Title: Green Heat Network Fund (GHNF) Consultation IA **IA No:** N/A **RPC Reference No:** N/A **Lead department or agency:** BEIS **Other departments or agencies:**	Impact Assessment (IA) **Date:** 09/11/2020 **Stage:** Consultation **Source of intervention:** Domestic **Type of measure:** Capital support **Contact for enquiries:** Phoebe Zhang
Summary: Intervention and Options	**RPC Opinion:** RPC Opinion Status

Cost of Preferred (or more likely) Option (in 2019 prices)			
Total Net Present Social	**Business Net Present Value**	**Net cost to business per year**	**Business Impact Target Status**
£602m	N/A	N/A	N/A

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

To deliver Net Zero and future carbon budgets, virtually all heat will need to be decarbonised and heat networks is a crucial aspect of the critical path towards achieving heat decarbonisation in the UK.

Government intervention is necessary to overcome the key market failures and barriers (such as higher costs, investor risk aversions and co-ordination failures) that prevent low-carbon heat networks from competing against well-established high carbon heat generation alternatives (e.g. gas boilers and gas combined heat and power) for investments.

The proposed intervention, the Green Heat Network Fund (GHNF) is a £270m capital support programme for low carbon heat networks. It intends to capitalise on the progress of the existing Heat Networks Investment Project (HNIP), putting the heat network market on a self-sustaining and low-carbon path as well as aligning with the introduction of low-carbon regulation in the 2020s.

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

The objectives of the GHNF are as follows:

- Achieve carbon savings relative to a gas counterfactual;
- Increase the volume of low-carbon heat delivered by heat networks;
- Increase market readiness ahead of heat network sector low-carbon regulation and the Future Homes Standard.

The intended effects are laid out in the consultation with headline appraisal results shown in GHNF Cost and Benefit Analysis section of this IA.

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

The short list of options is as follows:

1. **Do nothing** – Continue existing HNIP support to 2022 with no further government funding for the market. This would stunt the growth of the heat network market.
2. **Green heat network fund (preferred option)** – 3-year capital support from 2022/23 – 2024/25 to invest in new and existing low-carbon heat networks, which will help transition the market away from its reliance on gas-powered generation technologies and help scale up low-carbon heat networks using heat pumps and waste heat recovery technologies.
3. **Regulation including low carbon heat network zones** – Bring forward regulation on the decarbonisation of heat networks and low carbon heat network zones to encourage market growth without any prior capital support. This would achieve limited impact due to an under-developed market and supply chain.

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:** -5.3	**Non-traded:** -5.0
Will the policy be reviewed? GHNF will be evaluated. **If applicable, set review date:** N/A		

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 SELECT SIGNATORY: ______________________ Date: ______________________

Summary: Analysis & Evidence Policy Option 2

Description:

FULL ECONOMIC ASSESSMENT

Price Base Year	PV Base Year	Time Period Years	Net Benefit (Present Value (PV)) (£m)		
2019	2020	30	**Low:** Optional	**High:** Optional	**Best Estimate: £602m**

COSTS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition)	**Total Cost** (Present Value)
Low	Optional		Optional	Optional
High	Optional		Optional	Optional
Best Estimate	N/A		£20m	£601m

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

The key monetised costs in comparison to the counterfactual are:

- Increased capital costs of investing in low-carbon heat networks compared to the counterfactual. This is a large cost of an estimated £216m.
- The costs of the forgone electricity from gas-CHP technology in the counterfactual. This is a significant cost of an estimated £384m.

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

N/A

BENEFITS (£m)	**Total Transition** (Constant Price) Years		**Average Annual** (excl. Transition)	**Total Benefit** (Present Value)
Low	Optional		Optional	**Optional**
High	Optional		Optional	**Optional**
Best Estimate	N/A		£40m	£1203m

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

The key monetised benefits in comparison to the counterfactual are:

- Significant monetised carbon savings – an estimated £654m.
- Monetised air quality improvement – an estimated £51m.
- Reduction in (gas) fuel costs – an estimated £443m.

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

- Jobs impacts – the GHNF is expected to support both direct and indirect jobs.
- GVA benefit – the GHNF is expected to lead to an increase in GVA.
- Electricity systems impact – heat networks with thermal storage can be used to drive electricity systems benefit relative to the counterfactual.

Key assumptions/sensitivities/risks	**Discount**	3.5%

- Assumed mixture of generation technologies funded by the GHNF.
- Assumed split of new and existing heat networks funded by the GHNF.
- Technology coefficients of performance and thermal efficiencies.
- Capital costs of generation assets and distribution infrastructure.
- Carbon values.

BUSINESS ASSESSMENT (Option 21)

Direct impact on business (Equivalent Annual) £m:	

Costs: N/A	**Benefits:** N/A	**Net:** N/A	**Score for Business Impact Target (qualifying**
			N/A

Evidence Base

Problem under consideration and rationale for intervention

1. Clean Growth is one of the four grand challenges of the UK Government's Industrial Strategy and decarbonising heat is a vital part of this ambition. Heat is a major part of our economy and accounts for around a third of UK carbon emissions and almost half our energy usage[1]. To deliver Net Zero and our future carbon budgets, virtually all heat will need to be decarbonised.
2. Heat networks are a crucial aspect of the critical path towards decarbonising heat in all decarbonisation pathways. As low-carbon infrastructure, they are the most cost-effective way to decarbonise areas with high heat densities. They are uniquely able to unlock otherwise inaccessible sources of larger scale renewable and recovered heat such as waste heat and heat from rivers, mines and sewage treatment plants.
3. Without further government support to overcome the market failures and barriers present in the heat networks market which prevent low-carbon heat networks from competing with high carbon heat generation (such as gas-powered boilers), the nascent heat networks market may lose investor confidence and decline, limiting the contribution of heat networks to decarbonising heat and potentially failing to meet the UK's decarbonisation targets.
4. These market failures and barriers, which would require targeted interventions to overcome, are outlined as below:
    a. **Un-/under-valued negative externalities**: Greenhouse gas (GHG) emissions represent a cost to society which is not reflected in the prices for fossil fuels i.e. gas for heating. As a result, these costs are not likely to be fully factored into investment decisions, this is expected to lead to the under provision of low-carbon heat networks than would be socially optimal.

    b. **Information failures, uncertainty, and risk aversion**: Given the bespoke nature of heat networks and the nascent nature of the market, existing heat network operators may not feel confident that they possess the technical experience, skills, or knowledge on how to best optimise the performance of a low-carbon heat network. Private investors unfamiliar with the market and technology who do not value the wider returns to society are expected to underinvest, preferring to invest in more established technologies such as gas boilers, or gas combined heat and power (CHP) generation - the current dominant technology for heat networks, which gets revenue from both heat and electricity generation and therefore has strong project economics. Low carbon heat network projects must also meet higher hurdle rates to attract investment reflecting higher project risks, which is more challenging to achieve. The returns from long-lived low-carbon infrastructure is largely dependent on the wider climate and energy policy framework (e.g. carbon pricing and regulation), which is uncertain. Additionally, there is also uncertainty on how new low-carbon heat networks will perform in practice, as these low-carbon sources are relatively untested and have not been deployed at scale in the UK.

    c. **Co-ordination failures**: Identifying where a heat network is the most cost-effective option often requires co-ordination between the heat network developer and multiple parties including local authorities, housing associations, private landlords etc. As heat networks require a certain amount of heat demand to be viable, difficulties co-ordinating across parties could mean a heat network is scaled back or not deployed even if it would have been the most cost-effective option.

    d. **Higher costs**: Heat networks have additional initial infrastructure costs associated with constructing the network that other heating solutions do not. In addition, low-carbon heat sources such as large air source or water source heat pumps currently come at a cost premium when compared to the counterfactual (which consists of mostly heat from gas-CHP or gas boilers). This is expected to further deter investments going into certain low-

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf

carbon heat networks as the additional cost would need to be recouped by reducing returns or increasing heating prices for consumers.

5. Currently, most investment cases for heat networks are built around gas-CHP technology, due to the power and grid service revenues available. The HMG's existing Heat Networks Investment Project (HNIP) has been successful in enabling the UK heat networks market to get off the ground, and will bring forward lower-carbon technologies sooner for some projects but the heat network market itself cannot make low-carbon heat competitive with gas. In addition there is currently limited funding available to unlock the large-scale waste-heat sources for heat networks which the CCC believe should be delivering a third of heat supply for networks by 2050 (including energy-from-waste plants, sewage plant heat recovery, heat recovery from mines and commercial premises heat recovery). For this next phase of HMG support, we are aiming to build on previous heat network policy further through ensuring that heat networks are low-carbon, closing the cost gap with high-carbon heat sources such as gas (which do not currently have a sufficient carbon price).

6. To fully realise heat networks' role in heat decarbonisation, there is also wider government support planned to set up a heat network regulator to improve consumer standards, give consumers equivalent statutory rights to those in gas and electricity and introduce longer-term carbon emissions limits on the market, as well as to potentially consider the development of a zoning policy to explore and determine local low carbon heat network zones. However, introducing the standards and emissions limits too early without tackling existing market failures and barriers, market growth will likely be suppressed and zoning potential limited.

7. Therefore, to successfully contribute to decarbonising heat through the expansion of low carbon heat networks, a more targeted support mechanism is required to overcome the current market barriers in terms of minimising the finance gap between low-carbon heat generation and gas-fired heating technologies. The following intervention options, alongside a no support scenario have been considered:

   i) **Do Nothing** - Continue to provide capital support to the heat network market until the conclusion of HNIP in March 2022. At this point government support to the market will stop and the future growth of the sector would be determined by market forces. There is likely to be a residual impact of HNIP, however the market is expected to grow at a slower rate than during the HNIP period. Some low-carbon networks are expected to be deployed, but likely to longer time scales and on a smaller scale. Heat networks will still be required to meet the 2050 net zero target. However, given the stunted market growth, less cost-effective heating decarbonisation solutions are likely to be installed instead of heat networks.

   ii) **Green Heat Network Fund (GHNF)** – £270m targeted support for low-carbon heat networks to continue the growth in the market capitalising on the progress of HNIP and development made by the Heat Networks Delivery Unit (HNDU), and to transition the market away from its reliance on gas-powered generation technologies. This option will deploy large, low-carbon heat networks using heat pumps and waste heat recovery technologies which are not currently deployed at scale in the UK. This is the **preferred option** as it is targeted at the specific issues we are seeking to address. To meet Net Zero by 2050, the CCC recommended that 18% of total UK heat demand is to be delivered through heat networks and currently heat networks only provide around 2% of UK heat[2]. Given the scale of heat decarbonisation challenge, there is significant growth potential for the heat network sector. In fact, the latest £1.7 billion worth of active pipeline opportunities

[2] https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2015/11/Element-Energy-for-CCC-Research-on-district-heating-and-local-approaches-to-heat-decarbonisation.pdf

from HNIP and HNDU applications[3] present early evidence of this market demand, where some of these projects could potentially be supported by GHNF. As GHNF intends to support the deployment of large scale heat network projects with a diverse range of technologies, a smaller volume of funding would limit the scale and diversity of deployment and our decarbonisation ambition. The £270m is deemed appropriate as the minimum level of funding required to achieve the intended scale needed to facilitate market growth whilst decarbonising heat. A higher volume of funding would be desirable and the programme can be further scaled up should the current budgetary constraint be relaxed.

iii) Regulation and low carbon heat network zones – There are plans to introduce regulation to the market which will require heat networks to be low-carbon by means of a carbon emissions standard as part of the heat networks market framework. This option would be to bring forward the implementation of this decarbonisation standard and combine it with a heat network zoning policy to identify and determine the lowest cost, low-carbon heating pathway at a local level, *without* any additional support on market development prior (i.e. without implementing GHNF first). However, without support from GHNF to first grow the market, improve existing networks, reduce technology costs and develop the supply chain for low-carbon networks in the early 2020s, heat networks are not expected to be the most cost-effective option in many areas and the industry is likely to be ill-equipped to meet the increased demand and struggle to meet the decarbonisation standard in the market framework. Thus, the success of a low-carbon heat network zoning policy is predicated on the market growth delivered by other heat network policies.

8. As set out above, the GHNF is the preferred option as it will directly or indirectly tackle the market failures and barriers early on, which will enable further market and supply chain development by stimulating the increased deployment of low-carbon technologies at scale and thereby prepare the heat network market for future regulation and zoning policy. It will also indirectly help reduce coordination challenge through selecting projects with sound coordination efforts as the project's deliverability assessment part of the application process, which will generate learning to better inform subsequent projects. Furthermore, the GHNF is needed after HNIP closes in early 2022 to avoid an investment hiatus and so the decarbonisation of existing networks and deployment of new low-carbon heat networks can be ensured, which is necessary for the 4th and 5th carbon budgets and the UK's 2050 net-zero target.

Summary of the preferred option and implementation plan

9. A call for evidence has been carried out on GHNF and a Consultation, which this Impact Assessment (IA) is supporting, will be conducted to further gather evidence and views to inform scheme design and implementation. Therefore, the current proposal will be subject to further revisions dependent on consultation responses and the availability of further evidence.
10. The GHNF scheme currently proposed aims to incentivise the transition of the heat network market to a low-carbon one via targeted financial support. Specifically, GHNF seeks to build on the progress made by the Heat Network Investment Project (HNIP) and the Renewable Heat Incentive (RHI) by ensuring that heat networks are incentivised to integrate low-carbon heat sources, including large-scale heat pump systems and waste heat recovery, which are capital intensive and too expensive for projects to adopt without HMG support. GHNF will help to put the heat network sector on a self-sustaining path by the late 2020s ahead of sector low-carbon regulation. As part of the National Infrastructure Plan, GHNF will contribute towards the upgrade of the UK's energy infrastructure as well as to HMG's strategy to transition to clean growth.

[3] Around half of the active pipeline consists of projects supported by HNIP, with the other half is being developed. See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/910199/Heat_Networks_Project_Pipeline_April_to_June_2020.pdf

11. Given the above aim, the proposed GHNF has the following **policy objectives**:

    i) Achieve carbon savings and decrease in carbon intensity of heat supplied;
    ii) Increase the total amount of low-carbon heat provision and utilisation in heat networks (both retrofitted and new heat networks);
    iii) Increase market readiness of the heat network sector ahead of this sector's low-carbon regulation, achieved by wider clean market growth, supply chain capacity expansion and cost reductions, and ensure compliance with existing regulations.

    As there are still substantive uncertainties with regards to scheme design, more specific targets in the form of SMART objectives will follow post consultation as part of the Outline Business Case development.

12. By 2025, market regulation for lower-carbon projects is likely to become the default for new heat network projects for new builds under the Government's Future Homes Standard, and the regulation of carbon emission standards in the proposed Heat Network Market Framework will help ensure that existing gas-fired heat networks are encouraged to transition to low-carbon sources. Financial support through the proposed GHNF will help build the heat networks supply chain and bring technology costs down to ensure market readiness ahead of these measures.

13. GHNF support is proposed to be delivered through a competitive allocation process which assesses the deliverability of supply chain commitments as part of the application criteria. The rationale is to help ensure the projects that show promise in advancing supply chain improvements in the market will have more targeted support with the intention to drive down costs of low-carbon heat networks over time. However, the level of competition is yet to be identified dependent on consultation outcome.

14. GHNF's grant allocation process, though yet to be finalised, is expected to be similar to HNIP's. HNIP applications are assessed through a model that looks at the heat and carbon savings that could potentially be delivered by the projects against a counterfactual. In addition, over the spending period, BEIS and the Delivery Partner will use this model to track the costs of heat network infrastructure in order to assess the supply chain benefits of the scheme.

15. Climate change policies, including heat network policy, are devolved matters. It has not yet been determined whether the scheme proposed will apply to both England and Wales or if the Welsh Government will develop a separate scheme. BEIS is currently working with the Welsh Government to understand the potential for alignment on the GHNF. Similarly, given the devolution, projects within Scotland and Northern Ireland will not be eligible to this scheme.

16. Subject to approval, the GHNF is expected to launch in April 2022 and will run until March 2025. Details on the scheme design and implementation plan are provided in the consultation document that this IA is supporting. There is ongoing policy work on GHNF to determine and finalise the scope for eligibility, the scoring criteria and the commercial arrangements for delivery. As the final policy will be dependent, to an extent, on the responses to the consultation, this IA will not go into detail on the implementation plan for GHNF.

Monitoring and Evaluation

17. Learning from HNIP to-date is mostly on process simplification which consists of using a grant only instrument for GHNF (rather than grant and loan) and streamlining the reporting process and administrative burden of projects by reducing the number of benefit metrics in the proposed Benefits Realisation Plan. Other learning also includes improvement of assumptions for cost benefit analysis e.g. GHNF takes into consideration of project developers' optimism bias in capital expenditure, whereas HNIP did not. HNIP is still an ongoing programme and GHNF will continue to use the evidence generated by existing and upcoming HNIP projects, as far as possible, to inform its design and processes.

18. To advance the policy objectives defined above and assess whether GHNF delivers value for money, GHNF will be expected to deliver the following measurable benefits which will be monitored through projects funded (see details in Annex B):
    - An increased proportion of thermal energy supplied through low-carbon sources;
    - A decrease in carbon intensity of thermal energy delivered by GHNF supported heat networks;
    - Carbon savings relative to the alternative thermal energy source;
    - Increased use of thermal energy recovery in heat networks funded via GHNF;
    - Increased investment in the UK heat network market leveraged by GHNF funding;
    - Increased supply chain capacity and capability in the UK;
    - Reduction in costs of low-carbon generation in heat networks;
    - Greater innovation and energy efficiency in heat networks.

19. It is important that a scheme of the size and scope of the GHNF is properly evaluated. This will help to determine whether it has had its intended effect on the heat network market but will also capture any lessons that can be learned from it which can inform other schemes. As was the case with HNIP, we propose to commission an independent evaluation of the GHNF which will get under way when the scheme is operational. This evaluation will follow the principles of realist evaluation, focusing on contextual questions of "what works, for whom, under what circumstances?" and will use an evolving Theory of Change to examine the way in which the GHNF will achieve its intended outcomes.
20. As part of the evaluation process, it is envisaged that applicants for GHNF funding will be asked to take part in interviews with researchers to obtain their feedback on the scheme. It is also likely that applications will be shared with the appointed evaluators on a confidential basis, under a data sharing agreement with BEIS. Successful applicants to the GHNF will be required to take part in the evaluation of the GHNF as a condition of their funding. However, the GHNF will seek to minimise the burden on them, e.g. through the sharing of project management information and monitoring reports with the evaluators. In the case of unsuccessful applicants, or those who, for whatever reason, decide to withdraw an application, their participation will be requested on a voluntary basis. Feedback from participants in the research will be anonymised and all data collection and sharing will be compliant with the General Data Protection Regulation.
21. The precise terms of the evaluation will be finalised, and an evaluator appointed, as the scheme is further advanced. However, the evaluations will consider various aspects of the GHNF such as the "applicant experience" and the impact that the scheme is having, both on the projects awarded funding and on the market as a whole. Outcomes are likely to include a series of reports which will be published online on gov.uk.

Rationale and evidence to justify the level of analysis used in the IA (proportionality approach)

22. This IA is to support the GHNF consultation following a recent call for evidence. Certain aspects of the scheme design have been developed and are relying on the responses to this consultation to inform them. The cost benefit analysis in this IA is therefore predicated on a series of assumptions made about the nature of the projects that will be funded via the GHNF.
23. The analysis in this IA provides an indication of the nature and scale of the costs and benefits associated with the currently proposed GHNF. Naturally, the quality of the evidence on which the analysis is based on varies - see more details on modelling assumptions and uncertainties below. As the scheme design develops and we progress to future stages of Business Case development, more or higher quality evidence is likely to become available. We will use the responses to the consultation and ongoing research to strengthen the evidence base and update the associated analysis and CBA model, in a proportionate manner, to reflect improved assumptions and any design changes.

GHNF Cost Benefit Analysis

Headline Methodology

24. In support of the GHNF consultation and business case which feed into the HMG's public spending decisions, an economic assessment to understand the value for money of the proposed GHNF scheme is carried out following the cost and benefit analysis (CBA) guidance and methodology set out in the HM Treasury's Green Book[4], and the related supplementary appraisal guidance on energy use and greenhouse gas emissions[5].

25. The relevant costs and benefits valued or monetised are those for society overall, and take into consideration the social, economic, environmental and financial impacts which are to be assessed against a Business As Usual (BAU) counterfactual (i.e. what would have taken place in the absence of intervention). The resultant social net present value (SNPV), in the case of GHNF is determined by appraising the social costs and benefits of the heat networks that are assumed to be deployed under the scheme over a specified appraisal period, which are then compared to those that would be incurred by meeting the same heat demand profile with gas-fired technologies (the BAU counterfactual).

26. See below for the headline analytical results of the currently proposed GHNF followed by more details on methodology and key assumptions. Please note this CBA analysis only provides an indication of the scale of potential social costs and benefits given assumed scheme design. They are subject to further revisions and updates as scheme design and business case develop.

Headline Results

27. With the proposed funding for GHNF at £270m as per the outcome of a spending bid for the March budget earlier in the year, the GHNF is expected to fund the delivery of an estimated 1.15TWh of low-carbon heat annually. This means, in comparison to the gas-fired counterfactual, an estimated 2.3Mt of non-traded carbon savings could be achieved within Carbon Budget (CB) 4, 5 and 6, and 10.3Mt of total carbon savings by 2050, saving carbon at £5/tCO2e (see Figure 1).

28. Indeed, the currently proposed GHNF is expected to deliver value for money with an estimated SNPV of £602m and an associated benefit-cost ratio (BCR) of 2.4, i.e. every £1 of CDEL spent will deliver £2.40 of benefit.

Figure 1 - GHNF key results

Metric	Value
SNPV (£m)	£602m
BCR	2.4
Total non-traded carbon savings for CB4, 5 and 6	2.3 mtCO2e
Total carbon savings up to 2050	10.3 mtCO2e
Social carbon cost effectiveness	£5.0/tCO2e

29. The SNPV can be broken down by net costs and benefits. Where the costs are lower for the scheme relative to the counterfactual, this provides a societal benefit as you are providing the

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

[5] URL: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794737/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal-2018.pdf

same heat demand at lower cost than the counterfactual, therefore they are shown as positive numbers in Figure 2 below. Where costs are higher relative to the counterfactual, these represent a net cost, so are displayed as negative numbers.

30. As illustrated in Figure 2, the proposed GHNF would lead to a net increase of £216.5m in total capital costs relative to the counterfactual. This is due to both higher capital costs of low-carbon heat generation technologies as well as the costs of new distribution infrastructure for new heat networks. There is also a significant cost of £384.2m due to forgone electricity production by moving away from gas-CHP to low carbon heating. This cost reflects the grid having to produce the electricity that is no longer produced by gas-CHP.

31. The benefits of the scheme, however, do outweigh the costs. Over the appraisal period, the GHNF leads to a significant carbon saving benefit of £653.6m, a large air quality benefit of £50.9m and a substantive £442.8m reduction in fuel costs relative to the counterfactual. The benefits stem largely from the improved thermal efficiencies of the low carbon heating technologies relative to the counterfactual. The benefit is particularly significant from waste heat (both low and high temperature).

Figure 2 - Net costs and benefits

Net benefits	**Monetised value, in £m**
Carbon impact	£653.6m
Air quality impact	£50.9m
Operating cost savings	£55.6m
Fuel cost savings	£442.8m
Net costs	
Capital costs (include both heat generation and distribution network)	-£216.5m
Loss of CHP electricity production	-£384.2m

32. The private NPV, which consists of capital costs, operating costs and fuel costs incurred by businesses and individuals relative to the counterfactual as a result of GHNF, amounts to -£102m. Given limited evidence on heat prices for low-carbon heat networks, it is assumed that low-carbon heat network consumers will pay similar prices for heat as the equivalent counterfactual, and therefore receive similar revenue as the counterfactual (where the two net to zero). Despite a negative private NPV, the social benefits of GHNF arising from reductions in carbon emissions and air quality improvements, as well as private fuel cost savings, leads to an overall positive SNPV.

Assumptions

33. There are a number of key methodological and data assumptions driving the analysis. The rationale of using and applying these assumptions are explained in more details below. Where relevant, our data assumptions e.g. cost of technologies, are based on the best evidence currently available to us from industry and data collected through HNIP. Methodological assumptions are based on analytical judgement given data availability, proportionality and informed by experts' views. As such, all assumptions contain a degree of uncertainty and are subject to further updates if better evidence becomes available. The uncertainties around certain key assumptions are further explored by sensitivity analysis – see more details in the 'Model Risks and Limitations' section below.

34. The key assumptions which drive the modelling results are described below - more detailed information on the values and evidence sources of these assumptions can be found in Annex A.

Figure 3 – Key modelling assumptions

Funding, heat demand and deployment assumptions	Quality Rating	Impact Rating
Funding caps at £270m (as per March 2020 Budget bid) and covers support for new network infrastructure in addition to low-carbon heat generation.	Medium	High
Appraisal period goes out to 2050 (i.e. approximately 30 years) only, despite longer asset lifetime. This is to reflect the large uncertainty around the gas counterfactual beyond 2050 as Net Zero commitment could put gas technologies out of commission by then.	Medium	Medium
There is enough market demand to support the annual delivery of 1.15TWh of heat up to 2050.	High	High
An assumed 50:50 split of support from GHNF for building new heat networks and decarbonising existing heat networks, with the same equal split for individual gas boilers and gas-CHP heat networks as respective counterfactual technologies.	Medium	High
Additionality of the funding – it is assumed that 85% of the funding is additional, which is aligned with the assumption used in HNIP's value for money analysis.	High	Medium
Technology cost and performance assumptions		
All heat networks are assumed to be district heat networks (determined by minimum of 2GWh per year of heat threshold) which the mix of heat generation technologies within the portfolio of projects reflect.	Medium	Medium
Capital, operational and fuel[6] costs of the different heat generation technologies for both the factual heating technologies, and the counterfactual.	Medium	Medium
An assumed optimism bias on technology costs where costs are likely to be, on average, 21% higher.	Medium	Medium
The thermal efficiencies, load factors and thermal losses of the different technologies.	Medium	Medium
Other assumptions		
Green Book Supplementary Guidance[7] - Fuel prices, carbon prices and air quality pollutant values from official sources.	High	High
The social cost of the grid producing electricity that would have been produced by gas-CHP is quantified using a bespoke LRVC curve which reflects the true cost of this electricity production.	Medium	Medium

35. The CBA comprises the following costs of the projects funded against the counterfactual:

- Capital costs of the generation assets and distribution infrastructure
- Operating costs of the generation assets and distribution infrastructure
- Fuel costs – LRVC of gas and electricity
- Carbon emissions costs
- Air quality costs
- Gas-CHP electricity production costs

36. Where possible the assumptions used have been kept consistent with those used in HNIP, unless we have updated our evidence base. Through the consultation responses, we hope to test and validate many of the key assumptions used in our analysis. Where necessary, these

[6] Fuel costs for Energy from Waste plant i.e. costs for waste is currently assumed to be free (for the projects) given they would be disposed (to landfill or be burnt) regardless of the heat provision. Where funded thermal generation technologies use electricity as a fuel input, fuel costs and emissions are accounted for in line with Green Book supplementary guidance recommended methodology.

[7] https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

assumptions will be updated following the consultation. A more detailed breakdown of the cost assumptions used in the CBA is provided in Annex A.

General methodological assumptions

37. Given the funding that could potentially be allocated to GHNF is £270m post the March 2020 budget bid, this analysis is carried out assuming that being a hard constraint and calculates the amount of heat that could be delivered i.e. 1.15 TWh/year subject to this constraint and other technical assumptions.

38. The appraisal period for the analysis would normally be based on the life of the longest-lived asset – the distribution network which has a lifetime of 60 years. However, given UK's commitment to Net Zero by 2050, it is very uncertain that the counterfactual world would exist beyond 2050. As such, the appraisal period for the analysis stops at 2050 i.e. 30 years. This means some benefits cannot be estimated beyond 2050 due to the uncertain counterfactual. However, a qualitative assessment of the costs and benefits beyond 2050 will be developed later as we progress through business case stages.

Counterfactual

39. Currently, the default generation technology for heat networks is gas-CHP. These plants have previously delivered carbon savings for heat networks because when they export electricity to the grid this has been produced with gas and produced more efficiently than the average grid source. However, since 2012 the average carbon intensity of grid electricity has fallen from 0.519kg CO_2/kWh to 0.136kg CO_2/kWh, which has reduced these carbon benefits. The economics of gas-CHP, due to the revenues from electricity export, makes it the dominant technology for existing heat networks, which will continue to be deployed without further intervention. For this reason, gas-CHP is the technology choice for existing heat networks in the counterfactual.

40. As building heat networks require a lot of coordination effort across multiple parties, as well as further investment in network infrastructure, in the absence of regulatory requirement (e.g. Future Homes Standard) or incentives, property developers are likely to go for the standard, cheaper and easiest to implement heating solutions for new builds i.e. conventional gas boilers in individual homes. As such, this makes gas boilers the likely counterfactual alternative for new low carbon heat networks.

41. Thus, the counterfactual for the GHNF reflects a likely BAU alternative of gas-based heat generation i.e. gas-CHP for existing heat networks and new gas boilers for new heat networks. Given limited evidence, we have little certainty on what the split between new and existing networks should be, we therefore at this point, assume GHNF will provide equal support to building new and decarbonising existing heat networks, and therefore, their counterfactual gas technologies also have this 50-50 split – see Figure 4 below. For existing heat networks, it is assumed that there would be no additional distribution infrastructure costs, where costs only incur from replacing existing gas heat generation assets with low-carbon ones.

Figure 4 – New versus existing heat networks and associated counterfactuals

New/Existing	Counterfactual	% of Heat Demand
New	Individual gas boilers	50%
Existing	Gas-CHP heat networks	50%

Low Carbon Heat Generation Technology

42. In the proposed GHNF, one of the key project eligibility criteria is that a project needs to produce at least 2GWh/yr of heat, which effectively can only be delivered by a district heating network system. As such we do not currently anticipate many communal networks being

funded under GHNF. For simplicity, this analysis has been carried out assuming this 2GWh/yr threshold with district heating systems being the main type of heat networks. If the eligibility size threshold changes due to responses to the consultation, the cost benefit analysis would be updated.

43. The GHNF will be expected to fund heat network projects with a mixture of heat generation technologies. For the purpose of modelling, these heat network technologies, as shown in Figure 5, are broadly grouped into three temperature segments, with an assumed technology mix and deployment to meet the estimated 1.15TWh/year annual heat demand:

    a. Low temperature ambient heat – this is heat that can be extracted by air, ground and water source heat pumps, which could also include solar thermal. It is assumed around a fifth of heat demand could be delivered by a mixture of ground and water source heat pumps and solar thermal with air source heat pumps.

    b. Low temperature non-ambient heat – this is low temperature waste heat sources where the heat is upgraded by a water source heat pump to be used in a network. This could also include solar thermal. For modelling simplicity, heat generation technologies in this segment have been assumed to be water-source heat pumps with elevated input temperatures, where the inlet temperature of waste heat is either at 30, 40 or 50 degrees. This is to reflect the various types of waste heat sources.

    c. High temperature waste heat - high grade heat that does not require upgrade, e.g. heat from an Energy from Waste (EfW) incinerator, and potentially biomass and hydrogen. For modelling simplicity, heat in this segment is modelled exclusively as Energy from Waste.

Figure 5 – Heat demand profile by technology type

Temperature Segment	**Heat Demand (TWh/year)**
Low Temperature Ambient	0.25
Low Temperature Non-Ambient	0.45
High Temperature Waste Heat	0.45

44. The modelling methodology and assumptions on technology mix and deployment expected from each temperature segment are based on:
    a. Proposed project scoring criterion on carbon content, where low and high temperature waste heat sources would each be lower carbon relative to ambient heat sources using ground-source or water-source heat pumps;
    b. Best available evidence to-date, which includes evidence of the existing and pipeline of low-carbon projects from HNIP, a recent study on the availability of EfW and the 2015 National Comprehensive Assessment (NCA) for heat networks, which is due to be updated.

    We are in the process of finalising the 2020 NCA, which includes a study we have commissioned ARUP to conduct on all waste heat sources. As such, the above assumptions are subject to further revision or update based on the new evidence that would emerge from this research as well as consultation responses.

45. Where possible, assumptions on technology costs and performance (i.e. capital costs, operating costs and thermal efficiencies of heat network generation and distribution technologies) have been kept consistent with HNIP. The HNIP assumptions were agreed in conjunction with colleagues in the heat networks industry which represent our best view currently.

46. To reflect possible optimism bias on technology costs where projects tend to underestimate, the capital cost assumptions have been increased by 21%. This adjustment is based on

evidence presented at an Environmental Audit Committee[8], and is consistent with other infrastructure project-based cost benefit analysis across government.

Model risks and limitations

Key uncertainties

47. When appraising a large-scale capital spend programme, particularly one where the scheme design is not finalised, uncertainties exist, which need to be recognised and managed. The uncertainties and risks that affect the GHNF CBA are scheme design and implementation related or methodological (including data choices and assumptions). As more evidence emerges including responses from the upcoming consultation, subsequent analysis will be updated to reflect any changes. The key uncertainties are outlined below:

    a. Programme funding risks – spending review uncertainties around the £270m funding given the latest spending review is only one year and does not cover the GHNF spend horizon. Changes in funding amount would impact SNPV. The estimated costs and benefits are directly scalable to the funding awarded i.e. an increase in funding will lead to a proportionate increase in the estimated SNPV, and holding all else constant, the BCR and CCE will remain unchanged.

    b. Implementation risks - GHNF funding is expected to be spent over the 3-year funding period, with an additional 1-year to complete construction or start operation. Implicit within this is the assumption that there are enough existing and new heat networks to accept the volume of low-carbon heat being brought online and they have enough flexibility (technical, contractual etc.) to accept this heat. *Mitigation:* extensive work is being carried out to ensure there is a strong pipeline of projects that will apply for funding, including raising market awareness of the programme through call for evidence and consultation.

    c. Coordination and alignment risks – not all market barriers are financial, with regards to the deployment of large- scale heat through both low and high temperature waste heat opportunities, this is also dependent on aligning the involvement of numerous actors such as owner of the waste heat source, the heat network project and the consumers. The model implicitly assumes all these actors are aligned and convinced through a capital grant to do something which is not BAU. *Mitigation*: this would be mitigated through other heat network transformation works such as the sector market framework as well as support from the Heat Network Delivery Unit on project development.

    d. Uncertainty on eligible heat network type – the model currently assumes GHNF only funds district heat network given it proposes only heat networks that can provide a minimum of 2GWh per year of heat will be eligible, which rules out most communal network, or other network configurations such as shared ground loop or ambient heat networks. *Mitigation:* industry and wider views will be gathered as part of the consultation to gain more clarity on this. If new evidence emerges, the CBA model will be revised accordingly.

    e. Uncertainty around funding additionality – assuming not all funding will be truly additional, GHNF funding's additionality is currently assumed to be 85%, in line with HNIP[9]. So there remains a risk that GHNF supported projects could be less additional and will have gone ahead anyway. *Mitigation*: the scheme intends to build in a competitive process to award funding which could remove some level of uncertainty. However, the mechanism to do this and the level of competition is yet to be scoped out and will be influenced by the consultation response. Sensitivity analysis has been carried out illustrate impact (see below).

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[8] Select Committee on Environmental Audit, - https://publications.parliament.uk/pa/cm200607/cmselect/cmenvaud/1110/111004.htm

[9] There is limited evidence on additionality from HNIP funded projects given that the programme is ongoing and further evaluation is yet to take place. The current 85% additionality is a simplifying and conservative assumption and will get updated should new evidence arises.

f. Uncertainties around key technology related assumptions – they consist of: (i) the make-up of new vs. existing heat networks funded via the GHNF (ii) heat generation technology mix across and within temperature segments; (iii) costs and thermal efficiencies. *Mitigation*: sensitivity analysis (see section below) has been done to illustrate the impacts of these assumptions on the model, but further analysis and research as well as consultations will be carried out to collect more evidence to inform or validate these assumptions. This includes work on project pipeline development, consultations, waste heat research and the 2020 NCA.

g. Uncertainty around carbon value - the value placed on changes in greenhouse gas (GHG) emissions is currently under review, since the UK has increased its domestic and international ambitions. Accordingly, current central carbon values[10] are likely to undervalue GHG emissions, though the scale of undervaluation is still unclear. *Mitigation:* 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 (see Sensitivity Analysis below). HMG is planning to review these carbon values in due course, and we will update our assumptions in the CBA model accordingly when they become available.

Sensitivity Analysis

48. Modelling the expected outcomes of the GHNF is inherently uncertain. The modelling is reliant on several assumptions and inputs that are necessary to understand the impact of the GHNF, however they cannot be predicted with complete certainty over the appraisal period. Additionally, the GHNF is a demand-led scheme, therefore assumptions on the split of the technologies funded and the appropriate counterfactual are necessary but, in reality, will depend on the applications made for funding.

49. The sensitivities of the following key CBA assumptions on SNPV have been tested:

   a. **Carbon prices** – The benefits of delivering low-carbon heat depend on the wider energy and climate policy framework including future decisions on carbon valuation. When appraising policies that abate carbon, HMG applies a consistent approach in using carbon prices which are published in the HMT Green Book supplementary guidance and are applied per tonne of carbon abated. These figures are published with low, central, and high uncertainty ranges. The analysis assumes central carbon prices, we have also considered a high carbon price impact on the SNPV in the sensitivity analysis.

   b. **Capex** – Heat networks have large initial infrastructure cost requirements and therefore capex levels have a significant role in heat network deployment. Additionally, capex values remain a significant source of uncertainty due the nascent nature of the heat networks market and the fact that low carbon generation technologies haven't been deployed at scale. While we have estimated capex costs based on existing information from HNIP, we have also considered its impact on the SNPV with sensitivity of +/- 15%.

   c. **The split of new vs existing heat networks funded by the GHNF** – The counterfactual thermal generation source (gas boiler or gas-CHP) for each heat network depends on whether it is an existing or new heat network. Given the demand-led nature of the scheme, it is difficult to accurately predict how funding will be split between new and existing heat networks, therefore there is inherent uncertainty in the counterfactual mix which partly determines the SNPV. Additionally, existing heat networks do not incur network costs which are a sizable cost component in the SNPV. The CBA assumes a 50:50 split of new to existing heat networks, in the sensitivity analysis we model the SNPV impact of a 30% and 70% split of new heat networks.

   d. **The technology mix of deployed thermal generation sources –** We have assumed that the GHNF will fund projects that broadly fall into three groups. Each of these

[10] The Green Book Supplementary Guidance on valuing energy use and greenhouse gas emissions publishes low, central and high values of carbon for sensitivity analysis

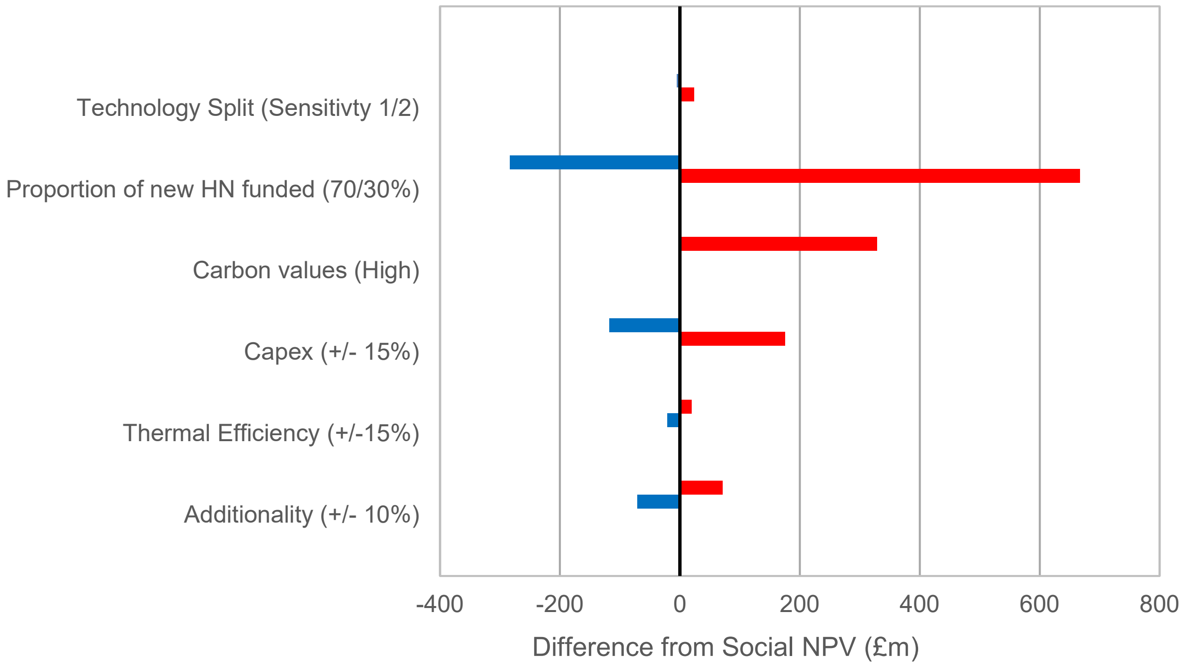
technologies has its own set of assumptions which in turn determine the level of heat network deployment. Similar to the prior assumption, the demand-led nature of the scheme means there is innate uncertainty surrounding the split of technology used to model the SNPV. See Figure 6 below for the assumed technology mix used in the CBA alongside the tested sensitivities.

Figure 6: Social Net Present Value (SNPV) Sensitivities of Technology mix

Thermal Generation Technology	Central scenario	Sensitivity 1: Heat diverted from EfW to Heat pumps	Sensitivity 2: Heat diverted from EfW and Waste Heat Sources to Heat pumps
Low temp ambient (TWh/Yr)	0.25	0.40	0.55
Low temp non-ambient (TWh/Yr)	0.45	0.45	0.30
High temp waste heat (TWh/Yr)	0.45	0.30	0.30

e. **The efficiency of thermal generation sources –** The cost effectiveness of heat delivered by the GHNF partly depends on the thermal efficiencies of the technologies deployed. Given that these technologies have not been deployed at scale yet, there is uncertainty around the performance of these technologies over their expected lifetime. Technology efficiencies have been estimated from HNIP data, and we consider a +/-15% movement for our sensitivity analysis.

Figure 7: Social Net Present Value (SNPV) Sensitivities – See Annex B for sensitivity assumptions used



50. As illustrated by Figure 7 above, the sensitivity analysis results indicate that the SNPV is most responsive to changes in the proportion of new heat networks funded. The analysis suggests that the lower the proportion of new heat networks funded, the higher the modelled SNPV. Although the counterfactual technology of existing heat networks is assumed to be gas-CHP, which has greater foregone electricity generation benefits, this is outweighed by the assumption that existing networks do not incur network costs which forms a sizable portion of capex and therefore yields a net benefit, which means that the GHNF could potentially achieve greater delivery of low-carbon heat via decarbonising existing networks within the appraisal

horizon, which improves the SNPV. However, investing in new heat networks is likely to increase the number of consumers connected to low-carbon heat networks, support greater growth in the heat network market and lead to wider benefits that are not captured in the SNPV.

51. Carbon price variations have a large impact on the SNPV, although this effect is less pronounced than the proportion of new heat networks funded. The responsiveness of the expected SNPV to carbon price variations illustrates the key role green ambition has on the valuation of carbon abatement.

52. Capex level sensitivities also have a significant impact on the expected SNPV however this is not as considerable as the two sensitivities above. Given the large initial infrastructure costs associated with heat networks this is expected, as lower capex levels increase the cost effectiveness of heat delivered through the GHNF. Lower capex levels also mean that the GHNF can lead to greater deployment of heat networks, which is beneficial for the SNPV.

Non-Quantified Wider Impacts

53. There are potential costs and benefits of GHNF which remain un-monetised and are not included in this cost benefit analysis, due to the difficulty in providing robust estimates. These include:

    a. **Jobs impacts** – Investment in the heat networks sector is expected to support UK jobs, in the design, construction and operation of heat networks. Direct jobs impacts have been estimated using a jobs multiplier informed by evidence from the construction sector. This analysis indicates that the GHNF could potentially support up to 2,500 direct jobs and 1,000 indirect jobs on average a year between 2021/22 – 2024/25. Estimating jobs impacts is uncertain for the GHNF given the specific projects to be funded are unknown at this stage. The jobs impacts are estimates of jobs supported, the jobs are not necessarily all created.

    b. **Gross-Value Added (GVA) impacts in the wider economy** – The investment in heat networks is expected have multiplier effects in the wider economy such as: providing energy savings for users of heat networks; increasing or safeguarding UK jobs (see above); and developing the operations of Energy Service Companies (ESCos). The in-direct GVA impacts are uncertain and therefore have not been quantified in this analysis.

    c. **Spill-over benefits** - The increased investment in the heat network market is likely to lead to a number of in-direct spill-over benefits from the lessons learnt, skills developed and any opportunities which occur as a result of the GHNF.

    a. **Potential electricity system impact** - Larger heat networks with thermal stores and an electric source of heat are strategically important in making a low carbon power supply sector more resilient, by delivering an option to reduce intermittent peaks in electricity generation. A smart and flexible electricity system could save between £17-40bn to 2050[11], the flexibility/storage capabilities of heat networks could contribute toward this.

    b. **Costs of gas and electricity grid infrastructure** – The capital and operating costs of heat generation is accounted for in the factual and counterfactual scenarios. However, we have not valued the reduced demand on the gas-grid, or the additional cost placed on the electricity grid from electrifying heat networks. The net impact of this is complex as the value will depend on how the counterfactual and factual technologies change over time i.e. if the counterfactual is individual heat pumps they are expected to place higher demands on the electricity grid than heat networks. In addition, given the large-scale reinforcing of the grid required to accommodate renewables, electric vehicles

[11] An analysis of electricity system flexibility for Great Britain, 2016, link: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/568982/An_analysis_of_electricity_flexibility_for_Great_Britain.pdf

and heat pump heat networks are expected to provide a benefit (reduction in reinforcement) or come at a small additional marginal cost, particularly given the flexibility benefit discussed above.

c. **The option value of delivering a self-sustaining market in heat networks** - The value of being able to deploy networks in greater volume in the future and utilise infrastructure for lower carbon heat technologies. As the networks are largely technology agnostic, the deployment of heat networks in the right locations are likely to be a low-regrets option in a wide range of future low-carbon heat scenarios.

d. **Health benefits** – The analysis values air-quality benefits due to changes in energy consumption. Additional health benefits could occur where heating can be provided to consumers at a lower cost. The lower cost could stimulate a behavioural response from some consumers to heating their homes to a higher temperature for thermal comfort than they would otherwise, in some circumstances this would result in improved health outcomes.

Impact on small and micro businesses

54. Small and micro business assessments refer to the impact of regulation on small business, and whether the burden can be reduced. Since this impact assessment isn't regulatory, a small and micro business assessment hasn't been included.

Wider impacts (consider the impacts of your proposals)

55. The impact of GHNF on people sharing protected characteristics depends on where supported heat networks are located, and their customer base. As the GHNF is a demand-led scheme, we are not able to estimate where individual projects will be located or who will be affected.

56. However, due to the nature of heat networks being mainly an urban technology and appropriate for multi-tenancy buildings, heat networks tend to serve people sharing some of the protected characteristics. In particular, the findings of the Heat Network Consumer Survey (HNCS) describe that heat networks tend to serve vulnerable and elderly consumers[12]:

- *Elderly*[13]*:* 44% of heat network consumers in the survey were retired, whilst the wider population proportion was 14%. Furthermore, in heat network households, 44% had at least one person aged 65 or older.
- *Vulnerable*[14]*:* The HNCS outlined that 40% of those on heat networks met one of their conditions for being a vulnerable consumer[15], whilst 27% were considered to be financially struggling[16].

57. The wider indirect outcomes expected from the proposed programme would include the increase in number of consumers connected to heat networks, improved performance, and bolster the capability and capacity of the workforce. Any person or persons sharing protected characteristics connected to a supported network would benefit from any cost savings and service improvements.
58. The GHNF is a capital support programme, and therefore will not introduce any regulatory measures that would have a wider impact on UK's international trade obligations. Therefore, a summary of trade implications has not been included in this IA.

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[12] Heat Networks Consumer Survey (2017) www.gov.uk/government/uploads/system/uploads/attachment_data/file/665447/HNCS_Results_Report_-_FINAL.pdf

[13] Ibid pg17

[14] Ibid pg17

[15] Conditions: Long term health problems, caring responsibility for someone with long term health problems, hearing/visual impairment, received extra support or assistance from gas or heating supplier, help in reading or understanding energy bills, relocation of prepayment meters to ensure they can be safely used, or priority in an energy emergency.

[16] Determined by agreement with the statement 'keeping up with my heating and hot water costs is a bit of a struggle'.

Annex A - Methodological Assumptions

General Assumptions

Assumption	Value	Evidence
Network Distribution Losses	20%	Agreed with technical experts in HNDU.
Additionality of Funding	85%	85% additionality has been used in the HNIP analysis. This assumption is being kept consistent with HNIP.
Optimism Bias	21% applied to all capex	Environmental Audit Committee Special Report[17]
Average Plant Run Hours (Load Factor)	3627 hours per year	Based on HNDU's project database.
Carbon Values	IAG Tables published values	Greenbook Supplementary Guidance
Air Quality Values	IAG Tables published values	Greenbook Supplementary Guidance
Discount Rate	3.5% per HMT Green Book	Greenbook

Technology Mix

NB: The technology mix, as indicated by the numbers below are hypothetical and for modelling purpose only and **does not** indicate GHNF funding profile for each technology types.

Heat delivered by segment	(TWh/ Yr)
Low Temperature Ambient	0.25
Low Temperature Non-Ambient	0.45
High Temperature Waste Heat	0.45

Low Temperature Ambient Heat Sources

Air Source Heat Pump	0%
Ground Source Heat Pump	30%
Water Source Heat Pump	50%
Solar Thermal W/ Air Source Heat Pump	20%

Low Temperature Non-Ambient

30 Degrees	25%
40 Degrees	25%
50 Degrees	50%

High Temperature Waste Heat

Energy from Waste	100%

[17] Select Committee on Environmental Audit Ni
nth Special Report, https://publications.parliament.uk/pa/cm200607/cmselect/cmenvaud/1110/111004.htm

Heat generation technology cost and performance

Air Source Heat Pump

Assumption	Value	Evidence
Capex	£400/KW(th)	Assumption based on evidence from separate venders
Opex	1% of capex, per year	Consistent with HNIP
Coefficient of Performance	251%	Central BEIS value.
Lifetime	20 years	Consistent with HNIP

Water-Source Heat Pump

Assumption	Value	Evidence
Capex	£545/ KW(th)	Assumption based on evidence from separate venders
Opex	1% of capex, per year	Consistent with HNIP
Coefficient of Performance	331%	Central BEIS value.
Lifetime	20 years	Consistent with HNIP

Ground-Source Heat Pump

Assumption	Value	Evidence
Capex	£545/ KW(th)	Assumption based on evidence from separate venders
Opex	1% of capex, per year	Consistent with HNIP
Coefficient of Performance	284%	Central BEIS value.
Lifetime	20 years	Consistent with HNIP

Low Temperature Waste Heat

- For modelling simplicity, we have assumed that low temperature waste heat generation uses a water source heat pump, with some additional capex costs which may be incurred to modify the heat pump for utilising waste heat.
- To account for the different sources of waste heat, three different inlet temperatures have been modelled. The only difference between the generation sources is the coefficient of performance, which improves as the inlet temperature increases.

Assumption	Value	Evidence
Capex	£545/ KW(th)	Assumption based on evidence from separate venders
Opex	1% of capex, per year	Consistent with HNIP
Coefficient of Performance (30 degrees)	400%	Based on studies of improved heat pump performance, and a

		sink temperature of 60 degrees.
Coefficient of Performance (40 degrees)	500%	Based on studies of improved heat pump performance, and a sink temperature of 60 degrees.
Coefficient of Performance (50 degrees)	600%	Based on studies of improved heat pump performance, and a sink temperature of 60 degrees.
Lifetime	20 years	Consistent with HNIP

Energy from Waste

Assumption	Value	Evidence
Capex	£209/ KW(th)	Consistent with HNIP
Opex	1% of capex, per year	Consistent with HNIP
Z-Factor	8	Consistent with HNIP
Lifetime	55 years (Of EfW plant)	Consistent with HNIP

Gas-CHP

Assumption	Value	Evidence
Capex	£545/ KW(th)	Consistent with HNIP
Opex	1% of capex, per year	Consistent with HNIP
Thermal Efficiency	42%	Consistent with HNIP
Electrical Efficiency	38%	Consistent with HNIP
Lifetime	15	Consistent with HNIP

Gas Boiler

Assumption	Value	Evidence
Capex	£55/ KW(th)	Consistent with HNIP
Opex	1% of capex, per year	Consistent with HNIP
Thermal Efficiency	85%	Consistent with HNIP
Lifetime	15 years	Consistent with HNIP

Distribution Network

Assumption	Value	Evidence
Capex	£300/ MWh for distribution network and £150/MWh for ancillary costs	Based on a study of BEIS supported projects
Opex	1% of capex, per year	Consistent with HNIP
Lifetime	60 years	Consistent with HNIP

Sensitivity analysis assumptions

Sensitivity Run	Low	Central	High
Additionality	75%	85%	95%
Thermal efficiency	-15% from Central	Input data	+15% to Central
Capex	-15% from Central	Input data	+15% to Central
Carbon values	Central and High sourced from Green Book Supplementary guidance		
Proportion of New Heat Networks funded	30%	50%	70%

Annex B - Benefit Indicators

In order to monitor progress towards the benefits and ensure the GHNF is on track to deliver them, a set of indicators are proposed below:

Benefit ID	Benefit	General Indicator	Baseline/ Counterfactual	Relevant GHNF Objective
GHNFB1	An increased proportion of thermal energy supplied through low-carbon sources	Volume of thermal energy supplied from low-carbon sources via GHNF projects TWh/yr	0	Increase Carbon Savings from heat networks
GHNFB2	Decreased carbon intensity of heat delivered by GHNF supported heat networks	Average carbon intensity of heat networks $kgCO_2e/kWh$	Average Carbon Intensity of Heat Networks at time of scheme launch	Increase Carbon Savings from heat networks
GHNFB3	Carbon Savings relative to the alternative heat source	Carbon Savings $MTCO_2e$	Alternative thermal energy source	Increase Carbon Savings from heat networks
GHNFB4	Increased use of waste thermal energy recovery in heat networks funded via GHNF	TWh of thermal energy from waste heat GHNF projects	0	Increase the proportion of thermal energy delivered by heat networks

GHNFB5	Increased investment in the UK heat network market	No. of reported first time investors in GHNF	0	Increase the proportion of thermal energy delivered by heat networks
GHNFB6	Increased supply chain capacity in the UK – market wide	- Enhanced investment in local economies (£) - Increased no. of skills and training offers in sector	0	Market Readiness
GHNFB7	Reduction in costs of low-carbon generation in heat networks	HNDU and market data on Capex	Current Capex Value	Market Readiness
GHNFB8	Innovation and energy efficiency	- Reduction in kWth of installed capacity - No. of DSR - No. of energy conservation measures - No. of networks recovering cooling	0	Market Readiness