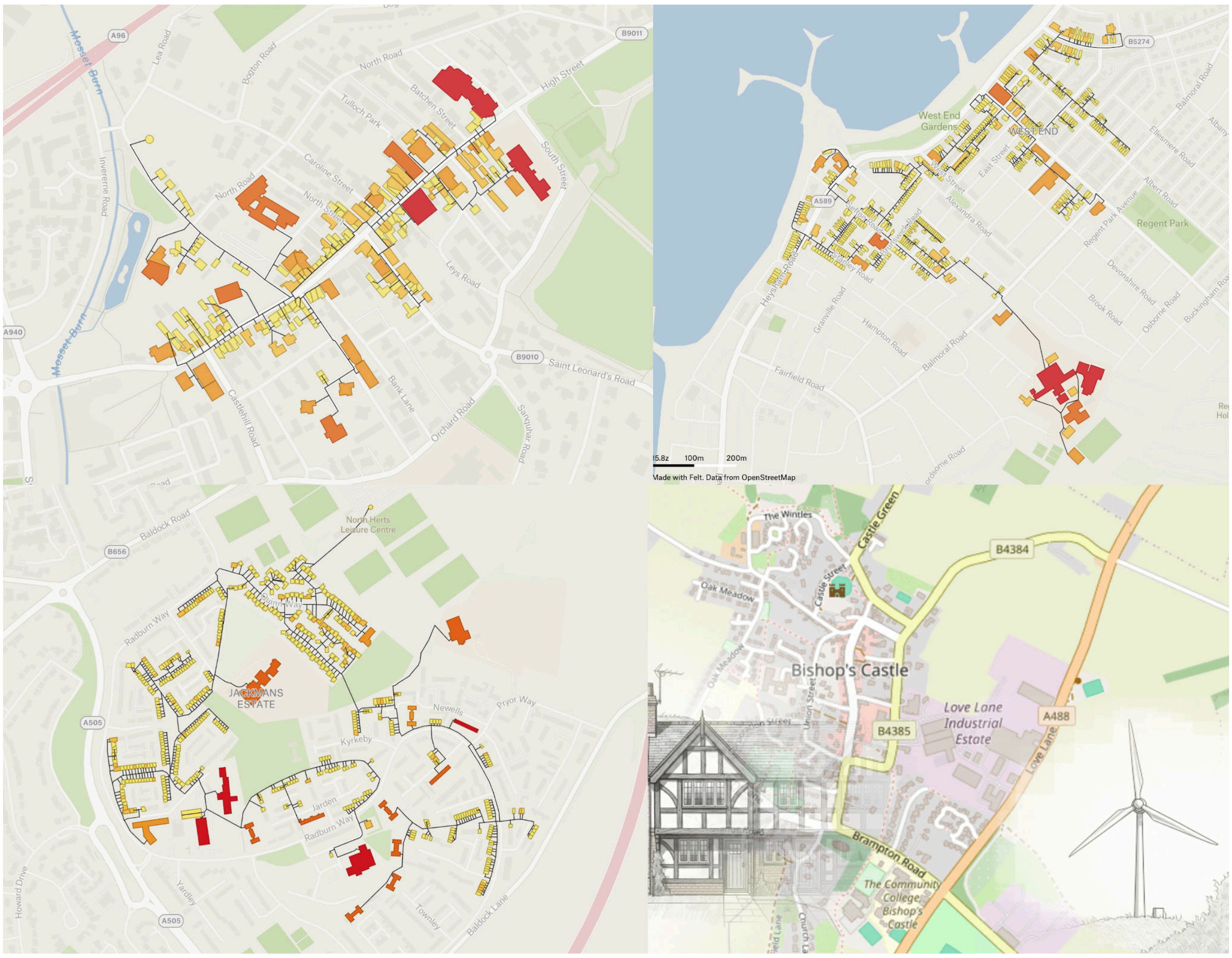
Community Heat Development Unit

Final Report



Ben Cannell, Becky Oliver and Dave Green

sharenergy

Energy Redress Scheme

Funded by the Energy Redress Scheme

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Contents

Glossary of Terms

Term	Description
ASHP	Air source heat pump
CAPEX	Capital expenditure: the initial cost of construction, separate from the cost of developing and planning the system
CBS	Community Benefit Society
CDHN	Community District Heat Network
CHDU	Community Heat Development Unit
CHP	Combined Heat and Power
COP	Coefficient of Performance. Ratio of heat produced by a heat pump, by the electrical energy it consumes.
DHN	District heating network
GSHP	Ground source heat pump
SCOP	Seasonal Coefficient of Performance. COP calculated using the heat produced and electricity consumed throughout a whole year.
WSHP	Water source heat pump
kW	Unit of power.
kWh	Unit of energy. For example a 3kW kettle running continuously for 1 hour consumes 3kWh of electrical energy.
MWh	1,000 kWh
GWh	1,000,000 kWh

1. Executive Summary

The Community Heat Development Unit (CHDU) project was set up by Sharenergy[1] specifically to study where community led heat networks would be most viable. The work has taken two years with funding from the Energy Redress Scheme and assistance from Carbon Alternatives[2], Community Energy England[3], Lux Nova Partners[4] and Marches Energy Agency.[5]

The work has included:

1. A literature and policy review of low carbon heat networks and heat network proposals in the UK and abroad.
2. Development of a techno-economic model that would enable a search for the low carbon heat network sites most likely to be viable[6]. This model uses inputs such as building density and annual heat demand to estimate heat network parameters such as network length and annual losses, alongside estimating the network energy requirements by performing calculations including hourly matching of heat pump electrical demand and renewable generation. Methodologies developed in the model enable low carbon heat network capital costs to be estimated at specific sites alongside income streams, operating expenditure and cashflow.
3. A GIS-based site search across Mainland Great Britain which identified three locations for case studies: Morecambe & Letchworth in England and Forres in Scotland.
4. Production of case study reports and delivery of a community heat network workshop for each area.[7]
5. Participation in parallel work on the proposed Bishop's Castle heat network with a case study for a distributed heat model for the town.[8]

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[1] https://www.sharenergy.coop
[2] https://carbonalternatives.co.uk
[3] https://communityenergyengland.org
[4] https://www.luxnovapartners.com
[5] https://mea.org.uk
[6] https://communityheat.org.uk/techno-economic-model
[7] Appendices 3-5
[8] Appendix 6

6. Development of a dedicated website where the developed resources are available for study and use.[9]

In addition Marches Energy Agency advised on the appropriate levels of work in individual properties to ensure connection to a centralised district heat network could meet their heating requirements, and the associated costs. Sharenergy authored an article on the proposed heat network zoning regulations and what they mean for communities which was published on the We Own It website, and Lux Nova produced a report covering some of the legal considerations of setting up a community owned Heat Network.

The chosen heat network model for the main study was for a mix of housing and non domestic buildings with heat generated by centralised air source heat pumps. In all cases a wind turbine would be required to provide cheaper electricity to drive the system and thermal storage would be incorporated to enable as much of the wind generation to be used as possible. Back up and top up heat would be provided by gas or oil boilers which are sized to be able to replace the heat pumps when required, with the heat pumps sized to produce around 85% of the annual heat demand. This model is not net zero but achieves significant carbon savings and is considerably more economical than an all-electric system. The systems could however be changed to being all-electric later.

A decentralised model utilising share ground loops and shoebox heat pumps in each property was discounted for the purposes of this study. We are aware of work going on elsewhere on such decentralised systems (e.g. Net Zero Terrace streets[10]) and did not want to duplicate that work. We also see significant advantages in a centralised system if it can be made to work.

All four areas that were studied were suitable for a centralised heat network with advantages over other low carbon heat models, e.g. they all had properties that were of a sufficient density and that had constraints over fitting individual air source heat pumps. All case study areas also had sufficient anchor loads (i.e. large energy users that could form the backbone of a heat network such as a school or a

[9] https://communityheat.org.uk
[10] https://nzts.info/

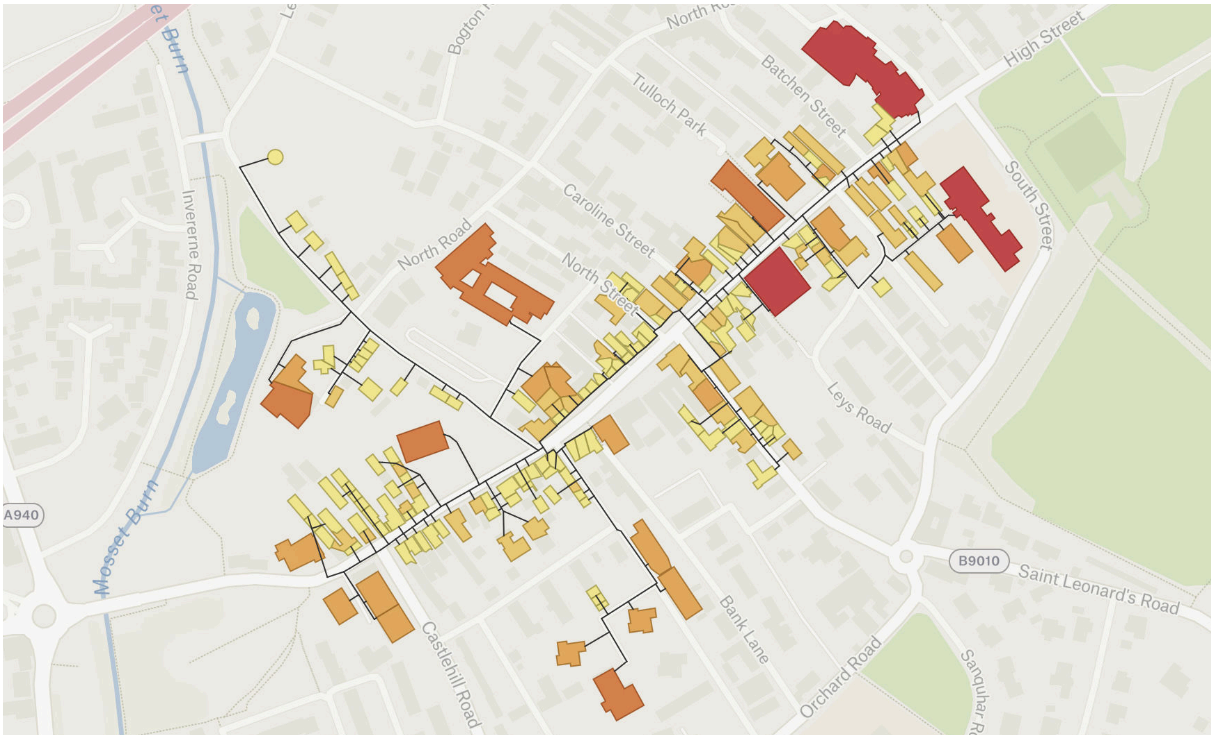
leisure centre) but two of these anchor loads obtained funding to fit their own heat pumps during the study period (Bishop's Castle and Letchworth).

It was recognised from the beginning of the project that making a community led heat network viable is a difficult task, hence the emphasis on finding the sites most likely to be viable. During the study various factors made it even more difficult to make a community led heat network viable, these include:

- Stagnation of oil prices (with which any heat network would have to compete).
- Effective halving of the Green Heat Network Fund in England from 4.5p/kWh of heat delivered in the first 15 years to 2.5p (due to the competitive nature of the fund).
- Increased construction costs, especially for pipework and trenching.

With the current energy prices the only main case study scheme that could be viable is Forres. This is due to a different funding system in Scotland, the higher heat demands further north and the local particularities. Near the end of the study period the team working on the Bishop's Castle heat network project announced that they did not have a viable model at this time (this is now proceeding as a wind only project though delivering heat remains as a medium to long term ambition for the group).

Forres was also the area where most interest was shown in the proposal put to them. The Forres workshop was the best attended of the three and a follow up webinar for those who missed the workshop was arranged.



Proposed community heat network in Forres

The other potentially viable model is the decentralised model explored in the Bishop's Castle case study report. This model utilises a Local Energy Supply (LES) arrangement to deliver electricity discounts to local properties in conjunction with funding and advice for fitting individual heat pumps. The LES model was developed by Energy Local but has only limited reach to date. The Government is currently consulting on amending the electricity balancing codes to codify the LES system through modification P441. The proposal is that P441 will allow Licence Exempt Suppliers (those who generate relatively small amounts of electricity) to be exempt from some of the charges associated with feeding electricity though the grid, this enables a discount to the customer coupled with an increased price to the generator. The reduced customer price would narrow the gap between the electricity and oil or gas prices. The increased price to the generator (in this case, a local Community Benefit Society) would be used to partially fund the up front costs of heat pump installations which should encourage their uptake. The exact details of how the system will work, or how many companies will offer it, is still not clear. We are expecting that P441 will come into effect in 2026.

Consideration was also given to how community heat networks could be owned and run. It is felt that some degree of local community ownership is essential and it seems unlikely that further local authorities will want to follow Cambridgeshire's example and set up and run systems similar to Swaffham Prior. Models of 100% Community Ownership and Heat Entrepreneurship, where the Community society owns the heat and renewable generation equipment and supplies heat via the network, have been explored with legal considerations advised on by Lux Nova.

If Community societies are to develop heat networks in their areas, they will need a high degree of support. We envisage a federated system where multiple individual societies are supported by a specialised centralised development, advice and administration service with the addition of well supported peer to peer learning between the societies. Unfortunately, we do not think the time is right for setting up this centralised service at this point as options for viable heat networks are so limited. However, the ideas for such a service developed as part of this project should be further developed for the future.

1.1. Recommendations

1. Carry out further studies on the proposed Forres Heat Network.

   This is the case study that is the most viable of the three and it has invoked the most interest. Funding should be sought to develop the ideas presented through this study.

2. Carry out further studies on the Local Energy System model.

   There is interest in looking further at this model in Bishop's Castle. Further work would be useful when the final details of the P441 modification are published.

3. Carry out further studies on pipework systems and house connections to drive down costs.

   There is very little information available on the real costs of retrofitting heat networks to individual houses of the archetypes at the CHDU case study sites and it is felt that work to develop more effective ways of joining multiple small properties to a heat network, using local contractors, would be very useful.

4. Campaign for the Green Heat Network Fund or its successor to take more account of the extra carbon saved through community-led heat networks, with local renewable generation, which supply heat to multiple smaller properties that are hard to decarbonise any other way.
5. Work towards the setting up of a Centralised Support service for Community led heat schemes.

2. Introduction

2.1. Context

The UK faces a huge challenge in trying to decarbonise its heat, doing so whilst keeping heat affordable makes it even more difficult. Provisional 2024 UK emissions figures published by the Department for Energy Security and Net Zero (DESNZ) report that greenhouse gas emissions from "Buildings and Product Uses", the majority of which is from burning fossil fuels for heating and cooking, represents around 21% of the UK's annual emissions, Figure 1. 66% of emissions from this sector are from fuel combustion within residential buildings, equating to **14%** of the UK's total annual emission.

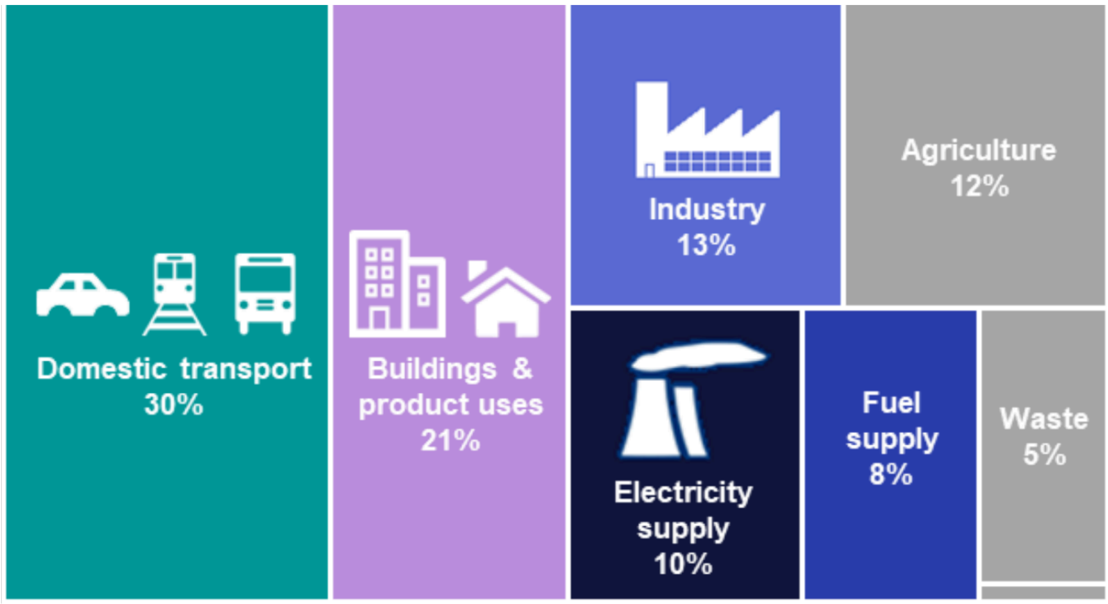


Figure 1: Emissions in the UK[11]

There is no "one size fits all" solution to this problem. Whilst many businesses could transition to heat pumps relatively easily (given higher power electricity connections and more available space around the curtilage of the building), a significant proportion of the UK housing stock is not suitable for traditional heat

[11] https://assets.publishing.service.gov.uk/media/67e4060df356a2dc0e39b4cd/2024-provisional-greenhouse-gas-emissions-statistics-statistical-release.pdf

pump installations. Around 25% of English and Welsh housing is made up of flats, and this increases to around 35% in Scotland, with the prevalence of tenements in the larger cities of Edinburgh and Glasgow. Flats and tenements are ideal candidates for inclusion in district heating schemes, having both heat density and constraints around installing individual heat pumps in many cases. Terraced housing can also be problematic. Terraced housing can vary dramatically in scale, and smaller terraces might not be able to install individual heat pumps due to a lack of available space, or failing to pass permitted development rules around noise, which is one of the driving factors behind the Net Zero Terrace Streets project.

Figure 2: Terraced properties in Rossendale with very little space for individual air source heat pumps

Additionally, terraces converted into flats or HMOs will always be challenging if an individual heat pump might be required for each living unit.

Heat Networks (HNs) are split into two subsets in the Energy Act: communal heat networks (CHNs) and district heat networks (DHNs). A communal heat network refers to a group of heating systems in a single building, such as a communally heated block of flats: it will usually involve a group of properties or businesses owned by a single landlord.

District heat networks are larger networks which might join single privately owned houses, blocks of flats, an entire road or roads, social housing developments, municipal buildings, businesses, industrial premises or even most of a city together in a system which is usually heated by a single energy centre. The energy centre may bring together multiple sources of heat or energy and control these in such a way as to deliver heat throughout the network, though there may also be non-renewable sources of heat used to top-up or back-up the principal heat sources.

Until the mid 2010's, district heat networks usually used Gas Combined Heat and Power (CHP) plants, but UK and devolved nation policy has now left Gas CHP behind, and all new networks will principally be heated by heat pumps or other low carbon heat sources such as waste heat from sewers, data centres or Energy from Waste (EfW) plants.

At present under 3% of UK heat is delivered through heat networks and district heating schemes. One of the notional targets for heat delivered in this way was set by the Climate Change Committee in the Sixth Carbon Budget report, as follows:

By 2030 37% of public and commercial heat demand is met by low-carbon sources. Of this low-carbon heat demand 65% is met by heat pumps, 32% district heating and 3% biomass. By 2050 all heat demand is met by low-carbon sources of which 52% is heat pumps, 42% is district heat, 5% is hydrogen boilers and around 1% is new direct electric heating[12].

The Seventh Carbon Budget[13], published earlier this year, targets delivering low carbon heat to 22% of non-residential buildings using heat networks by 2040, and 9% of residential buildings.

It is well known that communal and district heat networks have been delivered successfully in other European countries, and for the most part they are considered well run and administered utilities by their customers. Conversely,

12 https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

13 https://www.theccc.org.uk/wp-content/uploads/2025/02/The-Seventh-Carbon-Budget.pdf

much of the UK public do not necessarily even understand what a heat network is. Research carried out in 2012 suggested that less than 10% of respondents had heard of the term. More than half were “not quite sure” what was involved.

2.2. Objectives and Scope of this Report

District heat networks are key infrastructure which Sharenergy believe should operate for social and environmental benefit, aiming to be trusted, transparent and accountable. Community ownership of district heat networks can help achieve this through ensuring local governance and representation.

Most attempts to establish community-owned and operated centralised heat networks in the UK have not been successful to date. The most common contributory factors for this are nearly always hard location-specific constraints: lack of heat density and suitable building archetypes. However, they usually also include soft constraints such as local group resource capacity, access to relevant expertise, cheap capital, government policy and market conditions. For this reason, “conventional” centralised district heating schemes which are community owned or operated may simply not be appropriate in all locations.

The Community Heat Development Unit (CHDU) project aims to assist communities by identifying locations in mainland Great Britain where low-carbon heat networks may be more feasible based on technical and commercial markers of success, and to define what support structure may need to be established to enable community owned district heating networks to be developed.

This report will describe markers for success based on the research Sharenergy have carried out looking at schemes delivered across the UK and Europe to date, and analysis and modelling activities completed by Sharenergy. This document reports on the following areas:

- The value proposition of a centralised heat network
- Identifying the stakeholder groups that will be involved in the deployment of a heat network
- The various roles that community enterprises might take on in the development and implementation of a heat project
- Identifying different market segments and revenue streams

- Suggesting the most suitable governance model for the stakeholders
- Considering viable financial arrangements such as how much grant will be required to make schemes tenable for community investors
- Assessing possible legal barriers and the regulatory environment for communities

This report also considers a counterfactual to a centralised heat network, using an "Energy Local Club" arrangement to allow generators and consumers / prosumers to interact in what is often referred to as a Smart Local Energy System. This configuration is referred to as the "distributed ASHP and wind model" throughout this report.

3. Summary of the Literature Review

At the beginning of the CHDU project, a literature review was undertaken which took into consideration over 50 different data sources and assessed around 100 low carbon heat network projects from around the UK, with further reference to projects overseas. The networks covered an extremely wide range of characteristics, with network sizes from single, communally heated buildings, up to over 60,000 properties (Drammen, Norway). Technologies included different heat pump types, waste heat, mine water and process heat. Ownership models included the full spectrum of fully public through to fully private (or community) owned and operated.

The literature is summarised below and the full report is available on the CHDU project website[14].

3.1. Relevant Operational Projects by Heat Source

Water Source Heat Pumps (WSHP)

There are examples of mine water heating schemes in the UK and abroad although most UK schemes are fairly small. While the recently commissioned Gateshead[15] mine water heat network appears to be a positive example of mine

[14] https://communityheat.org.uk
[15] Gateshead's District Energy Network, including mine water heating, to deliver carbon reductions

water heating, many of the UK schemes (communal heat networks or a few buildings) reported water quality issues resulting in non-viable maintenance requirements, ultimately leading to schemes being decommissioned. A published review of the performance of mine water heating schemes[16] deemed them to be too risky for small / medium sized projects due to the unknowns associated with groundwater systems, borehole drilling and water quality. This site specific variability reduces the replicability of a mine water heat scheme. Schemes at mine water treatment sites are perhaps more viable, but there are a limited number of treatment sites in the UK.

There are a couple of examples of Scottish heat networks which use heat from sewage water, both at a treatment centre (Stirling[17]) and using a sewer main (Galashiels[18]). More examples are available internationally[19].

River sourced WSHPs may be a good option for community scale heat networks. The SCoP of river source heat pumps is higher than air source heat pumps (ASHPs) given the average river water temperatures in winter are higher than air temperatures and the heat transfer coefficient of water is greater than air. The pumping requirements of a river source heat pump can be lower than open loop mine water or aquifer GSHPs, which extract water from deeper in the ground. There are a number of examples of recently developed WSHP heat networks and network scale heating schemes in the UK and abroad demonstrating feasibility while operating networks at relatively high flow temperatures of 70-85°C, for example, the Viking[20] heat network at the outskirts of Jarrow. Also, there are a number of UK heat network projects in development which make use of river source heat pumps e.g. Exeter City Centre, Queens Quay[21] on the River Clyde and the Mersey Heat project.

[16] A review of the performance of minewater heating and cooling systems
[17] CHP case study - Stirling Energy Centre
[18] Borders College - Scotland
[19] https://wastewaterheat.online/case-studies
[20] https://www.southtyneside.gov.uk/article/3772/Overview
[21] https://www.cibsejournal.com/case-studies/a-new-era-for-heat-queens-quay-heat-pump/

The majority of existing large scale river sourced WSHPs connected to operating heat networks in the UK and abroad are located in river estuaries suggesting they are less suited to inland locations, perhaps due to the lower freezing temperature of brackish water.

Ground Source Heat Pumps (GSHPs)

Most of the existing operational heat networks in the UK which use GSHPs are small in size serving relatively low thermal demands. Flagship Homes have completed multiple closed loop GSHP installations to improve the heating and hot water systems of their tenants. The modular installations, heating 20-30 homes, potentially offer a replicable solution.

Within the reviewed feasibility studies, GSHPs are generally recommended due to the SCoP being higher than ASHPs during winter, when the load is highest. Also, it is rare that there is a water body that might provide an alternative viable heat source at the feasibility study locations. Open loop systems are favoured over closed loop systems since a given heat demand can potentially be supplied by fewer boreholes, requiring less CAPEX. However, closed loop systems require less maintenance and fewer environmental permits.

Many of the reviewed projects have referred to encountering unexpected ground conditions while drilling boreholes for GSHPs or mine water WSHPs. For example, the Swaffham Prior project originally intended to use an open loop GSHP extracting water from a subsurface aquifer, however ground investigations indicated that the required abstraction rates could not be achieved from the Greensand aquifer underlying the site. This resulted in a more costly closed loop GSHP system being installed. This suggests that variable ground conditions between sites present a risk to the replicability of a model which relies on specific ground conditions.

The only example identified at the time of review of an operational ambient heat network in the UK, which connects to domestic buildings, is the Kensa “Heat the Streets” project in Stithians, Cornwall. This system offers users a higher SCoP value than an ASHP for a standing charge but exposes users to fluctuations in electricity prices unless they have access to a novel electricity supply arrangement. Internationally, the main use case for ambient networks appears to be where there is heating and cooling demand in a 5th generation heat network, however this is a relatively new concept with the first adopter projects being in-development.

Air Source Heat Pumps (ASHPs)

There are a few examples of ASHP powered heat networks in the UK: Bunhill in Islington, Hebburn Estate in Gateshead and the Carron Estate in Glasgow. These networks primarily heat multiple pre-existing communally heated buildings in highly urbanised areas. In Denmark, large scale ASHPs are being installed in Denmark coupled with large thermal storage tanks to reduce the use of biomass in existing heat networks.

A feasibility study at Bishop's Castle recommended an ASHP as a primary heat source when coupled with a wind turbine and solar PV installation. Multiple studies recommended bolstering open loop GSHPs with ASHPs to meet peak winter demands.

Biomass

Biomass is the most common low carbon heating technology used in heat networks internationally with 29.8% of Denmark's heat networks being heated by biomass fueled CHP[22]. In the UK, there are multiple examples of community owned heating projects using biomass to heat small district and communal networks, particularly while RHI payments were available.

During the course of the CHDU project, Sharenergy staff visited Rocks Green, a housing association estate built in 2008 with 91 homes connected to a biomass district heating network. Heat is provided by 2 x 150kW wood chip boilers backed up by 2 x 200kW oil boilers. The relatively low thermal demand of the properties, use of underfloor heating and installation of HIUs which do not require domestic hot water tanks, allows the network to operate efficiently at low flow and return temperatures of 60°C and 45°C. This translates to relatively low heating and hot water costs with one resident reporting paying ~£600 annually for a 2 bed house.

[22] https://www.sciencedirect.com/science/article/pii/S1364032122000466#bib94

Note that the DESNZ heat network zoning regulations[23] make reference to upcoming tightening of environmental permitting requirements which may affect the use of solid biomass as a heat source due to the fine particulates produced through combustion. There are also questions over the sustainability of large scale biomass combustion when there is not a local fuel stock source.

3.2. Local Generation and Energy Centre Equipment

Local Electricity Generation

Local electricity generation is often used to power heat pumps via private wire installations, inferring that investment in local generation is financially beneficial over the project lifetime compared to using electricity from the grid. All reviewed feasibility studies of community scale heat networks which used heat pumps concluded on-site renewable generation would be financially beneficial to the projects.

Secondary and Peak Demand Heat Source

All heat network projects include thermal storage to help balance demand and generation. Back-up heat and peak demand is primarily provided by fossil fuel powered heat sources with gas CHP being used at locations where there is also a requirement to generate electricity for local consumption. A number of feasibility studies suggest using ASHPs to help meet the peak demand of networks heated by open loop GSHPs or river source heat pumps (RSHPs) due to water flow rate limitations.

In Denmark, there are examples of ASHPs being added to existing biomass-fueled networks with very large thermal storage tanks[24]. The ASHPs are run when electricity is cheap (i.e. it's windy) playing an important role in balancing the grid, and store hot water for later use in the network.

[23] https://www.gov.uk/government/consultations/proposals-for-heat-network-zoning-2023
[24] https://www.fenagy.dk/en/cases

The Bunhill project in Islington demonstrates that maintaining the original fossil fuel heat supply in existing communally heated buildings can provide heating resilience and reduce the scale or requirement for centralised backup boilers.

3.3. Network Customers

In the UK, the operational low carbon heat networks generally connect to large heat users, including council offices, public buildings such as leisure centres and communally heated blocks of flats. This trend is expected to continue given that projects which have been awarded Green Heat Network Funding are focussed on these types of buildings, and they are the focus of the upcoming Heat Network Zoning regulations. In Europe, the examples of low carbon heat networks are generally large residential networks which were initially developed to be heated by fossil fuel CHP and are transitioning to lower carbon energy sources either by incrementally introducing large WSHPs or moving to 5th generation ambient loop networks.

3.4. Heat Network Ownership

The majority of low carbon heat networks summarised in this review are owned in part or full by local authorities or housing associations. This is notably different from the distribution of UK heat network ownership including all heat sources (predominantly Gas CHP), which is dominated by the private sector.

3.5. Heat Network Funding

All UK based operational low carbon heat networks reviewed in this document receive grant funding from central government, with most projects being the recipients of significant payments to offset the initial CAPEX required to install the network or non-domestic RHI payments.

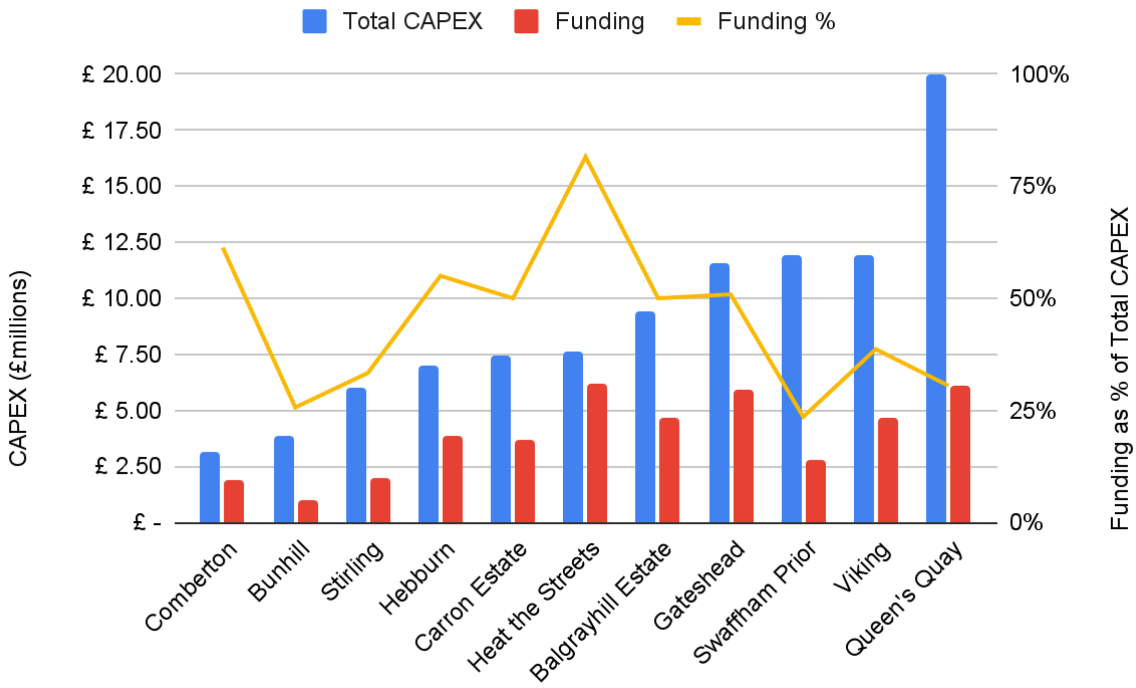


Figure 3: Project CAPEX compared against grant funding

Figure 3 presents the total CAPEX of the reviewed operational projects compared with the funding received from UK government or EU grants. Note that the reported funding values do not include usage dependent payments such as the RHI scheme, or carbon offset payments. The operational low carbon heat network projects presented in Figure 3 had between 25% and 75% of their CAPEX funded by government or EU grants with an average funding proportion of 50%.

The distribution of CAPEX funding received from different funding bodies is presented in Figure 4.

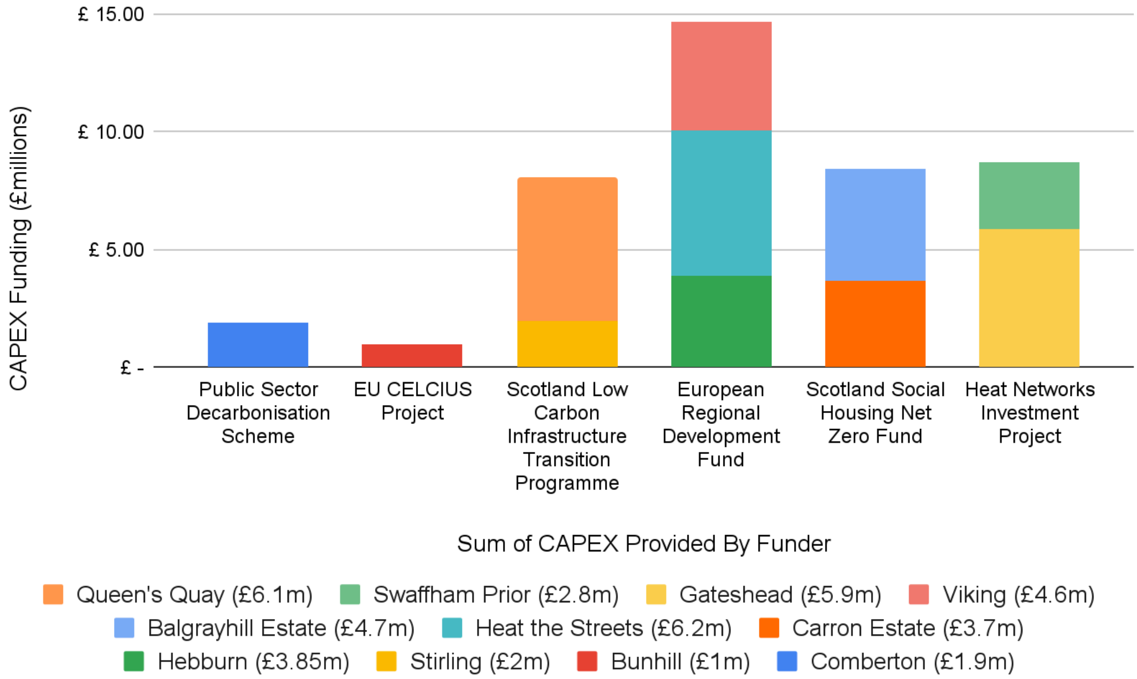


Figure 4: Summary of funds received by reviewed projects

Note that the funding for the Heat the Streets project is understood to cover developments at four locations in addition to the Stithians ambient loop network described in this report.

The source of the remaining CAPEX funding of the projects presented in Figures 3 and 4 is illustrated in Figure 5. The reviewed projects were predominantly funded by local authorities with projects involving social housing being paid for by the housing association. The Stithians project was the only reviewed project which received CAPEX grant funding and private investment.

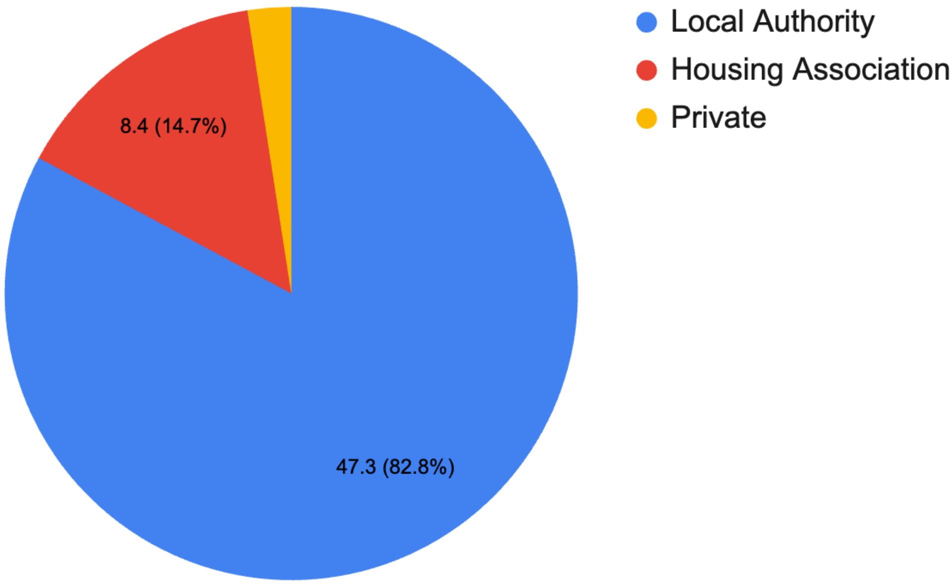


Figure 5: Source of remaining CAPEX funds in £million

All of the funding schemes in England and Wales which existing operational heat networks have made use of have closed or are inaccessible for projects outside of the EU. The more recently opened GHNF is the only known fund which future heat network developments within the scope of the CHDU project could currently apply to, assuming they are configured to meet the specific application criteria.

3.6. Planned Heat Networks in the UK

A review of the Heat Networks Planning Database(HNPD) and Project Pipeline summary documents[25] was conducted to understand the configurations of UK Government supported heat network projects currently in development or planned for future development.

A review of the HNPD (including project records from 2021-2024) indicates that ASHPs are the predominant heating technology in low carbon heat networks with at least 100 customer connections. Figure 6 illustrates the number of projects in the HNPD which are primarily heated by low carbon heat sources, split by technology. The figure also compares the average number of connected properties per network.

[25] https://www.gov.uk/government/publications/heat-networks-pipelines

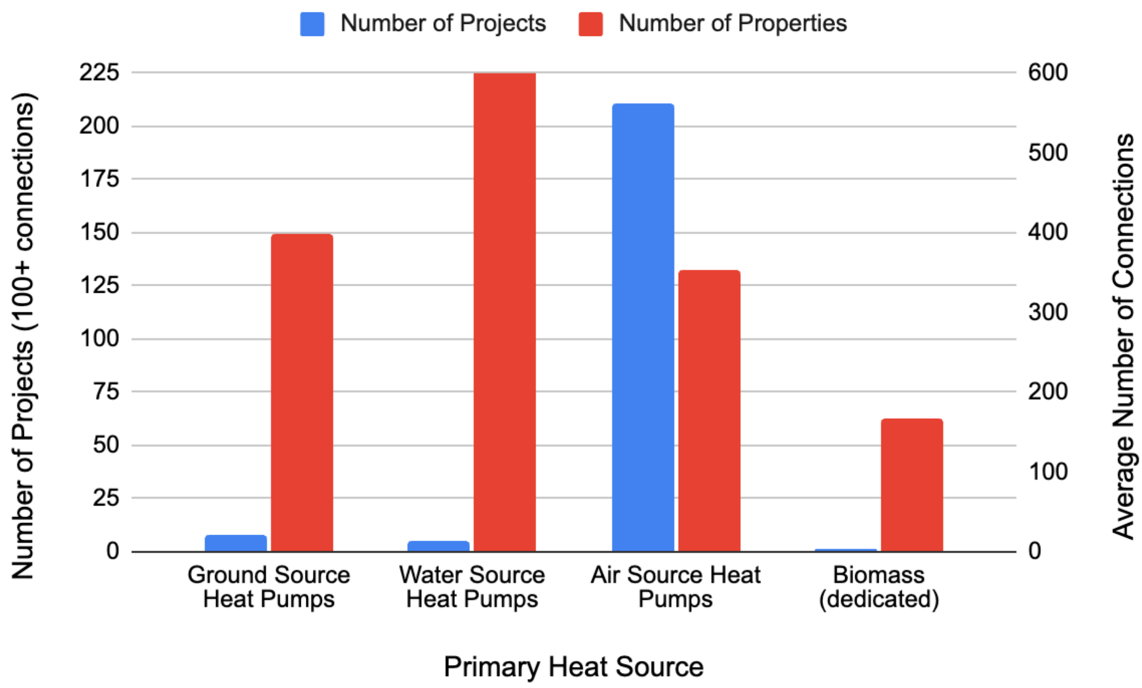


Figure 6: Numbers of connections for larger low-carbon heat networks (100+ customer connections)

Figure 6 suggests that water source heat pumps are being selected as the heat source for larger heat networks compared to other heating technologies. This is somewhat skewed by a couple of very large planned developments including the 15,000 home Seaham Garden Village and 4,304 property Granton Water development in Edinburgh.

The other main observations from the review of the HNPD are that:

- Most planned district heat networks include connections to communally heated blocks of flats.
- Heat networks heated by ASHPs are expected to achieve the highest project IRR values after grant funding, compared to other heating technologies.
- GSHPs may be chosen instead of ASHPs for networks with more dispersed buildings.

4. The Value Proposition: Centralised District Heating

Affordable heat is something that offers enormous value to everyone, yet it is not something that many people consider much in their day to day lives, unless it becomes unaffordable. Poorly heated homes are a significant social and wellbeing problem. The BRE estimated in 2023 that the financial impact on the NHS through poor quality homes is close to £1.4 billion per annum[26], and most of the problems seen are caused by inadequate heat supply, leading to condensation, damp and mould, which in turn can lead to mental health issues. A heat network serving such properties needs to deliver affordable heat to enable these problems to be overcome.

4.1. Fuel Bills

Gas, Oil or LPG which make up over 85% of heating types in the UK. Conventionally, the heat network proposition to consumers will target this as the maximum sale price for heat, otherwise there is a risk that no-one will want to join the network. Matching customers' existing heating costs is also a requirement of the UK's heat network grant funding schemes, such as the GHNF.

Off gas towns have been lauded as locations where a heat network may be more viable since heating oil can be significantly more expensive than mains gas, particularly during the winter months. However, oil prices have stagnated over the last two years with a unit price less than gas, and no standing charge, so focussing on off-gas grid locations over on-gas locations is not currently justifiable from a cost of heat perspective. Wise oil consumers can make good bill savings by buying at the right time of year, with prices moving around on a weekly basis.

LPG is much more difficult to purchase on a "just in time" basis: retail contracts are often designed to tie people to a specific supplier for longer periods, leading to less price competition.

[26] Cost of poor heating, tenure analysis, BRE 2023

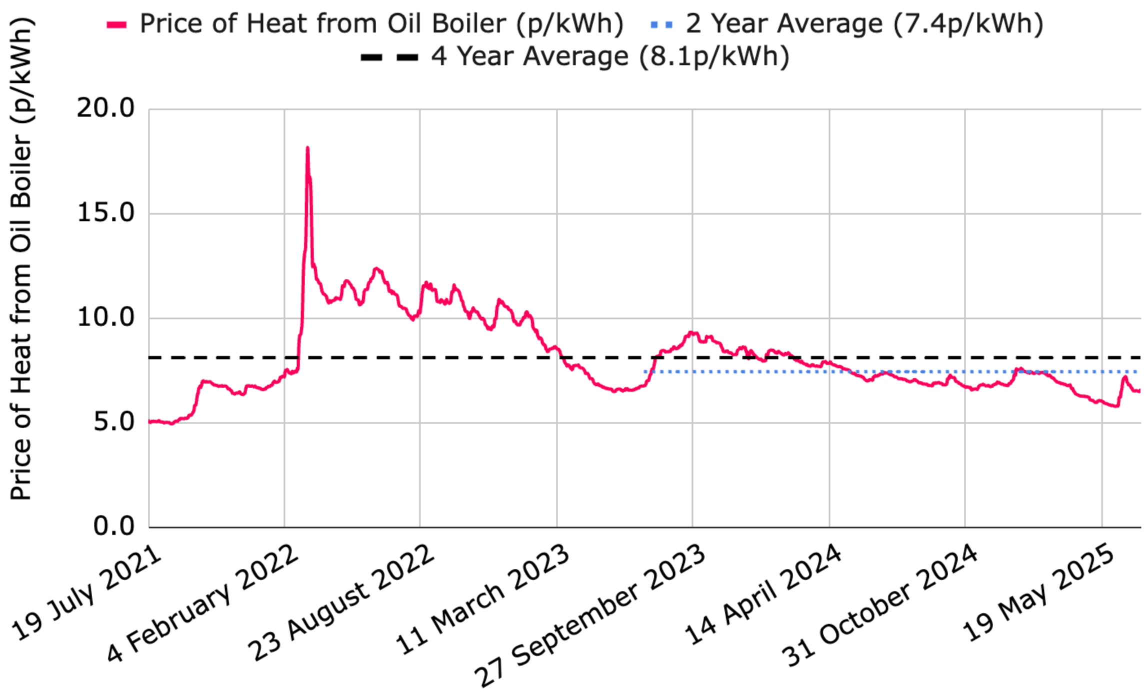


Figure 7: Four Year History of Price of Heat from Heating Oil[27]

Heating a property using E7 storage heating / direct electric is more expensive than a gas or oil fueled wet heating system so connecting these properties to a district heating system will reduce their annual running costs, although there is a cost associated with installing a wet heating system. Offering cheaper bills to those on gas, heating oil and LPG is much more difficult.

4.2. Value for the domestic end user

4.2.1. Insulation from spikes in oil and gas prices

The cost of oil and gas used in heating systems is subject to fluctuations in global market prices. The most recent significant spike in global prices was following the beginning of Russia's invasion of Ukraine in February 2022. A low carbon heat network which has much of its energy supplied by local wind generation will help shield residents from spikes in national energy prices, offering long-term price stability.

[27] Assuming an oil boiler efficiency of 85%.

4.2.2. Cheaper Installation Than An Individual Heat Pump

The average cost of installing an individual ASHP is estimated to be £14,754 per domestic property. This has been calculated using monthly average ASHP installation costs reported on the MCS dashboard[28] from June 2022 to July 2025 and taking the projected value on the 01/08/2025 of £13,198. This cost is reported to cover the "full cost of the installation that is charged to the customer"[29] including materials and labour and is recorded before any reduction due to the Boiler Upgrade Scheme grant[30].

An average cost of £1,556 per property has been added to the £13,198 to cover some radiator and insulation upgrades to enable the maximum required flow temperature of the properties' heating systems to be reduced. These retrofit costs are based on estimates by Marches Energy Agency[31] who are a partner of the CHDU project. The costs of installing an ASHP in a domestic property is summarised below.

Cost	**Value**
ASHP Purchase and Installation	£13,198
Building Improvements	£1,556
Boiler Upgrade Scheme Grant	-£7,500
Total (cost to household)	**£7,254**

Table 1: Assumed Cost of ASHP Installation

There are different approaches to how charging for the connection might be treated. These will depend on project finances and the attitude of the owner / operator. Broadly speaking, connection for a domestic property to a heat network is approximately the same as installing an ASHP at a typical house. The scheme

[28] https://datadashboard.mcscertified.com/InstallationInsights
[29] https://www.nao.org.uk/wp-content/uploads/2024/03/Decarbonising-home-heating-HC-581.pdf
[30] https://www.gov.uk/apply-boiler-upgrade-scheme/what-you-can-get
[31] https://mea.org.uk

owner may elect to take these costs on board to help drive uptake then charge for late adopters to connect to the scheme. The CHDU techno-economic model assumes that customers would be offered connection to a community owned DH scheme at no upfront cost during its initial construction phase. The cost borne by the customer of connecting to the scheme at a later stage would depend on the availability and applicability of the aforementioned grant schemes and financial performance of the scheme.

It may be possible to part fund connection costs through funding pots such as ECO, HUG or the Warm Homes scheme. This requires the appropriate organisation to apply for eligibility: ECO, HUG and the Warm Homes Local Grant are both local authority accessed schemes, and it will be heavily dependent on their engagement as to whether the funds can be accessed for a CDHN. This area of funding is likely to be changing on an annual basis, so it will be important to engage with the local authority as soon as possible if a CDHN wishes to utilise this funding.

4.2.3. Reduced Risk Through Managed Services

There is a significant benefit to heat customers in knowing that the chance of the schemes' entire heating plant breaking down is very low. The cost of maintenance and equipment replacement costs are rarely considered when people talk about heating their home, and when the public are asked about their ability to pay to replace a broken boiler, many people will admit it would be a significant blow to their budgets.

A Which? Magazine survey[32] asked people whether they could afford to replace their boiler if it broke down in the near future, and over 1/3 of respondents admitted it would be a challenge. Given a heat pump installation is likely to be at least 4 times more expensive it seems likely that many people will find joining a heat network could offer a very useful solution to reducing risk and high one-off costs, as opposed to installing their own heat pump.

[32] https://www.which.co.uk/reviews/boilers/article/planning-for-your-boilers-replacement-aS3Cg6E7NurH

There is clearly a benefit in not having to own and maintain a boiler (or heat pump). However, the cost of ownership of a boiler is not something that is very easy for most people to quantify, and it is complicated by the different approaches people take to maintain their heating equipment. The Heat Trust suggests[33] that the cost of boiler ownership is likely to be in the region of around £400/ year. This is made up of two parts, the cost of installation amortised over the boiler lifespan and the cost of insurance and repairs over the lifetime of the boiler. This is approximately split 60 / 40% respectively.

However, there are many people who choose not to, or cannot afford to, insure their boiler and have it inspected regularly. There is every chance that more disadvantaged demographics will see £400 as an untenable proposition, given it represents about half of the typical heating fuel bill for a modestly sized house.

It makes sense that those planning to engage with the community on heat networks have a very clear idea about whether it is likely there will be assistance for both connection and standing charges for those in receipt of benefits or falling into disadvantaged demographics in some other way.

For the purposes of heat network modelling, an annual standing charge of £375 per property has been assumed which is equivalent to the overheads from ownership/replacement of the boiler (c.£275 p.a. when amortised across the boiler lifespan) combined with the removed cost of a gas standing charge (c.£100 p.a.). There is still the question of whether there could be some kind of banding for properties of different sizes. It may also be possible to ameliorate this cost for disadvantaged groups through some other form of assistance through the local authority, utilising funding pots such as ECO or HUG.

4.2.4. Low Carbon Heat In Buildings Not Able To Install Individual Heat Pumps

Heat networks do not always offer the lowest possible emissions value per kWh of delivered heat. When a heat network using centralised heat pumps is compared to

[33] https://www.heattrust.org/assumptions-data

individual heat pumps, it will often have higher capital per property, largely due to the purchase and installation of the network pipework. The operational costs of the centralised network will also tend to be higher because of the network pumping costs and higher system losses. However, the ability to provide much of the electrical demand of the heat network plant using local renewable generation, and store the resulting heat cheaply using large thermal storage tanks, counteracts these higher costs and enables operational carbon emissions to be reduced below that of individual heat pumps.

Many people may want to install their own heat pumps but cannot for various practical reasons. One of the most common reasons that presents itself is physical constraints: lack of space for the evaporator (ASHP), no garden / curtilage (GSHP) or noise (ASHP, proximity to nearby properties). There are various technology solutions and changes to planning constraints which may alleviate these issues for some buildings, but there are likely to be many households or buildings which could be decarbonised more practically through heat networks.

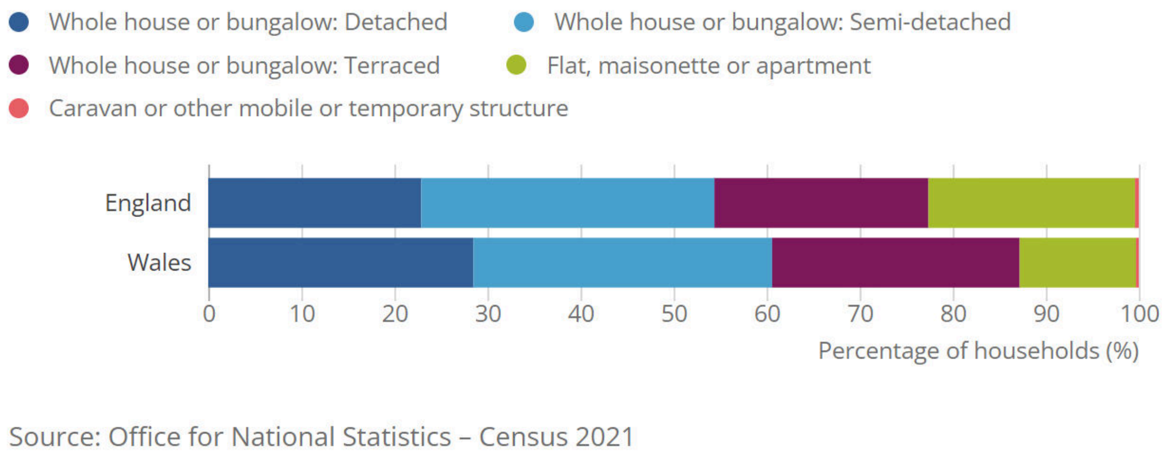


Figure 8: Proportion of housing types across England and Wales. Scotland has an even higher percentage (40%) of flats and tenements vs other construction types

At present flats, apartments and tenements will struggle to see individual heat pump solutions in the near future. Given many individual flats in tower blocks were never fitted with gas boilers for various reasons (or had them taken out in the wake of the Ronan Point disaster[34]), it's likely that they will currently be heated with electric heating or gas fired communal heating systems.

Communal heating systems are ideal for replacement with heat pumps and given the residents will already be paying for metered heat (or have it included in their rent / service charges), there is likely to be less resistance to a switch.

Storage heated flats in multiple occupancy buildings will require conversion to wet central heating systems or air-conditioning installations, but the financial case compared to the operational cost of the original equipment will be stronger.

4.3. Wider Value For Society

4.3.1. Additional local and social value

The Local Multiplier (LM) effect[35] is a relatively well understood economic concept which attempts to assess the additional value to money staying inside the local economy. Whilst every project is different, commonly quoted figures suggest that locally spent money often has 2 – 4 times more value than that spent outside the local economy.

There are clearly opportunities for job creation as well as local businesses being able to deliver some of the infrastructure required, such as: ground works and civil engineering, plant installation, mechanical services (plumbing, electrical), operational services etc.

4.3.2. Environmental value

Environmental value is something that may be of interest to participants in a heating scheme, as well as local and national government. This is quantified in sections 6 and 9 of the HMRC Greenbook methodology[36].

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34 https://en.wikipedia.org/wiki/Ronan_Point

35 https://www.nefconsulting.com/briefing-measuring-local-economic-impact/

36 https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government/the-green-book-2020#a1-non-market-valuation-and-unmonetisable-values

Briefly, environmental value will be improved through:

- Effects on air quality: reduced particulates and associated benefits to health.
- Reduced noise from local heating systems (condensing boilers / heat pumps).
- Reduced vehicle movements for LPG and oil deliveries in off gas grid locations.
- Reduced carbon emissions from the combustion of fossil fuels.

4.4. Wider Value For The Electricity Network

A centralised DH scheme using large thermal (or even interseasonal) storage can utilise the ability to either turn up/down or even off at times of peak congestion. Flexibility services offer significant advantages to both Distribution System Operators (DSOs) and Transmission System Operators (TSOs).

Regarding grid flexibility and load management, these systems offer peak load reduction as the network heat pumps can pre-heat water during off-peak periods and store it, thereby reducing demand during peak hours. They also provide valuable demand response capabilities, allowing rapid adjustments to operations based on electricity price signals or grid conditions. This flexibility helps mitigate grid congestion by shifting heating loads away from peak times, thereby helping to reduce transmission and distribution constraints.

The inclusion of local renewable generation in a centralised DH scheme enables most of the heat demand of the network customers to be met without requiring electricity to be supplied by the grid. There will also be embedded generation benefits due to the renewable generation exporting electricity into the local distribution network, close to areas of electricity demand. Thermal storage is more beneficial when combined with local renewable generation since the storage can effectively absorb variable renewable energy by storing excess generation when wind and solar production is high. In areas with Active Network Management, this leads to reduced curtailment, as excess renewable electricity that might otherwise be wasted can be converted to stored heat.

System efficiency and resilience can see improvements, enabling improved capacity factors through more consistent operation of electricity infrastructure via better load distribution. This can reduce reliance on carbon-intensive peaking power generation facilities.

These systems might (at scale) contribute to reduced infrastructure costs by helping to defer or avoid investments in grid upgrades and peak generation capacity.

5. Community District Heat Network (CHDN) Model

5.1. Network Type

Heat networks are categorised into 5 different generations. At a basic level this describes the temperatures at which they operate: first generation networks used saturated steam (120°C) to distribute the heat, whereas fourth generation (4Gen) networks generally distribute heat at 70 degrees or below, Figure 9.

There has been much discussion in the UK about the emergence of 5th Generation Networks (5Gen), especially with their use in the St Stithians heat network in Cornwall[37] and Net Zero Terraces project[38].

5Gen heat works are often described as “ambient loop”. The idea is that the main distribution loop is run at ambient temperatures (10°- 20°C), with each individual house having their own heat pump fed from the loop to bring the water up to temperature appropriate for heating and hot water.

However, 5Gen is not a panacea. The benefits normally cited include:

- Low temperature = low losses, meaning un-insulated network pipes can be used.
- End-user heat generation leads to higher efficiencies.

There are also downsides to 5Gen:

- It is more difficult to incorporate waste heat into the network.

[37] https://www.bbc.co.uk/news/uk-england-cornwall-65054335
[38] https://nzts.info/

- The cost of generating heat is dependent on the end-user's electricity tariff and it is more complicated to use local renewable generation to reduce this compared to connecting centralised heat pumps via private wire.

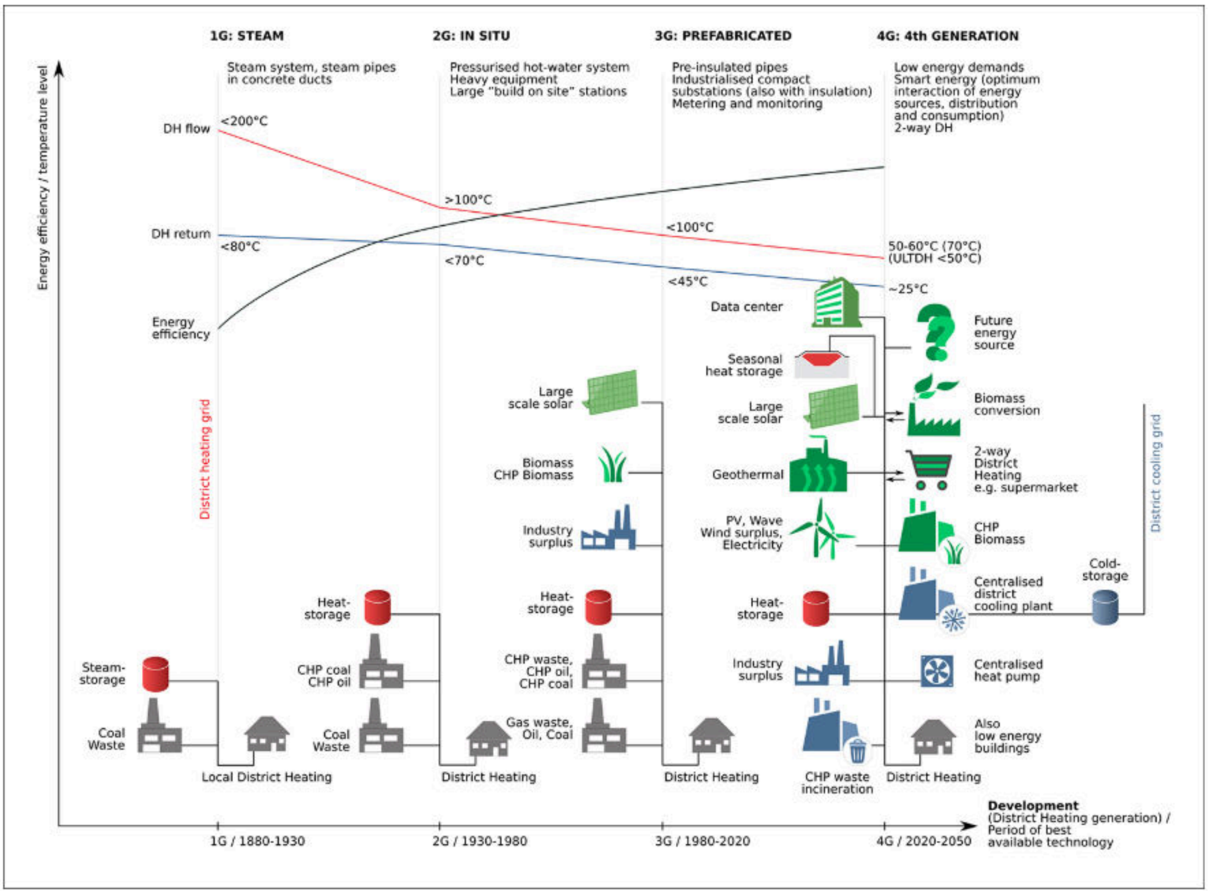


Figure 9: Illustration of the concept of different generations of district heating systems[39]

What many people will be concerned about is the overall levelised cost of heat (LCOH) when comparing 4Gen heat networks to 5Gen. The linked report[40] shows that this can be a nuanced issue:

"The analysis shows that the economy of scale obtained by centralized heat generation in LTDH [Low Temperature District Heat, 4Gen] [70°C flow temperature]

39 https://dbdh.org/district-heating-generations-clarification-of-the-term/#:~:text=Therefore%2C%20the%20focus%20in%20the,C%20and%2070%C2%B0C.

40 https://www.sciencedirect.com/science/article/pii/S0360544221018612

systems, provides significant competitive advantage over ATDH [Ambient Temperature District Heat, 5G] systems, which rely on end-user heat generation … The analysis shows that the competitive advantage of LTDH increases as the energy demand of the connected buildings becomes lower. The reason for the increased competitiveness of LTDH with low energy buildings is that the *__fixed cost__* *of the heat supply system becomes more dominating, which gives more advantage to the economy of scale of central heat generation.*

While the uncertainty of the cost of establishing the uninsulated pipe network used by the ATDH system is high in the study, the impact of the distribution network on the LCOH from ATDH is generally low, below 25%. Which implies that even if the estimated 40 % discount of installing an uninsulated pipe network compared to an insulated pipe network of equal dimension is too high, the results would not change significantly.”

Fig.8. The LCOH for the average high energy (HE) and low energy (LE) buildings in DK. Ts represents the system supply temperature.

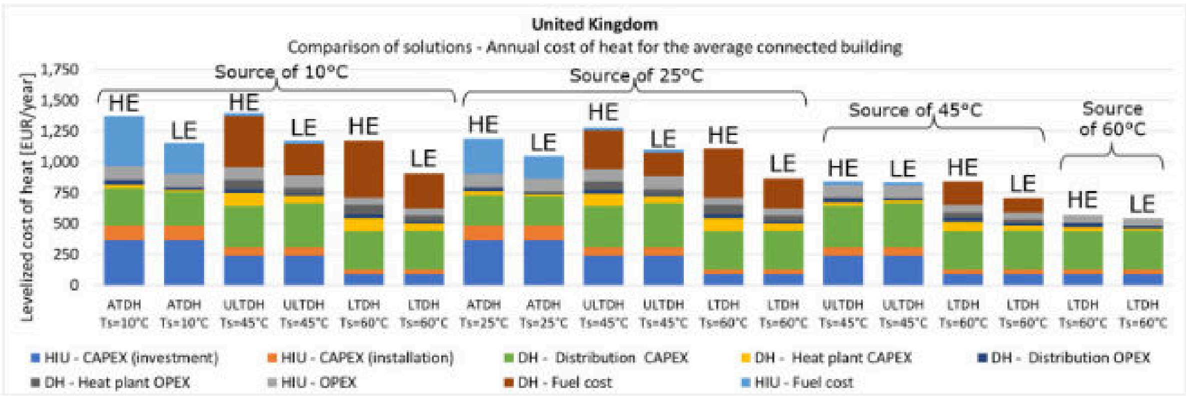


Figure 10: Economic comparison of 4Gen *and* 5Gen *heat networks in the UK*

The choice of whether to consider 4Gen or 5Gen network designs will be heavily dependent on the characteristics of the case in question, such as the mix of domestic and commercial properties, heat sources available and the requirements for cooling. It has been assumed that 4Gen was the more appropriate choice for a wider discussion on community scale heat networks, but the Net Zero Terraces project[41] demonstrates an alternative viewpoint for a specific topography. Note that a counterfactual to the centralised 4Gen approach is discussed in Section 17 of this document.

5.2. Technology Choice

Initially all heat pump technologies were considered but it quickly became apparent that constraint mapping the whole of the UK for all heat pump technologies would be prohibitively time consuming.

Large scale GSHPs were discounted due to the location specific constraints, a network site needs nearby space to install arrays of boreholes, and the requirement for significant initial investment and hence higher borrowing costs.

The correlation between disused mines and high density domestic housing indicates that mine water based WSHPs could be a good solution for community heat networks however evidence reported in the CHDU Literature Review deemed them to be too risky for community scale projects due to the unknowns associated with groundwater systems, borehole drilling and water quality.

River based WSHPs were also considered however, so far, these have mostly been installed in river estuaries alongside a heat network suggesting that they are less viable in fresh water locations, due to the risk of freezing during the periods of peak demand, and associated preventative costs. The process of applying for the necessary abstraction and discharge licenses is understood to be slow and expensive.

These considerations led to the assumption that ASHPs would be the most suitable technology choice for defining a replicable CHDN, as they have far less location specific constraints. That is not to say other heating technologies should be discounted out of hand; they were omitted to keep the scope of locations as open as possible. Any areas identified in the CHDU site identification process[42] could also consider hydro generation and ground or water source heat pumps where practical.

[41] https://nzts.info/
[42] https://communityheat.org.uk/interactive-map/

The CHDN model also utilises fossil fuel boilers for both top up and back up purposes. The heat pumps are only expected to meet around 80-90% of the total heat requirement of the network. The final 10-20% being met by fossil fuel boilers allows the heat pumps to be approximately half the capacity of a 100% solution, the final 10-20% represents the coldest days in the year. This could be met by electric boilers in the future, but at present it is uneconomically viable to do so.

5.3. The Role of Renewables

From the outset, the aim was to model the lowest carbon solutions possible, that's to say renewables would inherently be part of the energy modelling. This proved to be not only desirable from an emissions perspective, but also financially necessary. Without "cheap" electricity to run the centralised heat pumps, the operational costs of the network were too high to be competitive with fossil fuels. For this reason ground mounted solar PV and onshore wind turbines were included in the CHDN heat network energy modelling and project finances.

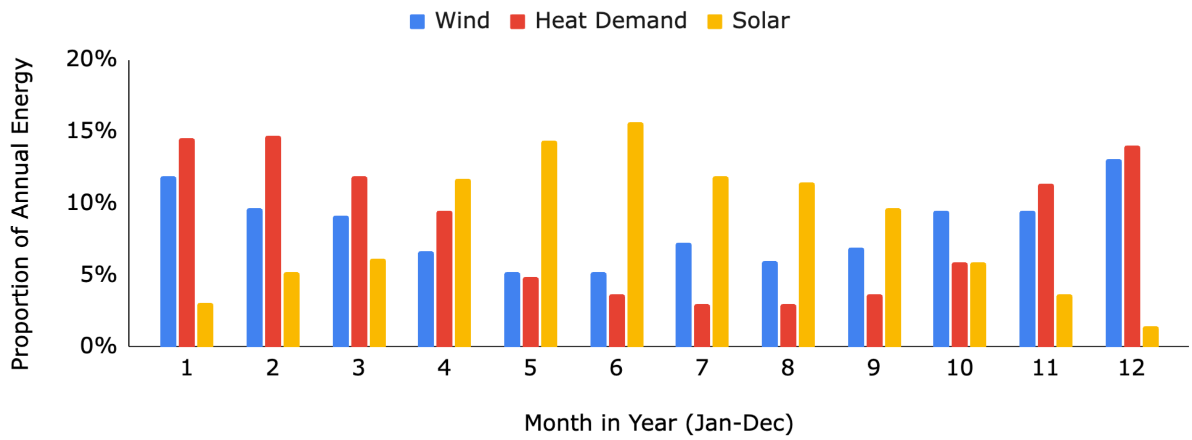


Figure 11: Example monthly breakdown of heat demand and renewable generation

In general, solar PV proved to add significantly less value to the proposition compared to wind, the seasonal generation profile being poorly matched with network heat demand, i.e. peak solar generation is in summer whereas peak heat demand is in winter. Solar PV has therefore been omitted as a fixed requirement in the CHDU constraints modelling. Whilst hydro could also potentially be very useful, the number of suitable locations (a good hydro site near heat dense towns), is vanishingly small. Wind turbines are therefore the preferred generation to match with potential low carbon heat network sites.

6. Techno-economic Modelling

A key aim of the Community Heat Development Unit (CHDU) project is to identify locations in mainland Great Britain where it may be feasible to develop a centralised, low-carbon district heating network. This is achieved by completing a screening process which uses a techno-economic model to estimate the technical and financial viability of a heat network at specific sites using parameters such as building density and heat demand.

The methodologies used in the CHDU techno-economic model are reported in full on the CHDU project website[43] alongside an interactive version of the model and summarised below.

6.1. Heat Pump COP Model[44]

The CHDU heat network model uses large multi-stage air source heat pumps (ASHPs) to provide most of the heat to the network. These heat pumps use electrically powered pumps to move heat from the air into the heat network[45]. The efficiency of heat pumps at a single point in time is referred to as their coefficient of performance (COP) which is the ratio of the heat energy emitted to the electrical energy consumed. The instantaneous COP of an ASHP varies due to operating conditions such as the temperature of the air entering the unit, typically the outdoor ambient air temperature, and the temperatures of the incoming and outgoing coolant. The seasonal COP (SCOP) of the heat pump is calculated by dividing total heat energy generated within a calendar year by the total electrical energy consumed.

The CHDU ASHP model uses hourly air temperature profiles extracted from Renewables Ninja[46]. The national site search process used a Birmingham air temperature profile which was shifted based on the mean air temperature at

[43] https://communityheat.org.uk/techno-economic-model/
[44] https://communityheat.org.uk/techno-economic-model/heat-pump-model/
[45] https://www.heatgeek.com/how-are-heat-pumps-over-100-efficient/
[46] https://www.renewables.ninja/

specific sites. Site specific air temperature profiles were used when assessing case study sites.

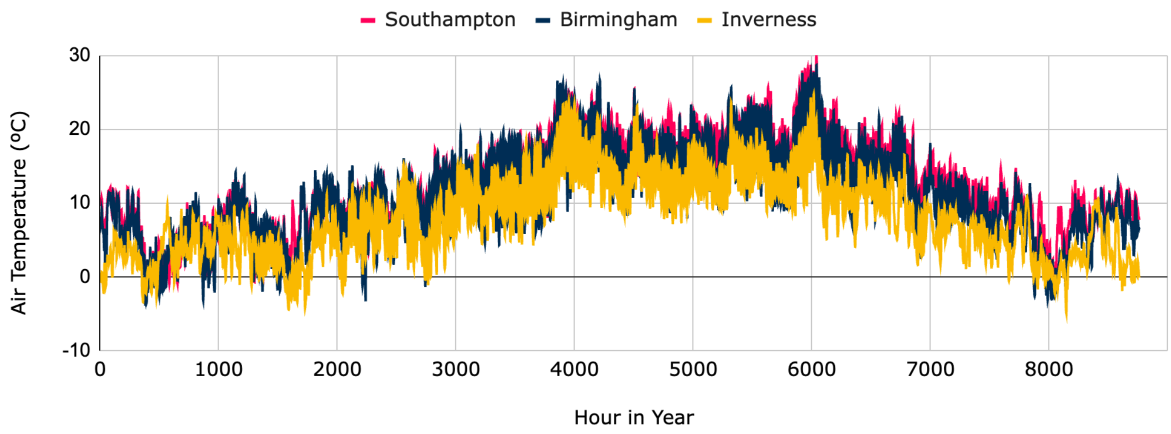
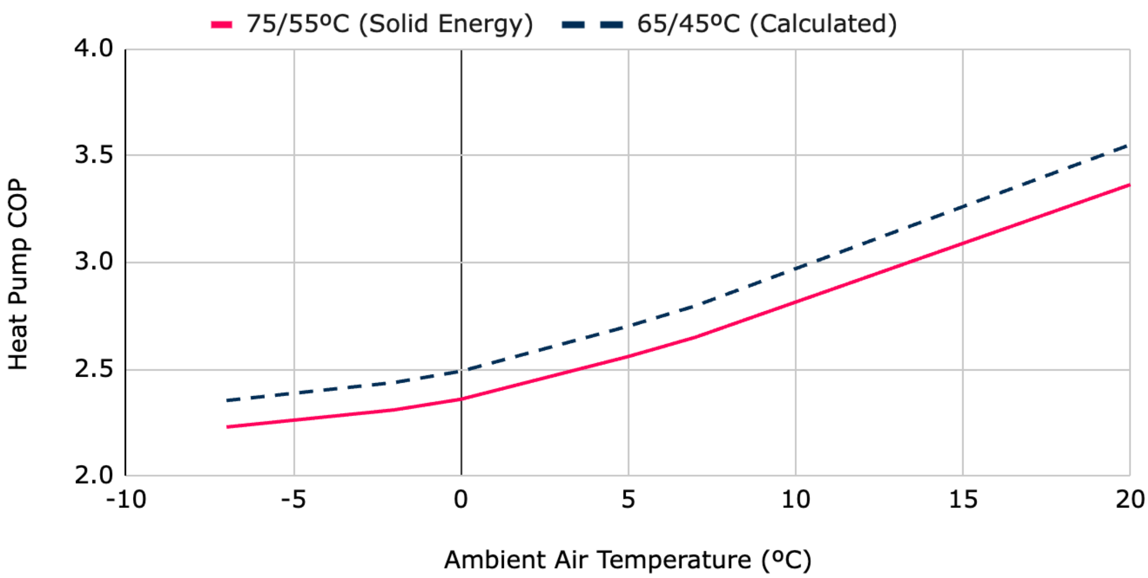


Figure 12: Hourly air temperature profiles at different UK locations

The ASHP manufacturer Solid Energy provided COP values for different ambient temperatures and a flow/return temperature of 75°C/55°C. These values were linearly scaled to the expected average flow/return temperature of the CHDU heat networks of 65°C/45°C using relationships derived from ASHP COP data extracted from the open-source modelling tool PyLESA[47]. The source and calculated COP values are presented in Figure 13.



[47] https://www.softxjournal.com/article/S2352-7110(21)00044-3/fulltext

Figure 13: ASHP COP Values Calculated from Solid Energy Data

6.2. Network Length[48]

Pipework and trenching are one of the most expensive aspects of a heat network. Accurate cost estimation, which heavily relies on network length, is essential for determining financial viability. Typically, network length is estimated using specific site data and optimization software like THERMOS. However, since the generalised CHDU model is developed for the purpose of screening sites across mainland GB without detailed knowledge of local road layouts or identified connected buildings, a generalised approach was developed.

An approach was developed to estimate the required pipework length based on the network area, the geographical area the network supplies, and the building density, the number of buildings connected to the network within the network area. A heat network with higher building density (more houses in the same area) or a wider network area (same number of buildings over a larger area) will generally require more pipework.

The CHDU model developed a predictive relationship between building density, network area, and network length using 16 THERMOS simulations provided by Carbon Alternatives, Figure 14. These simulations covered a range of housing types and non-domestic buildings in both urban and rural UK locations. The result is a simplified method for estimating network length based on these key generalized parameters, which is suitable for the initial high-level feasibility screening conducted by the CHDU techno-economic model.

[48] https://communityheat.org.uk/techno-economic-model/network-length-estimation/

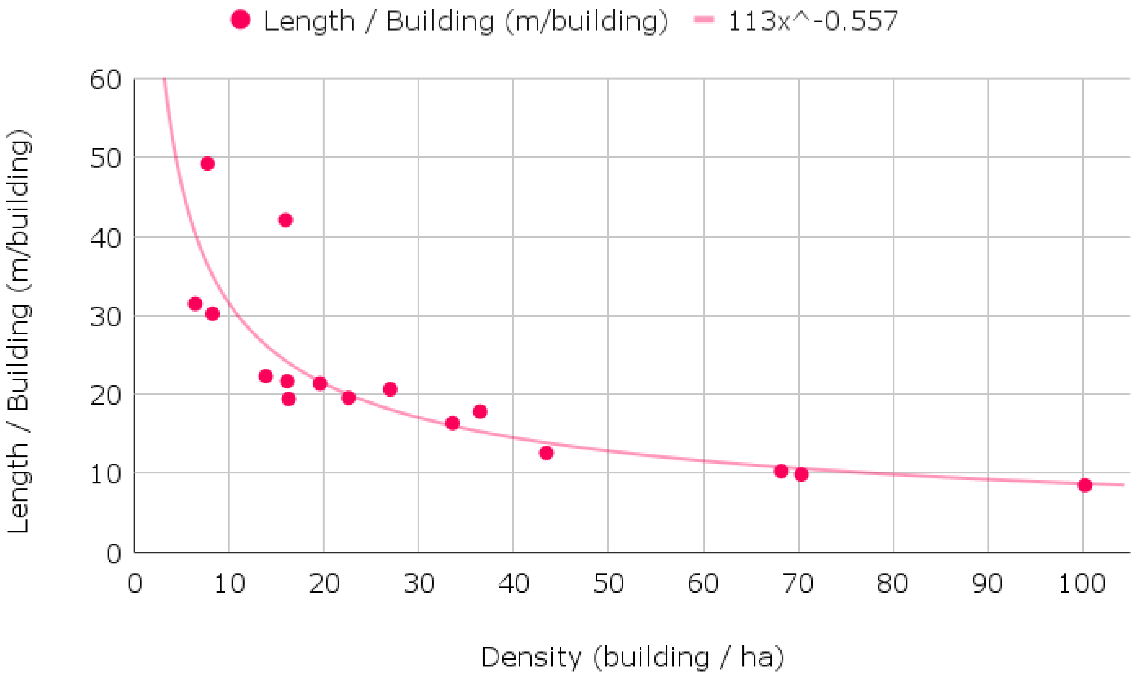


Figure 14: Relationship between building density and network length

6.3. Pipework Heat Losses[49]

In any heat network, some transfer of heat between the pipes and their surroundings takes place. In district heat networks, heat losses from the pipes into the surrounding medium can be as significant as ~20% of the system's total heat load. This can have a significant effect on both the efficiency and profitability of the heat network. Estimating heat losses in a pipe network is complex, as it requires specific data on:

- The length of the pipework.
- The distribution of pipe diameters (which varies significantly between projects).
- Operating temperatures (flow and return).
- Insulation material and pipe design.
- Ground conditions.

[49] https://communityheat.org.uk/techno-economic-model/pipework-losses/

Since the CHDU model aims to screen sites across Great Britain without a detailed, site-specific pipe layout, a simplified, generalized approach is necessary. Using 14 of the 16 THERMOS simulations provided by Carbon Alternatives, a relationship between network length and pipework heat losses was derived, Figure 15.

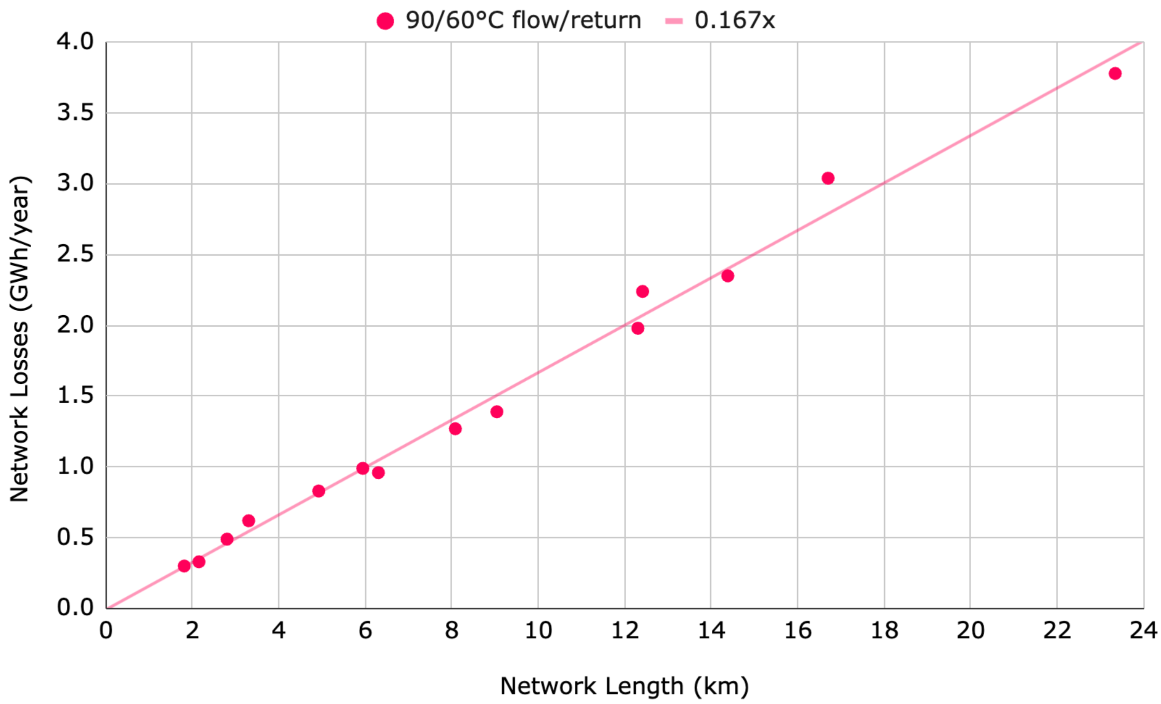


Figure 15: Relationship between network length and annual heat loss

In addition to pipework losses, a value for losses at the heat interface units in each property within the network are included at 0.7kWh/day per connection. This is as recommended by the CIBSE CP1 code of practice. The total annual heat loss value is spread evenly across the hourly heat demand profile of the network. The electrical demand of the heat pumps and fuel demand of the back-up boilers is then calculated based on this hourly profile.

6.4. Wind and Solar Generation Profiles[50]

The CHDU model assumes that a financially viable community heat network will include local renewable electricity generation. This is crucial because:

[50] https://communityheat.org.uk/techno-economic-model/renewables-generation-profiles/

- Heat networks relying on heat pumps require significant electricity to operate.
- Based on the experience of low-carbon heat networks which are in operation or development, using on-site renewable generation reduces the cost of electricity purchased from the grid, improving the financial viability of the heat network.
- Wind generation is particularly beneficial as its output tends to have a good seasonal match with the heat demand curve (more wind in colder, high-demand periods).

The CHDU model uses hourly solar and wind profiles to estimate the amount of energy that is expected to be generated in each hour of the year, and hence how much will either be used by the heat network or sold to the grid. Since the model is applied to a nationwide site search, a normalised profile derived from historical nationwide generation data[51] is used. During the site searching process, these normalised profiles are scaled so they sum to the annual wind and solar generation targets at a particular site.

6.5. Building Heat Demand Profiles[52]

Analysis of heat network viability requires understanding of three key aspects of thermal demand:

- Annual Thermal Demand: The total heat energy required over a year (to estimate the annual energy requirements).
- Peak Thermal Demand: The maximum heat required at any moment (used for sizing heating plant, storage and backup).
- Thermal Demand Profile: The hourly variation of heat demand throughout the year (crucial for calculating operating costs, especially with variable electricity tariffs and thermal storage).

The CHDU model uses site-specific annual thermal demand values for domestic and non-domestic buildings as input. Since hourly site specific data is unavailable for initial screening, the model uses generalized demand profile shapes and then scales them to the site-specific annual demands. The generalised domestic

[51] https://www.energydashboard.co.uk/historical
[52] https://communityheat.org.uk/techno-economic-model/thermal-demand-profiles/

demand profile is derived using the open-source modelling tool PyLESA using a 200 house network with a diverse range of housing archetypes. The non-domestic demand profile is derived from aggregating 17 hourly non-domestic thermal demand profiles from the nPro[53] software in the CHDN techno-economic model including retail buildings, schools, leisure centre with swimming pool, a nursing home and theatre.

6.6. Heat Pump and Back-up Plant Sizing

The aim of the CHDU project is to support the development of low-carbon heat networks, however sizing the heat pump based on the maximum annual heat demand value would result in a heat pump being significantly oversized for much of its operation. Instead the CHDN model aims to provide 80-90% of the total annual demand using heat pumps, with 10-20% of the demand provided by back-up hydrocarbon boilers, Figure 16. Calculations indicate that this reduces the required peak output of the heat pump by about 50%, significantly improving the financial viability of the heat network, while still achieving a carbon reduction of ~85% compared to 100% hydrocarbon boilers.

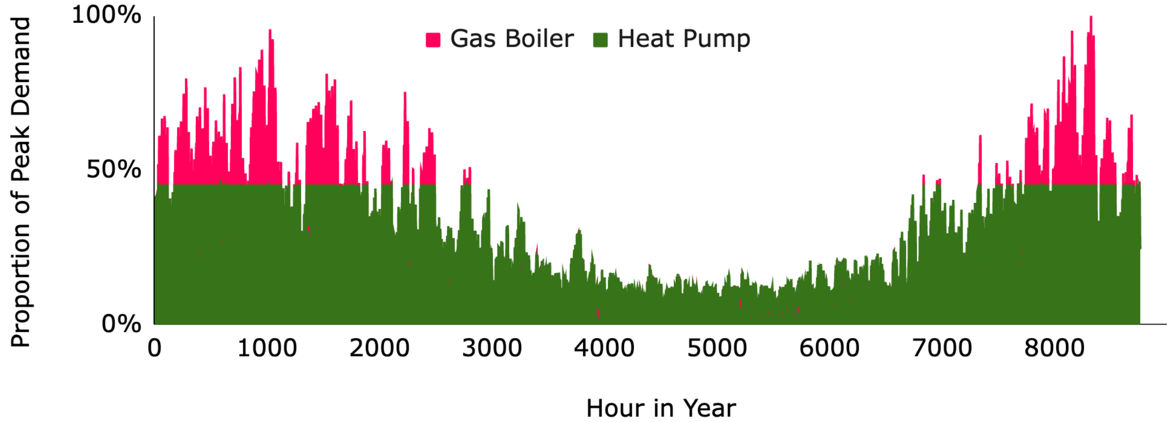


Figure 16: Example split of heat supply throughout a year, 10% of heat from gas

The back-up plant is still sized to meet 100% of the peak thermal demand to ensure that the network can still provide 100% of the thermal demand to consumers during heat pump outages. The hydrocarbon boilers could be replaced in future with electric boilers to further reduce carbon emissions.

[53] https://www.npro.energy/

6.7. Thermal Storage[54]

Thermal storage, in the form of a large, insulated tank, is included in the CHDU's centralised heat network design. Its primary functions are:

- Load Decoupling: It separates the timing of heat generation from the timing of heat demand.
- Integration of Renewables: Crucially, it enables the use of low-cost, on-site renewable electricity (from wind or solar) to charge the store whenever it is available, even if heat demand is low at that moment. This is essential for maximizing the use of renewable energy.
- Optimized Operation: It allows the central heat pumps (ASHPs) to run more continuously and efficiently, avoiding frequent start-ups and shut-downs.

The benefits of thermal storage on the finances of an ASHP heated heat network including local renewable energy generation have been assessed using PyLESA. Twelve PyLESA simulations were run using a network of 200 domestic buildings with heat provided by ASHPs powered by a mixture of grid electricity and wind turbines connected via private wire. The results of these simulations were used to determine the change in cost of heat generation when including different volumes of thermal storage.

The benefit of including thermal storage in the network is modelled as a reduction in the cost of heat generation. Specifically, this is modelled as a percentage reduction in imported grid electricity. A thermal storage volume of 200m3 is assumed within the CHDU model beyond which the cost-benefit of thermal storage reduces for the typical network sizes considered by the CHDU. The percentage reduction in the cost of heat for a specific network site is estimated using the linear relationship for a 200m3 hot water tank presented in Figure 17.

[54] https://communityheat.org.uk/techno-economic-model/thermal-storage/

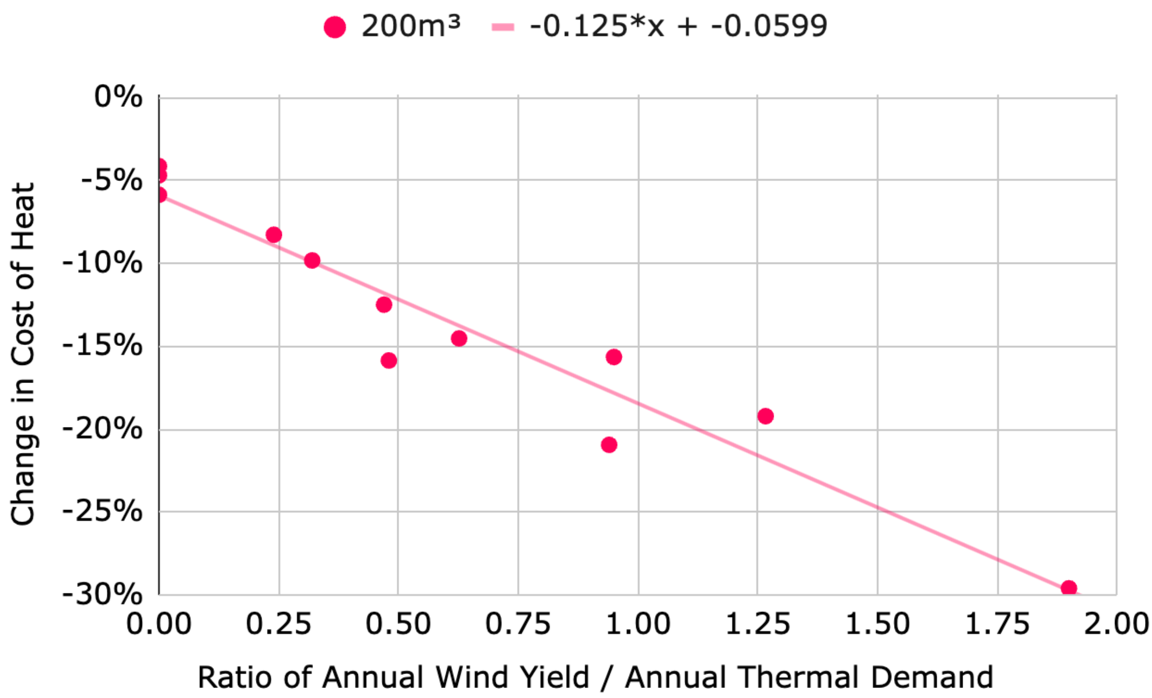


Figure 17: Change in cost of heat for 200m³ thermal store

6.8. Pipework Costs[55]

Pipework and trenching are a major portion of the capital expenditure for a heat network. Accurately costing this requires detailed knowledge of the network layout, pipe sizes, and local ground conditions, which was not feasible for the CHDU's generalized national screening. The CHDU model uses a simplified, high-level assessment of the pipework and trenching costs based on the network's total estimated length (calculated separately).

It is difficult to obtain quotes for pipework material and installation costs without details of specific pipework layouts, hence pipework costs have been reviewed from the following publicly available sources:

- THERMOS software in-built costs.
- Brightwell-cum-Sotwell heat network feasibility study.
- G0 Great Staughton heat network feasibility study (based on costs used in Swaffham Prior feasibility studies).

[55] https://communityheat.org.uk/techno-economic-model/pipework-costs/

- Kings Langley heat network feasibility study.
- Sustainable Energy Authority of Ireland, Inner City costs.

Costs of twin pipe systems of different diameters were extracted from each source along with hard dig trenching costs and inflated to 2024 prices using the Bank of England inflation calculator.

An analysis of 16 THERMOS simulations showed that approximately 70% of the pipework cost in domestic-focused networks is for smaller pipe diameters (65mm or less). The THERMOS costs for these smaller diameters were found to be higher than 75% of other cost sources reviewed, meaning using THERMOS provides a conservative (non-overly optimistic) cost estimate. The output from these 16 simulations also confirmed that there is a highly linear relationship between the total network length and the combined pipework and trenching costs.

The model calculates the total network pipework costs by applying the linear relationship derived from the THERMOS data to the site's estimated network length, based on the conservative assumption of 100% hard-dig costs.

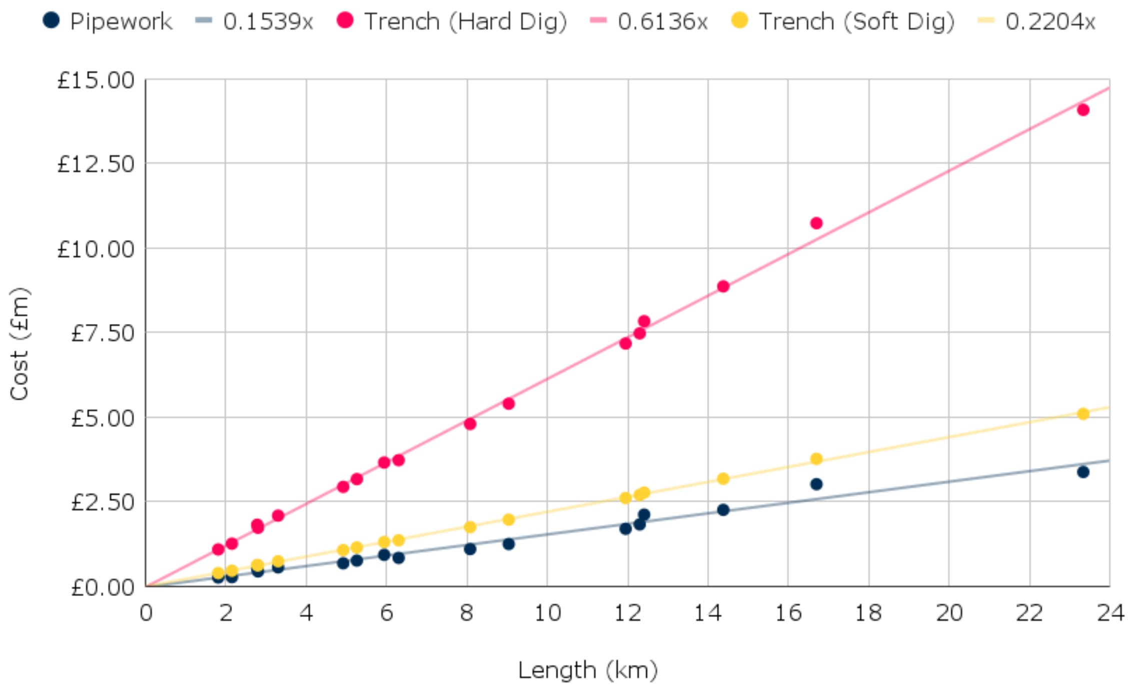


Figure 18: Pipework and trenching costs for 16 THERMOS simulations

6.9. CAPEX Costs

The capital costs assumed in the CHDU techno-economic model are detailed in the "Network CAPEX Costs" page on the project website[56].

6.10. Operation and Maintenance Costs

Regular maintenance of the heat network is essential since customers are relying on it to supply their heat and may require specialised subcontractors due to the technical complexity of the heat network. The CHDU heat network financial model includes the costs associated with operating and maintaining network plant equipment, the pipework and the renewable generating assets.

The model also includes costs associated with running the local Community Benefit Society and the insurance of key network assets.

Full details of the operations and maintenance costs included in the TEM are provided on the "Financial Modelling" page of the CHDU project website.

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[56] https://communityheat.org.uk/techno-economic-model/network-capex-costs/

6.11. Financial Modelling[57]

The goal of the financial modelling is to assess whether heat networks at specific sites are financially viable and compare the financial performance of networks at different locations across the UK as part of a nationwide site search.

The methodologies implemented in the CHDU techno-economic model to financially model centralised, low carbon, district heat networks including capital costs, operating expenses, revenue from heat sales and electricity generation, financing mechanisms, subsidies, and more, are explained in detail on the "Financial Modelling" page of the CHDU project website. The model covers the lifecycle of the network from development and construction to operation and maintenance over a 50 year assumed project lifetime. Replacement costs of the heat pumps, energy centre equipment and renewable generators are modelled at 25 years.

The main source of capital grant support is from the Green Heat Network Fund (GHNF) which is available for the development of new low and zero-carbon heat networks in England. Scotland's Heat Network Fund provides a similar level of support to the GHNF for projects based in Scotland. The core metrics used determine the total award value of the grant in the CHDU model are:

- Up to 4.5p per kWh of heat delivered over the first 15 years of operation of the heat network.
- Up to 50% of the total construction CAPEX costs.
- Up to £1m of which can be used towards commercialisation costs.

Limitations in the availability of GHNF grant money for domestic focussed heat networks is discussed in Section 13 of this report.

The CAPEX and development costs which are not covered by the GHNF grant are assumed to come from loans. Development costs, beyond the initial £1million of GHNF grant, are assumed to be borrowed at a rate of 8% over a term of two years. CAPEX costs in excess of the remaining GHNF grant are financed at a rate of 6%, with the pipework being financed over a term of 50 years, and the remaining heat

[57] https://communityheat.org.uk/techno-economic-model/financial-modelling/

network equipment and renewable electricity generators financed over a term of 25 years. All loans are modelled as annuities.

Each 100-200 building heat network project is expected to require investment within the region of £10 million. While it is anticipated that part of the funding will be achieved through community share offers, it is assumed that these would only be able to raise 5%-10% of the total amount and hence have not been explicitly modelled in the CHDU financial model.

7. Opportunity Mapping

A site search has been conducted across mainland GB to identify the most feasible locations where a centralised heat network incorporating large air source heat pumps and on-site renewable electricity generation could be developed. Specifically, these are areas the CHDU techno economic model has identified as being able to generate enough income through sales of heat and electricity to cover a project's operating and maintenance costs and pay off the loans required to finance the project.

The outputs from the opportunity mapping process alongside map layers of building density and annual heat demand, are published on the CHDU project website[58] in an interactive online map.

[58] https://communityheat.org.uk/interactive-map/

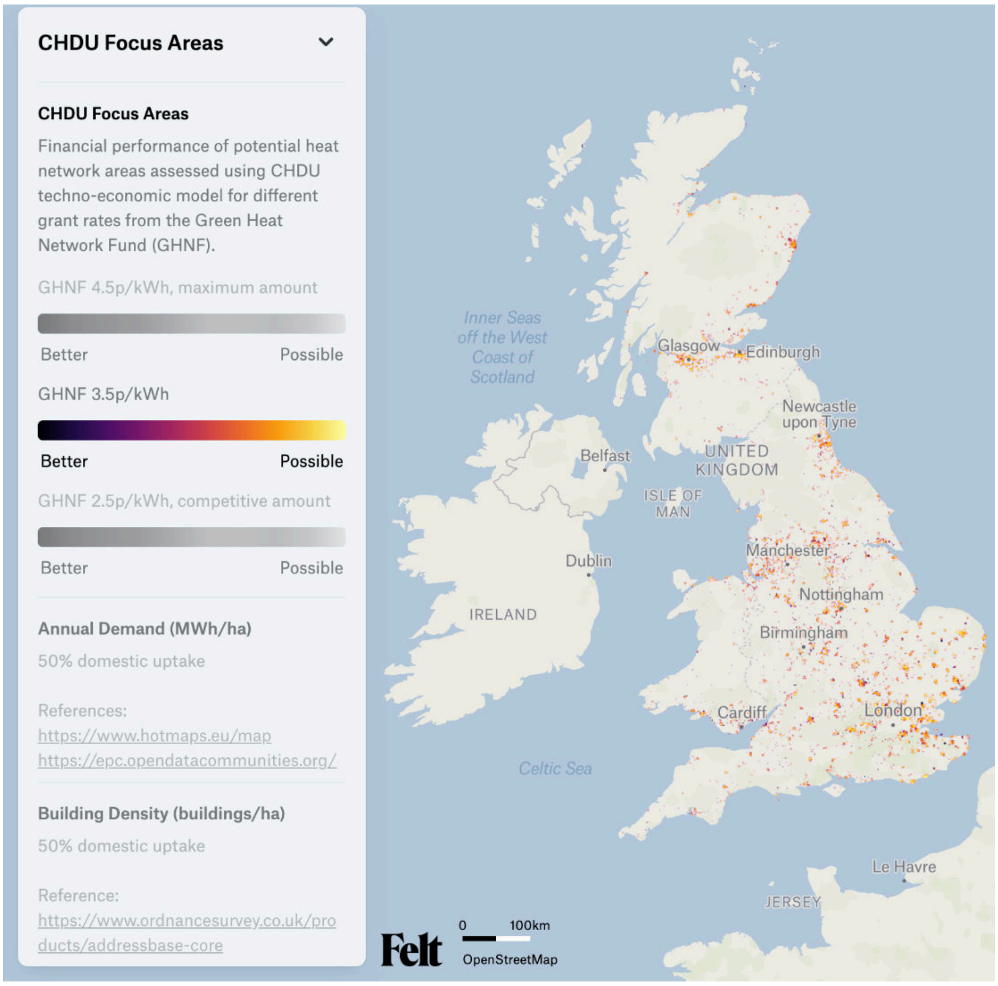

Figure 19: Interactive online map

7.1. Site Screening Process

The following steps that have been used to identify the more feasible domestic focussed, low carbon heat network locations are described in detail in articles published on the CHDU project website and summarised below:

1. Conduct wind constraints mapping exercise to identify potential renewable generation sites based on land usage designations.
2. Estimate site specific annual wind energy yields.
3. Identify areas of suitable heat demand assuming an uptake of 50% amongst domestic properties and 100% of non-domestic properties (typically a handful of anchor loads).

4. Estimate building density assuming an uptake of 50% amongst domestic properties and 100% of non-domestic properties.
5. Use the CHDU techno economic model to estimate the financial performance of the CHDU heat network configuration at a specific site using inputs calculated in the above steps.

The main inputs which varied on a site-by-site basis were:

- Availability and annual yield of potential local wind generation.
- Domestic and non-domestic building density.
- Domestic and non-domestic building annual heat demand.

7.2. Wind Constraints Mapping

A wind constraints mapping process has been completed to identify land parcels in mainland Great Britain which may be suitable for wind turbine development with the aim of associating them with potential heat network sites. The constraints mapping process has been completed using Geographic Information System (GIS) techniques and building type/location and land usage datasets.

It was assumed that multiple 1 MW wind turbines, with a tip height of up to 100m, would be developed alongside a heat network, with larger multi-megawatt turbines considered on an individual basis during the development of site specific case studies. The buffer zones applied to different building and land usage types are:

- Domestic buildings: 500m
- Non-domestic buildings: 100m
- Roads: 100m
- Powerlines: 100m
- Scheduled Ancient Monuments: 500m

Estimates of the potential annual energy yield at each of these land parcels have been completed by estimating the number of 1 MW turbines which could fit within each area and then cross referenced against location specific wind turbine capacity factor data[59] for a 1 MW wind turbine.

[59] https://globalwindatlas.info/en/

The maximum annual energy generation at each potential wind site was limited to 11,040 MWh, equivalent to the annual yield of a 4.2 MW wind turbine with a capacity factor of 30%. This is considered a reasonable practical limit for the scale of onshore wind to be developed by a community near an urban conurbation. Ambition Lawrence Weston have developed and operate a 4.2MW wind turbine on the edge of Bristol.

The datasets used in the wind constraints mapping process are listed on the CHDU project website[60].

7.3. Heat Demand Density

The site screening process required estimates of annual heat demand for domestic and non-domestic properties so the potential income from heat sales could be determined. The different sources of heat demand data which have been considered and used to create the heat demand map layers used in the site searching process are discussed in detail on the CHDU project website[61].

The sources of heat demand data which were considered are:

- Hotmaps[62]
- Pan European Thermal Atlas[63]
- THERMOS
- UK CHP Development Map[64]
- EPC Certificates[65]
- DEC Certificates

The following datasets were used to estimate building heat demand data during the CHDU site searching process:

- Domestic demand: Hotmaps domestic dataset due to its availability at a 1ha level and reasonable correlation against domestic EPC data reported in the reviewed heat network feasibility studies.

[60] https://communityheat.org.uk/interactive-map/wind-constraints-mapping/
[61] https://communityheat.org.uk/interactive-map/thermal-demand-mapping/
[62] https://www.hotmaps-project.eu/hotmaps-project/
[63] https://heatroadmap.eu/peta4/
[64] https://chptools.decc.gov.uk/developmentmap
[65] https://epc.opendatacommunities.org/

- Non-domestic demand: Combination of the Hotmaps non-domestic dataset and DEC data. DEC data is used when available for buildings within a 1ha area, else the Hotmaps non-domestic data is used.

Note that the CHDU site searching process reduced the heat demand density of domestic buildings by 50% to represent a 50% uptake of heat network connections within an area.

A map layer of building heat demand density is published on the CHDU project website alongside the output of the site searching process.

7.4. Building Density

The economic viability of a centralised district heat network is directly related to the density of buildings within an area. For example, increased building density increases the number of connections to a network and hence the overall connection cost, but will also increase the income from standing charges and tends to be proportional to heat demand density. The CHDU techno economic model uses building density to estimate the trench and pipework length required to deliver heat to connected buildings and estimate the number of connections of domestic and non-domestic buildings.

To enable use of the techno economic model in the CHDU site searching process, map layers of domestic and non-domestic building density across mainland GB were created using Ordnance Survey AddressBase Core[66] data. The domestic building density has been reduced by 50% to represent a 50% uptake of heat network connections within an area

A map layer of building density is published on the CHDU project website alongside the output of the site searching process.

7.5. Site Identification

The CHDU techno-economic model was used to assess the technical and financial viability of potential heat network sites across mainland GB using a GIS based workflow implemented using the Python[67] programming language. The wind

[66] https://www.ordnancesurvey.co.uk/products/addressbase-core
[67] https://www.python.org

constraints, building and heat demand density map layers were inputs into the site assessment process. The main outcome of the site identification process was the selection of 3 sites to develop heat network case studies to assess the feasibility of the proposed low carbon heat network model in detail.

An initial assessment was conducted which involved running the CHDU model with millions of different combinations of inputs to determine the distributions of parameters which defined a viable low carbon heat network (using large ASHPs and local wind generation). For example, this initial assessment indicated that the average annual heat demand within the networks should be at least 240MWh/year/ha, and viable networks were likely to cover an area of 5ha up to 30ha. The outputs of this assessment were used to apply some initial filtering to the GIS based site searching process to reduce the scale of the problem and minimise the computational requirements.

Figure 20 presents the main steps in the site identification process:

1. The process began by using the combined domestic and non-domestic annual heat demand density map layer, with domestic demand reduced by 50% to represent a 50% customer uptake.
2. The heat demand layer was filtered to only include 1ha squares with an annual heat demand of at least 240MWh.
3. The remaining heat demand squares were combined into potential network sites. Potential sites of different areas were assessed ranging from 5ha up to 30ha (increasing in 5ha increments) to assess different network sizes.
4. The resulting 6 groups of sites were associated with nearby wind generation sites (with a proximity of up to 3km) and the CHDU techno-economic model was used to assess the financial viability of each site, scoring the site based on the initial predicted payback period.

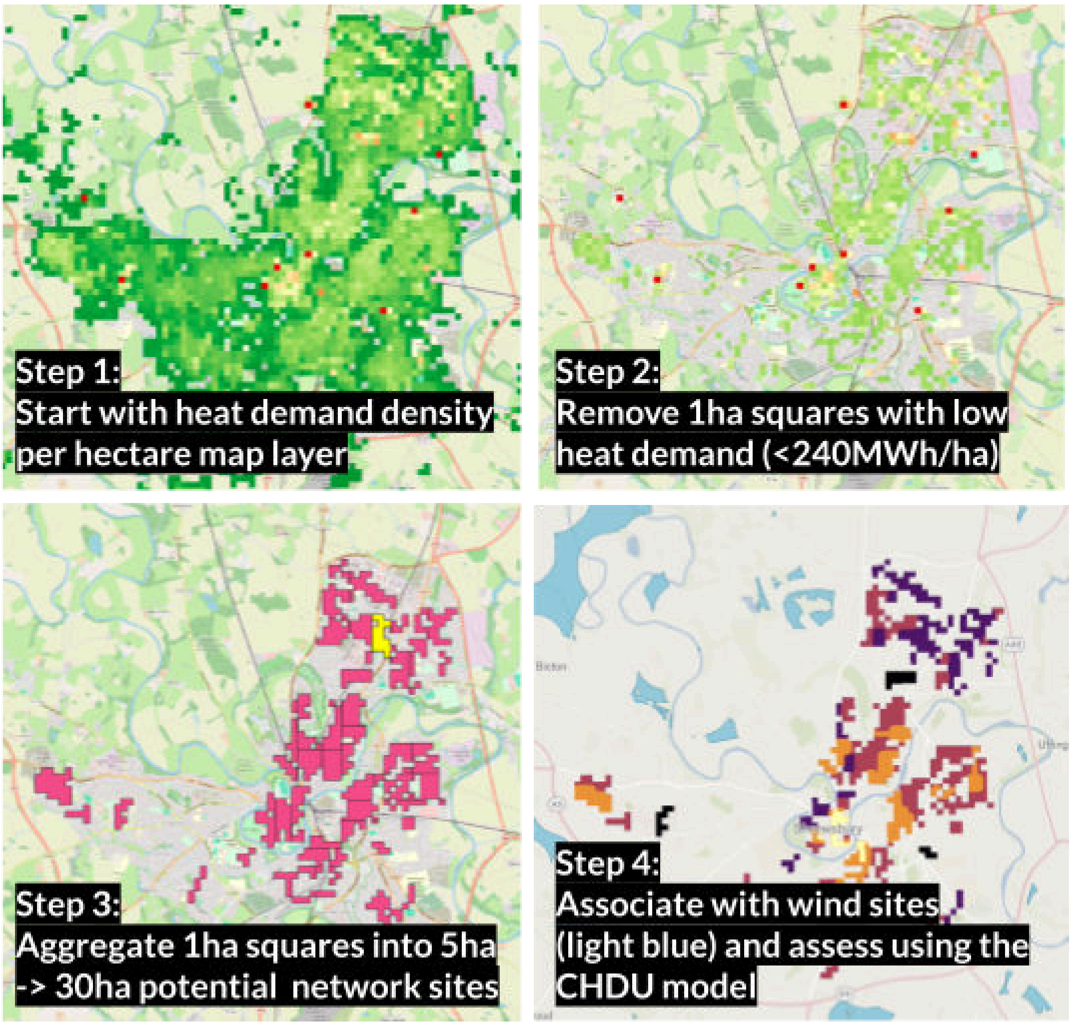

Figure 20: GIS process followed to assess sites

7.6. Locations Off Mains Gas

The CHDU site searching project has focussed on locations which are connected to the mains gas network (i.e. on-gas locations). Decarbonising buildings located in conurbations which are off the mains gas network (off-gas locations) has the potential to achieve greater carbon savings compared to gas heated properties. Also, homeowners may be keener to change their heat source since heating oil prices fluctuate regularly and can be significantly more expensive than mains gas, particularly during the winter months. The counter argument to this is that off gas locations are generally more rural and hence less populated.

The CHDU project reviewed off gas locations and with the exception of some small towns in the north west of Scotland, off gas locations tend to be poorly suited to a heat network due to the lack of suitable anchor loads e.g. Bishop's Castle is unusual being an off gas grid town with high density housing stock in close proximity to a leisure centre and swimming pool. Also, despite the increased potential for heating oil prices to fluctuate, average prices have stagnated over the 2 years and are currently cheaper than mains gas, making it harder for a low carbon heat network to match existing heating costs in off-gas locations.

7.7. Case Study Selection

Working with Community Energy England and Local Energy Scotland[68], the sites with lower initial payback periods were correlated with locations of existing community energy organisations. A refinement process was conducted to review the best sites which were located close to community energy organisations who had responded positively to a request for local CHDU project partners. This resulted in 3 sites being taken forward to case study stage:

1. **Morecambe West End** - working with Morecambe Bay Community Renewables (MORE Renewables)[69].
2. **Letchworth Jackmans Estate** - working with River Ivel Community Energy[70].
3. **Forres High Street** - working with local representatives via Local Energy Scotland.

8. Case Studies: Low Carbon District Heat Network

Case studies were completed to assess the feasibility of the proposed CHDU low carbon centralised heat network configuration at the 3 locations identified through the site searching process. The aim of these cases studies was to:

- Engage with local stakeholders and initiate local representation and advocacy.

[68] https://localenergy.scot
[69] http://www.morerenewables.co.uk
[70] https://riverivelcommunityenergy.com

- Use location specific heat demand and building layout information to propose an initial network layout.
- Review the potential of local wind turbine sites.
- Propose indicative sizing of energy centre plant.
- Assess the financial viability of a local community owned low carbon heat network.
- Assess the potential carbon savings.

Carbon Alternatives[71] provided technical support during the development of these case studies, including developing the network layouts using the THERMOS software and producing initial estimates of the heat network plant sizing using the EnergyPro[72] software.

Case study reports for each of the locations are available in the Appendices of this report and are summarised below.

8.1. Proposed Networks

Forres High Street

A low carbon heat network focussed on Forres High Street is proposed. This area is of particular interest since much of the building stock are Victorian terraced houses with minimal outdoor space, interspersed by dense blocks of flats and a number of public buildings owned by Moray Council. The hard to insulate nature of much of the housing in the area and lack of space to install individual ASHPs means that connecting to a centralised heat network may be a more viable option for heating decarbonisation compared to installing individual heat pumps.

The proposed low carbon heat network aims to supply ca. 200 domestic properties and ca. 120 non-domestic properties, mostly located along Forres High Street, supplying around ~90% of their 7.5GWh annual heat demand using a large 1.69MWhth ASHP with ~10% of the heat being supplied by centralised gas back-up boilers. The heat sources would be installed alongside a 400m^3 hot water tank to store heat when it can be produced cheaply for use later. The proposed scheme includes the development of a ~3MW onshore wind turbine to supply around 90%

[71] https://carbonalternatives.co.uk
[72] https://www.emd-international.com/software/energypro

of the electricity consumed by the ASHP. This wind turbine could potentially be located towards the north west of Forres and would supply electricity to the ASHP via a direct wire, exporting any excess generation to the electricity network.

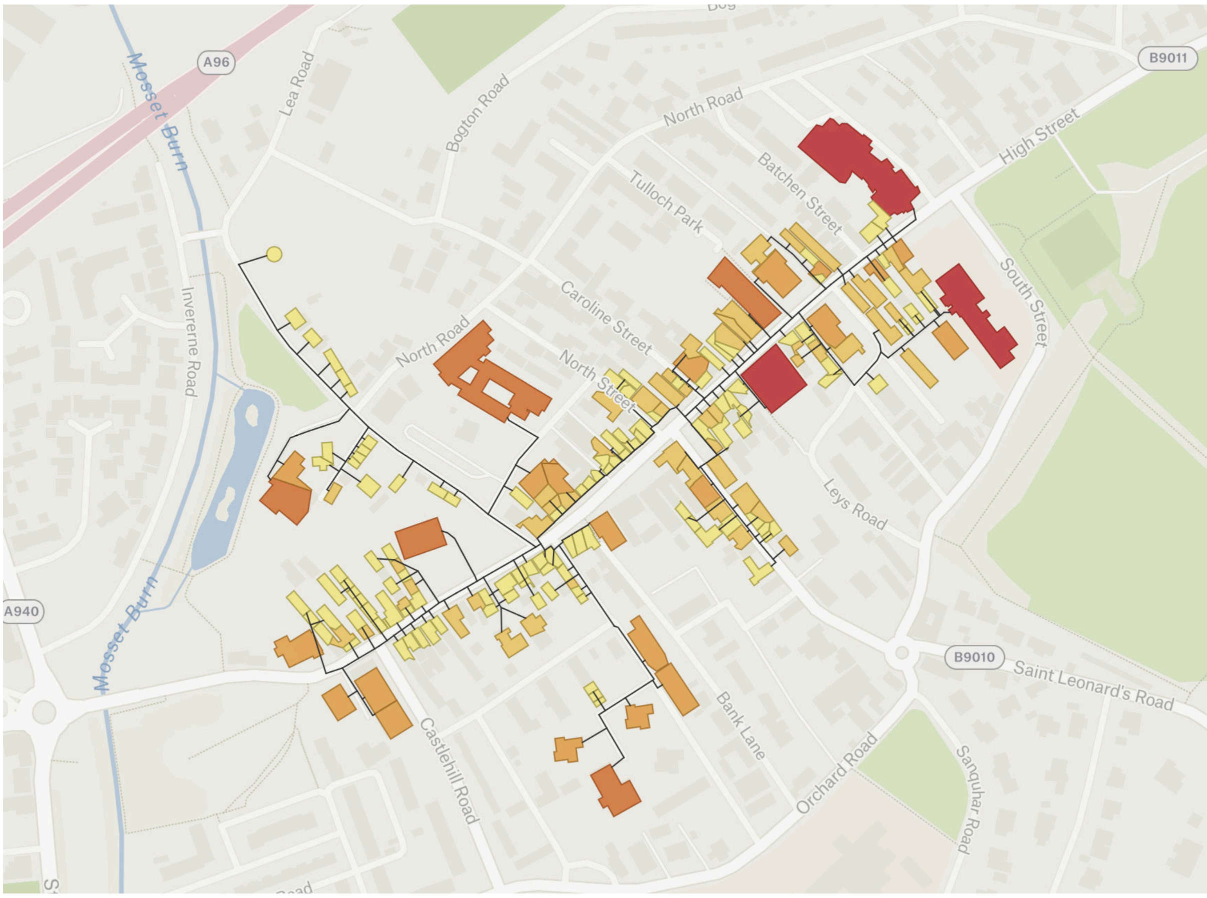

Figure 21: Proposed Forres heat network layout

The case study report for the proposed heat network in Forres is provided in Appendix 3.

Morecambe's West End and Sandylands

The proposed low carbon heat network in Morecambe is centred around the West End and Sandylands areas of the town. This area is of particular interest since much of the housing stock are large, solid walled Victorian terraced houses, ranging between 2 and 4 storeys, with minimal outdoor space. The hard to insulate nature of these properties and lack of space to install individual ASHPs means that connecting to a centralised heat network may be a more viable option for heating decarbonisation. There are also a range of potential non-domestic anchor loads in the area including multiple schools and a swimming pool.

The proposed network connects to 555 domestic and 59 non-domestic customers supplying 80% of their 13.3GWh annual heat demand using a large 2.25MWhth ASHP with the remaining 20% being supplied by centralised gas back-up boilers. The heat sources would be installed alongside a 600m3 hot water tank to store heat when it can be produced cheaply for use later. It is proposed that a 4.26MW wind turbine is developed which could supply approximately 90% of the annual electrical demand of the network. The wind turbine could potentially be located towards the south east of the network site, an area which already has a number of turbines in operation.

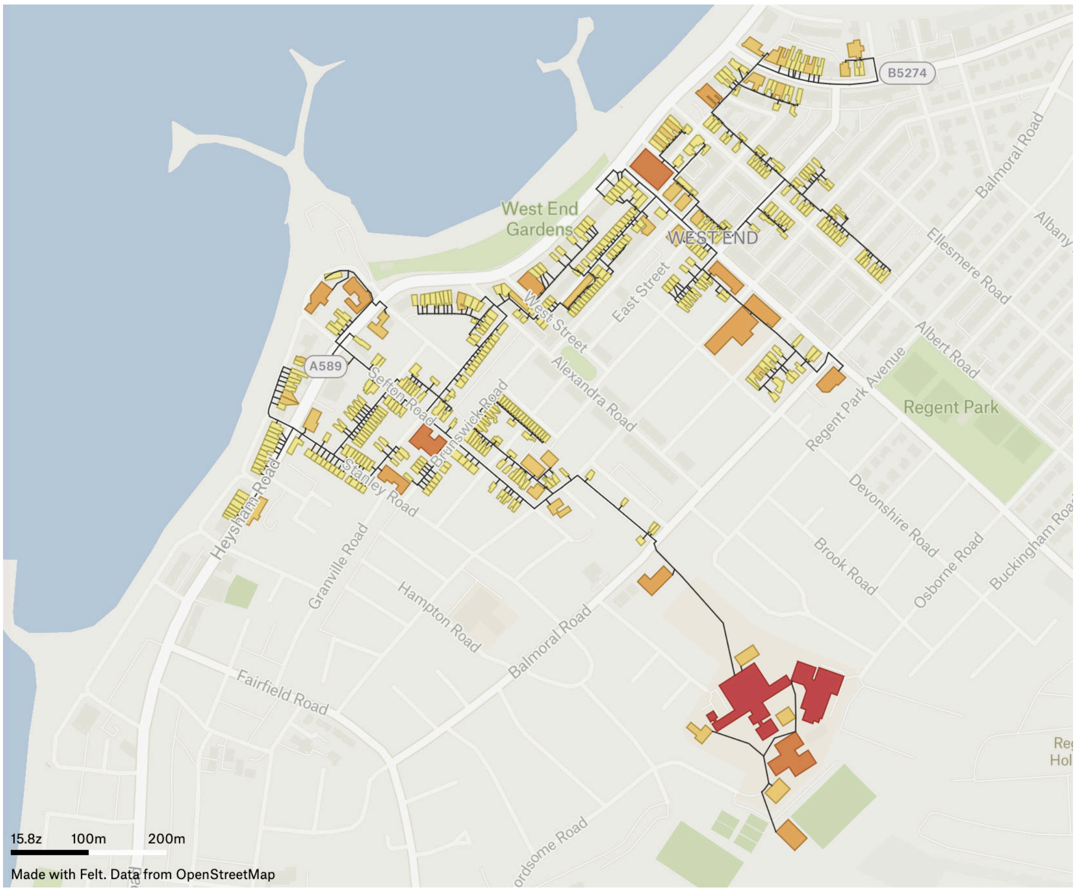

Figure 22: Proposed Morecambe heat network layout

The case study report for the proposed heat network in Morecambe is provided in Appendix 4.

Letchworth Jackmans Estate

Jackmans Estate has a high proportion of terraced houses (51%) and blocks of flats (25%), 40% of which is social housing. The area has a large amount of space between the rows of terraces and blocks of flats which means there is potential for a large portion of the network pipework to be installed at a significantly lower cost than if installed in the highway. Part of the attraction for considering a heat network on the estate was the potential to also supply heat and electricity to North Herts Leisure Centre, a significant anchor load, however during the course of the CHDU project it became apparent that the leisure centre was proceeding with upgrading its heating system to use individual ASHP, using funding from the Public Sector Decarbonisation Scheme. The proposed network route connects 825 domestic properties and 2 schools.

Figure 23: Proposed heat network layout at Jackmans Estate, Letchworth

Much of the area also has relatively low indices of multi-deprivation compared to elsewhere in the country suggesting that residents have limited means of funding installation of a low carbon heating system on an individual basis. This is part of the reason that a heat network has been investigated within the estate since a network may be able to attract external investment, enabling decarbonisation of households' heating systems without requiring them to front the installation costs.

The proposed low carbon heat network aims to provide around 90% of the 11.1GWh annual heat demand of connected buildings using a large 1.69MWhth ASHP with 10% of the heat being supplied by gas back-up boilers, installed alongside a 400m3 hot water tank. A 3MW wind turbine is proposed which could be located to the south east of the heat network which would supply 85% of the network's electrical demand and most of the electrical demand of the leisure centre, following electrification of its heating system.

The case study report for the proposed heat network in Jackmans Estate is provided in Appendix 5.

8.2. Estimated Financial Performance

The financial performance of the scheme has been estimated using the CHDU techno-economic model, including the following site specific inputs:

- Air temperature and hence ASHP SCOP profile.
- Heat demand profiles.
- Wind generation profile.
- Number of building connections.

The key network and financial metrics are listed in the table below.

	Forres	Morecambe	Letchworth
Connected Buildings/Dwellings	333	614	827
Annual Heat Demand (GWh)	7.0	13.3	11.1
Network Length (km)	2.93	7.59	10.36
Linear Heat Density (MWh/m)	2.40	1.75	1.07
Modelled Average Connection Cost	£8,500	£6,500	£4,881
CAPEX + Commercialisation	£15.6m	£27.0m	£23.1m
CAPEX + Comm. per Property	£47,000	£44,000	£30,000
Grant Amount	£4.8m	£9.0m	£6.0m
Grant % of CAPEX + Comm.	30%	33%	26%
25 Year IRR	6.5%	6.6%	4.8%
Initial Payback (years)	24	24	-
Annual Carbon Savings (tCO2e)	1,099	1,856	1,479
g/CO2e per kWh of Lifetime Heat	18	29	41

Table 2: Predicted financial performance of proposed heat networks at case study locations

The proposed low carbon heat networks in Forres is the most viable of the assessed schemes despite requiring the most capital investment per property. This is largely due to the linear heat density of the network being the highest due to the relatively short network length and increased heating demand in the north of Scotland.

The network in Morecambe has been assessed to have a similar financial performance to the Forres network, however this depends on the average connection charge per building being reduced from ca. £8.5k to ca. £6.5k. This may be achieved by: charging the public sector and larger non-domestic anchor loads a connection fee but set at a price which is less than the cost of these buildings decarbonising their heating on an individual basis; some low income households may also be able to have their connections funded by the Warm Homes: Local Grant[73] if plans to extend the fund to include heat network connections are implemented; there is limited experience in the UK of retrofitting buildings of the types in Morecambe's West End to a heat network so it is recommended that location specific options for retrofitting the buildings in the area using local contractors are investigated to establish potential cost reductions.

The proposed scheme in Letchworth is not expected to be financially viable without the North Herts Leisure Centre acting as an anchor load despite the opportunity for much of the pipework to be installed in areas suitable for "soft-dig" trenching, and the potential to fund network connections using the Warm Homes funds.

All schemes require significant grant funding. The English schemes in Morecambe and Letchworth require the maximum amount of funding from the Green Heat Network Fund, at a rate of 4.5p/kWh (of heat delivered over the first 15 years of operation). The current competitive nature of the GHNF suggests that these schemes could only access 56% of the required funding amount (equivalent to a grant rate of 2.5p/kWh). The limitations of the GHNF are discussed further in Section 13 of this report.

The scheme in Forres assumes a grant from Scotland's Heat Network Fund equivalent to 50% of the eligible CAPEX plus an additional £950k grant for commercialisation costs.

The ratio of potential grant funding to total capital costs is presented in Figure 24.

[73] https://www.gov.uk/apply-warm-homes-local-grant

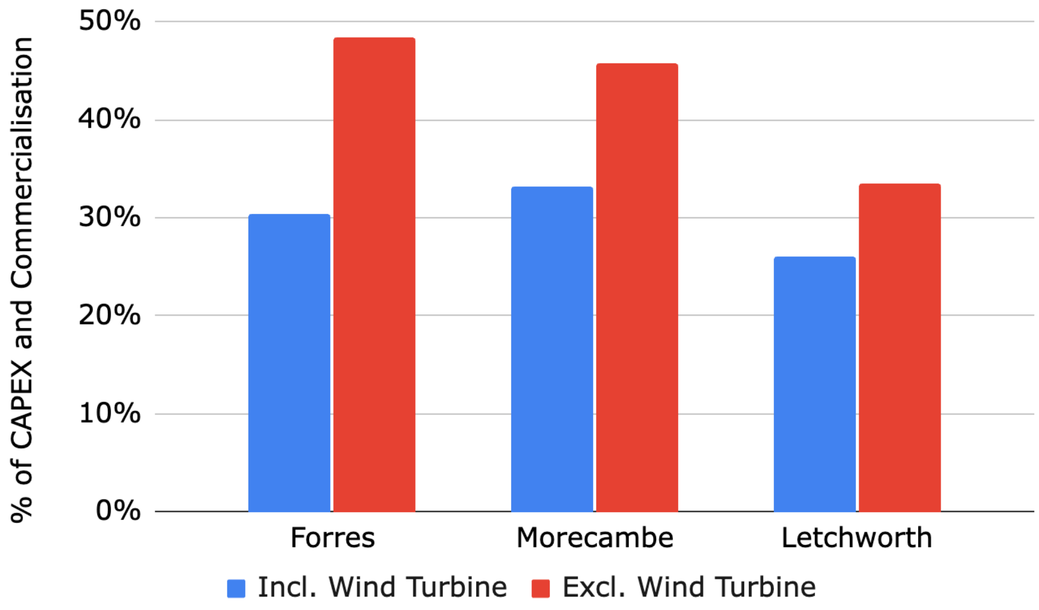

Figure 24: Grant as % of CAPEX and commercialisation costs for CHDU Case Studies

8.3. Local Support

Evening workshops were organised in each of the three case study locations to begin to establish an understanding of whether there is local support for developing community owned heat networks. The local community energy organisations marketed these events through their networks. Sharenergy also made contact with members of the relevant local authorities, local groups representing residents and local environmental and climate focused organisations, with the support of Community Energy England.

The event in Forres was the best attended, with 10 people joining from the local area including representatives from CEM, Moray Climate Action Network, AES Solar, tsiMoray and local residents and community advocates. Graham Leadbitter, the Scottish National MP for Moray West, Nairn and Strathspey, and Shadow SNP Spokesperson for Energy Security and Net Zero was also in attendance.

Figure 25: Charlotte Goodwind of CEM, Graham Leadbitter MP and Ben Cannell at the public event in Forres

The attendees were generally supportive of the proposed scheme and conversations are ongoing regarding whether any local organisations would be willing and able to act as local advocates for the heat network project.

The events at Jackmans Estate, Letchworth, and Morecambe were poorly attended with only 3 attendees from the local area at each event. At Morecambe, this is despite approximately 400 leaflets being delivered directly to properties by More Renewables.

There is significant work to be done to share the heat network concept with local residents and establish local support.

8.4. Next Steps

The initial focus for Forres and Morecambe should be on local engagement to build community support. The immediate technical priority is developing a local multi-megawatt wind project, which is designed to be financially robust as a standalone venture. This wind generation would then serve as the foundation for the proposed future low-carbon heat networks. An alternative opportunity being held for future exploration is the potential to use the wind generation to directly lower residents' electricity bills and fund individual heat pump installations through an "Energy Local" style scheme; an option discussed in detail in Section 17 of this report. For the proposed heat networks, a critical preparatory step is obtaining detailed quotes for retrofitting the local housing stock and installing Heat Interface Units (HIUs). Specifically in Morecambe, it is expected that by utilizing local tradespeople and tailoring the connection strategy to the area's multi-storey terraced houses, the average connection cost could be substantially reduced from the ca. £9,000 proposed in reference materials.

In contrast, the Letchworth project's financial viability hinges on supplying behind the meter electricity to North Herts Leisure Centre and significantly reducing the cost of connecting domestic properties. With planned changes to the Warm Homes funding scheme, the average connection cost is approximately £5,000. For the scheme to become fully viable, this average cost must drop to ca. £2,300, necessitating a better estimate of the cost of connecting the specific properties within the Jackmans Estate. The clearest path to viability, however, would be the extension of the Boiler Upgrade Scheme to cover heat network connections; this would drop the average connection cost below £2,000, making the scheme immediately viable.

9. The Development Journey

9.1. Preliminary Development Phase

The first stage involves several activities that can happen at the same time, with different organizations working on behalf of various stakeholders. Who does what typically depends on which stakeholder they represent and the expected ownership structure.

- High level pre-feasibility study
- Stakeholder engagement with local authority and “on the ground" community activity with people and businesses in the locality

- Surveying sample of properties in the catchment area
- Data collection and analysis
- Renewable energy site searches and constraint mapping
- Preliminary design work
- Initial business case development and high-level financial modelling
- Development Funding application

This phase begins with a broad assessment of whether the project is feasible. Meanwhile, engagement starts with local authorities and community members in the area. Technical teams survey representative properties in the target neighborhood to understand what they're working with. They gather and analyze relevant data about the area and its energy needs.

Teams search for potential renewable energy sites in the area, noting any restrictions. Engineers develop early design concepts based on this information. Financial specialists create a basic business case based on a range of options with projected costs and returns. Heads of Terms or Expressions of Interest are agreed with landowners and key anchor loads. Finally, the team prepares and submits applications for development funding.

9.2. Secondary Development Phase

After completing the preliminary phase, the project moves forward with more detailed work.

- Feasibility study
- Legal planning
- Public consultation and stakeholder engagement
- Finance negotiation
- Land option and access negotiation
- Planning and Permitting applications
- Detailed business case development
- Decision making on final network size and design
- Procurement process

A thorough feasibility study examines all aspects of the proposed network. The project team conducts public consultations and continues engaging with stakeholders, ensuring everyone is informed and heard. Financial negotiations become more specific as the project takes shape, with the relevant ownership model options being explored, along with possible procurement frameworks.

The project team secures options on the land parcels and access routes identified in the initial design stage and submits the required planning applications and permits to any relevant authorities. The business case becomes more detailed and precise. Engineers finalise the technical design, and procurement specialists begin conversations with potential contractors and suppliers.

9.3. Construction Phase

- Project management and finalising connection agreements
- Legal work
- Logistical planning
- Civil works (digging and water services, heating plant room preparation)
- Pipework laying (in road)
- Plumbing works (connection to the property)
- In property preparation (plumbing and electrics, heating distribution modifications, insulation work)
- Testing and Commissioning
- Handover and training of operators

Construction begins with civil engineering work: digging trenches, installing water services, and preparing spaces for heating equipment. Workers lay pipes under roads to create the network's infrastructure, then connect these pipes to individual properties. Inside buildings, the retrofit activity will take place, modifying plumbing, electrical systems, and heat distribution equipment as needed.

Once construction is complete, engineers test all systems thoroughly to ensure they work properly. Finally, the team hands over the operational system and trains the people who will run it.

9.4. Operation and Administration Phase

Once operational, a heat network system requires continuous monitoring and optimisation to ensure reliable, efficient and safe operation. This involves several interrelated activities:

- **Monitoring and optimisation:** performance monitoring is essential to maintain smooth operation and identify opportunities for efficiency improvements. Data collected from the system informs operational adjustments, helping to optimise energy delivery, minimise losses, and maintain compliance with regulatory standards.
- **Maintenance:** regular inspections and preventative maintenance are critical to extend asset life and avoid system failures. Maintenance staff will perform scheduled checks, identifying potential issues before they escalate, and carrying out minor repairs or upgrades to improve system performance.
- **Minor upgrades:** in addition to routine maintenance, periodic minor upgrades may be implemented to improve efficiency, incorporate technological advancements, or respond to changes in user demand.
- **Metering and charging:** accurate metering is essential both for operational oversight and for billing purposes. Administrative staff are responsible for managing metering systems, monitoring consumption data. and producing accurate invoices for customers. This includes ensuring compliance with relevant regulations and providing transparent information to support fair and consistent charging.

Overall, these activities form a continuous cycle of monitoring, maintenance and optimisation, ensuring that the heat network operates efficiently, meets regulatory requirements, and delivers reliable service to all customers.

10. Heat Network Owner / Operator Models

The European parliament has given funding to several projects that aim to help people learn about different approaches to heat network development, such as the CoolHeating project[74].

It is easily possible that more than one ownership model may be appropriate for CDHNs in the UK, however, given the direction of travel seen in public policy consultations and the upcoming allocation of District Heat Network Zones (DHNZ), it seems likely that nearly all centralised district heat schemes will end up falling under combined public / private partnership arrangements in some way. A local authority might become a DHNZ operator or owner themselves, allowing a fully publicly owned structure.

Public / Private Partnerships (PPPs) are models that reflect the increasing transfer of risk and responsibility from the public sector to private operators. In the context of the CHDU project, the private operator would be community owned. In the wholly public model without any private participation, the city or municipality takes on all of the risk associated with the investment.

In these various models, political responsibility for the provision usually remains with the public authority. Participation of the private sector contributes to solving the challenges of the wholly public model by providing long-term investment perspective, enabling access to additional investment sources, and providing private sector experience and innovation.

The prevalent owner / operator models are shown below. In the case of a CDHN, "private" could be interpreted as "community owned", as well as the more common meaning of "business owned", or a combination of the two.

[74] https://www.coolheating.eu/

	Operation and management	Payment for services	Investment	Ownership
Traditional public provision	Public	Public	Public	Public
Management agreements	Private	Public	Public	Public
Leasing	Private	Private	Public	Public
Concession agreement	Private	Private	Private	Public
Privatization	Private	Private	Private	Private
Heat entrepreneurship	Private	Public/ Private	Public/ Private	Public/ Private
ESCO's	Private	Private	Private	Public/ Private

Figure 26: Owner/Operator models prevalent in Europe: H2020 CoolHeating project

It's important to note that one of the main reasons that 100% private ownership is not seen more in the range of models illustrated here, is that the amount of profit generated by heat networks is typically very small. Without grant funds, the financial case for many networks is so weak that they would not attract any private investment at all. The "CHDU - Literature Review" document available in Appendix 1 demonstrates this in some detail.

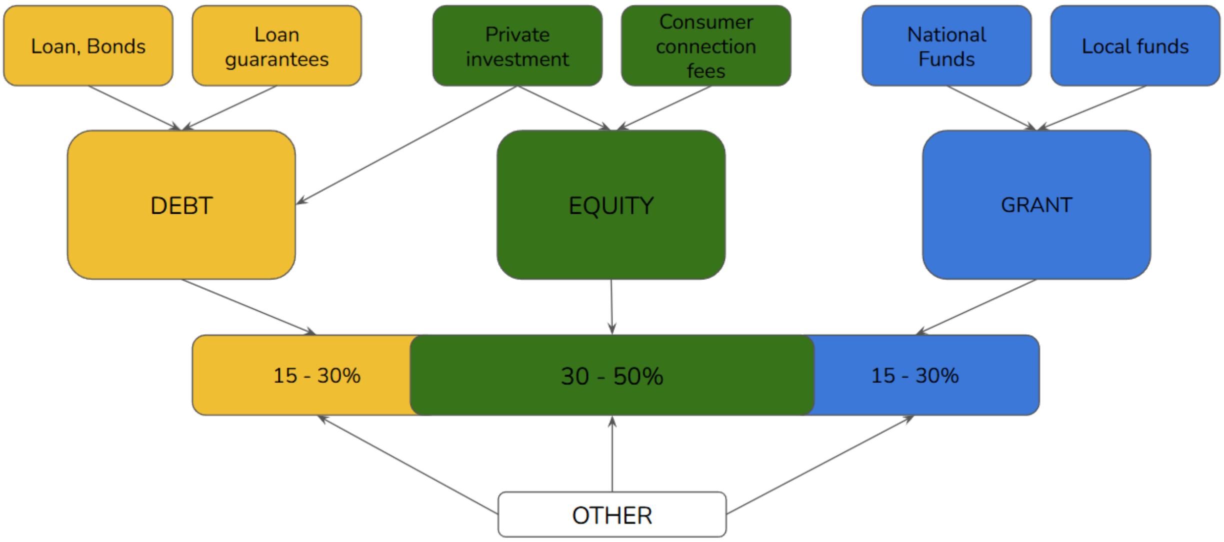

Figure 27: Typical finance arrangements for district heating schemes across Europe (adapted from CoolHeating 2020)

Project lengths are typically reported as 30 or 40 years. Operational projects are often planned with much longer timeframes, such as the Viking heat network[75] with a predicted 45-year payback period, even though it was eligible for the Renewable Heat Incentive payments.

[75] https://www.southtyneside.gov.uk/article/3772/Overview

10.1. Roles and responsibilities in delivering a heat network

Network size will probably dictate the level of involvement that a community enterprise might take and what roles in the management and ownership they are able to take on, based on their capacity and experience.

There will be many key partners in any heat network, and the roles they undertake may well vary depending on the size and nature of the network. For this reason, the table below should be interpreted as indicative only. Note that most Local Authorities have struggled in recent years and it is understood that very few are in a situation where they can take on the risk of owning or developing a sizable heat network.

Partner type	Advocacy	Development	Construction	Finance	Ownership	Operation
Community enterprises	Yes	Yes	Scale dependent	Scale dependent	Scale dependent	Scale dependent
Local Authorities	Yes	Yes	Scale dependent	Scale dependent	Maybe	Maybe
Housing Associations	Yes	Yes	Scale dependent	Maybe	Maybe	Maybe
Business	Yes	No	Yes	Maybe	Maybe	Maybe
District Heat Zone Co-Ordinator	Yes	Scale / location dependent	Yes	No	Maybe	Maybe
Landowners	Yes	No	No	No	No	No
Financial institutions	No	Yes	No	Yes	No	No
Supply chain	Yes	Yes	No	No	No	Yes

Table 3: Typical roles in heat network development

10.2. Key partners in a centralised community heat network

Local Authorities: may be responsible for the full range of activities carried out in the development of a network, from advocacy through to full ownership and operation through a special purpose vehicle (SPV), though it may well sub-contract or concession some of the sub-activities such as metering and billing or administration. Some of this activity could be carried out by community enterprises. The SPV could also be partially owned by a community enterprise, though there are restrictions on a community enterprise raising share capital for a scheme which it does not control.

Other scenarios might see local authorities offering up their assets (libraries, sports centres, office buildings) as "anchor loads" to community owned networks.

Housing Associations / Social Landlords: could also take ownership and operation of their own heat networks where they own large tranches of housing in a geographical area, opening ownership or partial ownership up to community enterprise.

Banks and other institutional lenders: projects at this scale may take years to develop and receive several tranches of development and capital funding throughout the project lifespan. This may be in the form of debt or equity using a range of finance instruments such as bank loans, pension investment funds, national infrastructure funding and regional development funding.

The Local community: no matter the scale of the network or its ownership / operation model, communities are at the heart of CHDNs. They could be involved in many ways:

1. Education, advocacy and outreach
2. Carrying out building surveys
3. Liaising with the local authority
4. Planning
5. Fund raising
6. Partial through to 100% ownership
7. Financial operation and management

For a community organisation to take on the responsibility of building and running a local heat network it would be crucial to have administrative and management support services available. This could be through a dedicated central society or co-op servicing multiple such schemes. Such an arrangement would also enable some peer to peer support to take place between the societies, channelled through a central co-op.

Local Business: can offer a crucial role in assisting with advocacy, as well as becoming a customer of the network by acting as an anchor load. The DESNZ Heat Network Zoning Consultation[76] suggested that businesses may be compelled to join heat networks in the defined DHN zones, though there is no legal mechanism to do so at this time, and no guarantee that they would have to in areas outside the zones.

10.3. Customer Segmentation - Domestic

There are several customer groups which may all have different attitudes to the idea of being connected to a heat network. Community Enterprises should be mindful that there is no guarantee that sufficient numbers of people being canvassed through community outreach in the initial stages will be as interested in the idea of joining a network as might be required to make it successful. Some of the more prevalent issues for different groups are discussed in this section.

10.3.1. Owner Occupiers

Owner occupiers are an obvious choice for targeting. Not only might they be more interested in the idea of local community related projects (than private landlords), they are also able to actually make decisions about their own property.

Nonetheless, there may well still be significant resistance. For many people, carbon reduction is not an issue that governs their day to day lives however they will have to consider how to replace their fossil fuel heating at some point in the future.

[76] https://www.gov.uk/government/consultations/proposals-for-heat-network-zoning-2023

10.3.2. Private and social renters

Rented properties make up approximately 35% of homes across the UK, just under 20% of homes are privately rented and just over 15% are social rented.

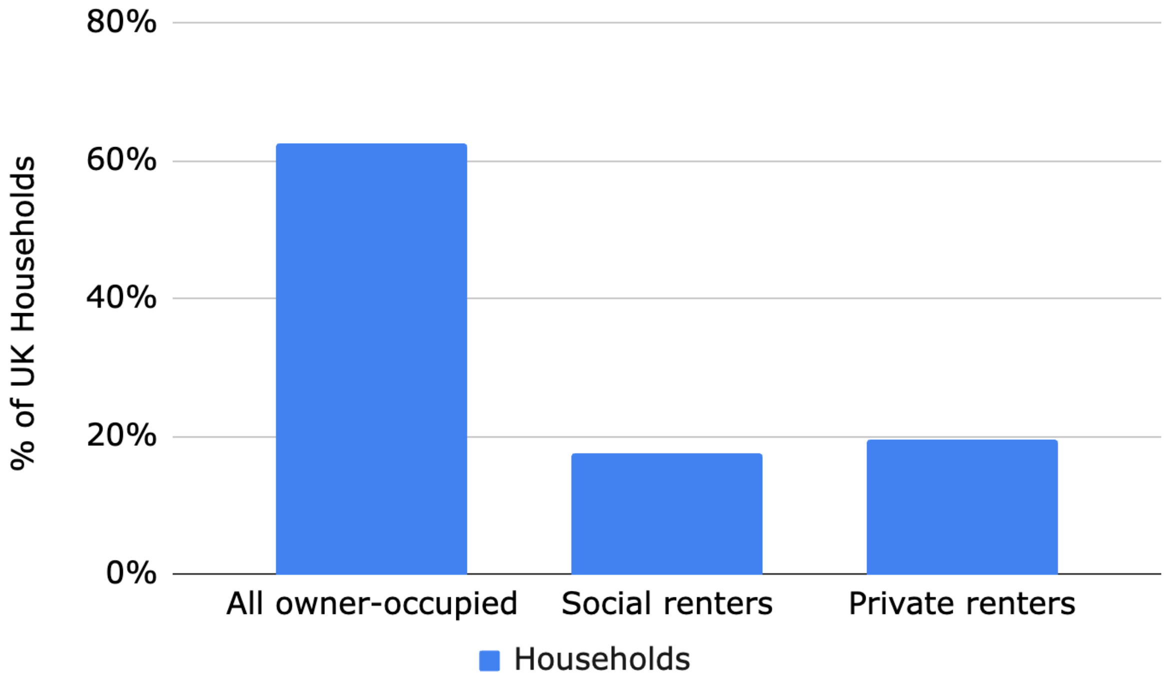

Figure 28: Tenure of homes across the UK[77]

Private renters are obviously not able to make a decision to connect to a heat network, they can only hope to have a sympathetic landlord if they wish to join a heat network.

Social renters may not be able to make decisions about whether to connect to a heat network themselves, but they are an important part of the CDHN stakeholder groups. If social landlords are to be persuaded to consider putting their housing stock onto a heat network, it is vital that the tenants themselves are well educated about the value proposition and are not reluctant to engage when communicating with their landlords and the CDHN developers.

[77] Census-based statistics UK: 2021, Table 12 https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/censusbasedstatisticsuk2021

10.3.3. Landlords (private housing)

Landlords of private rented property present an extremely difficult sector to engage with. Private landlords have been awaiting the outcome of government thinking on the approach of stiffer regulation around the Minimum Energy Efficiency Standards (MEES) in rented housing for some time. This ongoing situation has been somewhat of a political football for the last 5 years, and any landlords that are considering investing in building improvements are likely to be holding back until there is greater clarity[78].

It cannot be expected that private landlords will switch their heating systems away from conventional heating systems under the current regulatory environment, discussed further in Section 16 of this report. Additionally, if connection charges are significantly higher than replacement boilers, it would be unrealistic to expect any of them to make a switch unless required to.

It is worth noting that Scottish Government may have different policy provisions in the future (moving towards banning direct emission heating systems), that would make this a more straightforward decision-making process in Scotland[79].

10.4. Customer Segmentation - Commercial

10.4.1. Landlords (social housing)

Social landlords are important stakeholders because of the sheer volume of housing that is owned by them. When people discuss the success of Sweden in the penetration of heat pumps into the housing market, this is because a very high proportion of homes are in municipal ownership and heated by district heating using heat pumps: it is not because many private homes purchase individual heat pumps.

It is feasible that social landlords could retrofit and own / operate their own district heating schemes exclusively, though it is very unlikely to make financial sense to do so without including larger anchor loads or incorporating waste heat.

[78] https://www.nrla.org.uk/news/requirements-for-upcoming-epc-and-mees-changes
[79] https://www.gov.scot/policies/energy-efficiency/the-heat-in-buildings-programme

A more interesting role for them as far as CDHN developers are concerned, is to take part in helping to develop a project in the wider area:

- As an anchor load i.e. (in the form of high-density housing in a tight geographical area).
- Advocacy in the community.
- Development finance source (where part of a scheme).
- Project finance source (where part of a scheme).
- Access to grant funding schemes which will fund the installation of low carbon heating technology such as the Warm Homes: Social Housing Fund.

The type and density of housing they have in a catchment area will heavily influence whether they might decide to join a network particularly if individual heat pumps could be fitted instead. But if they were in control of several co-located tower blocks, these could make ideal customers especially where there are existing communal heating systems.

10.4.2. Anchor loads (Business and Public sector)

For several reasons large non-domestic heat off-takers, known as anchor loads, generally improve the financial viability of a heat network which primarily connects to domestic properties:

- Commercial users will be “good” customers, consuming a lot of heat and contributing to cashflow.
- Commercial heat is often required at different points in the day and sometimes even through the night. This helps justify the heating network being on for longer periods, where otherwise it might be kept warm at the beginning / end of the day just to deliver heat to a small number of relatively low heat users.
- The pipework to a commercial connection point will deliver many more units of heat per unit length of pipework (i.e. there is an economy of scale).

“Flat” anchor loads such as swimming pools (i.e. the heating profile doesn’t vary much hour by hour), with high heat demands being most beneficial to heat networks. Utilising as many of them as possible will help justify creating a larger network that might support the connection of more homes. Significant operations with large premises may also be able to house the heating plant and back-up boilers, utilising the existing gas supply.

10.5. Public / Private Partnerships (PPP)

Traditionally, PPPs have referred to relationships between the public sector and commercial businesses. Arrangements used in schemes across Europe have been diverse. The common denominator of all these models is that the private sector partners have had responsibility for designing, building, and operating the scheme[80]. There are many variations on this theme:

- BLT (Build Lease Transfer)
- BOO (Build Own Operate)
- BOOT (Build Own Operate Transfer)
- BOT (Build Operate Transfer)
- BRT (Build Rent Transfer)
- D&B (Design and Build)
- DBFO (Design Build Finance Operate)
- PFI (Private Finance Initiative)
- FBOOT (Finance Build Own Operate Transfer)

There are several community enterprises that have managed to raise relatively large sums of development and construction capital (into the millions of £££s) to deliver a diverse range of community owned projects across the UK, such as Awel Aman Tawe's EGNI project[81], or Sharenergy's Big Solar Co-Op[82]. However, none at the time of writing this document, can claim to have delivered projects involving the sort of complexity and volumes of capital that might be expected in typical DH schemes seen in the commercial sector. These schemes delivered under PPP may follow different approaches with the increasing transfer of risk from public to private. Private might imply the community, rather than a for-profit business.

80 https://www.coolheating.eu/images/downloads/CoolHeating_D5.1_Guideline.pdf
81 https://aat.cymru/egni/
82 https://bigsolar.coop/

10.5.1. Management Agreement

A Management Agreement is a form of PPP in which the public sector invests in and retains ownership of the service infrastructure, while outsourcing day-to-day operations and management to a private contractor. Contracts are typically short- to medium-term (2-5 years).

- Responsibilities of the operator:
    - Manage staff, operations and routine maintenance (including minor equipment replacement).
    - Collect bills on behalf of the public authority, sometimes bearing part of the non-payment risk.
    - Receive a fixed management fee, often supplemented by performance-based bonuses or penalties.
- Risk allocation:
    - Public sector retains most financial and investment risks.
    - Private sector may carry some operational and collection risks, but limited exposure overall.
- Advantages:
    - Brings in private sector expertise to address poor management and inefficiencies.
    - Separates operation from regulation, improving transparency and accountability.
- Limitations:
    - Efficiency gains may be modest, as the operator has limited financial risk and incentive to innovate.
    - Limited opportunities for major capital investment or financing from the private sector.

10.5.2. Lease Agreement

A Lease Agreement is a medium-term PPP (typically 8-15 years) in which the public sector (lessor) retains ownership of assets while the private sector (lessee) operates, manages and maintains the system, often with responsibility for certain upgrades.

- Responsibility of the lessee:
    - Operate and manage the system, including routine and preventative maintenance.
    - Collect tariffs/revenue from users, assuming the full revenue collection risk.
    - Cover operating costs and fund minor replacements
    - Maintain asset records and ensure the system is handed back in agreed condition.
    - May oversee capital projects, though large-scale investment usually remains with the public sector.
- Responsibilities of the lessor (public sector):
    - Retains asset ownership.
    - Receives lease payments/rent from the lessee, often reinvested into system upgrades.
- Risk allocation:
    - Lessee assumes revenue and operational risk, and much of the asset risk.
    - Lessor retains major investment responsibility and policy/regulatory authority.
- Advantages:
    - Stronger incentives for operational efficiency and better asset management compared to management agreements.
    - Encourages private sector accountability for service delivery and revenue collection.
    - Public sector benefits from steady rental income to support reinvestment.
- Limitations:
    - Typically does not mobilise significant new capital investment.
    - Requires strong regulatory oversight to prevent asset deterioration or under-maintenance.
    - Reduces public sector's direct intervention in day-to-day operations.
    - Risk of degraded assets at contract hand-back if monitoring is weak.

10.5.3. Concession Agreement

A Concession Agreement is a long-term PPP (typically 25-30 years or the lifetime of the facility) in which a public authority (grantor) grants a private party (the concessionaire) rights to renovate, finance and operate existing infrastructure, or in some cases to develop new facilities under models such as Build-Own-Operate-Transfer (BOOT), with the underlying assets often remaining under public ownership.

Under the concession, the operator recovers its costs and earns a return through user fees, and may also be required to pay a concession fee to the authority. The concessionaire assumes responsibility for a wide range of risks, including demand, design, finance, construction, and operation. In some cases, the public authority may share demand risk. User charges can either be fixed in the contract or determined by the concessionaire, subject to regulatory oversight and tariff-setting provisions agreed upon in advance.

This model provides the benefits of management and lease agreements, while creating stronger incentives for efficiency and life-cycle cost optimisation, and enabling the mobilisation of private finance. However it requires robust framework conditions, including:

- Independent and transparent tariff-setting mechanisms
- Clearly defined allocation of risks and performance requirements
- Provisions address workforce considerations and non-non-commercial service obligations.

10.5.4. Heat Entrepreneurship

This conceptual model was developed in Finland to help facilitate biomass-based heating plants through a partnership arrangement. Figure 29 modifies this concept to suit the current UK energy markets and offers a chance for co-operative involvement without running the heat network itself. This plays to the strengths of the current activities that community energy enterprises are already familiar with.

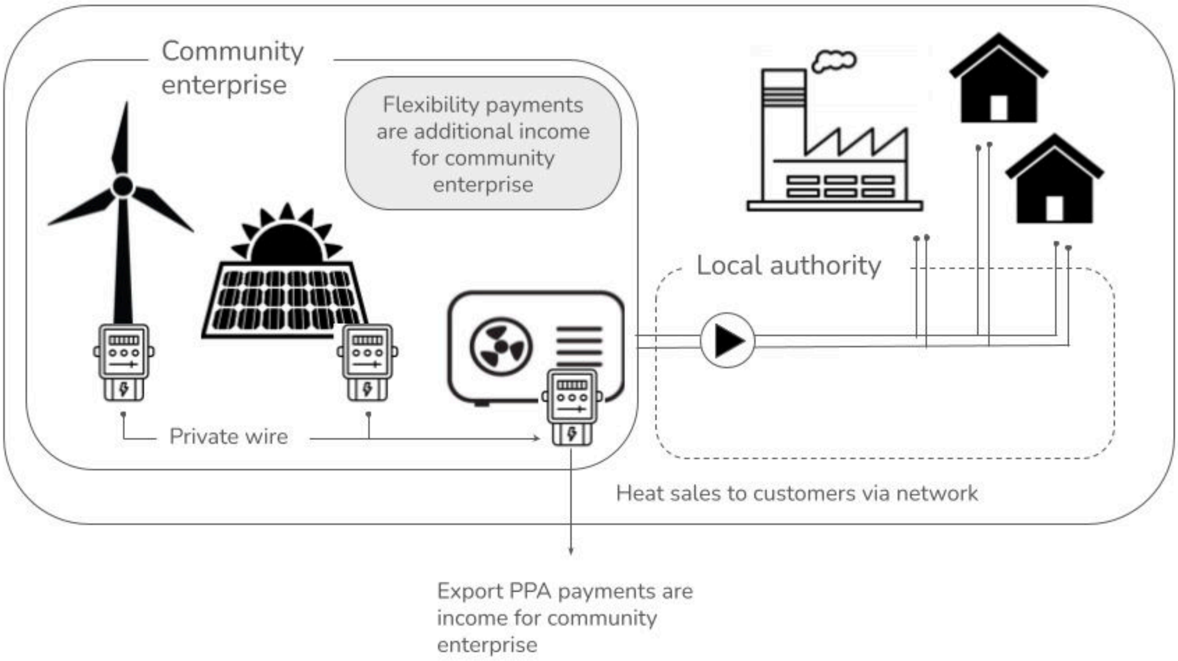

Figure 29: Possible UK Heat Entrepreneurship model based on the Finnish Biomass concept

This model appears to be very applicable to community enterprises, because there is a possibility for them to take on only the amount of risk and CAPEX that they feel comfortable with. It could act in any form of ownership structure identified previously.

At its most simple and least risky, involvement could be limited to simply owning renewable generation assets, selling electricity to the heat network operator. This would be well within the normal experience of existing community energy organisations.

This concept could be expanded to the community energy organisation also owning and operating the energy centre, selling heat to heat network customers. The community energy organisation would become a Heat Network Supplier which is a regulated role under the UK heat network regulations, discussed further in Section 13 of this report. Using the example in the above figures, the local authority who owns the network pipework would take on the Heat Network Operator role. This setup would oblige the community energy organisation to work under a heat supply contract (or equivalent agreement) and they would be responsible for metering heat supplied to customers and ensuring accurate billing. It is not currently clear in the regulations whether the Heat Network Operator or Heat Network Supplier are responsible for heat disruption.

10.5.5. Privatisation

Privatisation refers to the transfer of ownership, management, or responsibility for public service provision to the private sector. This can take different forms:

- Full divestiture of a utility, where assets are sold outright to a private entity. In such cases, the operator typically requires a service licence and becomes fully responsible for delivering services to users.
- Private provision of new assets, often through Build-Operate-Transfer (BOT) arrangements, usually applied to new operations. Here, the private party finances, builds, and operates the facility, with revenue commonly derived from performance-based availability payments made by the public authority rather than direct user fees.
- In some contexts, privatisation may also encompass community ownership models, where responsibility for services or assets is transferred to user groups or cooperatives rather than commercial operators.

Privatisation can expand investment capacity, bring in private sector expertise, and introduce stronger performance incentives. However, it also requires clear regulatory frameworks, robust service contracts, and safeguards to ensure affordability, service quality, and protection of public interests.

11. Activities Of The Community Enterprise

There are many activities that a community enterprise could carry out in a CDHN. This section addresses the most important of these roles.

11.1. Advocacy

It is vital that engagement with the local community is commenced early in the development of CDHNs. One of the overarching problems with centralised heat networks will be encouraging enough households, in the right locations, to join to make the scheme viable. Given the importance of encouraging as many people as possible to join is one of the biggest influences on project success, advocacy is probably the most important activity for the community to get right.

Initially, the primary role of the community enterprise will simply be to start the conversation locally with the people who will be involved in making the project a success. Discussions should start with the local authority after checking local area energy plan documents for what the expected development activity in the area is likely to be. Local authorities may not have had the bandwidth to develop any plans in detail, if at all.

One of the most important sectors of the stakeholders to engage with is the business community, for the development of anchor load opportunities: speaking to the local authority should also help identify businesses and commerce groups in the area that might be open to conversations around developing a project.

When engaging with residents or business owners for the first time, many of them will not understand what a heat network is, nor understand what the implications of joining a heat network might be for them or their business.

It is recommended that initial engagement makes it clear that a community centralised district heat scheme is unlikely to save money on fuel bills, and concentrates on the other wider benefits such as protection from future price shocks, management of maintenance, improved bill profiling and carbon reduction.

11.2. Legal Structure And Governance Of The Community Enterprise

There are multiple routes a group may take to becoming a legally recognised entity able to make funding applications. Typically a Co-operative, Community Benefit Society (CBS) or Community Interest Company (CIC) will be used to secure development funding[83]. The correct structure to use will depend on the overall aims of the enterprise, the ownership stake in the investment vehicle or management company (if any), and how it might distribute any benefits to the

[83] https://www.uk.coop/start-new-co-op/start/choosing-your-legal-form

community. A CBS is the simplest structure available for any scheme that wants to raise share capital.

Some of the legal issues surrounding the communities involvement in DHNs are explored in a separate document prepared for the CHDU project by Lux Nova Partners[84]. This is summarised in Section 14 of this report.

Governance of the community enterprise will vary a little by the type of structure they choose to form, but the principles are similar. 'Articles' are written that state the intention of the group and structure of decision-making processes in the running of the enterprise. A board is appointed that ensures the articles are carried out in the interests of the community and shareholders that contribute money, time and effort. Using a CBS or CIC means that there must be an "Asset Lock":

An asset lock is a constitutional device that prevents the distribution of residual assets to members. The purpose of an asset lock is to ensure that any retained surplus or residual value cannot be appropriated for private benefit of members and should be used for public or community benefit.

Using a CBS gives an option to use either voluntary or statutory asset locks. Financial due diligence of these structures is regulated by the Financial Conduct Authority[85].

11.3. Ownership

There are different levels of ownership stake that the community enterprise might take in a CHDN, varying from low to high involvement (and therefore risk).

Community energy organisations who are aiming to develop an asset but are not willing to take on a project at the scale of a heat network, might aim for the Heat Entrepreneurship model and own / operate any renewable energy and heat generation assets which are connected to the scheme. This may give them an

[84] https://www.luxnovapartners.com/

[85] https://www.uk.coop/resources/community-shares-handbook/2-society-legislation/24-asset-lock-provisions-cs

opportunity to generate good project IRRs where there is a captive off-taker using a high proportion of the renewable energy generated.

Some enterprises may wish to aim significantly higher, with a shared ownership stake in the operational organisation, which could be a combined venture between public and private business. Both Welsh government[86] and Scottish government[87] have Shared Ownership policies. Shared ownership with a local authority may be necessary to enable access to lower cost finance through the National Wealth Fund[88]. **Note that there are restrictions on Community Benefit Societies raising share capital to invest in projects they do not control.**

There is also a possibility for 100% community ownership, which is a situation seen in Denmark[89]. There is a question about whether it is appropriate for community enterprises to get involved in development funding which is high risk activity. It seems more likely that financial ownership (whether partial or full) will happen once the project has been "de-risked" somewhat, that's to say, all the project feasibility work has been carried out and it is relatively clear that the project has a high chance of success. Another option is that ownership is only transferred once the scheme has been completely built and has been operating for some time. Community "buy-out" has been a feature of some projects in Europe.

12. Role of a Central Unit

One of the original aims of the CHDU project was to identify a role for a "Community Heat Development Unit" and develop a business plan for a CHDU organisation. It is anticipated that a centralised CHDU organisation would depend on a pipeline of viable CDHN projects to support a different stages of feasibility, development and into operation. Throughout the course of the CHDU project it became clear that it is currently hard to make the financial case for developing multiple CDHNs due to the lack of available grant funding, low price of

[86] Guidance on local and shared ownership of energy projects in Wales
[87] Community benefits of onshore renewable energy developments in Scotland
[88] https://www.nationalwealthfund.org.uk/local-authority-services/our-lending-offer
[89] https://dbdh.org/how-to-help-communities-establish-district-heating-networks/

hydrocarbon heating compared to electrified heating, and current lack of local support for developing CDHNs at the case study locations.

Should Government support for domestic focussed heat networks improve or the difference between the cost of electricity and gas or heating oil (the “spark gap”) reduce, then there may be a stronger requirement to establish a CHDU organisation.

12.1. Possible Roles of a CHDU Organisation

There are strong arguments for individual CDHNs to be owned and governed locally rather than ownership to be centralised at a national or regional scale. The main arguments are:

- The Energy Act limits the electricity generation owned by a Small Supplier to 5MW installed, up to 2.5MW of which can be supplied to domestic properties. Ownership of the wind turbine(s) by the Central Body would result in these generation limits being reached once the model had been extended to multiple sites. It makes more sense for the wind turbine(s) to be owned by a CBS local to the turbine site who could also act as a Class A Small Supplier[90] which would benefit them when supplying excess electricity not consumed by the heat network.
- Different local authorities may require different types of entities to be set up to develop and operate the heat network.
- Local CBSs may prefer to adopt a Heat Entrepreneurship model or a Full Ownership model. Note that both ownership models require the local CBS to act as a regulated Heat Network Supplier.

Assuming that CDHNs are owned locally, the roles that a CHDU organisation could usefully fulfill are:

- Set up local CBSs.

90 https://www.legislation.gov.uk/uksi/2001/3270/schedule/4#:~:text=Class%20A%3A%20Small%20suppliers,is%20supplied%20to%20domestic%20consumers.

- Support local CBSs to carry out local engagement activities. For example, by providing training on consistent engagement strategies and supplying materials.
- Subcontracted back-office support common across multiple sites. For example, heat network metering and billing services which are compliant with the Regulator will be required for each CDHN site.
- Act as a conduit for engaging with funders. A centralised organisation could have greater impact when attracting funding by demonstrating a cohesive pipeline of projects, which would perhaps diversify the risk of individual projects being unsuccessful.
- Act as an advocate for the local CBSs.
- Facilitate running share offers. It is expected that some of the funding for a CDHN project will be provided by community share offers. Local CBSs will need support setting up and running share offers, and ongoing support to maintain the share register.
- Facility knowledge sharing and learnings between different CDHN projects.
- Interface with nationwide contractors who would complete the more specialist aspects of heat network development.
- Support the training of local contractors to conduct ongoing operation and maintenance of the CDHNs.

12.2. CHDU Operating Model

Of the different types of scale model available, Figure 30, the Federation model has been identified as being well suited to meet the requirements of a centralised CHDU.

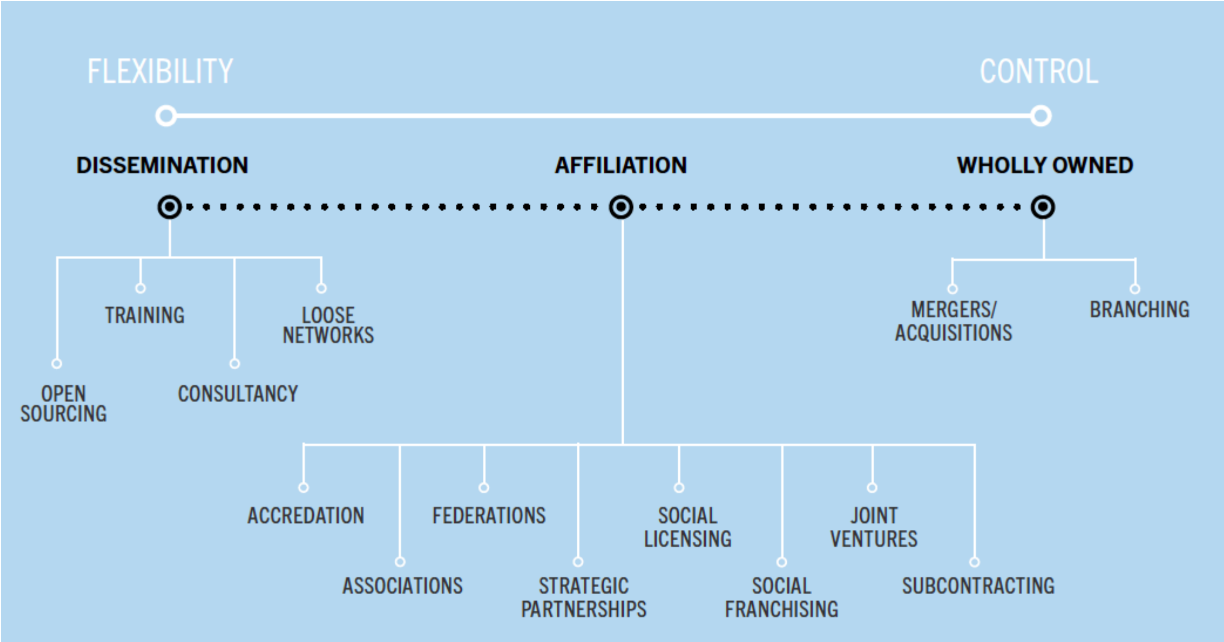

Figure 30: Types of scale model[91]

The CHDU would be established as a separate Co-operative whose members were the local CBSs who own the local CDHNs, wholly or partly. The board of the CHDU could include a representative from each local CBS to help ensure the CHDU is meeting the needs of its members.

12.3. Funding the CHDU Organisation

Ongoing operation and maintenance costs which could be performed by the central CHDU, such as performing meter and billing activities or operating each local CBS, would be paid by each local CBS using income generated by the heat networks and have been accounted for in the financial modelling at each of the CHDU case study locations. It is expected that grant funding would be required to establish and support the central CHDU until a pipeline of CDHN projects was established.

[91] https://www.the-sse.org/resources/scaling/introduction-to-social-replication/

Specific funding routes have not been identified during the CHDU project since it is expected that the proposed community owned heat networks will be developed in the near future.

13. Finance

District heating networks should eventually pay for themselves, but it can take many years for the development and build costs to be recovered. As previously discussed, the payback period will be affected by how much grant has been injected into the project. Without income from grant funding, community enterprises will need to be searching widely for all possible sources of assistance. It also means that CHDNs need investors who are looking for a relatively secure long-term revenue stream rather than a quick return on capital, such as bonds or investment from pension funds.

The public sector tends to pursue lower heat prices and better socio-environmental impacts, than the private sector, who will primarily pursue better returns on investment. Historically in EU projects, local authorities have been able to source finance for public projects at lower rates of interest than commercial lenders. The UK National Wealth Fund, (the UK Infrastructure Bank), will be able to lend at attractive rates to Local Authorities[92] on terms up to 50 years, which is well aligned with the minimum lifetime of heat network pipework.

The lower-than-commercial-rates for infrastructure debt is why many European schemes are publicly owned with only the most financially viable schemes attracting involvement from private sector companies.

Many successful privately owned district energy systems still have arms-length local authority involvement, helping to secure financing and grants for the project through funding feasibility studies, or improved outcomes generally described as “wider values”, i.e. improved environmental and social benefits.

[92] https://www.nationalwealthfund.org.uk/local-authority-services/our-lending-offer

13.1. Sources of Development Capital

The very beginning of the funding journey will be to make sure that the proposed project is viable to help access development capital. This will require a positive feasibility study. Typically, the funds can be accessed through different national organisations as per the tables below.

Country	Government backed services
England	Great British Energy Community Energy Fund
Wales	Welsh Government Energy Service
Scotland	Community Energy Scotland Local Energy Scotland - CARES

Table 4: Government Backed Sources of Development Capital

Source	Link
Social Investment Business	https://www.sibgroup.org.uk
National Lottery: Climate Action Fund	https://www.tnlcommunityfund.org.uk/funding/programmes/climate-action-fund-our-shared-future
National Lottery: People and Places	https://www.tnlcommunityfund.org.uk/funding/programmes?min=10000&location=wales
Social Investment Wales	https://wcva.cymru/funding/social-investment-cymru/

Table 5: Other Sources of Development Capital

Once an initial high level feasibility assessment has been completed, there are several other sources of funding from the UK government to help bring projects forward. Applying to them will inevitably mean partnering with a local authority.

- The Heat Network Development Unit (HNDU)
- The Green Heat Network Fund (GHNF, which replaced the The Heat Network Innovation Programme)
- The Heat Network Support Unit (HNSU, Scotland only)

13.2. Sources of Capital and Commercialisation Funding

13.2.1. The Green Heat Network Fund

The Green Heat Network Fund (GHNF) is a capital grant programme that initially opened to applicants in 2022 with additional funding available until 2027/28. A successor to the Heat Networks Investment Project, it is a core element of the UK Government's support for low and zero carbon (LZC) heating and cooling networks. The GHNF provides support for eligible commercialisation and construction costs. Prospective projects are assessed for funding using a range of criteria[93]:

- A carbon gate of 100gCO2e/kWh thermal energy delivered to consumers
- Domestic and micro-businesses must be offered a price of heat lower than a low carbon counterfactual for new buildings and a gas/oil counterfactual for existing buildings
- Demonstration of a Social IRR of 3.5% over 40 years
- Urban networks need a minimum end customer demand of 2GWh/year, rural off-gas-grid networks need a minimum of 100 dwelling
- Maximum grant requested up to but not including 50% of the combined total commercialisation + construction costs (with an upper limit of £1million for commercialisation)
- The total 15-year kWh of heat/cooling forecast to be delivered will not exceed 4.5 pence of grant per kWh delivered (at time of writing)
- Where projects include wider energy infrastructure in their application, income generated/costs saved/wider subsidy obtained should be greater than or equal to the included costs

Of those criteria, the nominal upper benchmark of 4.5p/kWh is the main limiting factor, with this figure functioning more as a ceiling than as a target. The competitive nature of the fund means that only the most economically efficient projects are likely to exceed. As a result, successful bids are generally asking for a support level closer to 2.5p/kWh to improve their chances of being funded.

[93] Green Heat Network Fund (GHNF): Scheme Overview, 2022

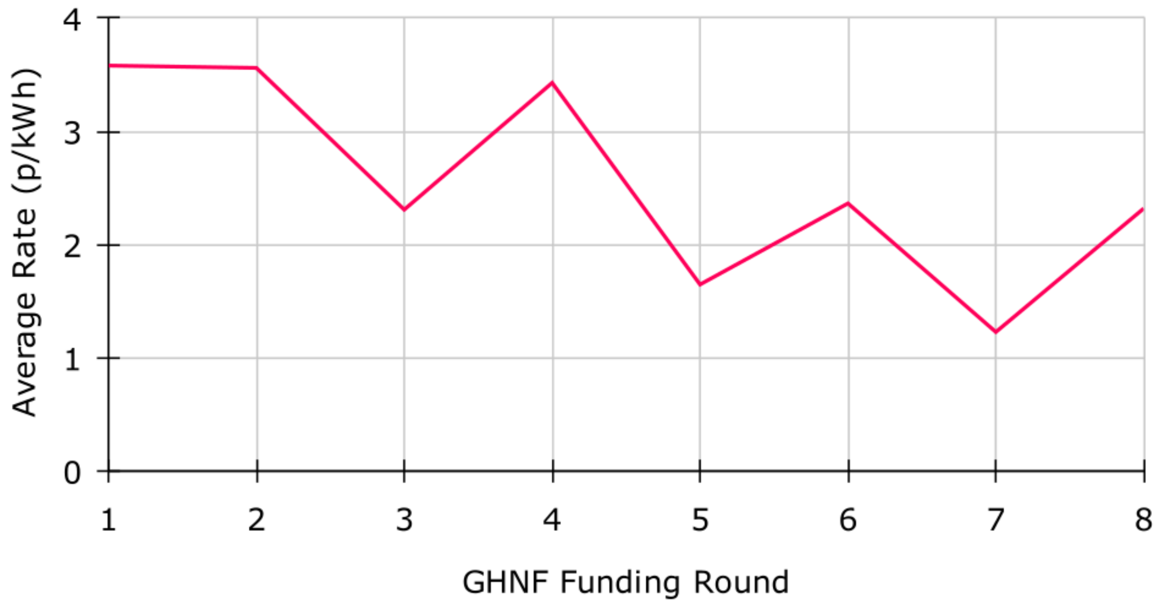

Figure 31: Average GHNF grant rate awarded to successful applicants

This approach favours larger schemes focussed on connecting non-domestic properties with high heat demands early in the network's life. Moreover, the fund allows the network to charge large connection fees to non-domestic buildings which can be set at a price equivalent to each building installing an individual low-carbon heating system, such as an individual heat pump. For public buildings, these significant connection fees are understood to have been funded by the public purse in some locations using schemes such as the Public Sector Decarbonisation Scheme (PSDS), which essentially means networks focused on supplying public sector buildings become publicly funded twice over (GHNF and PSDS), to the financial benefit of heat network developers. Note that Phase 4 of the PSDS scheme closed in November 2024 with no future funding being committed by Government[94].

This drive for competitiveness has a significant effect on the level of CAPEX support available to networks focussed on retrofitting to residential properties. It is anticipated that domestic customers must be charged a minimal connection fee to join a low-carbon heat network to encourage uptake. This is reflected in the

[94] https://www.salixfinance.co.uk/news/public-sector-decarbonisation-scheme

GHNF guidance since it is stated that the cost of heat supplied to existing domestic properties and micro businesses must not exceed the cost of their existing gas/oil heat supply. Therefore the cost borne by the network of connecting to existing domestic properties must be higher than non-domestic properties, and without any other funding routes available to reduce the connection cost (e.g. the Boiler Upgrade Scheme[95] does not currently extend to heat network connections) community heat networks should be able to access more funding from the GHNF.

13.2.2. Warm Homes Scheme

Warm Homes: Local Grant

The Warm Homes: Local Grant scheme offers funding to properties with an EPC rating of D or below to improve their energy efficiency and install a low carbon heating system, providing the household meets various criteria mostly based on income. Qualifying households can access grant funding of up to £15,000 for low carbon heating measures. Funding is allocated to the Local Authority who deliver the scheme locally.

While the scheme will not currently subsidise the cost of connecting to a low carbon heat network, the scheme guidance documentation suggests that connections may soon be eligible stating that: "*The department is therefore working at pace to ensure that connections to low-carbon communal heating and district heat networks are covered by appropriate quality standards, with a view to then incorporating them into the Warm Homes: Local Grant.*".

Warm Homes: Social Housing Fund

The Warm Homes: Social Housing Fund[96] supports investment in insulation and low carbon heating in social housing. Funding is targeted at installing insulation and home improvement measures to reduce the energy consumption, and hence heat demand, of properties with low EPC ratings aiming to bring properties up to

[95] https://www.gov.uk/apply-boiler-upgrade-scheme

[96] https://assets.publishing.service.gov.uk/media/68529d0bff16d05c5e6aa680/warm-homes-social-housing-fund-wave-3-guidance.pdf

a minimum rating of C. In general, the scheme provides up to £7,500 of funding for insulation measures, which must be cost matched by the social landlord, and another £7,500 for installation of a low carbon heating system. Similar to the Warm Homes: Local Grant, the scheme will not currently fund connections to a low carbon heat network, however this is expected to change in the near future.

Wave 3 of the scheme is now closed however it is expected that a fourth wave of funding will become available post 2028[97].

13.2.3. Energy Company Obligation (ECO)

The ECO scheme is a UK government initiative with phase 4 currently running from April 2022 until March 2026. The scheme obligates large energy suppliers to provide funding to combat fuel poverty and help the country meet its net-zero carbon emissions targets by improving the energy efficiency of low-income and vulnerable households.

The scheme specifically targets homes with low Energy Performance Certificate (EPC) ratings (D, E, F, or G) that are occupied by low-income residents, typically those receiving certain government benefits. ECO4 emphasizes a "whole-house" approach, requiring deep retrofitting measures to bring poorly insulated homes up to standard. The scheme provides grants to cover some or all of the cost of installing various energy efficiency and low-carbon heating measures, including insulation, new heating systems and smart heating controls.

ECO4 funding can be used to contribute to the cost of connecting a building to a district heating system: "*Under ECO, a new connection to district heating system is the eligible measure and requires the installation of a heat meter for each household, as well as registration with the Heat Trust, or equivalent.*"[98]

[97] https://www.uswitch.com/gas-electricity/guides/warm-homes-social-housing-fund/

[98] https://www.ofgem.gov.uk/sites/default/files/2022-09/ECO4%20Guidance_New%20Measures%20and%20Products_V1.0_0.pdf

13.2.4. Community Shares

Co-operative and community benefit societies can issue shares to the public to help run their society. A CBS is the simplest structure available for any scheme that wants to raise share capital. Based on Sharenergy's experience it is anticipated that up to ca. £600k of share capital could potentially be raised for a single project, which is no more than 5% of the total capital investment required for a community scale heat network project. CBSs would typically need administrative support to set up and run a share offer.

13.2.5. Community Bond Offer

Big Solar Co-op[99] recently raised £1.8m in a bond offer on the Ethex[100] platform for their groundbreaking new Whiteborough Solar Park. The bonds could be wrapped in an ISA, meaning interest is tax-free. Bond offers could potentially be used to raise some of the funds required to construct a community scale heat network project.

13.3. Sources of Debt

13.3.1. National Wealth Fund

Following commissioning, a large portion of the capital costs of a heat network will be refinanced through a long-term loan. Low carbon heat networks are long term infrastructure and require patient lenders who do not expect to receive the returns on their investment which private organisations tend to seek (e.g. IRRs >10%). The National Wealth Fund[101] is understood to be the cheapest means of accessing debt with rates which are set at gilt pricing +40bps at the time of writing. Access to the National Wealth Fund assumes that the Local Authority will be at least partially involved in developing and owning the scheme. Based on current prices, loans for purchasing and installing the pipework would have a term of **50 years** and an interest rate of **5.35%**. The loan for purchasing and

[99] https://bigsolar.coop
[100] https://www.ethex.org.uk/invest/big-solar-coop
[101] https://www.nationalwealthfund.org.uk/local-authority-services/our-lending-offer

installing the network energy centre, household connections and renewable generation would have a term of ca. **25 years** and an interest rate of **5.95%**.

14. Legal Implications for Community Enterprises Operating Centralised District Heating Schemes

Lux Nova provided high level advice on some of the legal implications for a community enterprise developing a district heating scheme, which has been provided in Appendix 7.

It focuses on two main scenarios: (a) "Heat Entrepreneurship" model where a community enterprise generates and sells heat into a network owned by another entity, and (b) "100% Community Owned" model where the community enterprise owns both the generation equipment and the network.

The report reflects Lux Nova's understanding of the current regulatory framework however it is not exhaustive as the position is still evolving with further secondary legislation expected in 2025 and beyond. A summary authored by Sharenergy is provided below.

14.1. Development Activities

The responsibility for digging up roads to install a DHN typically falls to the entity granted the concession to build, operate, and maintain the network.

- Heat Entrepreneurship Model: In this model, the community enterprise is unlikely to be responsible for road excavation if it only supplies heat and has not been granted the concession to build, operate, and maintain the DHN. Instead, this responsibility would more likely fall to the local authority or a joint venture. Local authorities have the power to construct and maintain pipes for conveying heat.
- 100% Community-Owned Model: Under this model, the community enterprise would likely be responsible for digging up roads. It will need to consider whether it is able to obtain a licence from the Regulator pursuant to the Energy Act 2023[102] and be able to fulfil any necessary conditions

[102] https://www.legislation.gov.uk/ukpga/2023/52

attaching to such licence. If it cannot obtain such a licence, it will need to apply for a section 50 licence under the New Roads and Street Works Act 1991[103] which could be more costly and lead to delays.

14.2. Operational Activities

The regulatory framework for heat networks in Great Britain is evolving, with Ofgem appointed as the regulator under the Energy Act 2023. The framework establishes an authorisation regime for heat suppliers and network operators, sets consumer protection requirements, and defines guaranteed performance standards, with potential financial penalties for non-compliance. Ofgem will commence its regulatory role in the second phase of implementation, starting in 2025, in accordance with the Heat Networks (Market Framework) (Great Britain) Regulations 2025.

Roles and Operational Models:

- Roles: Under the regulatory framework, entities will be classified as either a "Heat Network Operator" or a "Heat Network Supplier". Operators control the transfer of thermal energy on the network, while suppliers have a contractual relationship with consumers. Organisations taking on either role will need to apply to be authorised by the Regulator.
- Heat Entrepreneurship Model: In this model, the local authority or a private entity would typically act as the operator, with the community enterprise acting as the supplier[15]. The community enterprise would be responsible for contracts with consumers, billing, customer service, and supporting vulnerable customers.
- 100% Community-Owned Model: The community enterprise assumes both operator and supplier responsibilities. This would require it to meet both supplier responsibilities and additional operator responsibilities, such as technical requirements, ensuring a reliable heat supply, and having arrangements for continued operation in case of failure.

[103] https://www.legislation.gov.uk/ukpga/1991/22/section/50

- Enforcement: The regulatory framework introduces new offences, such as operating without authorisation or providing misleading information. Maximum penalties for non-compliance are carried across from existing Gas and Electricity markets and can be as high as 10% of a company's turnover or £1 million. The community enterprise must also ensure a fair pricing regime to comply with Ofgem's rules.
- Metering and Billing: The Heat Network (Metering and Billing) Regulations 2014 (HNMBR), as amended, still apply and set out specific obligations for heat suppliers. This includes classifying buildings into "viable," "open," and "exempt" classes, which determine the metering and billing requirements. The HNMBR requires heat suppliers to submit notifications to the Office for Product Safety and Standards (OPSS) upon becoming operational and every four years thereafter. Failure to comply with the HNMBR is an offense and can lead to significant legal consequences.

The Regulator is introducing Step-In arrangements to ensure continuity of service if a heat network operator or supplier fails. Heat network operators and supplies will need to maintain a Continuity Plan and either contractual step-in with another entity or a Special Administration Regime (SAR). It is still unclear how the SAR will be funded in its entirety and the impact on customer tariffs.

14.3. Ownership Issues

If a community enterprise owns a DHN on public land and a burst pipe causes damage, the enterprise would be responsible for the damage. It should have insurance to cover third-party property damage. If a local authority employee damages the pipes, the community enterprise may be able to claim against the local authority, depending on the contractual agreements in place.

The Energy Act 2023 provides licensed DHN developers with rights to access consumer properties for maintenance. If a consumer denies access for maintenance or defaults on payments, the legal remedy is likely set out in the Customer Supply Agreement (CSA). Failure to maintain equipment installed on a consumer’s property due to denial of access is unlikely to lead to Regulator enforcement action. The framework also includes provisions for consumer complaints related to disconnections or payment issues.

14.4. Conclusions

The Lux Nova report concludes that a community enterprise will need significant financial, technical, and administrative resources to comply with the new regulatory framework and become an authorized heat supplier or operator. The consequences of non-compliance are severe, with the potential for large financial penalties. The evolving regulatory landscape for district heat networks is complex, and community enterprises must carefully consider if they can meet these requirements or if an alternative structure, such as an ESCo model, would be more practical to handle the regulatory burden.

15. UK Heat Network Policy - Heat Network Zoning

The government's consultation on Heat Network Zoning[104] in England was published in December 2023, the outcome of which is yet to be published at the date this report was authored. The Zoning consultation proposes a framework where the Department for Energy Security and Net Zero (DESNZ) designates "zones" where heat networks are the lowest-cost, low-carbon heating solution. Local or regional bodies, acting as Zone Coordinators, would then license these zones for development through a competitive process. The core of the proposal involves granting licensed developers significant powers, including a near-monopolistic position and the power to compel certain properties and heat sources to connect.

Sharenergy authored an article published by We Own It[105] outlining concerns related to the proposed regulations and its impact on community owned schemes. The main three questions raised in Sharenergy's consultation response are:

- **Lessons from Monopolistic Infrastructure**. The concern is that licensing a monopolistic infrastructure (like heat networks) to private operators via a competitive process repeats the mistakes seen in the rail and water sectors in the UK. Competitive processes tend to reward financial models that

[104] https://www.gov.uk/government/consultations/proposals-for-heat-network-zoning-2023

[105] https://weownit.org.uk/news/government-s-national-heat-network-plan-what-s-it-communities

back-load costs and load infrastructure with debt, potentially leading to poor long-term outcomes for consumers and infrastructure maintenance. Sharenergy's consultation response calls for greater emphasis on partnership working (public, private, and third-sector) to grow the sector and retain wealth locally. It also suggests that the infrastructure should be understood to transition into public ownership after an initial operational phase.
- **Neglect of Social Benefit**. The lack of an explicit mandate for social benefit is a significant concern, especially when developers will hold such powerful, monopolistic rights. Social offers from developers can vary massively. Without a mandate, consumer interests and community purpose may be sidelined in favour of profit maximisation. Zone Coordinators should have a mandate to benefit their communities and consider governance (like the involvement of social enterprises) as a legitimate factor when awarding licenses.
- **Provision for Residential Properties**. The consultation is conspicuous in its omission of requirements for domestic properties to connect, despite households accounting for 60% of national heat consumption. The consultation does not anticipate any requirement for residential properties to connect, nor does it obligate developers to enable their connection, effectively leaving out a large portion of the decarbonisation challenge. Regulations should be designed to encourage, or possibly oblige, developers to offer connections to domestic properties and provide appropriate regulation for how these connections are treated.

The delay in publication of the Government's response to the Heat Network Zoning consultation means there is uncertainty as to how related policy will affect communities progressing the development of low carbon heat networks at the CHDU case study locations. It is currently unclear whether the proposed case study networks will be located within designated heat network zones. None of the locations are currently within the Heat Network Zoning Pilot[106] locations.

[106] https://www.gov.uk/government/publications/heat-networks-zoning-pilot

16. Barriers To Centralised District Heating

Despite the many benefits that district heating may bring, it is important to understand exactly how expensive projects can be. With this cost comes perceived risk. The UK Government has been grappling with the concept of delivering district heat for many years. In 2009 it commissioned a report[107] which identified and discussed these problems in some detail. None of these problems have yet been solved.

16.1. Regulatory

In the UK, a SAP rating (represented in an EPC certificate) is the standard measure of building energy efficiency. It is a combined metric that brings together energy performance and cost of heating and lighting the house into a single score.

The SAP regime can allocate poor scores to heat pumps and district heating schemes. This is problematic for the entire home ownership chain: owner occupiers and private landlords all want high EPC ratings since a low score makes the property appear less desirable and may limit lending choices for mortgages or funding. For example, many "green" mortgages offer incentives for homes only in the A-C bands. Even social landlords will not want their housing stock to have low scores, because of the general policy drive towards net zero; either their own internal targets or those set by decarbonisation funding schemes such as the Social Housing Decarbonisation Fund which uses a gated metric (houses must achieve an EPC band of C or higher) for eligibility.

Any district heating scheme must allow for customers to reduce their heat demand and allow for future expansion of the scheme to compensate.

16.2. Economic and Commercial

Putting pipes under the road and reinstating is clearly a very expensive business. Connecting each building is also a considerable expense. A 2016 report by Burro

107 https://webarchive.nationalarchives.gov.uk/ukgwa/20121205174605/http:/decc.gov.uk/assets/decc/what%20we%20do/uk%20energy%20supply/energy%20mix/distributed%20energy%20heat/1467-potential-costs-district-heating-network.pdf

Hapold[108], which was used to inform the CHDU techno-economic modelling, priced connecting a house with an existing central heating system to the network at ca. £13,000, inflated to 2024 prices[109], which is approximately the same price as installing an individual ASHP. A building without existing radiators (i.e. storage heaters) added nearly another £7,000 per property. This is before any money has been spent on the actual heating plant and pipes running under the road. Larger diameter pipes can run into the £000's per metre to install. The average for bulk schemes analysed by DECC in 2015[110] was in the range of £1,100 to £2,000/m at today's prices.

Because the project finance is likely to run into decades to reach a return on investment, it reduces the number of lenders or funds that are either willing or able to offer finance on suitable terms.

When all of the CAPEX costs have been distributed across the project, amortised and then added to the OPEX costs, it makes achieving a target price for heat approaching that of individual gas or oil boilers extremely challenging. At the time of writing this report, the UK average price of heat is at around 8.6p/kWh[111] (assuming a gas boiler efficiency of 84%). This equates to a spend of around £990 a year for heating and hot water for a "typical" UK house[112]. Assuming a DH connection cost of each house of £13,000, it will take 13 years, not allowing for inflation, just to cover the cost of connections, with the heating plant, pipes under the road and operational overheads still to be paid for.

The UK tends to have a higher proportion of individual homes in the housing stock compared to other European countries where flats / apartments are more prevalent, meaning that comparing the overall pricing of schemes will nearly always result in negative outcomes.

108 https://www.usdn.org/uploads/cms/documents/161214_-_connecting_existing_buildings_to_dhns_-_technical_report_00.pdf

109 Including the district heating pipework to connect the network main in the street to the property.

110 https://assets.publishing.service.gov.uk/media/5a802b44e5274a2e8ab4e95d/heat_networks.pdf

111 Including a daily gas standing charge.

112 https://www.ofgem.gov.uk/sites/default/files/2023-05/TDCV%202023%20Decision%20Letter.pdf

Some of the initial CAPEX cost can be ameliorated by asking those joining the scheme to pay an initial connection cost. This has often been seen as a barrier to acceptance when tested in surveying, even though there is clearly a cost to owning a boiler in the form of replacement costs and ongoing maintenance.

As previously noted, a program of renovation / insulation activity on a significant portion of the buildings in a scheme could reduce the financial performance of the scheme by:

- Reducing the heat demand reduces the scheme's income which would affect its ability to pay back finance.
- This would also mean that the system would become poorly sized, and make it more difficult to run efficiently, potentially even leaving some areas of the network as stranded assets.

16.3. Procurement

Research conducted during the CHDU project highlighted:

- A **Heat Networks Delivery Unit (HNDU) analysis** found that UK heat network costs are substantially higher than those in other European countries with more mature heat network markets. Capital costs for district heating networks in the UK are estimated to be 30-40% higher than in Denmark and other countries with established district heating markets, with pipe costs being a major component of this difference.
- **Competitive tendering processes** in the UK often don't achieve the same cost efficiencies as those in countries with larger, more established district heating markets.

Contributing Factors

Limited UK supply chain and market maturity compared to countries like Denmark, Sweden, and Finland where district heating is more widespread. Better prices could be achieved with more sophisticated procurement frameworks, whereas in the UK procurement is done on a "one-off" basis.

- **Less standardisation in UK pipe specifications and installation practices**, leading to custom solutions that increase costs.

- **Lower economies of scale** in the UK market compared to countries where district heating serves a larger percentage of the population.
- **Less experience among UK contractors and installers** in district heating pipe installation compared to countries where the technology is more established.
- **Higher installation costs** for specialised installation work in the UK compared to some European countries.

These factors collectively contribute to the UK's relatively higher procurement costs for district heating pipe installation compared to international benchmarks. DESNZ is attempting to tackle some of these barriers to heat network development through the introduction of the Heat Network Zoning Regulations which are intended to provide more investment certainty and stimulate the heat network development market.

17. Counterfactual: Smart Local Energy Systems, Wind and Individual ASHPs

The focus of the Community Heat Development Unit (CHDU) project is on centralised district heat networks however there will be many communities who wish to create heating schemes where the physical constraints of a centralised district heat network (availability of high domestic heat density, adjacent anchor loads and local renewable generation) make the project too expensive or impractical. The main reason for a poor business case in rural or rural / urban locations is a lack of suitable heat density and appropriate anchor loads. This in turn implies that individual heat pumps are a preferable low carbon heating solution for many, though not all, houses.

An alternative and potentially more flexible approach for communities to adopt to deliver low carbon heat has been investigated, referred to here as a “distributed ASHP and wind scheme”, where electricity generated locally using wind turbine(s) is used to power domestic ASHPs which are located on an electricity distribution network supplied by the same primary substation.

17.1. Distributed ASHPs and Wind Scheme Concept

17.1.1. Smart Local Energy Schemes - Energy Local Model

Use of the existing electrical distribution network requires significantly less construction works and CAPEX than installing a private wire network to transfer electrical energy from the local renewables generation (i.e. a wind turbine) to customer's properties, or trenched pipework to deliver heat to customers via a centralised district heat network. There are also far less stakeholders involved.

There is however, a cost incurred for using the distribution and transmission networks and trading in the wholesale electricity markets. Energy Local[113] have managed to set-up Clubs which match local generation with local demand to reduce the overhead costs associated with electricity distribution.

Households and small scale renewable generators as members form an Energy Local Club as a co-operative. Each household has a smart energy meter installed to show when and how much power they were using on a half-hourly basis. The local renewable generator(s) also have smart meters installed, measuring output/export.

Members (households and generators) agree a price ("match tariff") that will be paid to the generator when they match their electricity use to when electricity is generated locally, for example, turning their washing machine on when they know the local wind turbine is operating.

The Club works with a licensed electricity supplier: to date, Octopus Energy and 100Green have both been involved in these schemes. These retail suppliers sell the extra power required to each household when there is not enough local electricity generated. The supplier is also responsible for reconciling the generation, export and retail energy flows, and sends each household normal bills for the balance of their total energy use.

[113] https://energylocal.org.uk

17.1.2. Energy Local Clubs Limitations

There are some important considerations when setting up an Energy Local Club:

- Energy Local Clubs are currently limited to matching generators and customers at the same voltage level on the distribution network. This means that MW+ generators could not currently be part of the same Club as domestic customers given domestic properties are connected to the low voltage (LV) distribution network.
- The tariffs available for end users are called "Time of Use" tariffs, and may not suit everyone. For an extreme example, if a home is heated with a heat pump, it's unlikely that much matched cheap solar energy would help reduce the running cost, whereas the seasonal profile of wind generation is a much better match with heat demand. Customers who join a Club are likely to pay more for peak electricity when local generation is not available, but should be able to achieve substantial savings overall, particularly if they adjust their demand to match times when electricity is being generated locally.
- Matching supply and demand are key, the purpose is to modify behaviour of club members to use energy at advantageous times of day. Note that proactive shifting of electrical demand to explicitly match wind generation has not been modelled in this case study report.
- Over-subscribed clubs (i.e. too many users matching with a small renewable asset) mean benefits would have to be spread very thinly. For this reason clubs might limit membership numbers.

The key limitation for the proposed distributed ASHP and wind scheme is the voltage level at which Club generators and consumers must connect to the distribution network at. The viability of such a scheme is dependent on the definition and implementation of the proposed P441[114] modification to the Balancing and Settlement Code (BSC). P441 is expected to define when the BSC and its Code Subsidiary Documents (CSDs) permit the netting of Imports from Exports through a Complex Site arrangement (i.e. Energy Local Club) and the scenarios in which this netting is permissible. It is anticipated that this will allow

[114] https://www.elexon.co.uk/bsc/mod-proposal/p441

generators and consumers to join an Energy Local style Club if they are served by the same primary distribution substation (e.g. 11kV-33kV substation) which would enable a multi-megawatt wind turbine to be part of the same club as domestic customers (<2.5MW of demand).

Progress is being made towards implementation of the P441 modification with the concept of Complex Site Classes being consulted on during October and November 2025[115].

17.1.3. Proposed Distributed ASHP and Wind Scheme

The proposed Distributed ASHP and Wind Scheme is an adaptation of the Energy Local model. The scheme members are a wind turbine generator and local domestic households which purchase much of the electricity generated by the wind turbine via an Energy Local Club style arrangement.

The increased income the scheme receives from the local sale of wind generation, matched on a half-hourly basis, is used to pay off the interest on loans used to cover some of the capital costs of installing individual ASHPs in some domestic customers' homes. Reducing the upfront capital investment of installing individual ASHPs is hoped to improve uptake of the technology, increase the income received by the local scheme generator, and provide domestic customers with a low carbon heating system which is price competitive compared to oil based central heating.

17.2. Proposed Business Structure

A new Local Community Benefit Society (CBS) could be established or an existing local CBS could take on ownership and management of the wind turbine and provide funding for individual customers to purchase heat pumps. The CBS would

115 https://www.elexon.co.uk/bsc/consultation/p441-assessment-procedure-consultation-on-complex-site-classes

act as a license exempt electricity supplier[116]. The club might need to be set up as a separate structure.

Approximately 50% of the domestic customers are assumed to join as 'heat and electricity' customers, who will receive an ASHP installation, with the remainder joining as 'electricity only' customers. The heat and electricity customers within the scheme will own their individual heat pumps which enables them (or the property owners) to access the Boiler Upgrade Scheme[117]. Electricity will be purchased by all customers through the licensed electricity supplier that the scheme partners with.

There may be a requirement for a Central Body to be formed which will provide some of the ongoing management and maintenance services and support access to finance. It is expected that this organisation will identify and work with a licensed electricity supplier to agree terms based on a pipeline of local schemes at different locations. If a Central Body is formed then a federation model may be a suitable structure to promote sharing knowledge and services between different sites. This model is illustrated below.

[116] A new CBS may need to be formed if an existing CBS is already supplying electricity as a license exempt supplier and would exceed the limitations of operating as a Class A Small Supplier (discussed later in this document).
[117] https://www.gov.uk/apply-boiler-upgrade-scheme

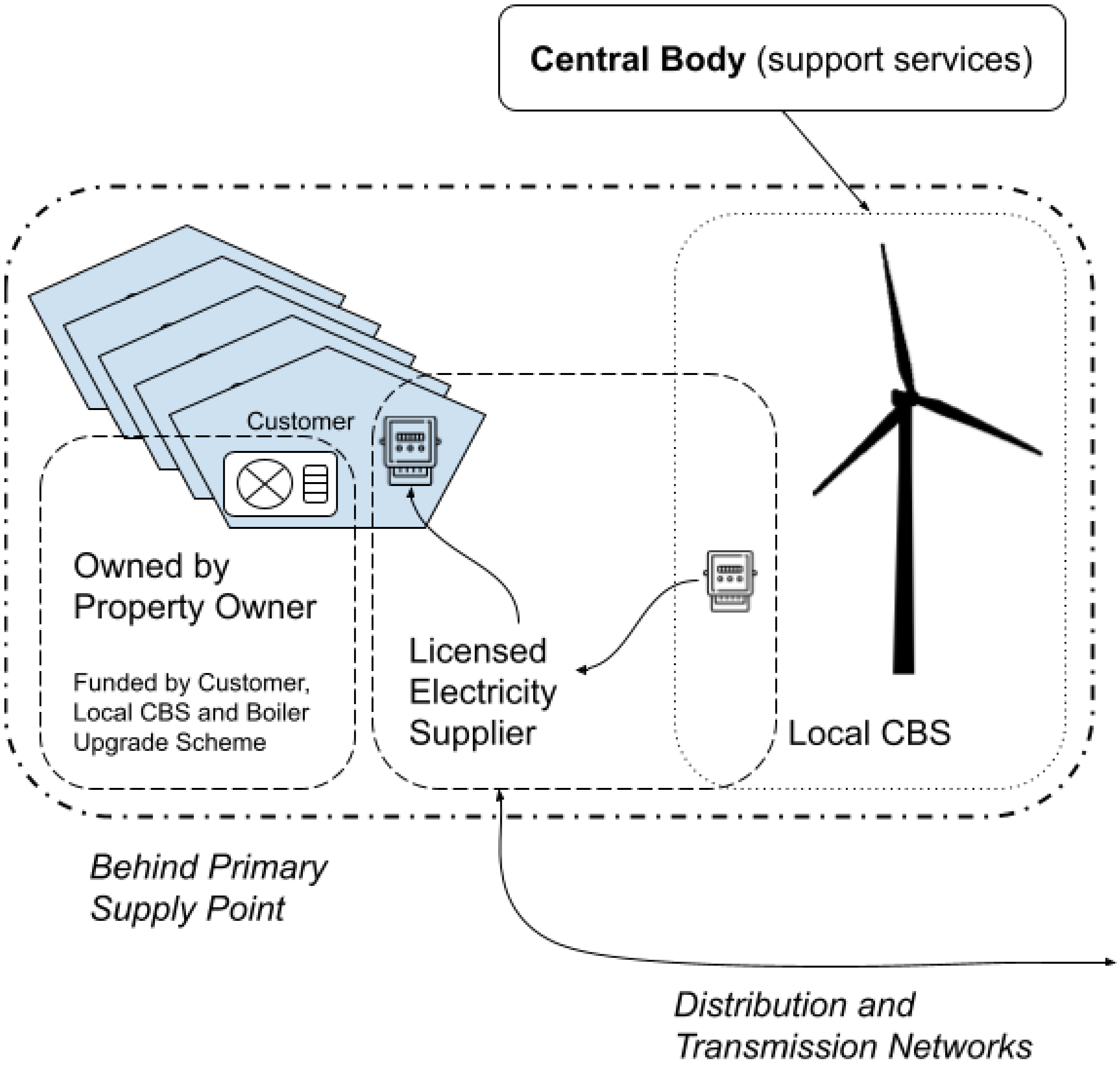

Figure 31: Schematic of Distributed ASHP and Wind Scheme

17.2.1. Wind Turbine Ownership

The Energy Act limits the generation owned by a Small Supplier to 5MW installed, up to 2.5MW of which can be supplied to domestic properties. Ownership of the wind turbine(s) by the Central Body would result in these generation limits being reached once the model had been extended to multiple sites. Since the aim of the CHDU project is to establish a scalable business model it makes more sense for the wind turbine(s) to be owned by a Community Benefit Society local to the turbine site. This CBS would also act as a Class A Small Supplier[118] who would supply electricity generated by the wind turbine locally to customers of the scheme.

17.2.2. ASHP Ownership

The base case is to assume that the ASHPs will be owned by the customer/property owner to ensure that Boiler Upgrade Scheme[119] funding can be accessed. The Central Body would work with the local CBS to engage with local installation and maintenance contractors to install the ASHPs and any heating system improvements.

Access to the control system of the ASHPs by the Central Body could be explored since aggregating the electric demand of the ASHPs and thermal storage across multiple sites could potentially open up opportunities to compete in flexibility markets.

17.2.3. Domestic Customers

Individual domestic customers who join the scheme and request an ASHP installation will be required to partially fund the purchase of their ASHP and its installation in their property. The cost of purchasing and installing each ASHP will be covered by a customer contribution of £3,000[120] and £7,500 from the Boiler Upgrade Scheme with any remaining costs covered by a 0% interest loan from the scheme. The customer contribution of £3,000 is equivalent to the cost of installing a new gas or oil boiler. The scheme will purchase and install replacement ASHPs after 15 years.

The heat and electricity customers will own the ASHP installed in their property. Heat and electricity customers will be required to pay an annual fee which covers loan repayments for the ASHP finance and ongoing maintenance costs. Customers

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118 https://www.legislation.gov.uk/uksi/2001/3270/schedule/4#:~:text=Class%20A%3A%20Small%20suppliers,is%20supplied%20to%20domestic%20consumers.

119 https://www.gov.uk/apply-boiler-upgrade-scheme

120 Roughly equivalent to the cost of replacing a gas/oil boiler.

could also have the option of fully funding their own ASHP and managing annual maintenance of the ASHP themselves, in which case customers will not be required to pay a standing charge to the scheme.

It is expected that all customers will be required to switch their electricity supplier to a common licensed supplier (e.g. 100Green) who will supply electricity generated by the CBS (Small Supplier) and grid electricity. Customers will also have to pay the normal electricity standing charge to the licensed electricity supplier.

If an ASHP customer leaves the scheme they will be required to pay off the remainder of the loan used to fund the ASHP installation.

P441 agreements are likely to be for up to three years. There is a risk that the P441 cannot be renewed on an acceptable basis. If this were to happen the club would need to be dissolved. This poses a risk to the heat and electricity customers in that they would be back on a normal tariff but we do expect the gap between electricity and oil prices to narrow in the future which would mitigate this risk.

If the club were to be dissolved the income to the society would drop. The effect of this would depend on when this event occurred and the PPA prices available for general export at the time. This is a risk that the share offer document would need to consider and it may put people off investing.

17.2.4. Non-Domestic Customers

At some scheme locations, there may be the potential for the wind turbine to use the same connection to the electrical distribution network (or upgrade the existing connection) as a large non-domestic property, for example the SpArC leisure centre in Bishop's Castle. Therefore there is the possibility for the turbine to supply electricity to these buildings behind the meter at a unit rate which offers a cost saving compared to purchasing electricity from their electricity supplier. This may improve the finances of the scheme however it may also reduce the number of domestic customers who could join the scheme, due to there being less wind generated electricity available for domestic customers.

17.3. Case Study: Bishop's Castle

As part of the Bishop's Castle Heat and Wind Project[121] planning permission has been granted for a 900kW wind turbine located to the south east of the town. Bishop's Castle is potentially well suited to the proposed distributed ASHP and wind scheme since there is a single primary substation which feeds the whole of the town, Figure 32. Bishop's Castle is off the gas grid, with most domestic properties using oil boilers.

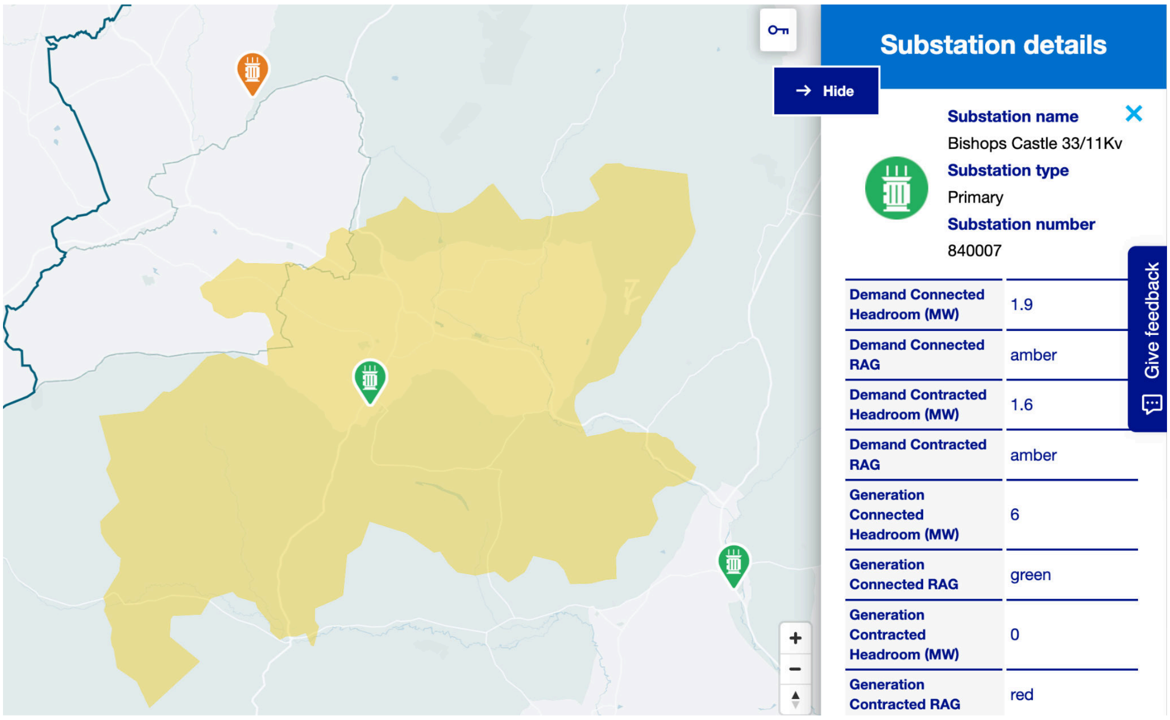

Figure 32: Area Served by Bishop's Castle Primary Substation[122]

A case study report has been developed for a distributed ASHP and wind scheme at Bishop's Castle which is available in Appendix 6.

The proposed scheme would generate revenue from behind the meter sales of wind generated electricity to the SpArC leisure centre and local domestic sales to

[121] https://stcenergy.org.uk/bishops-castle-heat-and-wind-project
[122] https://www.nationalgrid.co.uk/network-opportunity-map-application/

customers who join the Energy Local style scheme. Electricity generated from the planned 900kW wind turbine is estimated to be able to meet 49% of the annual electrical demand of a scheme including 115 domestic customers. Annual electricity sales are predicted to create enough revenue to partially fund ASHP installations in the properties of 58 heat and electricity customers and supply them with electricity at a discounted rate while achieving cost parity with existing oil heating systems, assuming a price of heat delivered by oil boilers of 7.42p/kWh[123]. This price of heat is equivalent to the 2 year average cost of heating oil. The remaining 57 customers will receive electricity at a discounted rate when matched with the local wind generation, reducing their annual electricity bills between £85 and £475 depending on whether they have already installed an ASHP.

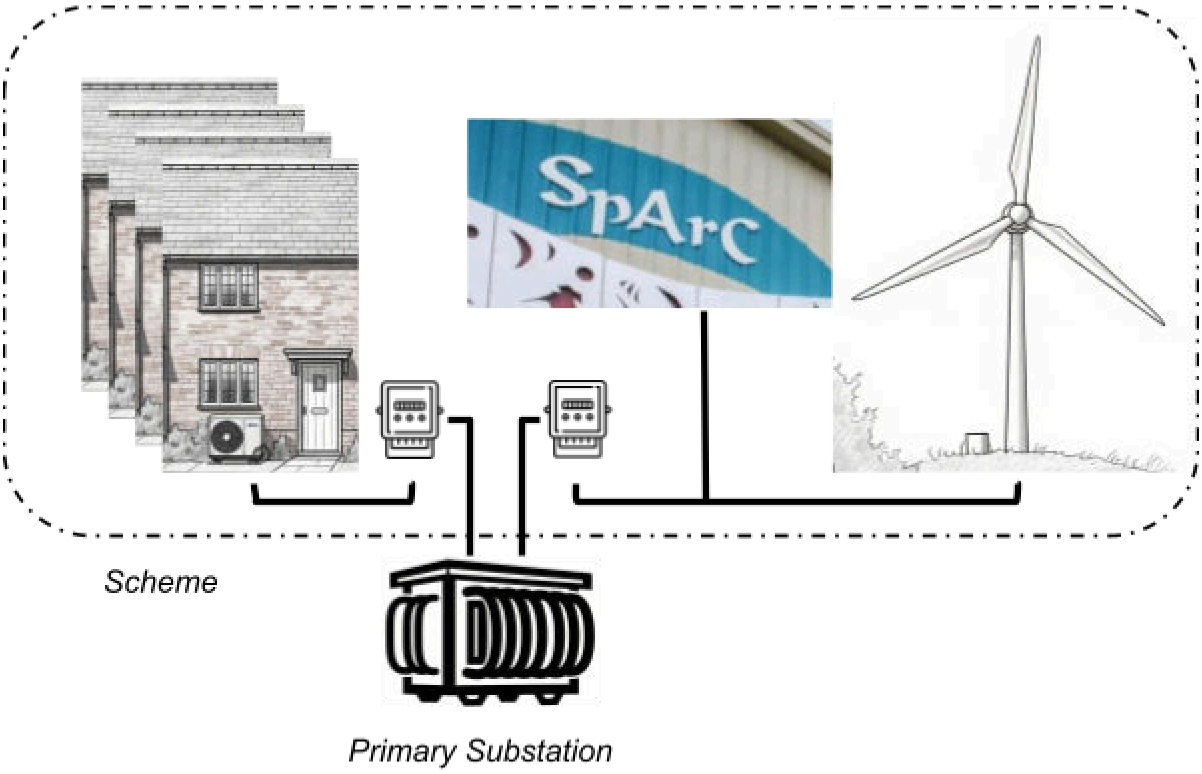

Figure 33: Illustration of Bishop's Castle Distributed ASHP and Wind Scheme

If 115 domestic customers joined the scheme, the initial payback period is estimated to be 15 years, with a 30 year project IRR of 10% on an initial capital investment of £1.7 million. The projected 30 year project balance is £1.9m.

[123] Based on an average oil boiler efficiency of 85%.

A sensitivity study has indicated that the scheme could expand to supply up to ~230 domestic properties with discounted electricity, of which 115 properties receive ASHP installations, without increasing customers' annual energy costs if the scheme chose to minimise its surplus. Further sensitivity studies have been completed which illustrate how the success of the scheme varies with: different heating oil prices, different PPA export prices, supplying electricity to Bishop's Castle Community College (BCCC) which neighbours the SpArC leisure centre and choice of electricity tariffs.

The scheme's main financial challenge is matching or reducing the annual energy cost of domestic customers compared to oil heating systems. Currently heating oil prices are low, averaging 6.8p/kWh[124] over the last year, at which price the scheme cannot be financially viable while also matching the current annual energy bills of domestic customers.

The annual energy bill of domestic customers on the scheme has been compared against customers who have installed an ASHP and are on an Octopus Cosy tariff. The comparison suggests that customers could save ca. £137 per annum by joining the scheme compared to completing their own ASHP installation and using an Octopus Cosy tariff. Customers who have already installed their own ASHPs are expected to save ca. £475 compared to using an Octopus Cosy tariff.

[124] Assuming an oil boiler efficiency of 85%.

18. Appendix 1 - Literature Review

19. Appendix 2 - Marches Energy Agency Report

20. Appendix 3 - Forres Heat Network Case Study

21. Appendix 4 - Morecambe Heat Network Case Study

22. Appendix 5 - Letchworth Heat Network Case Study

23. Appendix 6 - Bishop's Castle Distributed ASHP Case Study

24. Appendix 7 - Lux Nova Legal Advice Note