Title: Consultation Stage IA: Future Support for Low Carbon Heat **IA number:** BEIS007(C)-20-CG **Lead department or agency:** Department for Business, Energy and Industrial Strategy (BEIS) **Other departments or agencies:** N/A	**Impact Assessment (IA)** **Date:** 28/04/2020 **Stage:** Consultation **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**
£140m	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 proposed future support for low carbon heat aims to incentivise the cost-effective installation of low carbon heat technologies and the generation of renewable heat following the current support scheme for low carbon heating, the Renewable Heat Incentive (RHI).

What are the policy objectives and the intended effects?

The overarching aim of future support for low carbon heat is to incentivise the cost-effective installation of low carbon heat technologies and generation of renewable heat in order to: contribute to decarbonising heating in the UK and to meeting carbon budgets; develop the low carbon heat market and supply chain to support the mass roll out of low carbon heat technologies required in the 2020s; contribute to the UK Government legal obligation to reach net zero emissions by 2050.

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

Option 0 (counterfactual): do nothing/no support mechanism following the extended Domestic RHI and the flexible allocation of tariff guarantees in the Non-Domestic RHI.

Option 1 (preferred option): provide support for biomethane injection into the gas grid through the Green Gas Support Scheme and provide support for buildings technologies (heat pumps and in limited circumstances, biomass) through the Clean Heat Grant.

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:** +0.1	**Non-traded:** -22.8		

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: 28 April 2020

SUMMARY: ANALYSIS & EVIDENCE POLICY OPTION 1

DESCRIPTION: FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2020	2020	25	**Low:** N/A	**High:** N/A	**Best Estimate:** £140m

COSTS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant	Total Cost (Present Value)
Low	N/A		N/A	**N/A**
High	N/A		N/A	**N/A**
Best Estimate	N/A		N/A	**£2,460m**

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

Both the Green Gas Support Scheme and Clean Heat Grant will see costs arising from supporting eligible low carbon technologies, with a social cost of £2,460m within the central scenario. This is mainly as a result of the additional costs of installing low carbon technologies in place of conventional systems. For the Green Gas Support Scheme, there is also a cost associated with the impact of ammonia emissions arising from digestate (a by-product of biomethane production) on air quality. For the Clean Heat Grant, there is a small cost associated with carbon emissions in the traded sector.

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

For the Clean Heat Grant, installing a low carbon heat technology could lead to an efficiency-driven overall lowering of fuel bills, which could lead to an overall increase in energy consumption. This is known as a 'rebound effect'. This has not been quantified because of the heterogeneity in household responses and the lack of evidence for heating.

BENEFITS (£m)	Total Transition (Constant Price)	Years	Average Annual (excl. Transition) (Constant	Total Benefit (Present Value)
Low	N/A		N/A	**N/A**
High	N/A		N/A	**N/A**
Best Estimate	N/A		N/A	**£2,600m**

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

For the Green Gas Support Scheme, the main monetised benefits are the reduction in non-traded carbon emissions and the value of fossil fuels replaced through the production of biomethane. For the Clean Heat Grant, the main monetised benefits are the reduction in non-traded carbon emissions, and the improvement in air quality.

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

There is no agreed value for renewable energy, so the contribution of installations supported by the scheme towards targets under the EU Renewable Energy Directive (RED) is not monetised. Additional benefits include innovation benefits and reduced technology costs, due to learning from wider deployment and cost reductions in low carbon heating system installation driven by the scheme, leading to future decarbonisation being more cost effective. These benefits have not been monetised and are not included in the Social Net Present Value (SNPV).

Key assumptions/sensitivities/risks **Discount rate (%)** 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 deployment, carbon prices, fuel costs and the counterfactual. Sensitivity analysis is presented separately for the Green Gas Support Scheme and Clean Heat Grant, differences in the key sensitivities across the schemes make it difficult to accurately estimate an overall low and high estimate.

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

Executive Summary

1. This impact assessment is part of the consultation on The Future Support for Low Carbon Heat. It aims to appraise the impact of two proposed support schemes and illustrates the analysis that has supported key policy proposals.
2. We propose support for the following key technologies:
   a) Biomethane injection into the gas grid through the **Green Gas Support Scheme**. In the 2020 Budget, the Chancellor announced that this new support scheme will be funded by a Green Gas Levy. The scheme is expected to begin in financial year 2021/22 and will run until financial year 2025/26. The indicative scenario included in this analysis assumes that plants deployed under this scheme will receive tariff payments for 15-years following commissioning. The final payments are therefore assumed to be in 2040/41.
   b) Buildings technologies (heat pumps and, in limited circumstances, biomass) through the **Clean Heat Grant**, funded by the exchequer. The scheme is expected to begin in April 2022, with funding committed for two years, to March 2024.
3. To assess the impact of the schemes, we have developed deployment scenarios, which set out potential profiles for spend, carbon savings and renewable heat supported. These estimates have been produced by drawing on a range of sources, including market intelligence and evidence from the RHI, and the use of international evidence for the Clean Heat Grant.
4. We anticipate that the schemes could deliver annual generation of 2.9TWh of renewable heat in 2030/31 and deliver 10.3MtCO2e of non-traded carbon abatement over carbon budgets 4 and 5. There is considerable uncertainty about these impacts, which are explored in more detail in section 3.5.
5. There are also significant uncertainties in the Social Net Present Value (SNPV) of the scheme. Our central estimate of the SNPV is £140m. We have carried out sensitivity analysis to show the impact on the SNPV, when several modelling assumptions are changed.

Contents

Annex

1. Introduction and Background

1.1 Background

1. 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.[1] The scheme is an important contributor to the Government's stretching targets for both renewable heat, through the EU Renewable Energy Directive (RED), and carbon savings, through the carbon budgets. The scheme provides financial incentives to 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.
2. In order to allow time for the proposed schemes to be established and ensure a smooth transition to future support schemes for heat pumps and biomass, the Domestic RHI in Great Britain will remain open to new applicants until 31 March 2022. We will also introduce a third allocation of tariff guarantees under the existing Non-Domestic RHI with a flexible commissioning deadline, to help provide investment certainty for larger renewable heat projects and continue to support new biomethane production prior to the launch of a new Green Gas Support Scheme.

1.2 Problem under consideration

3. The UK is 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.[2] However, to meet our net zero target we will need to go much further.
4. Currently, heating our homes, businesses, and industry is responsible for a third of the UK's greenhouse gas emissions.[3] Decarbonisation of heat is recognised as one of the biggest challenges we face in meeting our climate targets. The government is aiming to publish a Heat and Building Strategy later this year, which will set out the immediate actions we will take for reducing emissions from buildings. These actions include the deployment of energy efficiency measures and low carbon heating as part of an ambitious programme of work required to enable key strategic decisions on how we achieve the mass transition to low carbon heat.
5. The objectives of proposed future support for low carbon heat are outlined in section 1.4.

1.3 Rationale for intervention

6. 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. This is partly due to the emerging nature of low carbon heating, which means that it does not benefit from economies of scale or from mature supply chains to the same degree as conventional technologies. 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 schemes will reduce the cost differential between fossil fuel and low carbon systems, hence incentivising deployment of low carbon technologies.

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[1] Conventional forms of heating include natural gas, oil, coal, LPG and direct electric heating.

[2] 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.

[3] 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

7. The main aspects of the economic rationale for subsidising low carbon heating in the domestic and non-domestic sectors are:
    a) The negative carbon externality associated with the conventional heating of buildings is not currently reflected in the cost of those systems. Deploying low carbon heating systems in buildings will reduce carbon emissions and improve air quality. Likewise, natural gas has a lower cost of production than green gas. Without government support, it is unlikely that green gas will be deployed instead of natural gas in the grid. Offering support for renewable technologies helps to overcome this barrier.
    b) Preparation of the supply chain (installer and manufacturer) for the mass roll-out and deployment of low carbon heating is needed to reduce the cost of decarbonising heat use in buildings, as well as meeting legally binding carbon targets.
    c) Raising consumer awareness, reducing deployment barriers and increasing innovation through increased deployment, result in spill-over benefits to society, which are not reflected in the price of low carbon heating.
    d) Low carbon heat adds a further non-monetised benefit, through diversifying the UK's energy supply, reducing UK economy's exposure to the volatility of oil and natural gas prices.
8. The proposed future support aims to address these aspects by incentivising the replacement of natural gas with biomethane under the Green Gas Support Scheme. The Clean Heat Grant will incentivise cost-effective installations, building supply chains to create the basis for future cost reduction, and developing installer skills and learning for better quality installations.
9. There are also a number of non-financial barriers to the uptake of low carbon heat. Important examples include awareness of technologies, availability of local suppliers, and the hassle involved in changing heating systems.

1.4 Policy objectives

10. Both the Green Gas Support Scheme and Clean Heat Grant aim to incentivise the cost-effective installation of low carbon heat technologies and generation of renewable heat in order to:
    a) Contribute to decarbonising heating in the UK and to meeting carbon budgets;
    b) Develop the low carbon heat market and supply chain to support the mass roll out of low carbon heating technology required in the 2020s;
    c) Contribute to the UK Government's legal obligation to reach net zero emissions by 2050.
11. The primary objectives and overview of the Green Gas Support Scheme and Clean Heat Grant are presented in section 2.

2. Outline of Policy Options

The policy options considered in this impact assessment are:

a) Option 0 (counterfactual): do nothing/no support mechanism following the extended Domestic RHI and the flexible allocation of tariff guarantees in the Non-Domestic RHI.[4]
b) Option 1 (preferred option): implement two new support schemes to decarbonise heat, targeting technologies considered to be more strategically important for the long-term decarbonisation of heat, and to improve value for money and consumer protection.

Option 0 (counterfactual): do nothing/no support mechanism following the extended Domestic RHI and the flexible allocation of tariff guarantees in the Non-Domestic RHI.

12. In this impact assessment, the quantified costs and benefits of future support schemes (option 1) are estimated against a counterfactual, where there is no support mechanism in place following the RHI scheme. In this scenario:
    a) The Domestic RHI will remain open to new applicants until 31 March 2022.
    b) A flexible, third allocation of tariff guarantees under the existing Non-Domestic RHI is introduced, with a commissioning deadline of March 2022, to help provide investment certainty for larger renewable heat projects and continue to support new biomethane production prior to the launch of a new Green Gas Support Scheme.

Option 1 (preferred option): implement two new support schemes to decarbonise heat

13. We propose to provide support to the following key technologies:
    a) **Biomethane injection into the gas grid through the Green Gas Support Scheme -** Biomethane injection offers a low-regrets, cost-effective way of contributing to near-term, legally binding carbon budgets and is also the only commercially-available technology capable of greening the gas grid. Under the indicative scenario set out in the Future Support for Low Carbon Heat consultation[5], deployment would be supported through a tiered tariff, paid on a pence per kilowatt hour (p/kWh) basis, over a period of 15-years from first injection of biomethane to the grid. Shorter potential tariff lengths are discussed in Annex B. In the 2020 Budget, the Chancellor announced that this new support scheme for biomethane will be funded by a Green Gas Levy.
    b) **Buildings technologies (heat pumps and, in limited circumstances, biomass) under the Clean Heat Grant -** The primary objective of supporting building level technologies is to grow confidence and supply chains - particularly the installer base - in low carbon heat technologies ahead of the phase-out of high carbon fossil fuel heating off the gas grid. The Clean Heat Grant will be exchequer funded.
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 Future Support for Low Carbon Heat consultation sets out the rationale for not supporting the following through this policy package:
    - Process heating
    - Biogas combustion
    - Solar thermal
    - Hybrid heat pump systems
    - Heat networks

2.1 Overview of proposals for the Green Gas Support Scheme

15. To meet our climate targets, we need to reduce our dependence on burning natural gas to heat our homes. The Future Support for Low Carbon Heat consultation sets out proposals for the most appropriate mechanism to accelerate the decarbonisation of our gas supplies, by increasing the

[4] Please see 'Stakeholder Notice – changes to the Renewable Heat Incentive: Extension of the Domestic Scheme and New Flexible Allocation of Tariff Guarantees' for more information.

[5] The Future Support for Low Carbon Heat Consultation is published on the same webpage as this impact assessment: https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

proportion of green gas in the grid. Biomethane produced through Anaerobic Digestion (AD) is currently the only green gas commercially produced in the UK, and therefore the policy proposal is to provide tariff support for biomethane injection into the gas grid.

2.1.1 Aims of the scheme

16. The primary objective of supporting biomethane injection is to contribute towards our near-term, legally binding carbon budgets by increasing the proportion of green gas in the grid. All scheme applicants will be subject to robust eligibility and sustainability criteria, to ensure cost-effective carbon abatement of the gas grid.
17. Further, producing biomethane plays an important role in reducing greenhouse gas emissions from waste and agriculture, and will support Defra's Resources and Waste Strategy,[6] which has committed the government to reducing the amount of food waste and legislating to ensure that every household and business in England separately presents food waste for recycling. The majority of biomethane plants are situated in rural areas and it is expected that these proposals will continue to create jobs in rural areas.

2.1.2 Scope of the scheme

18. New biomethane plants that meet all relevant eligibility criteria will be in scope of the scheme. Support will be provided via a tariff payment on a p/kWh basis of biomethane injected into the gas grid for the duration of the tariff payment period following commissioning. It is proposed that tariff rates will be tiered according to the volume of biomethane injection per annum for each plant and are expected to be adjusted each year in line with inflation.

2.1.3 Support mechanism

19. Under the scenarios set out in the Future Support for Low Carbon Heat consultation, plants deployed under the Green Gas Support Scheme will be supported through tariffs paid on a p/kWh basis. Tariffs are set to compensate investors for the additional cost of producing biomethane, when compared with the counterfactual (in this case, natural gas). This takes into account the additional capital costs, differences in operating costs and fuel (feedstock) costs, as well as a rate of return assumed to be required to compensate for the opportunity cost of funding the installation and production of biomethane. Tariffs are based on reference plants, which are representative plants of varying sizes that we expect to produce given amounts of biomethane, with their respective costs, revenues, and performance assumptions. For further information on reference plants, see Annex A. Details on cost, revenue and performance assumptions underpinning the tariff setting are contained in Annex D and further information on tariff setting is in Annex A.
20. The appropriate duration that tariffs will be paid for biomethane production following a plant's commissioning date has been reviewed during policy design, an indicative 15-year tariff payment length is proposed and has been applied to the analysis in this impact assessment (see Future Support for Low Carbon Heat consultation). Shorter tariff payment lengths of 10 and 12 years are considered in Annex B.
21. The analysis that forms the basis of the tariff setting and cost-benefit analysis assumes that biomethane production benefits from economies of scale, as some elements of capital costs and operating costs do not increase proportionately with output. That is, the unit cost of producing biomethane reduces to some extent as plant capacity increases. The cost of producing biomethane also depends on the feedstocks used because the cost varies in terms of feedstock price, plant operating costs, and additional capital costs. In order to ensure value for money, economies of scale and feedstock mix are accounted for in tariff setting to mitigate the risk of over-compensating plants for their biomethane production. The proposed tariff structure is therefore tiered – where the tariff payment rate varies with the volume of biomethane injected into the grid – and takes into account plant characteristics, such as the likely feedstock mix.

[6] Defra's Resources and Waste Strategy: https://www.gov.uk/government/publications/resources-and-waste-strategy-for-england

22. Further details on the tariff setting methodology can be found in Annex A, and further information on the policy proposals can be found in the Future Support for Low Carbon Heat consultation.

2.1.4 Budget management and value for money mechanisms

23. It is proposed that tariff guarantees are used in this policy to provide investor certainty. Tariff guarantees are expected to improve value for money by allowing investors to make better long-term decisions about their plant, enabling them to invest in the most efficient equipment and take sufficient time to commission without the need to speed up progress to avoid degressions. Further information on the tariff guarantees proposals are set out in the Future Support for Low Carbon Heat consultation.
24. The Future Support for Low Carbon Heat consultation also seeks views on delivering value for money by providing a means by which tariffs can change to reflect the true costs in industry. It is proposed that a degression mechanism, based on the RHI, but refined to more accurately reflect the biomethane industry, will be applied to the biomethane tariff rates. This impact assessment does not include the effects of degression due to high levels of uncertainty around deployment and how it would trigger degression, though more information on the mechanism can be found in the consultation.
25. In the 2020 Budget, the Chancellor announced that the Green Gas Support Scheme for biomethane will be funded by a Green Gas Levy. We aim to consult on the levy mechanism in due course.
26. Further information on policy proposals for biomethane injection, including allowing the dual participation in the government's Renewable Transport Fuel Obligation Scheme (RTFO), can be found in the Future Support for Low Carbon Heat consultation.

2.2 Overview of proposals for the Clean Heat Grant

2.2.1 Aims of the scheme

27. The aim of this scheme is to provide targeted support to follow on from the RHI, as part of government action to help build supply chains ahead of future measures to phase out high carbon heating.
28. In line with the increasing focus on strategic technologies, we intend to extend support for heat pumps and provide limited support to biomass.
29. Electrification of heat via heat pumps is one of the primary potential routes for decarbonising heat. Looking towards 2050, heat pumps could enable us to almost completely decarbonise heat as electricity generation decarbonises. The heat pumps we propose to support are air source heat pumps (ASHPs), ground source heat pumps (GSHPs) and water source heat pumps (WSHPs). We propose to support both low and high-temperature units, but not 'hybrids' installed alongside a fossil fuel system. Further information is available in the Future Support for Low Carbon Heat consultation.
30. 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 the Committee on Climate Change (CCC) says, to maximise the overall carbon abatement that is possible from sustainable biomass.[7] As far as it is proportionate to do so, we propose to introduce eligibility criteria so that biomass is not installed in individual buildings that would be suitable for a heat pump. We propose that support for biomass will not be permitted in urban areas. Further information on eligibility criteria is available in the Future Support for Low Carbon Heat consultation.

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[7] CCC (2018) Biomass in a Low Carbon Economy: https://www.theccc.org.uk/publication/biomass-in-a-low-carbon-economy/

2.2.2 Scope of the scheme

31. In order to target taxpayer funding most effectively in helping support the installer base for off gas grid regulations, we propose to introduce a 45kW capacity limit to focus this scheme on smaller installations.
32. For comparison, almost all domestic and non-domestic heat pump installations are less than or equal to 45kW in the RHI, while almost half of total domestic and non-domestic biomass installations are less than or equal to 45kW.[8]
33. A 45kW 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 Future Support for Low Carbon Heat consultation.

2.2.3 Support mechanism

34. We propose to 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 cost has often been raised as a barrier,[9] 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.[10]
35. We propose a technology-neutral, flat-rate grant of £4,000 for all technologies. The proposed grant level is based on several factors including stakeholder engagement, price elasticity research, and international evidence.
36. We are welcoming views and evidence through the Future Support for Low Carbon Heat consultation on varying the grant level by capacity.
37. Further detail on the proposed support mechanism can be found in the Future Support for Low Carbon Heat consultation.

2.2.4 Budget management

38. Support for building-level technologies will be exchequer-funded.
39. Under a grant scheme, we propose to issue vouchers on a first come first served basis.
40. Budget control involves limiting the amount of grants provided up to a pre-agreed budget cap.
41. To mitigate the risk of the budget being depleted more quickly than expected, we propose quarterly grant windows, each with a budget cap. This will help to maintain control over scheme costs, avoid intermittent deployment, and ensure that demand will be spread out across the year while keeping administration manageable.
42. We believe that these measures will increase industry confidence in the scheme's ability to support continued deployment of building-level technologies throughout its duration.

[8] Domestic and non-domestic RHI deployment data on capacity shows that over 99% of ASHP, 95% of GSHP and 46% of biomass installations are less than or equal to 45kW.

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

[10] 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

43. 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 Green Gas Support Scheme and the Clean Heat Grant. Given some inherent differences in the schemes, different modelling approaches have been taken and thus the results are presented for each scheme, as well as presenting the overall impacts combined.

3.1 Evidence Base

44. The appraisal values used in the analysis include:

    a) **Carbon prices** - HMT Green Book supplementary guidance on valuation of energy use and greenhouse gas emissions is used to value greenhouse gas savings.[11]

    b) **Electricity and fossil fuel air quality damage costs** - HMT Green Book supplementary guidance is used to measure air quality damage costs for natural gas, coal, LPG and oil. Updated values from the Department for Environment, Food and Rural Affairs (Defra) are used for electricity, these take into account electricity grid decarbonisation.[12]

    c) **Biomass air quality damage costs** - Based on latest available evidence, see Annex G.

    d) **Biomethane air quality damage costs** - Based on latest available evidence, see Annex E.

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

    f) **Biomass carbon emissions factors** - For biomass, carbon emissions factors are generated using the latest greenhouse gas conversion report.[13]

    g) **Biomethane carbon emissions factors** - Based on latest available evidence, see Annex F.

    h) **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).

45. Fertiliser prices used to value avoided costs are the average of monthly spot prices in 2019 published by Agriculture and Horticulture Development Board.[14]
46. All prices in this analysis have been converted into 2020 prices using the GDP deflator.[15]
47. The Green Book social time preference rate (‘discount rate’) of 3.5% has been applied for social present values.

3.2 Counterfactual

48. The counterfactual, against which impacts have been appraised in this impact assessment, is no deployment of low carbon heat technologies following the RHI. Further detail on the counterfactual modelling assumptions for the Green Gas Support Scheme and Clean Heat Grant are below.

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[11] 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

[12] The air quality values for electricity in the Green Book supplementary guidance use 2013 UK National Atmospheric Emissions Inventory (NAEI) emissions factors, this is based on an out-of-date electricity generation mix. Revised air quality values for electricity use emissions factors from the updated 2017 NAEI data.

[13] Greenhouse gas reporting: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

[14] Great Britain fertiliser prices: https://ahdb.org.uk/GB-fertiliser-prices

[15] GDP deflator: https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp

49. Green Gas Support Scheme:
   a) There is no evidence to suggest that any new biomethane capacity development would occur over the proposed policy period in the absence of a support mechanism. Based on internal evidence and data, biomethane production is currently not cost-competitive when compared with natural gas, so there will be no incentive to invest in biomethane production in the absence of policy support. It is therefore assumed that there is full additionality[16] as a result of this policy.
   b) The costs and benefits of biomethane injection are measured relative to the use of natural gas in the grid.
50. Clean Heat Grant:
   a) 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.
   b) 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.
   c) Although the RHI evaluation findings offer an insight into the current level of additionality, it is not possible to accurately assess the level of deployment that might occur without support. [17] Given this uncertainty, the analysis presented in this impact assessment assumes full additionality. The lower deployment scenario presented in the sensitivity analysis demonstrates the impact of a 70% additionality assumption. This scenario was chosen based on evidence from the RHI evaluation, which estimated that around a third of applicants say they would have installed a low carbon heating system without support from the RHI.[18]
   d) Assessing the impacts of the scheme against a counterfactual of no deployment of low carbon heating technologies, will provide greater clarity on what we expect the scheme to deliver. Assessing the proposals against a theoretical counterfactual, based on potential market response to no support mechanism after the RHI, would be highly subjective and therefore less transparent. Our chosen counterfactual is a more appropriate benchmark against which to assess performance and benefits in the future.
   e) Evidence from the RHI is used to estimate the mix of counterfactual technologies[19] being replaced by low carbon technologies under the Clean Heat Grant; see Annex H for details. The costs and benefits derived from a new low carbon 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.
   f) Given the uncertainty around the types of systems being replaced, an alternative counterfactual assumption of 100% oil boiler replacement is shown in the sensitivity analysis in section 4.7. This alternative was chosen based on our assumption that the majority of supported installations will replace fossil fuel systems in off gas grid buildings, oil is most commonly used fossil fuel to heat off gas grid buildings.

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[16] See glossary for additionality definition:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf

[17]RHI evaluation: https://www.gov.uk/government/publications/report-from-waves-1-24-of-the-domestic-rhi-census-of-accredited-applicants

[18] The level of additionality for the Clean Heat Grant may be different to the RHI evaluation findings for several reasons, primarily because the change in support mechanism from a tariff to an upfront grant will likely result in a different type of applicants. The RHI applicants tend to have larger homes than the national population and have funds available to pay for installations up front. Given the uncertainty around the scale of the impact on additionality, our central assumption is full additionality, with an alternative shown in the sensitivity analysis. This is a simplifying assumption and will be reviewed ahead of the final government impact assessment.

[19] Counterfactual heating technologies: oil, coal, LPG, natural gas and direct electric heating

3.3 Deployment

51. Deployment scenarios draw on a range of sources, including current trends in deployment, commercial intelligence and discussions with industry, the Clean Heat Grant also draws on international evidence. These are used to develop central estimates of the likely deployment for each technology. The cost-benefit analysis assesses the impact of the additional deployment supported by the policy proposals relative to the counterfactual.
52. Green Gas Support Scheme:

    a) Estimating the level of deployment we expect as a result of the Green Gas Support Scheme is challenging and subject to a high degree of uncertainty. Due to the demand-led nature of the proposals, this uncertainty results from the unknown response from industry to the policy. The ability to use past data to estimate deployment under the policy proposals set out in the Future Support for Low Carbon Heat consultation is limited because there were several changes under the Non-Domestic RHI from which it is difficult to disentangle the causality of deployment. Different sectors of the biomethane market may also respond differently to these proposals. Therefore, the deployment estimates are our best current assumptions based on the evidence available. Deployment estimates differ depending on the proposed tariff payment lengths. The analysis in the main body of this impact assessment is based on expected deployment under an indicative 15-year tariff payment period, with shorter payment lengths considered in Annex B. Throughout the consultation stage, we aim to refine our deployment estimates by gathering views on the proposed policy design.

    b) Assumed deployment is derived from a combination of commercial intelligence and the deployment of biomethane plants under the RHI, adjusted for the Green Gas Support Scheme policy proposals. Deployment estimates also account for the expected industry support as a result of the Non-Domestic RHI new third, flexible allocation of tariff guarantees.

    c) The volume of biomethane injected by each plant in relation to its 'capacity', is assumed to follow the BEIS internal biomethane ramp-up model. Based on RHI data, this regression model produces a relationship between time since deployment and biomethane flow rates. These flow rates are averaged over appropriate intervals, to estimate the annual proportion of capacity injected. See Annex D for further details.

53. Clean Heat Grant:

    a) The deployment estimates used in this analysis are derived from a range of sources, including trends in deployment under the RHI and commercial intelligence. These are used to develop central estimates of the likely deployment for each technology in 2022/23 and 2023/24.

    b) There is inherent uncertainty in projecting deployment. We have carried out sensitivity analysis to show the impact of a lower deployment scenario. Support for the Clean Heat Grant cannot exceed the £100m budget cap. The number of supported installations can therefore not be greater than our central deployment scenario. Trends in deployment under the RHI and commercial intelligence have been used to inform our central assumption that the full £100m budget will be spent.

3.4 Monetised costs and benefits

54. 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) **Resource costs** – The net economic cost of installing the low carbon heating technologies over and above the counterfactual costs, including capital, fuel, and running costs.

    b) **Generation Benefits –** For the Green Gas Support Scheme, the counterfactual costs are represented by generation benefits. Biomethane displaces the use of natural gas from fossil fuels. The value of the reduction in fossil fuels through the displacement of natural gas is valued using the long run variable costs of gas supply.

c) **Carbon savings** – The estimated value of the carbon abated in both the traded and non-traded sectors due to heat from low carbon sources replacing heat from fossil fuels.

d) **Air quality impacts** – The estimated value of the public health impacts of changes to emissions of Nitrogen Oxides and Particulate Matter. In addition, the impact of ammonia emissions arising from digestate (a by-product of biomethane production) on air quality. See Annex E for more details.

e) **Fertiliser savings** – Avoided fertiliser costs where digestate displaces synthetic fertiliser use in the agricultural sector.

55. For the Green Gas Support Scheme, each plant is appraised over its assumed economic lifetime[20] (20 years), and therefore the appraisal period for the scheme in total covers the period 2021/22 to 2045/46 to account for all biomethane plants deployed under the proposals.
56. For the Clean Heat Grant, low carbon buildings technologies have an assumed lifetime of 20 years.[21] The appraisal period for the scheme therefore covers 2022/23 to 2042/43.

3.5 Uncertainty

57. There are several uncertainties around the evidence and understanding of low carbon heating technologies. This section sets out the main sources of uncertainty for the Green Gas Support Scheme and Clean Heat Grant.
58. Green Gas Support Scheme:

a) Uncertainty around biomethane plant deployment supported by the scheme is described in section 3.3. Deployment has a direct impact on the amount of biomethane produced and associated impacts such as carbon savings and resource costs. Sensitivity analysis is performed on high and low deployment scenarios to demonstrate the impact of this uncertainty. Deployment estimates under different tariff payment lengths are considered in Annex B.

b) There are large variations in the stock of existing biomethane plants, and we expect new plants supported by these proposals will also be heterogeneous. These differences arise from a wide range of variables including feedstock inputs, equipment required, location, and costs. Resource costs of biomethane production per unit of gas produced therefore vary within the biomethane market.

c) Further, the greenhouse gas emissions associated with the production of biomethane are heavily dependent on the feedstock use and the assumed counterfactual use of those feedstocks. Counterfactual use of feedstocks are subject to a high degree of uncertainty and are discussed in more detail in Annex E. While feedstocks used by individual plants will vary, the robustness of the quantified carbon benefits in this document relies on the assumed feedstocks of the reference plant reflecting scheme-wide feedstock use (for more information on reference plants, see Annex A). The sensitivity analysis considers the impact of different feedstock mixes and the assumed disposal counterfactual. Other characteristics of individual plants, such as the efficiency of equipment used, may also impact on emissions but due to evidence constraints and the size of the expected impacts, these are not considered here.

d) These uncertainties can influence both areas of policy design and the modelled impact of the proposed support scheme. The main areas in which uncertainties feed through to impacts are:

   i. **Tariff setting** – Tariffs are based on a reference plant using an assumed feedstock mix and are set by the methodology outlined in Annex A. However, the market is not

[20] The economic lifetime included in this impact assessment is based on the assumed time following biomethane plant commissioning before further significant capital spend is required in order for the plant to continue operating.

[21] 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

homogenous and therefore the internal rate of return received by individual plants given the tariff specified may differ from that of our assumed reference plant.

ii. **Biomethane produced** – Uncertainty around deployment, influenced by both policy design and external factors, has a direct impact on the quantity of biomethane supported under this policy proposal. Biomethane production has a direct impact on all costs and benefits outlined in the analysis.

iii. **Carbon savings** – The assumed carbon savings are based upon assumptions on deployment and the emissions factors associated with our feedstock mix. As indicated, deployment affects the amount of carbon saving through the amount of biomethane produced under the policy, whilst the emissions factor uncertainty affects the greenhouse gas impact of each unit of biomethane produced.

59. Clean Heat Grant:

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

b) **Projecting deployment** - The factors that lead consumers to install low carbon heating systems are not consistent or predictable. This will impact the overall policy cost 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 influenced by individual and market wide reactions to the way policy is designed.

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

60. For both the Green Gas Support Scheme and the Clean Heat Grant, market intelligence and stakeholder views have been used to inform our modelling. We are welcoming further evidence through the Future Support for Low Carbon Heat consultation on the proposed support level.

61. Sensitivity analysis has been conducted to assess the impact of key uncertainties on the SNPV in section 4.7.

4. Impacts Appraisal

62. This section of the impact assessment quantifies the costs and benefits of the Green Gas Support Scheme and the Clean Heat Grant.

4.1 Headline impacts

63. Table 1 shows the combined headline impacts of the Green Gas Support Scheme and the Clean Heat Grant. The impacts presented are based on central modelling assumptions and the indicative 15-year tariff payment length.
64. Upstream carbon savings are those savings that result from the avoidance of emissions when certain feedstocks are used for AD rather than a different use. For more detail, see section 4.5 and Annex F.

Table 1: Headline impacts, central assumptions [22]

	Impact of proposals
Social net present value (SNPV) (£m)	140
Total scheme spend (£m, 2020 prices)	2,340
CB4 non-traded savings (MtCO2e)	4.4
of which upstream	*3.1*
CB5 non-traded savings (MtCO2e)	5.9
of which upstream	*4.3*
Annual renewable heat, 2030/31 (TWh)	2.9

4.2 Deployment

65. Deployment estimates are critical to quantifying the potential benefits and costs of the policy proposals. Given the uncertainty around projecting deployment, sensitivity analysis in section 4.7 shows the impact on costs and benefits under alternative deployment scenarios.
66. For the Green Gas Support Scheme, the deployment scenarios considered are outlined below. These deployment estimates are based on the indicative scenario of a 15-year tariff payment length. Shorter tariff lengths of 10 and 12 years are considered in Annex B. It should be noted that this analysis does not take into account the impact of any potential degression triggers.

    a) **High** – These estimates are based on the maximum deployment achievable over the length of the scheme (2021/22 to 2025/26) based on municipal food waste availability constraints. These were derived using internal analysis to assess what the maximum deployment could be before municipal food waste constrains deployment.

    b) **Central** – This is our best estimate of deployment, explained in section 3.3.

    c) **Low –** These estimates are based on BEIS judgement of the potential scenario in which the proposals set out for this scheme do not lead to the expected levels of industry investment.

67. Table 2 shows the expected deployment in terms of biomethane produced (GWh) under the Green Gas Support Scheme, based on the scenarios outlined above. Biomethane production is assumed to increase as plants deploy under the support scheme and ramp-up as they optimise, and then decreases in the latter years as plants reach the end of their economic life, at which point we assume they cease production as significant capital investment is required to continue operating and it is not clear whether it would be economical to do so. Production peaks between 2029/30 and 2040/41 at around 2,800 GWh per annum.

[22] Total scheme spend includes costs associated with administering the Green Gas Support Scheme and Clean Heat Grant.

Table 2: Green Gas Support Scheme deployment scenarios (GWh)

Deployment Scenario	2021/22	2022/23	2023/24	2024/25	2025/26 to 2045/46 (average per annum)	Total (2020/21 to 2045/46)
High	100	500	1,200	2,100	**3,200**	**70,100**
Central	100	400	900	1,600	**2,400**	**53,300**
Low	< 50	200	500	1,000	**1,400**	**30,800**

68. The Clean Heat Grant is expected to begin in April 2022, with funding committed for two years, to March 2024. The deployment scenarios considered are presented in Table 3. Support for the Clean Heat Grant cannot exceed the £100m budget cap. The number of supported installations can therefore not be greater than our central deployment scenario. Trends in deployment under the RHI and commercial intelligence have been used to inform our central assumption that the full £100m budget will be spent.
69. The scenarios in Table 3 represent our modelled assumptions of how total annual installations may be split by technology, they do not represent limits on deployment for each technology.

Table 3: Clean Heat Grant deployment scenarios

Deployment Scenario	Technology	2022/23	2023/24	Total
Central	Air Source Heat Pump	10,850	10,850	**21,700**
	Ground Source Heat Pump	1,300	1,300	**2,600**
	Biomass	350	350	**700**
	Total	**12,500**	**12,500**	**25,000**
Low	Air Source Heat Pump	7,600	7,600	**15,200**
	Ground Source Heat Pump	900	900	**1,800**
	Biomass	250	250	**500**
	Total	**8,750**	**8,750**	**17,500**

4.3 Spend

4.3.1 Green Gas Support Scheme

70. Table 4 shows the estimated spend on the Green Gas Support Scheme under each of the deployment scenarios considered. Spend increases during the initial years of the scheme because the first biomethane plants on the scheme ramp-up production over time and new biomethane plants begin deploying. Spend peaks at £150m in 2027/28 until 2036/37, after which spend declines as tariff payment periods for supported plants end.

Table 4: Green Gas Support Scheme spending profile (£m, 2020 prices)

Figures are rounded to the nearest £5m.

Deployment Scenario	2021/22	2022/23	2023/24	2024/25	2025/26 to 2040/41 (average per annum)	Total (2020/21 to 2040/41)
High	5	25	65	115	**165**	**2,840**
Central	5	20	50	90	**125**	**2,160**
Low	< 3	10	30	55	**70**	**1,250**

Figures may not sum due to rounding.

4.3.2 Clean Heat Grant

71. Table 5 shows an estimate of Clean Heat Grant spend under the deployment scenarios considered.

Table 5: Clean Heat Grant spending profile (£m, 2020 prices)

Figures are rounded to the nearest £5m.

Deployment Scenario	Technology	2022/23	2023/24	Total
Central	Air Source Heat Pump	45	45	**85**
	Ground Source Heat Pump	5	5	**10**
	Biomass	< 3	< 3	**5**
	Total	**50**	**50**	**100**
Low	Air Source Heat Pump	30	30	**60**
	Ground Source Heat Pump	5	5	**5**
	Biomass	< 3	< 3	**< 3**
	Total	**35**	**35**	**70**

Figures may not sum due to rounding.

72. We are consulting on the option of varying grant level by size of installation. We presently have limited data on how the actual cost of heating systems, ancillaries and labour varies by system capacity in Great Britain, to enable us to propose a suitable level by which the grant could be varied. We are also aware that products available on the market tend to cluster around certain sizes and that varying support levels through a strict formula is unlikely to accurately reflect these costs. Varying the grant level by size of installation may impact the distribution of spend and therefore potential deployment. For example, a greater volume of large installations will reduce the number of installations the scheme can support. Overall scheme spend will not exceed £100m.

4.3.3 Administration

73. We intend to appoint Ofgem as the administrator for both the Green Gas Support Scheme and the Clean Heat Grant Scheme.
74. 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 schemes, including handling queries, processing grant and tariff payments, and conducting an effective audit and compliance regime.
75. After 2024/25, both schemes will have closed to new applicants. However, there will be ongoing administration costs, such as maintaining IT systems and making payments to biomethane producers, which we expect to continue until 2040/41.
76. Table 6 shows our initial estimate of the administration costs. The costs presented are highly uncertain given that the detail of the schemes is subject to consultation and further policy development, so the costs are subject to change following further discussions and planning with Ofgem.

Table 6: Estimated administration costs (£m, 2020 prices)

Figures are rounded to the nearest £5m.

	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26 to 2040/41 (costs per annum)	Total (2020/21 to 2040/41)
Administration costs	5	15	10	10	10	< 3	85

Figures may not sum due to rounding.

4.4 Renewable heat supported

77. Annual renewable heat generated by the Green Gas Support Scheme and the Clean Heat Grant is estimated to be **2.9TWh** in 2030/31.

Table 7: Renewable heat supported

Renewable heat supported (TWh)	2030/31
Green Gas Support Scheme	2.8
Clean Heat Grant	0.2
Total	**2.9**

Figures may not sum due to rounding.

78. Due to the nature of biomethane installations, the level of renewable heat generated increases for a period of time following commissioning as the AD process typically results in a 'ramp up' of production of biomethane gas until conditions in the plants optimise. For further details see Annex D.
79. Within building level technologies, there are differences in what renewable energy is defined as for RED purposes. For example, in the case of biomass, renewable energy by RED definition is calculated through the application of a renewable heat proportion on total input energy, rather than that of output energy. For biomethane, all heat generated is considered to be renewable heat.

4.5 Greenhouse gas abatement

80. Table 8 shows the greenhouse gas savings estimated to be supported over carbon budgets 4 and 5 as a result of the Green Gas Support Scheme and Clean Heat Grant. The table also shows how much of this is traded or non-traded, and how much of this results from upstream savings.
81. The greenhouse gas abatement potential of the proposed policies is highly dependent on several factors, including the deployment and counterfactual assumptions.

Table 8: Profile of greenhouse gas abatement, central assumptions[23]

	CB4 (2023-2027)	CB5 (2028-2032)	Lifetime
Total non-traded savings (MtCO2e)	4.4	5.9	22.8
Of which upstream	*3.1*	*4.3*	*16.5*
Total traded savings (MtCO2e)	< -0.1	-0.1	-0.1

82. Table 8 shows the proportion of non-traded carbon savings which are estimated to be upstream savings. The upstream savings all relate to the Green Gas Support Scheme, specifically the avoidance of emissions that would have occurred if AD feedstocks had been put to a different use. For example, food waste assumed in our feedstock mix might have otherwise ended up in landfill. More detail on upstream emissions savings can be found in Annex F.

4.6 Carbon Cost Effectiveness

83. Under central modelling assumptions, the Carbon Cost Effectiveness (CCE) is **£67/tCO2e** for the Green Gas Support Scheme and **£25/tCO2e** for the Clean Heat Grant.[24]

[23] A positive value in Table 8 represents a reduction in greenhouse gas emissions, a negative value represents an increase in greenhouse gas emissions.

[24] 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

84. 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 4.8.

4.7 Social net present value (SNPV)

4.7.1 Green Gas Support Scheme

85. The components of the SNPV calculation for the Green Gas Support Scheme shown in Table 9 are based around our central assumptions and based on the indicative 15-year tariff payment length scenario.
86. Resource costs:
    a) Resource costs in the Green Gas Support Scheme are incurred during the construction and operation of biomethane plants. Annex D sets out the initial capital investment costs assumptions to deploy a biomethane plant and the ongoing operational costs, such as maintenance. Annex D also sets out fuel (feedstock) prices used in the modelling, with feedstock proportions set out in Annex C determining the average feedstock cost for reference plants being modelled.
    b) It is assumed that construction, and therefore capital investment, takes place in the year prior to first biomethane production. Examples of the costs represented here are costs incurred on labour to conduct civil engineering work and the purchase of capital equipment. Operational costs presented in full (100%) load terms are assumed be directly proportional to biomethane injection.
    c) Since biomethane plants are large investments that are likely to affect private sector capital allocation decisions, an opportunity cost of capital of 7.5% has been included within the resource costs presented.[25]
87. Generation benefits: Biomethane produced and injected into the gas grid displaces the use of natural gas from fossil fuels. The value of the reduction in fossil fuels through the displacement of natural gas is valued using the long run variable costs of gas supply.
88. Air quality costs:
    a) Digestate is a by-product of the AD process used to produce biomethane. It contains nitrogen, which can be emitted as ammonia, an atmospheric pollutant with negative effects on human health and the environment. Emissions arise from the processing and storage of feedstocks into digestate as part of the AD process, during the storage of digestate and its disposal – typically by spreading on agricultural land.
    b) Digestate is also rich in nutrients, so it may be used as a bio-fertiliser. When spread on land, it may displace the use of synthetic fertilisers. Synthetic fertilisers release ammonia emissions when used, so digestate emissions may partially be offset by a reduction in emissions from displaced fertiliser usage. We assume that 50% of the nitrogen content in digestate displaces nitrogen from synthetic fertilisers. This assumption was agreed with Defra. Different fertilisers emit varying levels of ammonia, so the fertilisers displaced are assumed to be in the same proportions as used in Britain for crops in 2018.[26] See Annex E for more details.
    c) Fertilisers assumed to be displaced by digestate spreading are associated with additional savings beyond the offset ammonia emissions. While digestate currently has no market value, when displacing fertiliser usage, it represents a cost-saving to the agricultural sector because of reduced fertiliser usage. To monetise these fertiliser savings, the same quantities of various fertilisers displaced by digestate in the air quality calculations are used. The savings are valued using average prices in 2019.[27]

[25] Green Book supplementary guidance recommends including cost of finance within appraisals. The rate of opportunity cost of capital was informed by a note produced by the Committee on Climate Change, Time preference, costs of capital and hidden costs: https://www.theccc.org.uk/archive/aws/Time%20prefernce,%20costs%20of%20capital%20and%20hiddencosts.pdf

[26] Table GB3.1: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/854404/fertiliseruse-report2018-20dec19.pdf

[27] Average of monthly spot prices from Great Britain fertiliser prices: https://ahdb.org.uk/GB-fertiliser-prices

89. As discussed in section 3.5, there are significant uncertainties around the costs and benefits that will accrue under these policy proposals. These include the deployment estimates, the feedstock mix used, and the underlying cost data. Due to these inherent uncertainties, the SNPV figures presented should be taken with due considerations of the sensitivity analysis carried out.

Table 9: SNPV and components, central deployment scenario

Figures are rounded to nearest £5m

	(£m)
Resource costs	−1,975
Air quality (ammonia) damage costs	−310
Generation benefits	+785
Carbon savings	+1,530
Fertiliser savings	+50
SNPV	**+80**

Figures may not sum due to rounding.

90. The sensitivity analysis presented in Table 10 shows the impact of key uncertainties on the SNPV and greenhouse gas abatement. The sensitivities considered are:

a) **Deployment** - As set out in the scenarios described in section 4.2, high and low estimates of deployment have been included as a key sensitivity given the inherent associated uncertainties.

b) **Carbon prices** - When appraising policies that abate carbon, the UK Government adopts a consistent approach based on the costs associated with meeting reduction targets, by applying a price to carbon. These carbon prices are published in the HMT Green Book supplementary guidance and are applied per tonne of carbon abated.

The value placed on changes in greenhouse gas (GHG) emissions is currently under review, now the UK has increased its domestic and international ambitions. Accordingly, current central carbon values are likely to undervalue GHG emissions, though the scale of undervaluation is still unclear. The potential impact of placing a higher value on GHG emissions can be illustrated by using the existing high carbon values series, in addition to the prescribed central values. HMG is planning to review the carbon values during 2020.

c) **Long run variable cost of gas** - Changes in energy consumption are valued by using the LRVCs. For biomethane, it is natural gas that is replaced and therefore the gas LRVC is used. These values are subject to uncertainty, and therefore, high and low estimates have been included in the sensitivity analysis.

d) **Air quality damage costs** - High and low damage cost sensitivities for ammonia emissions are presented using Defra's air quality damage cost guidance.[28]

e) **Food waste counterfactual** - There is uncertainty in the counterfactual disposal of food waste used for AD, which has an impact on the emissions savings associated with use of food waste as a feedstock. In the central case, we assume that all of the additional food waste used would otherwise have gone to landfill – the rationale for this assumption is described in Annex F. To test this assumption with sensitivity analysis, we assume that food waste used for AD has been split between landfill and incineration (with or without

[28] Air quality appraisal damage cost guidance: https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance

energy recovery) in the same proportions as local authority collected waste disposal in 2018/19 (20% landfill, 80% incineration).[29]

f) **No upstream carbon savings -** Upstream emissions savings contribute significantly to the carbon savings associated with biomethane production, however, there is significant uncertainty driven by the mix and counterfactual use of feedstocks. The sensitivity analysis shows the impact of the scheme without upstream savings from biomethane production.

g) **Production during tariff payment period only** - The appraisal period used for the Green Gas Support Scheme is the assumed economic lifetime of a biomethane plant (20 years). Should a biomethane plant stop producing following the tariff support period, then the realised carbon savings would reduce and therefore, this sensitivity shows the estimated impact of biomethane plants producing for only the indicative 15-year tariff payment length. The low, central and high sensitivities presented relate to the three deployment scenarios considered in section 4.2.

Table 10: Sensitivity analysis

SNPV figures are rounded to nearest £5m.

Scenario	Sensitivity	SNPV (£m)	Lifetime non-traded carbon savings (MtCO2e)
Deployment	High	105	28
	Central	80	22
	Low	45	12
Carbon prices	High	845	22
	Central	80	22
Long run variable cost of gas	High	280	22
	Central	80	22
	Low	−225	22
Air quality damage costs	High	335	22
	Central	80	22
	Low	−575	22
Food waste counterfactual	Central	80	22
	Low	−980	7
No upstream carbon savings	Central	80	22
	Low	−1,095	5
Production during tariff payment period only	High	−310	21
	Central	−235	16
	Low	−135	9

4.7.2 Clean Heat Grant

91. The components of the SNPV calculation for the Clean Heat Grant shown in Table 11 are based around our central assumptions.
92. Low carbon buildings technologies have an assumed lifetime of 20 years.[30] This means that additional deployment up to 2023/24 will continue to have an impact to 2042/43. Counterfactual

[29] Calculated from Table 2, Statistics on waste managed by local authorities in England in 2018/19 (MHCLG): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/849167/201819_LA_collected_waste_mgt_annual_Stats_Notice_FINAL_Accessible_v4.pdf

[30] 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

heating systems have an assumed lifetime of 15 years[31] and are therefore replaced within the appraisal period, incurring an additional capital cost in years 16 and 17 of the appraisal period.

Table 11: SNPV and components, central deployment scenario

Figures are rounded to nearest £5m

	(£m)
Capital cost	-165
Maintenance cost	-5
Non-traded carbon savings	+90
Traded carbon savings	-5
Long-run variable fuel costs	+95
Air quality	+50
SNPV	**+60**

Figures may not sum due to rounding.

93. The sensitivity analysis presented in Table 12 shows the impact of key uncertainties on the SNPV and greenhouse gas abatement. The sensitivities considered are:
    a) **Deployment** – The impact of a lower deployment scenario has been included. There is inherent uncertainty associated with estimating deployment. Support for the Clean Heat Grant cannot exceed the £100m budget cap. The number of supported installations can therefore not be greater than our central deployment scenario.
    b) **Carbon prices** – When appraising policies that abate carbon, the UK Government adopts a consistent approach based on the costs associated with meeting reduction targets by applying a price to carbon. These carbon prices are published in the HMT Green Book supplementary guidance and are applied per tonne of carbon abated. There is uncertainty around these prices, see section 4.7.1.
    c) **Long-run variable fuel costs** – 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.
    d) **Counterfactual mix** – 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. We expect that the majority low carbon technologies will replace fossil fuel systems in off gas grid buildings; oil is the most commonly used fossil fuel to heat off gas grid buildings. An alternative counterfactual assumption of 100% oil boiler replacement is shown in Table 12.
94. In all sensitivity scenarios, the SNPV is positive. Further detail on the assumptions underlying this sensitivity analysis can be found in Annex H.

Table 12: Sensitivity analysis

SNPV figures are rounded to nearest £5m.

Scenario	**Sensitivity**	**SNPV (£m)**	**Lifetime non-traded carbon savings (MtCO2e)**
Deployment	Central	60	1.3
	Low	40	0.9
Carbon prices	High	100	1.3
	Central	60	1.3
Long-run variable fuel costs	High	125	1.3

[31] BEIS assumption based on commercial intelligence.

Scenario	Sensitivity	SNPV (£m)	Lifetime non-traded carbon savings (MtCO2e)
	Central	60	1.3
	Low	25	1.3
Counterfactual technology	Central	60	1.3
	100% oil replacement	135	2.2

95. The above sensitivity analysis of the SNPV illustrates the significant uncertainty around the monetised benefits the scheme could deliver. The SNPV should therefore be treated with caution.

4.8 Non-monetised costs and benefits

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

a) **Investment** – Internal BEIS analysis suggests that there is significant additional investment in the UK into biomethane plants, and that the majority of the capital investment adds to UK jobs and GVA. If monetised, this would have a positive impact on the SNPV of the Green Gas Support Scheme.

b) **Rural economy** – Internal analysis suggests that over two thirds of biomethane plants are located in rural areas[32], with 85% of all UK plants located in areas with a lower than average GVA. If monetised, this would have a positive impact on the SNPV of the Green Gas Support Scheme.

c) **Supply chain development** – By incentivising additional deployment of low carbon heat technologies relative to the counterfactual, the scheme will support the development of low carbon heat supply chains. This will provide a base for the mass roll-out of low carbon heating in the 2020s, which will be needed to achieve the government's target of net zero carbon emissions by 2050. If monetised, this would have a positive impact on the SNPV of the Clean Heat Grant.

d) **Innovation and cost reductions** – BEIS expects that supporting low carbon heat deployment will reduce costs and possibly increase performance over time, as supply chains develop and barriers that customers currently face are reduced through technologies being deployed successfully. If monetised, this would have a positive impact on the SNPV of the Clean Heat Grant.

e) **Rebound effect**[33] – For some heat users, installing a low carbon heat technology could lead to an efficiency-driven overall lowering of fuel bills. 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 Clean Heat Grant is uncertain, there would be a potential reduction in carbon savings, with increased welfare benefits.

f) **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 Clean Heat Grant.

g) **Net zero contributions** – The carbon savings and renewable heat generation associated with these policy proposals are not considered in view of the requirements needed to meet the UK

[32] As defined using 2011 Urban Rural Classifications: https://www.gov.uk/government/statistics/2011-rural-urban-classification

[33] Socio-macroeconomic impacts of meeting new build and retrofit UK building energy targets to 2030: a MACRO-UK modelling study - https://sri-working-papers.leeds.ac.uk/wp-content/uploads/sites/67/2020/01/SRIPs-121.pdf

Government legislation to reach net zero emissions by 2050. If monetised, this would have a positive impact on the SNPV of both the Green Gas Support Scheme and the Clean Heat Grant.

h) **Renewable heat generation** – There is no agreed value for renewable energy, so the contribution of installations supported by the scheme towards targets under the RED is not monetised. In the absence of the scheme, additional action would be required to meet our RED targets, the cost of which is not reflected in the SNPV. If monetised, this would have a positive impact on the SNPV of both the Green Gas Support Scheme and the Clean Heat Grant.

4.9 Monitoring and evaluation

97. Monitoring and evaluation from the RHI, in addition to wider evidence, have been used to inform development of the policy proposal. However, there are still significant areas of uncertainty in the new scheme design. We plan to increase our evidence base through public consultation, before design of the Green Gas Support Scheme and Clean Heat Grant is finalised.
98. Given the high-profile nature and substantial spend of the Green Gas Support Scheme and Clean Heat Grant, 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 policy development. The monitoring will also be required to provide sufficient evidence to support robust scheme and budget management.
99. We will monitor deployment, as well as spend and benefits of the schemes following implementation. We will work closely with the scheme administrator to ensure information collected from applicants enables effective monitoring of the scheme against the key aims to increase deployment of low carbon heat technologies and contribute to decarbonising heating in the UK.
100. 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. It is expected that the evaluation will seek to answer questions such as:
    - To what extent has the scheme achieved its aims?
    - To what extent are the impacts from the scheme additional to what would have happened without the scheme?
    - 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)?
101. It is expected that the evaluation approach will follow the approach being applied in the evaluation of the RHI scheme. This approach uses a theory-based method to not only assess the overall impact of the scheme, but also identify the impact that the scheme is having in a range of different contexts with a range of different consumers. If this approach is adopted then the evaluation would include further analysis of scheme monitoring data, bespoke data collection from applicants through surveys and interviews and wider evidence gathering to inform impacts on the market for renewable heating systems.
102. More information on our monitoring and evaluation strategy will be provided in the final impact assessment. This will include proposed timelines for evaluation.

Annex

A – Biomethane tariff setting methodology

1. Tariffs are set to compensate developers for the additional cost of producing biomethane relative to revenues received. Costs taken into account are the additional capital, operating and net fuel (feedstock) costs,[34] while revenues in the absence of policy support are the wholesale gas revenues earned from selling the biomethane to the grid. After accounting for corporation tax and capital allowances, a discounted cash flow model calculates the tariff required per unit of energy produced to provide developers with additional biomethane revenue to achieve a 10% post-tax nominal rate of return. The tariff would be payable on all eligible units[35] of biomethane injected into the grid for a proposed length of 15 years from a project commissioning. Tariff setting and scheme costs and benefits of shorter tariff payment lengths are discussed in Annex B. Descriptions of the cost and revenue assumptions are set out in Annex D.
2. Elements of capital and operating costs do not increase proportionally with output, and therefore, as production increases, the marginal cost decreases and the average cost per unit of biomethane decreases. In addition, we expect plant characteristics to change at higher levels of production and have taken into account the feedstock mix when setting tariffs. To account for these economies of scale, a tiered structure is proposed, which provides a gradual reduction in the average tariff earned as capacity increases and attempts to provide a relatively consistent rate of return across the range of desirable plants which can deploy whilst ensuring value for money.
3. Tiering operates by paying a higher tariff for the first designated amount of biomethane injected into the grid (the 'Tier 1' tariff), and a lower tariff for subsequent biomethane injected (the 'Tier 2' and 'Tier 3' tariffs). The payment is based on the amount of biomethane produced by a plant over a period of 12 months. All biomethane plants will receive the higher Tier 1 payments for the set volume of biomethane injected into the grid, regardless of plant size and overall production in a given year. Tiering more accurately reflects these economies of scale and plant characteristics and therefore pays a rate proportionate to the production of biomethane in a given year.
4. The tiers have been set based on the following assessment:
    a) Tier 1: Set the limit to 60,000MWh. We propose to increase the Tier 1 limit compared to the RHI (40,000MWh), encouraging larger plants which can achieve better economies of scale.
    b) Tier 2: Set the limit for the next 40,000MWh. In some circumstances there may be sufficient feedstock available to generate greater volumes of biomethane and we want to incentivise plants to unlock greater economies of scale and continue producing biomethane under the Tier 2 tariff. This would bring the overall allowance under the first two tiers up to 100,000MWh.
    c) Tier 3: This is for levels of production above 100,000MWh. In rare circumstances where a plant can produce more than 100,000MWh of biomethane annually and achieve the very greatest economies of scale, it should be encouraged to do so.
5. To set Tier 1 and Tier 2 tariffs, the expected costs and revenues for an assumed representative plant producing an amount of biomethane close to the corresponding tier limit are used. Tier 3 tariffs are set using a reference plant with significant production falling under the Tier 3 tariff. The use of reference plants allows the calculation of the average tariff required for plants with specific costs, revenues, and performance assumptions according to their size. The tariffs calculated for Tier 2 and Tier 3 reflect both the average tariff rate required for the corresponding reference plant size and the revenues already received under preceding tiers.
6. The most recent plant cost information held by BEIS is for a 6MW plant and is based on internal BEIS modelling,[36] which in turn is based on the 2014 Biomethane Tariff Review underlying data.

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[34] Operating costs also include the cost of propane enrichment to prepare biomethane for grid injection. Feedstock costs are 'net' because food waste attracts gate fees which represent a revenue stream for plants.

[35] After allowances for the addition of propane and parasitic heat load provided from sources other than the biogas produced at the biomethane plant.

[36] Bioenergy Heat Pathways to 2050 Rapid Evidence Assessment, Ecofys & E4Tech (for BEIS) 2018, unpublished.

Capital and operating costs for different sized reference plants are estimated from costs for the 6MW plant and scaled up accordingly, whilst reflecting economies of scale identified within the 2014 Biomethane Tariff Review underlying data. For further information on cost and performance metrics, and reference plants, see Annex D.

7. The tariffs proposed in the Future Support for Low Carbon Heat consultation offer a range for each of the available tiers, which partly reflects the uncertainties of tariff setting. The consultation aims to gather evidence and stakeholder views during the consultation on the most appropriate tariff. The consultation tariff ranges are shown in Table A1.

Table A1: Consultation tariff ranges

Tier	Tier Limit	Tariff Range (p/kWh)
Tier 1	First 60,000MWh	4.90 – 5.50
Tier 2	60,000MWh – 100,000MWh	3.25 – 3.75
Tier 3	>100,000MWh	1.50 – 2.50

8. Although the Future Support for Low Carbon Heat consultation proposes a range of tariffs, the analysis undertaken is based on an indicative scenario of a 15-year tariff with our central assumptions and most relevant data. The tariff rates calculated using the methodology described in this annex are shown in Table A2.

Table A2: Tariff rates

Tier	Tier Limit	Reference Plant	Tariff Rate
Tier 1	First 60,000MWh	7.5MW	5.47p/kWh
Tier 2	60,000MWh – 100,000MWh	13MW	3.57p/kWh
Tier 3	>100,000MWh	30MW*	1.60p/kWh

*Note the Tier 3 reference plant does not use the central feedstock mix discussed in Annex C but uses 95% food waste and 5% maize. This is because plants of this significantly larger size are assumed to operate differently to smaller sized plants.

9. The indicative proposed tariff rates in Table A2 are paid on the basis of the criteria set out in Table A3.

Table A3: Proposed tariff payment basis

Biomethane Plants	
Period Payable	15 years
Internal Rate of Return	10%
Payment basis	Metered total biomethane output for eligible heat uses (biomethane output injected into the gas grid).
Payment timing	Quarterly in arrears when meter reading provided.
Tiering	Tariffs are paid for biomethane production at the appropriate tier rate.
Degression	Tariffs can be reduced (degressed) if spending hits certain triggers.

B – Tariff payment length

1. Throughout this impact assessment, the underlying analysis and results have focussed on the indicative scenario set out in the Future Support for Low Carbon Heat consultation, which is that biomethane plants will receive payments for a period of 15 years following commissioning. The consultation also seeks views on shorter tariff periods to support biomethane plants. This annex describes the estimated impact of a Green Gas Support Scheme with shorter tariff payment lengths; quantitatively estimating the expected impact of a potential 10-year tariff payment period, and qualitatively discussing the impact of a 12-year tariff. The options are compared with the central scenario of a 15-year tariff payment period.
2. Reducing the tariff payment length would, assuming the same tariff rate is applied, reduce the rate of return that plants will receive under the Green Gas Support Scheme. As it is expected that a 10% rate of return is required to incentivise deployment under our central assumptions, this is applied to the 10-year tariff payment option and compared with the indicative 15-year option in Table B1. The impact of this is that the tariff rate will have to rise proportionally to ensure that capital costs, operating costs, and fuel (feedstock) costs are recovered whilst still providing an investable rate of return. The table below shows the indicative tariff rates to compensate plants under the different tariff length scenarios.

Table B1: Tariff rates under tariff length scenarios

Tier	Tier Limit	10-year tariffs	15-year tariffs
Tier 1	First 60,000MWh	6.75p/kWh	5.47p/kWh
Tier 2	60,000MWh – 100,000MWh	4.23p/kWh	3.57p/kWh
Tier 3	>100,000MWh	2.41p/kWh	1.60p/kWh

3. Table B1 shows the tariffs that would be required under both a 10-year and a 15-year scenario to provide a 10% rate of return based on our tariff setting methodology. Even with a proportional increase in the tariff rate, a shorter tariff payment period is expected to have an impact on the amount of biomethane produced under the Green Gas Support Scheme because there is the potential for a significant risk to deployment. The primary reason for this is that it gives finance providers a much shorter window to recover from any delays. Market intelligence indicates that debt financiers typically require a buffer period between the end of the loan tenor and the end of tariff support to account for delays in project delivery, plant construction, and any operational issues that the plant may encounter. A shorter tariff period could magnify the impact of this buffer period on the overall project. With a significantly shorter tariff of 10-years, there is a risk of a lack of time to make up for any delays to construction which poses the expected serious risk to deployment, as investors may perceive biomethane as too risky an investment. It is likely that a 12-year tariff payment could result in similar issues, albeit the negative impact on deployment may be reduced.
4. The estimated deployment in terms of renewable heat generated under the 10-year tariff length options are shown in table B2, alongside the indicative scenario of a 15-year tariff payment length.

Table B2: Biomethane produced under tariff length scenarios (GWh)

Scenario	2021/22	2022/23	2023/24	2024/25	2025/26 to 2045/46 (average per annum)	Total (2020/21 to 2045/46)
15-years	100	400	900	1,600	2,400	53,300
10-years	100	300	700	1,300	2,000	43,900

5. As illustrated in Table B2, it is estimated that a reduction in tariff payment length will cause a reduction in deployment, and thus a reduction in the amount of biomethane production under the Green Gas Support Scheme. A reduction in biomethane production leads to a proportionate reduction costs and benefits. Table B3 shows the expected impact on carbon savings as a result of the assumed decrease in biomethane production compared with the central 15-year scenario.

Table B3: Carbon savings under tariff length scenarios (MtCO2e)

Scenario	CB4 (2023-2027)	CB5 (2028-2032)	Lifetime
15-years	4.1	5.6	21.6
10-years	3.3	4.6	17.8

6. In the sensitivity analysis in Table 10, we have assessed the impact of a biomethane plant ceasing production at the end of the tariff payment period. A shorter tariff payment length would also result in a significant reduction in carbon savings. If we assume that under all scenarios, biomethane production per plant stops when the tariff payment support stops, then there is a significantly greater decrease in the expected carbon savings over the lifetime of plants, as shown in Table B4.

Table B4: Carbon savings if production stops with tariff payments (MtCO2e)

Scenario	CB4 (2023-2027)	CB5 (2028-2032)	Lifetime
15-years	4.1	5.6	16.0
10-years	3.3	4.4	8.5

7. The reduction in biomethane deployment leading to a reduction in costs and carbon savings does not materially affect the Carbon Cost Effectiveness, which remains at £67/tCO2e under all tariff length scenarios, due to a commensurate reduction in resource costs and the amount of digestate produced per unit of biomethane would remain unchanged. However, it does have an impact on the main value for money metric used in this impact assessment – the SNPV. Table B5 below shows the SNPV of each of the potential tariff lengths considered in the Future Support for Low Carbon Heat consultation.

Table B5: SNPV under tariff length scenarios (£m)

Figures are rounded to nearest £5m

Scenario	SNPV
15-years	+80
10-years	+70

8. Should biomethane plants require a more than proportional increase in the tariff rate to compensate for the shorter tariff payment period, then a greater rate of return will be used to estimate the tariffs. In this case, value for money under the net present value and carbon cost effectiveness measurements would reduce under the Green Gas Support Scheme for shorter tariff payment lengths.

C – Biomethane feedstock mix

1. The assumed feedstock mix that underpins the analysis for the policy proposals is an average feedstock mix assumed over the range of biomethane plants expected to deploy under the Green Gas Support Scheme. It is on this basis that the typical reference plant has been constructed, and on which tariffs are based. Costs and carbon savings are sensitive to the feedstock mix, which in turn affects both the tariff setting results and the cost-benefit analysis. Further, the assumed feedstock mix has an impact on the ammonia emissions expected.
2. The feedstock mix assumed for this consultation takes into account RHI assumptions used in previous impact assessments, adjusted to reflect the expected impact of the policy proposals, and using commercial intelligence. Further, other policies that could affect biomethane plant feedstock mix are considered. The main policies that are expected to affect the feedstock mix under the proposals set out in this consultation are:
    i) Government's Environment Bill: The government's recently published Environment Bill would require that every household and business in England have a separate collection for food waste, so that this can be recycled. We would expect these measures to commence from 2023 and this will significantly increase the amount of food waste available for AD.

    ii) Minimum Waste Feedstock Requirements: Under the Non-Domestic RHI, applicants must generate at least 50% of their biomethane from waste or residue feedstock. For the Green Gas Support Scheme, the consultation seeks views on increasing the threshold above 50%.

3. The policies outlined above are expected to increase the amount of food waste used in AD under the Green Gas Support Scheme. Based on the above combination of evidence sources, the analysis undertaken in this impact assessment uses the feedstock mix (by energy content) shown below in Table C1.

Table C1: Feedstock mix assumptions

Feedstock	Proportion (energy content)
Food Waste	50%
Energy Crop (maize)	20%
Sewage	25%
Wet Manure	5%

Biomethane potentials

4. Biomethane potentials for each feedstock are taken from those within the UK and Global Bioenergy Resource Model,[37] and are shown in Table C2.

Table C2: Biomethane Potentials

Feedstock	Biomethane Potential (kWh/tonne)
Food Waste	1100

[37] UK and Global Bioenergy and Resources Model: https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

Feedstock	Biomethane Potential (kWh/tonne)
Energy Crop (maize)	642
Sewage	139
Wet Manure	124*

(*The UK and Global Bioenergy Resource Model expresses the biogas potential of wet manure in volatile solids terms. The figure shown is for fresh weight assuming that wet manure contains 8% solids, of which 80% are volatile solids)

D – Biomethane cost and performance

Summary

1. Table D1 shows the main sources for the underlying tariff calculations and proposals set out in the Future Support for Low Carbon Heat consultation. This includes sources of the associated resource costs (capital, operating and feedstock costs), as well as assumed gas revenues from injecting biomethane into the grid. These costs have been checked against cost information collected through market intelligence and the Non-Domestic RHI Evaluation, and therefore we are confident that the costs contained within the analysis and the basis of the tariff are based on the best available evidence at this time.

Table D1: Cost and Performance Assumptions

Component	Consultation Sources
Reference plant capacity	Tier 1: 7.5MW Tier 2: 13MW Tier 3: 30MW
Capex (for 6MW reference plant)	Internal BEIS Biomass Heat Pathways Model
Opex (for 6MW reference plant)	Internal BEIS Biomass Heat Pathways Model
Feedstock costs	Sources set out below
Feedstock mix	Set out in Annex B
Wholesale gas price	BEIS Fossil Fuel Price Assumptions: 2019[38]
Plant load factor	Plant Ramp-Up set out below

Costs

2. The principle for estimating costs and revenues for a plant, and therefore, the principles underlying the tariff setting for biomethane plants under the Green Gas Support Scheme, is to use costs of a typical reference installation. This is in-line with the principle of tariff setting used under the Non-Domestic RHI for biomethane and is judged to be the best available method for setting the tariff rates. The reference plant uses a number of inputs that affect the overall costs and carbon savings associated with biomethane production, for example the feedstock mix used. As described in Annex A, the tier limits and associated tariffs are based on the estimated production of a reference plant that is assumed to produce up to the tier limit.
3. It should be noted that although the method of using a reference plant for tariff setting is deemed appropriate under this scheme, it does not attempt to directly reflect the costs and carbon savings associated with each individual plant that would be supported under the scheme. Further, the relationship between plant size and production is uncertain and due to a number of plant specific reasons e.g. downtime required for maintenance. Therefore, actual production for a given plant size could differ from the assumed production used in the analysis of this impact assessment.

The assumed annual production of biomethane for our reference plants are shown in the Table D2.

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[38] Fossil fuel price assumptions: https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2019

Table D2: Reference Plant Costs

Figures rounded to nearest £0.1m.

Reference Plant	Capital Costs (£m)	Operating Costs (full load, £m/year)	Feedstock Costs (p/kWh)
7.5MW	17.4	1.8	0.77*
13MW	25.6	3.0	0.77*
30MW	50.7	6.6	-0.37†

* See Annex C for feedstock mix.

† With a feedstock mix of 5% energy crop (maize) and 95% food waste.

Capital and operating costs

4. The costs associated with our reference plants are based on the costs of a typical 6MW plant from an internal BEIS model,[39] which in turn was based on data gathered during the 2014 Biomethane Injection to Grid Tariff Review.[40] These costs have been sense-checked against commercially sensitive information collected to ensure that the estimates provided are based on the best available information at present. Specific cost breakdowns are dependent on the plant characteristics, e.g. the feedstock used and the distance from the gas grid. The costs used to inform the tariff rate payable under the proposals in the Green Gas Support Scheme are based on average plants that could deploy as a result of the policy proposals.
5. Based on the 6MW reference plant, costs have been scaled to reflect the increase in capital costs and operating costs, which it is estimated larger biomethane plants face, to more accurately reflect the costs incurred by the range of plants considered under our tariff tiering system. As described in Annex A, biomethane plants benefit from economies of scale in production as capital and operating costs increase proportionally less than the associated increase in biomethane production as capacity increases, reducing the average cost of production. This is reflected in costs shown in Table D2.

Feedstock costs

6. Tariff setting and the cost-benefit analysis are affected by the estimated feedstock costs used within the analysis, and feedstock costs vary proportionately to output of biomethane. A variety of sources have been used to estimate each feedstock cost, described below.

Food waste

7. Food waste collections are characterised by gate fees, i.e. an amount charged for waste disposal, usually measured per tonne. Gate fees are paid to biomethane plants for collecting waste and constitutes a revenue stream. Gate fees for AD purposes have seen a downward trend over recent years, which appears to be continuing.[41] In 2018, the median gate fees reported by local authorities was £27/tonne, a slight increase from the £26/tonne in 2017. The figure is skewed by longer-term contracts, and when we consider only those that have started in the past 3 years, the median is £19/tonne which reflects waste contractor expectations of declining gate fees more generally. It should be noted that there are significant geographical variations due to differences in local competition, as well as national legislation and policy.
8. Market intelligence and evidence from the Non-Domestic RHI evaluation[42] suggest that long term, secure contracts are becoming difficult to access, leading to a reduction in the certainty of this

[39] Bioenergy Heat Pathways to 2050 Rapid Evidence Assessment, Ecofys & E4Tech (for BEIS) 2018, unpublished.

[40] RHI biomethane injection to grid tariff review: https://www.gov.uk/government/consultations/rhi-biomethane-injection-to-grid-tariff-review

[41] Based on the Waste and Resources Action Plan (WRAP) Gate Fees report 2019: http://www.wrap.org.uk/gatefees2019

[42] Renewable Heat Incentive evaluation collection: https://www.gov.uk/government/collections/renewable-heat-incentive-evaluation.

income stream when making investment decisions. It is difficult to estimate the impact of the Defra Resources and Waste Strategy on gate fees because, although it will increase the supply of food waste, there may be competing demand side impacts that counter these effects.

9. Overall, based on the evidence from market intelligence gathered, the Non-Domestic RHI evaluation, and the WRAP Gate Fees 2019 report, and accounting for the fact that there will be a proportion of plants that do not receive a gate fee as they don't use food waste, a central gate fee of £7.50/tonne has been included in the analysis for this policy proposal. This has been estimated based on an understanding that gate fees are low and have been decreasing in recent years but do constitute a revenue stream for biomethane plants.

Energy crops

10. Although energy crops can be used in biomethane production, the proportion used in the feedstock mix is restricted by the minimum waste feedstock requirements. In our feedstock mix, we have used maize to represent energy crops. Evidence on the cost of maize is based on the UK and Global Bioenergy and Resources Model,[43] evidence gathered during the RHI evaluation, and market intelligence. The estimated cost of maize is £35/tonne, which has been used in the analysis in this impact assessment.

Manure and sewage

11. It has been assumed that manure and sewage do not incur a cost to biomethane plant operators, and therefore these feedstocks do not affect the financial element of this analysis.

Revenues

12. The main source of non-tariff revenue for biomethane plants is assumed to be the price received for injecting the gas produced into the gas grid. Biomethane injected into the grid is paid at the same rate as natural gas, so BEIS Fossil Fuel Price Assumptions: 2019[44] are used within the analysis for tariff setting. The revenues also depend on the amount of biomethane injected into the grid, and this is dependent on a BEIS ramp-up profile (see Ramp-Up Profile section below).
13. A by-product of biomethane production is digestate (see Annex E), which can be used as a fertiliser and therefore could constitute a revenue stream for biomethane plants should they sell this as fertiliser. Commercial intelligence suggests that digestate does not constitute a revenue stream. This is because of the relatively little information on digestate quality, which can vary depending on a number of factors including the feedstock and the lack of a formal market for digestate. The Future Support for Low Carbon Heat consultation seeks views on reasons for the lack of commercial demand for digestate and how the market for digestate can be strengthened. At this time, it is assumed that the reference plants do not receive revenues for their digestate.
14. Another potential revenue stream for biomethane plants are Green Gas Certificates (GGC). These have not been included at this time given the developing nature of the market and the resulting price volatility creating lack of certainty in revenues. It is therefore assumed they do not feed into the investment decision of a biomethane plant.

Performance

15. Costs and revenues, and therefore the tariff rate analysis and cost-benefit analysis, are affected by the estimated production of biomethane plants. It is estimated that it takes time for biomethane plants to optimise once they have commissioned, until they reach their assumed production capacity. This is reflected in a 'ramp-up profile' that is applied to the analysis of biomethane production under the Green Gas Support Scheme. Table D3 below shows the ramp-up profile[45].

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[43] UK and Global Bioenergy Resource Model: https://www.gov.uk/government/publications/uk-and-global-bioenergy-resource-model

[44] Fossil fuel price assumptions: https://www.gov.uk/government/publications/fossil-fuel-price-assumptions-2019

[45] Based on an internal RHI Biomethane Ramp Up Model (BRUM) which is based on past data of plant injections over time.

Table D3: Plant ramp-up profile

Year	1	2	3	4	5+
Capacity	53%	71%	84%	92%	92%

16. The cost, revenue, and performance assumptions and evidence presented above are the basis on which the proposals set out in the Future Support for Low Carbon Heat consultation have been analysed, and the tariff rates have been calculated.

E – Biomethane air quality impacts

1. The cost-benefit analysis undertaken for this policy proposal includes monetised air quality impacts of ammonia from supporting biomethane. Digestate is a by-product of the AD process that is typically spread on agricultural land as a bio-fertiliser and can displace the use of synthetic fertilisers. However, it contains nitrogen that can be lost to the atmosphere as ammonia, an air pollutant that has significant effects on human health and the environment. The UK Government has committed to reducing ammonia emissions by 16% by 2030 (compared with 2005 levels). Ammonia from all digestate from AD currently accounts for around 5% of UK ammonia emissions, and biomethane plants are a subset of all AD plants.
2. BEIS have worked with Defra to estimate the impact from our policy proposal on air quality. Ammonia emitted from the processing of feedstocks into digestate, the storage of digestate, and the spreading of digestate on land are estimated from feedstock tonnages used to produce biomethane – based on deployment and feedstock assumptions. This is partially offset by avoided ammonia emissions from the displacement of synthetic fertilisers (which also emit ammonia when used). We assume that 50% of the nitrogen content in digestate displaces nitrogen from synthetic fertilisers.
3. Different fertilisers emit varying levels of ammonia, so the fertilisers displaced are assumed to be in the same proportions as used in Britain for crops in 2018.[46] See Table E2.
4. Emissions factors used are consistent with those used to compile the 2018 National Atmospheric Emissions Inventory (NAEI).[47] Sewage sludge in the AD process is assumed to have no additional ammonia impact, compared to its counterfactual emissions from its disposal by conventional means. Spreading emissions for manure-based digestate have been partially offset by a reduction in emissions from the land-spreading of manure and spreading emissions for food waste-based digestate are reduced slightly by a reduction in upstream landfill emissions.[48]
5. Under the central scenario, it is estimated that this produces 3.03 kilo-tonnes of ammonia emissions but is reduced to 2.87 kilo-tonnes under the assumption that half of the nitrogen in digestate displaces synthetic fertilisers. A breakdown by feedstock and by process is shown in Table E1 below.

Table E1: Annual Ammonia Emissions at Full Ramp-Up

Feedstock	Energy mix	Feedstock processing and storage (Kt)	Digestate storage (Kt)	Digestate spreading (Kt)	Total ammonia emissions* (Kt)
Food waste	50%			1.18	1.28
Maize	20%	0.03	0.23	0.64	0.71
Manure	5%			0.94	1.03
Sewage	25%	-	-	-	-

46 Calculated from British Survey of Fertiliser Practice 2018: https://www.gov.uk/government/statistics/british-survey-of-fertiliser-practice-2018

47 UK Informative Inventory Report (1990 to 2018): https://uk-air.defra.gov.uk/assets/documents/reports/cat07/2003131327_GB_IIR_2020_v1.0.pdf

48 Tomlinson S.J., Thomas I.N., Carnell E.J., and Dragosits U. (2019) Reviewing estimates of UK ammonia emissions from landfill, composting & anaerobic digestion: Improvement Plan 2018. Report for Defra (AQ_IP_2018_20). April 2019. 63pp

Feedstock	Energy mix	Feedstock processing and storage (Kt)	Digestate storage (Kt)	Digestate spreading (Kt)	Total ammonia emissions* (Kt)
Total additional emissions from digestate					**3.03**
Net ammonia emissions where 50% of digestate nitrogen displaces fertilisers					2.87

(*processing and storage emissions been apportioned by quantity of feedstock or digestate, as appropriate).

Table E2: Fertiliser Mix

Fertiliser	Proportion (by weight)
Urea	8.7%
Urea ammonium nitrate	10.7%
Ammonium nitrate	37.4%
Other	43.2%

6. Under the proposals set out in the Future Support for Low Carbon Heat consultation, biomethane plants that deploy under the Green Gas Support Scheme will be required to use at least 50% of waste in their feedstock mix by output and we are consulting on increasing this minimum requirement. As such, we present sensitivity analysis to understand the impact of ammonia emissions under a scenario in which it is assumed that biomethane plants use up to 50% energy crops (e.g. maize) in their feedstock mix. Although it is technically possible for the feedstock mix to be made up of 50% energy crops, given the requirements imposed in order to receive the tariff payment, we do not expect this to be the case. This is because food waste plants do not typically use significant proportions of energy crops; given the biological processes involved, and because of the cost associated with purchasing energy crops. Changing feedstock mix can take several months, and food waste plants often will have contractual commitments to accept food waste (as opposed to supply a particular volume of gas).
7. The feedstock mix in Table E3 shows a potential scenario in which maize makes up 50% of the feedstock mix by biomethane output. For this we have assumed a proportional reduction in each of the waste feedstocks, so that the remaining mix is 32% food waste, 3% wet manure and 15% sewage.

Table E3: 50% Energy Crop Ammonia Emissions

Feedstock	Energy mix	Feedstock processing and storage (Kt)	Digestate storage (Kt)	Digestate spreading (Kt)	Total ammonia emissions* (Kt)
Food Waste	32%	0.03	0.26	0.75	0.82
Maize	50%			1.61	1.79
Manure	3%			0.57	0.62
Sewage	15%	-	-	-	-

Feedstock	Energy mix	Feedstock processing and storage (Kt)	Digestate storage (Kt)	Digestate spreading (Kt)	Total ammonia emissions* (Kt)
Total additional emissions from digestate					**3.22**
Net ammonia emissions where 50% of digestate nitrogen displaces fertilisers					3.05

(*processing and storage emissions been apportioned by quantity of feedstock or digestate, as appropriate).

F – Biomethane carbon emissions factor

1. The carbon emissions factors for biomethane production have been calculated in order to inform the carbon savings associated with the proposed policy, taking into account the most recent evidence available. The overall biomethane emissions factor for the policy proposal under our central scenario assumptions is −221gCO2e/kWh.
2. There are three components to the biomethane emissions impact from each feedstock in our assumed mix. They are:
    a) **Bio-generation emissions:** direct emissions associated with the production of biomethane.
    b) **Upstream savings:** savings associated with avoiding the counterfactual use of feedstocks.
    c) **Downstream savings:** savings associated with reducing fossil fuel consumption as a result of biomethane replacing natural gas in the gas grid.
3. These components are added together to produce an overall emissions factor for each feedstock, which are then weighted based on our assumed feedstock mix (50% food waste; 20% maize; 25% sewage; 5% manure).
4. Upstream emissions savings are as follows:
    a) **Food Waste:** upstream savings relate to diverting food waste away from landfill, where methane would be emitted. The estimate of upstream savings has been updated to take into account the published values for emissions from landfill. [49]
    b) **Manure:** upstream savings relate to the diversion of manure away from storage in slurry tanks or lagoons. These emit a significant amount of methane into the atmosphere. The estimated upstream savings from manure has been estimated using internal BEIS analysis based on data from an unpublished study by the University of Manchester.
5. Table F1 below shows the biomethane emissions factors for different feedstocks assumed in our feedstock mix.

Table F1: Biomethane Emissions Factor

Feedstock	Proportion	Bio-generation (gCO2e/kWh)	Upstream (gCO2e/kWh)
Food Waste	50%	80	−561
Maize	20%	130	0
Wet Manure	5%	86	−600
Sewage Sludge	25%	78	0
Weighted Average	**-**	**90**	**−310**

6. Downstream emissions avoided are equal to the emissions factor of natural gas, 184gCO2e/kWh.
7. There is significant uncertainty associated with the upstream emissions abatement associated solely with biomethane deployment under the Green Gas Support Scheme. This is mainly driven by uncertainty around the counterfactual disposal of feedstocks. In addition, waste sector policies also impact the disposal of feedstocks, raising issues of attribution of upstream savings. There is also uncertainty around the feedstock mix used. In particular, a lower proportion of deployment from plants using feedstocks with high potential for upstream savings (food waste and manure) would result in lower emissions savings.

[49] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

8. As discussed above, we assume that food waste used for AD would otherwise have been sent to landfill. Food waste across the economy is disposed of through a number of routes, including disposal (including waste going to landfill or to sewer), energy recovery (including incineration of waste to create electricity), and recycling (AD and composting). On balance, we believe it is most likely that food waste used for AD is diverted from landfill, as:
    a) Some plants expected to deploy under the Green Gas Support Scheme will have a dedicated source of waste feedstock, which may otherwise have gone to landfill.
    b) Commercial intelligence suggested that under the RHI a number of food waste plants are likely to use waste from business or industrial sources, which are more likely to send their waste to landfill than use it in energy recovery[50];
    c) Local authorities which send waste to recovery are often in long-term contracts to provide this waste, so it is more likely that local authorities will divert waste from landfill to AD rather than recovery to AD. Further, potential capacity constraints mean that the additional food waste is less likely to be diverted from recovery to AD.
9. However, this is still highly uncertain. To illustrate this, we present a sensitivity where food waste disposal is split between landfill and recovery in line with the proportions seen across the whole economy, we assume that food waste used for AD has been split between landfill and incineration (with or without energy recovery) in the same proportions as local authority collected waste disposal in 2018/19 (20% landfill, 80% incineration).[51] This results in a significant reduction in upstream savings from food waste, as recovery is a source of renewable electricity displacing fossil fuels, and as such has associated emissions savings. Diverting food waste from recovery to AD would increase carbon savings in the heat sector but decrease carbon savings in the electricity sector.

[50] https://www.legislation.gov.uk/ukia/2019/143/pdfs/ukia_20190143_en.pdf

[51] Calculated from Table 2, Statistics on waste managed by local authorities in England in 2018/19 (MHCLG): https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/849167/201819_LA_collected_waste_mgt_annual_Stats_Notice_FINAL_Accessible_v4.pdf

G – 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.[52] The RHI imposes a limit on oxides of nitrogen (NOx) and particulate matter (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.[53] The Clean Heat Grant 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.[54]

Table G1: Biomass air quality assumptions

Measure	PM2.5	NOx
Emission factors (kg/kWh)	0.000216	0.00036
Damage costs (£/kg), 2020 prices	90.97	14.80

[52] Biomass boilers: measurement of in-situ performance: https://www.gov.uk/government/publications/biomass-boilers-measurement-of-in-situ-performance

[53] Emission Certificate (RHI): https://www.ofgem.gov.uk/key-term-explained/emission-certificate-rhi

[54] Air Quality Damage Costs Appraisal Toolkit : https://www.gov.uk/guidance/air-quality-economic-analysis

H - Technical assumptions for the Clean Heat Grant

Counterfactual

1. Evidence from the RHI is used to make an assumption on the types of counterfactual heating systems that will be replaced by low carbon heating technologies in the Clean Heat Grant. The proportion of counterfactual fuels displaced by low carbon technologies are shown in Table H1.

Table H1: Counterfactual fuel types

	Fuel type displaced					
	Oil	LPG	Coal	Natural gas	Direct electric	**Total**
ASHP	37%	5%	6%	24%	28%	**100%**
GSHP	54%	7%	3%	18%	18%	**100%**
Biomass	68%	8%	6%	6%	12%	**100%**

2. The alternative counterfactual presented in the Clean Heat Grant sensitivity analysis assumes all low carbon heating technologies replace oil boilers.

Low carbon technology assumptions

3. Tables H2, H3 and H4 show the low carbon heating cost and performance assumptions used in the Clean Heat Grant cost-benefit analysis.

Table H2: Air source heat pump assumptions

Assumption	Central	Low	High	Source
Average capacity (kW) [55]	8kW	-		National Household Model using The Building Research Establishment Domestic Energy Model (BREDEM)
Average annual heat demand of counterfactual housing stock (kWh)[56]	11,500	-	-	National Energy Efficiency Data-Framework (NEED) 2018
Average capex	£9,600	-	-	Delta EE/ BEIS assumption[57]
Annual maintenance cost (£)	£100	-	-	BEIS assumption
Efficiency (%)	251%	218%	283%	Renewable Heat Premium (RHPP) scheme Metering[58]
Lifetime	20 years	-	-	BEIS assumption informed by RHI consultation
Fuel price series	Central LRVC	Low LRVC	High LRVC	HMT Green Book supplementary guidance[59]

[55] Information on system capacity is derived from the National Household Model (NHM). The average capacity for each low carbon technology is then found by applying RHI assumptions on fuel types being replaced (Table H1). More information on heat pump suitability and sizing methodology can be found here: https://www.gov.uk/government/publications/electric-heating-in-rural-off-gas-grid-dwellings-technical-feasibility
[56] Information on annual heat demand is derived from the National Household 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 RHI assumptions on fuel types being replaced (Table H1). Heat demand includes space heating and hot water.
[57] 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.
[58] The Seasonal Performance Factor (SPF) levels are based on the H4 system boundary. Low and high are based on the 25th and 75th percentile of the H4 system boundary.
[59]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

Table H3: Ground source heat pump assumptions[60]

Assumption	Central	Low	High	Source
Average capacity (kW)	9kW	-	-	National Household Model using The Building Research Establishment Domestic Energy Model (BREDEM)
Average annual heat demand of counterfactual housing stock (kWh)	12,400	-	-	National Energy Efficiency Data-Framework (NEED) 2018
Average capex (£)	£17,800	-	-	Delta EE/ BEIS assumption
Annual maintenance cost (£)	£100	-	-	BEIS assumption
Efficiency (%)	284%	261%	327%	Renewable Heat Premium (RHPP) Metering
Lifetime	20 years	-	-	BEIS assumption informed by RHI consultation
Fuel price series	Central LRVC	Low LRVC	High LRVC	HMT Green Book supplementary guidance

[60] For modelling purposes, water source heat pumps are assumed to have the same technical assumptions as ground source heat pumps.

Table H4: Biomass boiler assumptions

Assumption	Central	Low	High	Source
Average capacity (kW)	17kW	-	-	National Household Model using The Building Research Establishment Domestic Energy Model (BREDEM)
Average annual heat demand of counterfactual housing stock (kWh)	14,200	-	-	National Energy Efficiency Data-Framework (NEED) 2018
Average capex (£)	£18,100	-	-	Delta EE/ BEIS assumption
Annual maintenance cost (£)	£100	-	-	BEIS assumption
Efficiency (%)	70%	68%	76%	Biomass field trial[61]
Lifetime	20 years	-	-	BEIS assumption informed by RHI consultation
Fuel price series	Central LRVC	Low LRVC	High LRVC	HMT Green Book supplementary guidance

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