1a and 1b are presented in table 4.3. The results show that the SNPV in Option 1a is much greater than in Option 1b and this is due to the higher deployments and the scheme expansion. In both options the SNPV is positive, showing that the benefits outweigh the costs.

Table 4.3: SNPV and components, central deployment scenario (2020 prices, discounted)

Figures are rounded to nearest £5m

	Option 1a (£m)	Option 1b (£m)
Capital cost	-255	-80
Maintenance cost	-10	-10
Carbon savings	+500	+120
Long-run variable fuel costs	+5	+75
Air quality	+70	+30
SNPV	+310	+140

Figures may not sum due to rounding.

4.3 Preferred Option

62. Option 0 (offering no support mechanism for low carbon heating technologies for individual householders and small non-domestic consumers following the closure of the RHI) fails to provide additional carbon savings to contribute to decarbonising heating in the UK and meeting carbon budgets. Of the two options developed, Option 1a is the preferred option, as compared to Option 1b, and it is expected to lead to:

   a) Greater deployment of low carbon technologies.

   b) Greater carbon savings.

   c) A higher SNPV.

4.4 Renewable heat supported

63. Annual renewable heat generated by the BUS is estimated to be 0.3TWh on average from 2022 to 2050. In the first year the renewable heat generated is expected to be 0.1TWh, increasing to 0.3TWh in the second year before reaching 0.4TWh in steady state.

4.5 Greenhouse gas abatement

64. Table 4.4 shows the greenhouse gas savings estimated to be supported over carbon budgets 4 and 5 as a result of the BUS. The table also shows how much of this is traded or non-traded.
65. Emissions are mapped into traded and non-traded sectors in line with established Green Book supplementary guidance[47]. Grid electricity use is attributed to the Traded sector, whereas emissions from the likes of gas and oil consumption for space heating are attributed to the non-traded sector.
66. In the context of an electrification-focussed policy such as with the BUS approach, installing ASHPs and GSHPs in place of existing heating systems (except for direct electric heated

47 "Valuation of energy use and greenhouse gas" – BEIS (October 2021). LINK

properties) should result in non-traded carbon emission savings, but a comparably small increase in traded carbon emissions for the additional electricity being used relative to the counterfactual heating system (e.g., gas or oil).

67. The greenhouse gas abatement potential of the proposed policies is highly dependent on several factors, including the deployment and counterfactual assumptions.

Table 4.4: Profile of greenhouse gas abatement, central assumptions[48]

	CB4 (2023-2027)	CB5 (2028-2032)	CB6 (2033-2037)	Lifetime
Total non-traded savings (MtCO2e)	0.7	0.7	0.7	3.0
Of which upstream	-	-	-	-
Total traded savings (MtCO2e)	-0.2	-0.1	0.0	-0.4

4.6 Carbon Cost Effectiveness

68. Carbon Cost Effectiveness (CCE) shows the estimated average social cost of abating a tonne of carbon dioxide equivalent. A positive number of the indicator represents a net cost per tonne of CO2e, whilst a negative number is a net benefit per tonne of CO2e. There are non-carbon cost and benefits to decarbonising buildings, including air quality improvements and LRVC savings, as a result under the central modelling assumptions for the Boiler Upgrade Scheme[49] the Non-Traded CCE for Option 1a (the preferred option) is a net cost of £92/tCO2e, while the Non-Traded CCE for Option 1b (the alternative option) is a net benefit of £34/tCO2e.

69. The lower CCE in Option 1b compared with Option 1a is caused by a difference in the ratio of carbon to non-carbon elements of the SNPV, which is a result of a change in the proportion of technologies assumed to be deployed in each option[50].

70. Whilst Option 1b performs better than Option 1a in this metric, Option 1a is still our preferred option. Compared with Option 1b, Option 1a has a greater SNPV, is expected to achieve greater carbon savings, and through higher levels of deployment can also enable the developing of supply chains in advance of the introduction of regulations and a proposed market mechanism in the mid-2020s. Option 1a is also expected to lead to the full £450m budget being used in the three years of the scheme (£150m each financial year).

71. Although CCE may be viewed as a value for money measure, caution should be taken when using this metric because it does not capture the full range of wider benefits, such as those outlined in section 3.7.

4.7 Sensitivity analysis

72. Results in section 4.2 are sensitive to changes in several modelling assumptions, including deployment. Sensitivity analysis is conducted on Option 1a (preferred option). This shows the impact of key uncertainties on the SNPV and greenhouse gas abatement. In all sensitivity analysis scenarios, the SNPV is positive.

48 A positive value in Table 4.4 represents a reduction in greenhouse gas emissions, a negative value represents an increase in greenhouse gas emissions.

49 Further details on CCE calculations can be found in the HMT Green Book supplementary guidance: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

50 In Option 1B, a higher proportion of Direct Electric systems are replaced relative to Option 1A. The impacts of this on the SNPV components are summarised in Table 4.3 and Table 4.4. Specifically, Option 1B's Carbon Savings and the Traded to Non-Traded split.

Table 4.5: Summary of sensitivities tested

	Sensitivities tested	Rationale
Deployment	Lower deployment – 50% of central deployment scenario	We have high confidence in the supply chain's ability to deliver at least the central deployment scenario, however there is uncertainty around the grant levels needed to incentivise sufficient demand. The low deployment scenario shows the impact on the SNPV and carbon savings if demand is lower than expected. As the BUS support cannot exceed the £450m budget, a high sensitivity deployment is not tested.
Carbon values	Green Book high Green Book low	The impact of placing a lower and a higher value on greenhouse gas emissions can be illustrated by using the existing low and high carbon values series, in addition to the prescribed central values
Long-run variable costs of energy supply (LRVCs)	Green book high Green Book low	Changes in energy consumption are valued using the LRVCs. These values are subject to uncertainty, and therefore, high and low estimates have been included in the sensitivity analysis.
Counterfactual mix	100% oil replacement 100% gas replacement	Given the demand-led nature of the scheme, it is difficult to accurately predict where new low carbon technologies will be deployed, and the types of systems they will replace. The 2 respective sensitivity scenarios (100% oil and 100% gas) capture both extremes of counterfactual displacement possibilities (both yielding a positive SNPV)[51].
Additionality	100% additionality	RHI evaluation findings have been used to inform our central assumption of 70% additionality, however, as described in section 3.3, there is significant uncertainty around the deployment of low carbon heating technologies in the retrofit market that would occur absence of a support mechanism. An alternative assumption of 100% additionality is therefore also shown.

Table 4.6 Sensitivity analysis (rounded to nearest £5m), Option 1a

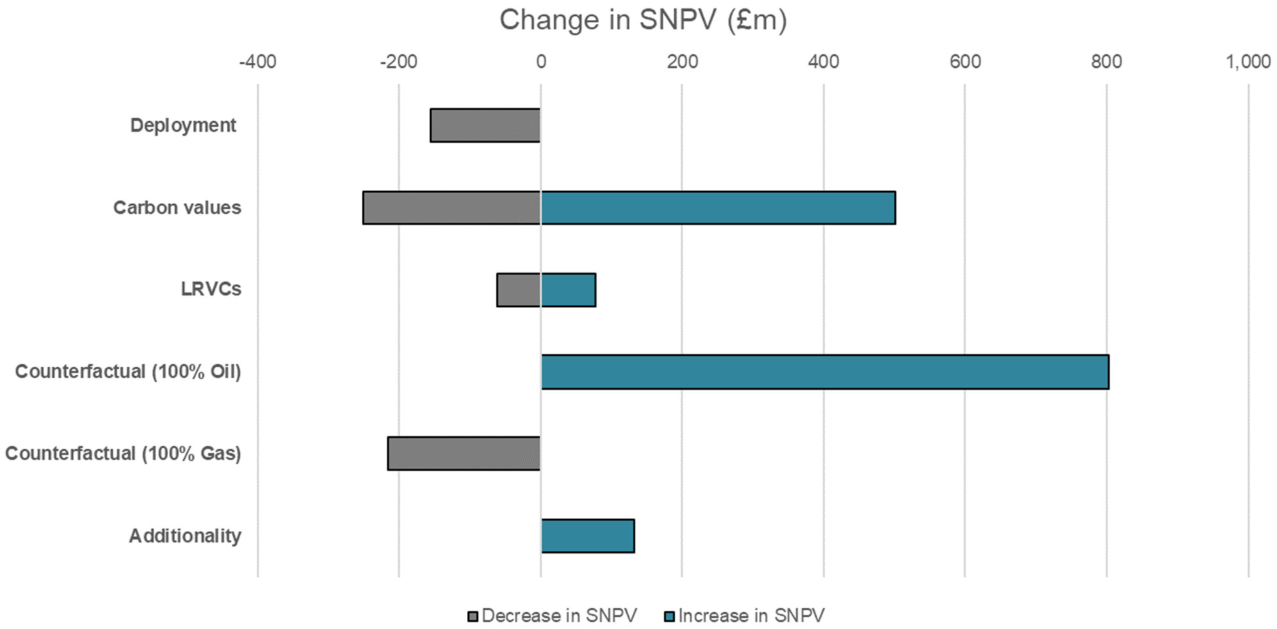
Scenario	Sensitivity	SNPV (to nearest £5m)	Lifetime non-traded carbon savings (MtCO2e)
Deployment	Central	310	3.0
	Low	155	1.5
Carbon value	High	560	3.0
	Central	310	3.0
	Low	60	3.0
Long run variable cost of gas	High	385	3.0
	Central	310	3.0
	Low	250	3.0
Counterfactual	100% oil	1,110	5.8
	Central	310	3.0
Counterfactual	100% gas	95	3.1
	Central	310	3.0
Additionality	High	440	4.2
	Central	310	3.0

73. Chart 1 shows the change, in £m, in the central SNPV for each sensitivity scenario tested. The change in counterfactual assumption from the RHI mix of counterfactual fuels to 100% oil

[51] This is discussed in further detail in Section 3.2 – Counterfactual.

replacement has the largest impact on the overall SNPV. This change is largely driven by an increase in non-traded carbon savings and an increase in air quality benefits.

Chart 1: Difference to overall SNPV following sensitivity analysis, Option 1a



4.8 Optimism bias

74. For the BUS scheme, uncertainty and the subsequent risk of optimism bias is most likely to occur in the overestimation of deployment, which will result in a decrease in the benefits expected from the scheme. As a result of the calibration on levels of demand under the GHG, the deployment estimates are anchored empirically[52]. Furthermore, key parameter assumptions for key metrics (e.g.*, such as on Additionality, discussed in Section 3.3, and the ASHP Coefficient of Performance)* can be considered as on the conservative side and thus further guard against an overestimated SNPV in the central scenario.

75. However, mitigation in the face of the inherent uncertainty of a demand-led scheme is also captured and mitigated for in the low deployment scenario presented in Table 4.6 (still yielding a positive SNPV). The BUS modelling assumptions used to inform cost benefit analysis are based on robust evidence, approved by relevant experts (e.g., BEIS engineers, Defra). Regarding installation cost assumptions, the relatively small-scale nature of the individual technology installations supported by the BUS make it unlikely that total costs in a given scenario will be substantially greater than those used in our modelling. This limits the uncertainty in these cost calculations estimations, and so an optimism bias adjustment is not considered to be appropriate here.

4.9 Non-monetised costs and benefits

76. There are several non-monetised costs and benefits that are not captured in the cost-benefit analysis, including:

    a) **Supply chain development** – By incentivising additional deployment of low carbon heat technologies relative to the counterfactual, the scheme will maintain low carbon heat supply chains. This will provide a 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. It will also help to create

52 See Paragraph 45 for further details.

green jobs and opportunities for UK manufacturers. If monetised, this would have a positive impact on the SNPV of the BUS.

b) **Innovation and cost reductions** – The mass roll-out of low carbon heating in the second half of the 2020s, enabled by the BUS, is expected to reduce costs and possibly increase performance over time. This is expected to take place as supply chains further develop and barriers that customers currently face are reduced through technologies being deployed successfully. These future cost reduction and performance improvement benefits from the BUS-enabled mass rollout of low-carbon heating technologies are not quantified in this impact assessment. If monetised, this would have a positive impact on the SNPV of the BUS.

c) **Rebound effect**[53] – For some heat users, installing a low carbon heat technology could lead to an efficiency-driven overall lowering of fuel bills (depending on characteristics such as the existing fuel system, home size and Energy Proficiency rating). Lower bills may then lead to an overall increase in energy consumption. This has not been quantified because of the heterogeneity in household responses and the lack of evidence for heating. If monetised, the impact on the SNPV of the BUS is uncertain, as there would be a potential reduction in carbon savings, but with increased welfare benefits.

d) **Health benefits** – Switching away from fossil fuels can lead to improved indoor air quality for occupants. In addition, making energy efficiency improvements ahead of installing a low carbon technology can lead to a warmer home and therefore improve the health of occupants, for example by reducing their risk of cardiovascular and respiratory diseases as a result of warmer internal temperatures. If monetised, this would have a positive impact on the SNPV of the BUS.

e) **Consumer familiarity and perception towards renewable heat** - the BEIS Public Attitudes Tracker indicates that 43% of the public are unfamiliar with air source heat pumps, having never heard of them[54]. However, customers who have installed renewable heating technologies have expressed high levels of satisfaction[55]. Heat pumps may require consumers and businesses to operate their heating systems in an unfamiliar way compared to conventional heating systems. The increased installation of low-carbon heating appliances will improve the familiarity of the public with technologies essential to reach the net zero target. If monetised, this would have a positive impact on the SNPV.

4.10 Regional impacts

77. As the BUS is a demand-led scheme, it is difficult to determine where in England and Wales deployment will take place. Evidence from the RHI (which includes Scotland) provides insight into where demand is likely to be based off current deployment trends, however the change in scheme design (from a tariff-based support mechanism to an up-front capital grant) may result in a change in the profile and geographic distribution of households installing low carbon heat technologies.

78. Table 4.7 shows the regional proportion of accredited domestic applications using the Domestic RHI deployment statistics data between April 2014 and August 2021 where for ASHPs the largest proportion of accredited applications was in Scotland (19%) followed by the East of England (16%). For GSHPs, the largest proportion of accredited domestic applications were in the South West of England (18%), followed by Scotland (13%). For biomass, the largest proportion of accredited domestic applications were in Scotland (30%), followed by the South West of England (13%)[56].

[53] Socio-macroeconomic impacts of meeting new build and retrofit UK building energy targets to 2030: a MACRO-UK modelling study.
[54] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/959601/BEIS_PAT_W36_-_Key_Findings.pdf Figure 15
[55] https://www.gov.uk/government/publications/rhi-evaluation-interim-report-applicant-reaction-to-reform-announcements
[56] BEIS (2020) RHI deployment data.

Table 4.7 RHI accreditations by region (%)[57]

Region	ASHP	GSHP	Biomass
North East	3%	2%	4%
North West	5%	8%	8%
Yorkshire and The Humber	9%	10%	10%
East Midlands	11%	9%	7%
West Midlands	5%	10%	6%
East	16%	9%	7%
London	1%	1%	<0.1%
South East	12%	12%	5%
South West	14%	18%	13%
Wales	5%	10%	10%
Scotland	19%	13%	30%
Total	**100%**	**100%**	**100%**

79. We expect jobs to be supported in regions with higher demand which will help support the government's levelling-up agenda, as we expect supply chains to be supported and jobs to be sourced outside of London. RHI statistics show only 1% of accredited domestic applications for BUS supported technologies were in London.

4.11 Full-time equivalents supported

80. An estimate of the number of full-time equivalents (FTE) supported through the BUS has been calculated using the Construction Industry Training Board (CITB) model[58] which calculates the number of full-time equivalents (FTE) supported through heat pump deployment. The CITB uses a bottom-up approach by looking at the time it takes to install heat pumps and covers a wider range of job spectrum associated with installations, hence giving a more accurate picture of the total direct jobs supported through the BUS (e.g., office jobs, surveyors).

81. In addition to the FTE directly supported through installation of low carbon technologies, jobs are also expected to be supported in the wider low carbon heating industry. These are known as indirect jobs and are included in our total estimate of FTE supported through the BUS.

82. The findings from the Low Carbon and Renewable Energy Economy (LCREE) Survey, published by Office for National Statistics (ONS)[59] have been applied to the CITB direct FTE estimate to provide indirect FTE estimates. For every direct FTE in renewable heat, it is estimated that there are 0.9 indirect FTE supported.

Table 4.8 Estimate of FTE supported (Option 1a, rounded to the nearest 50 FTE)

Option 1a	2022/23	2023/24	2024/25
Direct FTE	2,100	2,100	2,100
Indirect FTE	1,800	1,800	1,800
Total	**3,900**	**3,900**	**3,900**

[57] Table 2.3 - Renewable Heat Incentive statistics. LINK.
[58] https://www.citb.co.uk/about-citb/construction-industry-research-reports/search-our-construction-industry-research-reports/Sustainability/Building-Skills-for-Net-Zero/
[59] ONS (2020) LCREE Survey direct and indirect estimates of employment, UK, 2014 to 2018.

5. Monitoring and Evaluation

83. Given the high-profile nature and substantial spend of the Boiler Upgrade Scheme, a robust monitoring and evaluation approach will be implemented. The monitoring and evaluation will demonstrate the impact and outcomes of the proposed scheme, providing a measure of success against the aims set out in section 2, as well as providing evidence throughout the scheme to inform future low carbon heat policy development. The monitoring will also be required to provide sufficient evidence to support a robust scheme and budget management.

84. Monitoring and evaluation of the BUS will assess the extent to which it met its objectives and recognised expected impacts, as well as collecting that will support wider learning in relation to this policy area and aims to:

    - Support reporting of scheme benefits.
    - Support scheme management, including tracking of delivery, financial management and amendments to the scheme.
    - Provide evidence to understand the barriers and opportunities experienced during delivery to support future policy design.
    - Provide evidence of the impacts achieved by the scheme, to support both benefits reporting and future policy design.
    - Support an assessment of the value for money of the policy design including evaluation of the grant levels in response to market changes throughout scheme duration.

85. BEIS will monitor deployment, as well as spend and benefits of the scheme following implementation, and will work closely with the scheme administrator to ensure information collected from applicants enables effective monitoring of the scheme against the key aims of increasing deployment of low carbon heat technologies and contributing to decarbonising heating in the UK.

86. Our monitoring and evaluation will involve regular reporting to ensure that scheme objectives and the success of the BUS in delivering its benefits are kept under close review. For example, the evaluation contract will require the contractor to deliver an 'interim findings' report relatively early on in BUS delivery, based on early fieldwork. Furthermore, we will consider where early insights could be prioritised as part of the evaluation to enhance learning and scheme design. We will monitor a range of metrics to assess whether the scheme is on track. These metrics will include early indicators of the scheme's performance, budget management and benefits metrics. Early performance indicators will be based on frequently updated data that will quickly highlight any early warning signs regarding the scheme.

87. Reporting will identify early successes of the BUS and highlight any potential issues with the scheme. Where appropriate, we will consider how scheme design and/or delivery might be adjusted to address issues as quickly as possible. Monitoring and evaluation reports will be aligned with the scheme's internal budget management process. This will ensure the latest monitoring and evaluation evidence is available at the points where key budgetary and management decisions are made.

88. Post-implementation evaluation projects will provide further analysis of information not collected by the administrator. A thorough evaluation plan will be developed in advance of the scheme implementation and will be integrated into scheme delivery. We expect that the evaluation will seek to answer questions such as:

    - To what extent has the scheme achieved its aims?
    - How has the design of the scheme influenced the impacts that were achieved?
    - To what extent is the scheme offering value for money (for example, in comparison to previous schemes like the RHI)?

89. It is expected that the evaluation approach will follow a similar one to that applied in the evaluation of the RHI scheme. This approach uses a theory-based method which not only assesses the overall impacts of the scheme, but also identifies those impacts that the scheme will be having in a range of different contexts and on different consumers and installers. If this approach is adopted then the evaluation would include further analysis of scheme monitoring data, bespoke data collection from applicants through surveys, as well as interviews and wider evidence gathering to inform impacts on the market for renewable heating systems.

6. Equalities Assessments

90. To comply with the Public Sector Equality Duty, due regard has been given to the potential impact of BUS 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:

    - eliminate unlawful discrimination, harassment and victimisation and other conduct prohibited by the Act.
    - advance equality of opportunity between people who share a protected characteristic and those who do not.
    - foster good relations between people who share a protected characteristic and those who do not.

91. The main groups that will be affected by the policy are:
    - Consumers (both on and off gas grid) – who will benefit from subsidised installation of heat pumps and (in limited circumstances) biomass boilers.
    - Installers of heat pumps and biomass boilers – who will be contracted for installations of low carbon heat technologies and will apply for grants to contribute to the costs of undertaking the installation.
    - Manufacturers – who will likely see increased demand of low carbon heat technologies as the market grows.

92. It is our view that BUS should have limited adverse or disproportionately negative impact on people who share a protected characteristic. The BUS is a demand-led scheme with deployment expected to take place across England and Wales. There are no eligibility criteria regarding the protected characteristics in the BUS application process unlike other low carbon heat and energy efficiency schemes. One of the main intended outcomes of the policy, carbon emissions reductions to contribute to meeting carbon budgets 4, 5 and 6, is a non-excludable public good and therefore expected to benefit the majority of the population without distributional impacts for specific groups. Social Housing will be excluded from the Boiler Upgrade Scheme and therefore the scheme will not benefit the entire population. Social Housing will be specifically targeted through the Social Housing Decarbonisation Fund (SHDF) which will make financial support available for energy efficiency and low carbon heat upgrades.

93. The grant model is designed to broaden access to support versus tariff mechanisms where the full costs of installations are required to be paid by customers upfront. However, consumers will be required to meet the remaining upfront capital costs of installations as well as ongoing system maintenance and running costs. Overall, it is therefore possible that more people with protected characteristics may be able to access support under the BUS proposals compared with previous tariff-based support schemes, potentially advancing equality of opportunity between people who share a protected characteristic and those who do not. This view was shared by stakeholders in responses to the public consultation conducted on the Future Support for Low Carbon Heat consultation proposals in April 2020.

94. We recognise that the cost of a low carbon heating system may remain a barrier to those on lower incomes as the proposed grant levels are lower than the average additional cost of a low carbon system relative to a fossil fuel system. The BUS will be introduced alongside other complementary mechanisms for low carbon heat to support vulnerable, lower income households. The Home Upgrade Grant (HUG) will fully fund energy efficiency upgrades and low carbon heat installations, taking a whole house retrofit approach to the worst performing and low-income properties from 2022. The Social Housing Decarbonisation Fund (SHDF) will support social landlords to make energy efficiency and low carbon heat upgrades.

95. In designing the application process, with due regard to disability, we intend to develop a manual application process and form to assist those who are not able to apply electronically for any reason.

96. BUS is not expected to:
    - directly or indirectly disadvantage some people or groups more than others.
    - impact on equality of opportunity between people with protected characteristics and those without.
    - either foster or inhibit good relations between people with protected characteristics and those without.

7. Small and Micro-businesses Assessments (SAMBA)

97. In this SaMBA we have considered the impacts of the BUS on both low carbon heating suppliers and non-domestic BUS customers who will install a low carbon heating system.

98. In terms of low carbon heating suppliers, data from the Heat Pump Association indicates that the large majority of existing installers are small or micro businesses[60]. Since a key objective of the BUS is to build supply chains, the BUS should both maintain existing small or micro low carbon heat businesses and create opportunities for new businesses. Following the closure of the DRHI, the BUS is likely to benefit these small and micro businesses relative to the counterfactual where supply chains are not maintained or further developed.

99. The impact of the BUS on small and micro businesses who take up a low carbon heating system under the BUS is expected to be negligible. Our analysis assumes that the proportional take up of domestic and non-domestic installations will be in line with deployment seen under the RHI of installations with a capacity less than 45kWth. Based on RHI deployment data, we expect that approximately 5% of the BUS installations would be non-domestic. According to the Federation of Small Businesses, at the start of 2020 there were 5.94m small businesses[61].

Table 6.1 Non-Domestic and Domestic Renewable Heat Incentive ASHP, GSHP and biomass boilers with capacity less than or equal to 45 kW installed (Great Britain) - monthly cumulative to November 2019.

	Deployment	Proportion of total deployment
Non-domestic	2,878	5%
Domestic	57,750	95%
Total	60,628	100%

100. However, those non-domestic properties that are likely to take up the low carbon heating under BUS, would predominately be occupied by small or micro businesses given the size limit of installations (up to 45kWth).

[60] https://www.heatpumps.org.uk/wp-content/uploads/2019/11/Installer-Skills-Survey-Summary.pdf
[61] https://www.fsb.org.uk/uk-small-business-statistics.html

Annex

A – Biomass air quality assumptions

1. Biomass air quality emissions factors are based on research into the level of performance of biomass boilers under the RHI[62]. The RHI imposes a limit on oxides of nitrogen (NOx) and particulate matters (PM) emitted by biomass products. Applicants are required to provide a valid emissions certificate to show their boiler does not exceed these limits. The Ofgem website provides further information on RHI limits and emissions certificates[63]. The Boiler Upgrade Scheme will impose the same emissions limits and certificate requirements.
2. Biomass air quality damage costs are calculated using Defra's Air Quality Damage Costs Appraisal Toolkit[64].

Table A1: Biomass air quality assumptions

Measure	PM2.5	NOx
Emission factors (kg/kWh)	0.000216	0.00036
Damage costs (£/kg), 2020 prices	98.83	13.75

[62] Biomass boilers: measurement of in-situ performance: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance
[63] Emission Certificate (RHI): https://www.ofgem.gov.uk/key-term-explained/emission-certificate-rhi
[64] Air Quality Damage Costs Appraisal Toolkit : https://www.gov.uk/guidance/air-quality-economic-analysis

B - Technical assumptions

Counterfactual

1. Evidence from the NHM data and the RHI statistics were used to make assumptions on the types of counterfactual heating systems that will be replaced by low carbon heating technologies in the Boiler Upgrade Scheme for the respective Options and sensitivities. The counterfactual displacement assumptions for ASHPs were derived from the NHM data while those for GSHPs and biomass boilers were from RHI official statistics[65]. The RHI Statistics are also used to model the counterfactual for Option 1B in the Central Scenario. The estimated proportions of counterfactual fuels displaced by low carbon technologies are shown in Table B1.1 for Option 1A, and in Table B1.2 for Option 1B respectively.

Table B1.1: Counterfactual displacement by fuel type – Central Scenario (Option 1A)

	Fuel type displaced (%)					
	Oil	LPG	Coal	Direct electric	Natural gas	Total
ASHP	18	6	0	14	61	100
GSHP	51	7	4	28	9	100
Biomass	66	9	8	17	0	100

Table B1.2: Counterfactual displacement by fuel type – Central Scenario (Option 1B)

	Fuel type displaced (%)					
	Oil	LPG	Coal	Direct electric	Natural gas	Total
ASHP	31	4	7	41	17	100
GSHP	51	7	4	28	9	100
Biomass	66	9	8	17	0	100

2. The alternative counterfactuals presented in the BUS sensitivity analysis model scenarios where all low carbon heating technologies replace oil boilers *(100% oil displacement)* and gas boilers *(100% gas)* respectively[66].

Low carbon technology assumptions

3. Tables B2, B3 and B4 show the low carbon heating cost and performance assumptions used in the BUS cost-benefit analysis.

[65] Non-Domestic and Domestic Renewable Heat Incentive (RHI) monthly deployment data (Great Britain): December 2020 - LINK
[66] See Paragraph 36 for further details.

Table B2: Air source heat pump assumptions – Central Scenario (Option 1A)

Assumption	Central	Source
Average annual heat demand of counterfactual housing stock (kWh)[67]	11,500[68]	National Energy Efficiency Data Framework (NEED) 2018
Average estimated capex of an ASHP installed under BUS (£)*[69]	8,900	Delta EE / BEIS assumption[70]
Annual maintenance cost (£)	100	BEIS assumption
Efficiency (%)	244	Renewable Heat Premium (RHPP) Scheme Metering[71]
Lifetime	20 years	BEIS assumption informed by RHI consultation

*2020 prices

[67] Information on annual heat demand is derived from the National Housing Model (NHM), in addition to the National Energy Efficiency Data-Framework (NEED). The average annual heat demand for each low carbon technology is then found by applying the counterfactual assumptions on fuel types being replaced (Table B1 & B2). Heat demand includes space heating and hot water.

[68] The weighted average annual heat demand various between different property types and the counterfactual fuel type they are using to heat their homes, it is therefore ultimately sensitive to the counterfactual displacement of ASHP displacement.

[69] The weighted average capital costs of technologies deployed under the scheme will ultimately be sensitive to where deployment occurs and the types of property (and existing fossil fuel system being replaced), this is subject to uncertainty under a demand-led scheme.

[70] Capex assumptions are based on forthcoming report by Delta-EE: The Cost of Installing Heating Measures in Domestic Properties. The capex estimates include the cost of the device, labour fee, fittings, new buffer and cylinder tanks, retrofit of radiators and new controls. Converting an oil system would incur additional decommissioning cost for the oil tank. The Delta-EE information is used alongside BEIS market intelligence to model the anticipated capital costs available for different segments of households (and small businesses) to best reflect anticipated market developments over the lifetime of the BUS.

[71] The Seasonal Performance Factor (SPF) levels are based on the B4 system boundary. Low and high are based on the 25th and 75th percentile of the B4 system boundary.

Table B3: Ground source heat pump assumptions[72] – Central Scenario

Assumption	Central	Source
Average annual heat demand of counterfactual housing stock (kWh)	13,200	National Energy Efficiency Data Framework (NEED) 2018
Average capex (£)*	25,000	Delta EE / BEIS assumption
Annual maintenance cost (£)	100	BEIS assumption
Efficiency (%)	271	Renewable Heat Premium (RHPP) Scheme Metering
Lifetime	20 years[73]	BEIS assumption informed by RHI consultation

*2020 prices

[72] For modelling purposes, water source heat pumps are assumed to have the same technical assumptions as ground source heat pumps.
73 The Lifetime of the ground collector component is assumed to have a lifetime of 50 years. The ground collector component of the GSHP CAPEX calculation is adjusted pro-rate to reflect this.

Table B4: Biomass boiler assumptions – Central Scenario

Assumption	Central	Source
Average annual heat demand of counterfactual housing stock (kWh)	15,300	National Energy Efficiency Data Framework (NEED) 2018
Average capex (£)*	21,200	Delta EE / BEIS assumption
Annual maintenance cost (£)	100	BEIS assumption
Efficiency (%)	70	Biomass field trial[74]
Lifetime	15 years	BEIS assumption informed by RHI consultation

*2020 prices

[74] Biomass Boilers - Measurement of In-situ Performance (2019): https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance

C – Changes since consultation stage impact assessment

Assumption	Description of Change	Source	Impact on SNPV
Lifetime of biomass boilers	In the consultation stage IA analysis, all low carbon technologies (ASHP, GSHP and biomass) were assumed to have a lifetime of 20 years. This assumption has since been revised by BEIS engineers; biomass boilers are now assumed to have a shorter lifetime of 15 years.	BEIS engineer judgement	The shorter assumed lifetime of biomass installations led to a small reduction in SNPV.
Counterfactual mix of technologies	The assumed counterfactual mix of technologies used in BUS modelling is assumed to be the same as seen in the NHM data for ASHPs but for GSHPs and Biomass the same as seen in the Domestic RHI.	National Housing Model data and Official RHI deployment statistics.[75]	The updated displacement figures from the NHM data include a higher proportion of gas heating, this contributed to a large SNPV.
Capital costs of technologies	The average capital costs of technologies have been updated based on further analysis using the National Housing Model (NHM).[76] The NHM uses a Standard Assessment Procedure (SAP)-based energy calculator and dwelling information to estimate the size of heating system required and overall installation costs for each building archetype. The NHM information is used alongside BEIS market intelligence to model the anticipated capital costs available for different segments of households (and small businesses) to best reflect anticipated market developments over the lifetime of the BUS.	Underlying capital cost assumptions are based on research carried out by Delta-EE.[77] The average capital costs used in the BUS model are derived through modelling underlying Delta-EE assumptions in the NHM.	Capital costs estimated from the NHM data led to an increase in SNPV when compared to capital costs estimated from using the DRHI statistics.
Air quality damage costs	The electricity and fossil fuel air quality damage costs used in the BUS modelling have been updated to use the latest values from Defra. These costs supersede the air quality damage costs in the data tables supporting the Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas emissions.[78]	Defra	Updated damage costs from Defra are higher for fossil fuel systems compared to values published in the Green Book data tables, this led to a medium increase in SNPV.

[75] Renewable Heat Incentive Statistics: https://www.gov.uk/government/collections/renewable-heat-incentive-statistics
[76] The NHM contains detailed information from around 20,000 household samples, taken from the English Housing Survey, Living in Wales Survey and Scottish Household Survey. The samples are extrapolated to represent the housing stock in Great Britain.
[77] The Delta-EE study was carried out in 2017, prices have been inflated to 2020 prices for use in our analysis. Source: https://www.gov.uk/government/publications/cost-of-installing-heating-measures-in-domestic-properties
[78] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Additionality	There is limited evidence to suggest deployment of low carbon heating technologies in the retrofit market would continue in the absence of a support mechanism. For this reason, the central assumption in the consultation stage IA was 100% additionality. The additionality assumption has since been revised to 70%, following further analysis of RHI evaluation responses. Section 3.8 outlines uncertainties around estimating additionality, and an alternative assumption of 100% additionality is shown in sensitivity analysis.	RHI evaluation[79]	Reducing the additionality assumption from 100% to 70% led to a large reduction in the SNPV.
Grant levels (see further details below)	In the consultation stage IA, a £4000 flat-rate grant was proposed for each technology. We now propose a £5000 grant for ASHPs, £6000 grant for GSHPs and £5000 grant for biomass. The scheme budget has significantly increased and has subsequently expanded the deployment potential. As discussed in section 2.2, based on the evidence available, a flat-rate, technology neutral grant of £4000 is not expected to lead to the full £450m budget being used.	Key sources of evidence used to inform grant levels: • Delta EE Microgen Insight Study Owner-Occupier Stated Preference Survey (Delta EE, July 2015), unpublished • Grant level experiment carried out by Winning Moves, unpublished. • Heat Pump Association Roadmap[80] • Monitoring data from the RHI and Green Homes Grant (GHG).	The increase in grant level, budget and deployment potential, compared with the consultation stage IA, resulted in an increase in SNPV.
Deployment scenarios	In the consultation stage IA, the split of deployment across technologies was assumed to be the same as seen under the Domestic RHI. For the BUS IA, NHM data calculations was combined with GHG application statistics to estimate deployment scenarios for ASHP. For GSHP and Biomass boiler deployment, the GHG application statistics were combined with findings from grant level social research.	Green Homes Grant statistics[81]. Grant level experiment carried out by Winning Moves. National Housing Model data extract and analysis[82].	The updated deployment scenarios reflect a higher grant level and overall budget of the BUS scheme relative to the CHG proposal at consultation stage. These updates result in an increased SNPV.

[79] RHI Evaluation: https://www.gov.uk/government/publications/report-from-waves-1-24-of-the-domestic-rhi-census-of-accredited-applicants
[80] A road map for the Role of Heat Pumps.
[81] Green Homes Grant statistics: https://www.gov.uk/government/collections/green-home-grant-statistics
82 National Housing Model (2017) - LINK

Additional information on grant level setting

1. A more detailed rationale for the grant levels proposed for ASHPs, GSHPs and biomass are provided below.

2. **ASHP:** The proposed £5,000 grant for ASHPs has been chosen by considering

   2.1 **Price elasticity research**: The limited evidence on the relationship between cost and consumer uptake indicated that below £10,000, which is deemed a psychological threshold, price elasticity increased, and if costs were reduced to below £7,000, then uptake would climb sharply.[83] Based on our capital cost assumptions and analysis of the National Housing Model data extract, we expect a £5,000 grant would reduce the upfront cost of installing an ASHP for the majority of households in England & Wales to below the psychological threshold of £10,000, and close to £7,000, the point at which uptake should climb sharply. For market segments and household types who face lower upfront costs to install an ASHP, uptake after the impact of an upfront grant is anticipated to be even higher.

   2.2 **Social research:** BEIS commissioned Winning Moves to carry out a survey on RHI applicants, which explored whether or not they would have proceeded with their low carbon installation, if an upfront grant had been available, instead of the tariff support provided by the RHI. Applicants who had installed an ASHP were randomly allocated to one of three groups with each group being presented with a different grant value in the survey[84]. Findings from the survey showed that the cut-off point, beyond which a majority (over 50%) of RHI applicants would have proceeded with an ASHP installation if an up-front grant had been available, rather than an ongoing payment over seven years, was around £5,000. The research showed that 45% of RHI applicants said that they were either likely or very likely to go ahead with their ASHP installation if offered a £4,000 grant, and this increased to 68% if offered a £6,000 grant. When asked to indicate the minimum grant amount they would have required to have proceeded with their installation, the average minimum grant was between approximately £5,000 and £7,000.

   2.3 **Green Homes Grant:** Published Green Homes Grant (GHG) statistics[85] show that, from scheme launch on 30 September 2020 up to 31 March 2021, there were 5,652 applications for ASHPs. These were applications for the main scheme only, which offered a grant of two-thirds of the cost of eligible improvements, up to £5,000. Applicants for ASHPs under the GHG were therefore awarded a £5,000 grant, given the average cost of a system exceeds £7,500. Throughput on the GHG was affected by non-demand factors. However, there were no indications to suggest that demand was robust enough to withstand a reduction in the grant being offered below £5,000 and still maintain the level of deployment seen under the DRHI[86].

   2.4 While the Heat Pump Association (HPA) put forward £4,000 as a suitable level of upfront funding for ASHPs for off gas grid deployment in their heat pump roadmap[87], responses to the public consultation, monitoring statistics from the Green Homes Grant and the research carried out by Winning Moves suggests that a grant higher than £4,000 would be required to increase confidence in meeting the scheme objective of building the supply chain for low carbon heat ahead of the proposed introduction of regulations and a market mechanism in the mid-2020s. On this basis, an ASHP grant of £5,000 is our preferred option, and an ASHP grant level of £4,000, as consulted on, is presented in this IA as our alternative option.

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[83] Delta EE (2015) Microgen Insight Study Owner-Occupier Stated Preference Survey.
[84] The grant values offered to DRHI applicants who had installed an ASHP were £3,000, £4,000, and £6,000.
[85] BEIS (2021) Green Homes Grant statistics.
[86] In 2020, there were 9,600 accredited applications for ASHP under the domestic RHI. BEIS (2021) Renewable Heat Incentive statistics.
[87] Heat Pumps (2019) A Roadmap for the Role of Heat Pumps.

3. **GSHP:**

3.1 When interviewed for a domestic heat pump fieldwork project, installers were concerned that the GSHP market would see a major decline if the grant level for GSHP was not increased from £4,000 (as proposed in the consultation)[88].

3.2 Based on capital cost estimates from Delta-EE research, National Housing Model analysis, and our assumption on the counterfactual mix of technologies displaced, we expect the average cost of a GSHP deployed through the scheme to be around £25,000[89]. The high capital cost of GSHPs creates challenges for an upfront grant support mechanism, given a limited scheme budget and the need to reduce overall reliance on government subsidy. However, this impact assessment recognises the potential higher average efficiency that can be achieved by a GSHP (relative to an ASHP) as well as the greater longevity of elements of the capital cost components, this is detailed in Table B.3.

3.3 A £6,000 grant for GSHP was recommended by the Heat Pump Association in their roadmap, and £6,000 was also the main figure proposed by consultation responses. Findings from the Winning Moves social research showed that the proportion of respondents who said they would install a GSHP with a £6,000 grant was around 37%. We recognise that a £6,000 grant level is likely to be proportionately more attractive for shared ground loop projects that may achieve lower costs per property relative to individual retrofit installations. On balance, having carefully considered the ground-source heat pump industry feedback detailed in the BUS GR, an increased £6,000 grant is proposed for GSHPs.

4. **Biomass:**

4.1 While heat pumps are one of the primary technologies for decarbonising heat, around 20% of off gas grid fossil fuel homes are not currently suitable for low temperature heat pumps, and 5% not suitable for a high temperature heat pump, even following energy efficiency measures. There needs to be a viable low carbon alternative technology for such buildings. Solid biomass boilers are one of the technology choices that can provide adequate thermal comfort without the need for potentially costly or unfeasible energy efficiency upgrades, and where there is an existing supply chain that has been developed under the RHI. Under the BUS, it is proposed that biomass boilers will only be eligible in properties off the gas grid and those in rural locations, to mitigate the risk of deployment of biomass in locations where it could have a negative impact on air quality.

4.2 Under the RHI, we have built up a significant supply chain of both installers and sustainable fuel supply for biomass. It is important that there is support for biomass, subject to wider compatibility with government's approach to air quality policy, to maintain this supply chain. If all future support for biomass boilers were to be removed, it is likely that this existing supply chain would contract. This could have a knock-on impact on the UK biomass fuel supply chain which could push up prices for existing biomass users, leading to potential concerns around fuel poverty.

4.3 As with GSHPs, the higher upfront cost of biomass boilers means a grant level greater than £4,000 is needed to incentivise deployment. Findings from the Winning Moves social research showed that the proportion of respondents who said they would install a biomass boiler with a £9,000 grant was 88%. As the BUS is primarily targeted at supporting heat pump deployment, it is likely that a £9,000 grant could be too generous and lead to over-deployment of biomass boilers relative to the other technologies[90]. We therefore propose a grant level of £5,000, in line with the proposal for ASHPs.

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[88] Evaluation of the reformed Renewable Heat Incentive - Domestic Heat Pump Fieldwork (publication pending).

[89] GSHP cost assumption includes unit cost, fittings, buffer tank and cylinder, controls, retrofit radiators, labour and ground collector. In addition, £1,000 oil tank removal cost is added to the cost of replacing oil heating systems.

[90] Applicants who had installed a biomass boiler were presented with only one value for the grant (£9,000) due to a small population size.