District Heat Networks: Addressing Categorisation to Unlock Deployment Potential

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Abstract

District heating (DH) consists of substantial energy infrastructures in many urban areas around the world, which offer a significant opportunity for achieving economies of scale and increasing the energy efficiency of the built environment. Heat networks have been identified by the UK Government as an essential mechanism for decarbonising heat. However, different to other European countries, the UK heat network market is minimal, meeting only around 3% of overall heat demand. Many of these networks use Combined Heat and Power (CHP) technologies, often driven by carbon-intensive gas engines. If the UK is to achieve its net-zero target, these CHP systems need to be modified or replaced with low-carbon alternatives such as heat pumps. One challenge to the growth of low-carbon heat networks in the UK relates to a lack of clarity when categorising them as either communal or district. These systems have different merits and peculiarities that affect their potential as scalable tools for decarbonisation. This paper aims to address this challenge by proposing new definitions that clearly separate district and communal concepts. This is achieved by analysing the status of heat networks in the UK and London, which is complemented by a review of current definitions available in the literature. The potential implications of misclassification to the development of DH in the UK are then discussed, with a focus on how policy needs to establish clear boundaries in order to guide the transition towards a low-carbon DH market in the UK. By addressing the issue of inconsistent categorisation and improving data accuracy, this paper serves as a foundation for future research and development efforts aimed at overcoming the barriers to the broader deployment of low-carbon heat networks in the UK.

Keywords Decarbonisation; Heat Networks; Barriers to Deployment; Categorisation

1.0 Introduction

In 2016, heating production and distribution accounted for 37% of all Greenhouse Gas Emissions (GHG) emissions in the UK [1]. The Climate Change Committee (CCC) recommends that by 2050, 80-90% of households and all non-residential buildings utilise low-carbon heat in order to attain net zero emissions requirements [2]. It is expected that this will be the most challenging part of achieving net zero [3]. Several strategies can be employed to achieve this goal, including the shift towards electrified heating technologies, alternative gases such as hydrogen or biomethane, and the adoption of renewable heat sources like biomass. Heat networks can play a crucial role in enabling the implementation of these strategies at scale, by acting as a distribution system for these sources of heat. For example, heat pumps can be used as a heat source for a heat network, hydrogen or biomethane can replace natural gas in a heat network, and renewable technologies can be integrated with heat networks [4]. By supplying heating and cooling to a cluster of nearby buildings, heat networks can make the implementation of these approaches more cost-effective and efficient, while reducing carbon emissions in the heating sector [5]. The heat network market in the UK is almost non-existent compared to some other European countries [4], with only 3% of the country's total demand being met by heat networks [6]. However, the growth potential is significant, with government estimates suggesting that heat networks could provide heat to 17% of homes and 24% of commercial and public sector buildings by 2050 [6]

However, most of the 3% historical schemes out there are carbon-intensive as gas-fuelled combined heat and power (CHP) plants accompanied by backup large-scale boilers represent the main source of heat supply [7]. If the UK is to achieve its decarbonisation targets, these infrastructures will need to phase out burning natural gas or other fossil fuels. The starting point of modification is to accurately assess the current state of heat networks in the UK. However, this task is complicated as multiple databases exist, with inconsistent and incomplete coverage, as well as unclear definitions and incorrect categorisations. Addressing challenges related to incomplete or inconsistent data is crucial to gaining a clear understanding of the current state of heat networks and their potential for decarbonisation.

Inconsistent categorisation of heat networks poses several negative impacts, hindering accurate evaluation, comparison of performance, and the implementation of effective policies and initiatives. Clear and consistent definitions are therefore essential in improving the accuracy and comparability of data and research, as well as the effectiveness of decarbonisation efforts. Failure to address these issues may result in missed opportunities for scaling up low-carbon heat networks and achieving decarbonization targets.

This paper addresses the challenge of inconsistent categorisation of heat networks in the UK by proposing new definitions that separate district and communal concepts. To achieve this, the paper conducts a detailed analysis of available data on heat networks in London and reviews current definitions in the literature. Additionally, the paper highlights the potential implications of misclassification to developing district heating in the UK. It emphasises the need for clear boundaries in policy to guide the transition towards a low-carbon district heating market in the UK. By improving the accuracy and completeness of data through refining definitions and categorisations, this paper serves as a foundation for future research and development efforts to overcome barriers to the broader deployment of low-carbon heat networks in the UK.

2.0 Current Status of Heat Networks

Heat networks are a way of supplying heat to buildings from one or more centralised sources. They typically use a network of underground pipes to distribute thermal energy from central heat supply plants to multiple buildings. The heat is then delivered via forced air or hydronic systems within connected buildings. Heat networks are becoming increasingly popular in the UK to reduce reliance on fossil fuels and reduce carbon emissions.

2.1. Heat Networks in the UK and London

2.1.1. United Kingdom

The latest figures from 2020 show that around 14,000 heat networks currently supply nearly 480,000 consumers in the UK [6], up from an estimated 2,000 networks and 211,000 users in 2013 [8]. In addition, 990 heat network projects in the pipeline are seeking investment through the UK government's Heat Network Development Unit (HNDU) [9]. These projects are at different stages of development, from heat mapping to commercialization. The HN market in the UK is relatively small compared to other European countries [4], serving only 3% of the country's overall heat requirements [6]. However, the growth potential is significant, with government estimates suggesting that heat networks could provide heat to 17% of homes and 24% of commercial and public sector buildings by 2050 [6].

Heat networks provide heat from one or more central sources, which can be replaced over time with low-carbon alternatives without requiring infrastructure replacement [10]. It is essential to note that the prevalence of specific technologies in heat networks can vary depending on the size and nature of the network. For instance, smaller networks typically rely on gas boilers as the primary heat source, while more extensive networks often incorporate more diverse energy sources, such as energy from waste. In 2018, it was reported that 56% of the existing heat networks in the UK rely primarily on gas boilers, while 32% are powered by gas-fired combined heat and power (CHP) systems. Some networks are beginning to incorporate additional energy sources such as large-scale biomass (10%), while energy from waste and heat pumps each represent only 1% (see Figure 1). However, heat networks are transitioning to heating technologies with lower carbon intensities, and future networks in planning or construction phases are anticipated to employ more heat pumps, energy from waste, and efficient gas-fired CHP (59%) as opposed to gas boilers [11]. Gas-fired CHP has historically been considered a carbon-efficient alternative to gas boiler central heating. However, as the UK's power production has become more decarbonized and other low-carbon heat sources have become more prevalent, the carbon dioxide savings from CHP systems are diminishing. It is expected that they will eventually become outweighed by the carbon emissions associated with their operation. In essence, CHP may no longer offer carbon savings compared to grid electricity and gas boiler central heating [12]. In addition, Recent changes to building energy performance standards, such as the 2021 update to Part L of the Building Regulations in England and Wales, have placed tighter restrictions on the carbon emissions of heating systems [13]. Despite this, gas-fired CHP remains the most financially viable heat source under existing policies. [10].

While Heat networks can be implemented in urban and rural areas, they are particularly well-suited to densely populated urban areas where economies of scale can make them more financially viable. In addition, the Department for Energy Security and Net Zero (DESNZ), formerly known as the Department for Business, Energy & Industrial Strategy (BEIS), believes that London has the highest potential for heat network development among all UK regions due to its high density of heat demand [14].

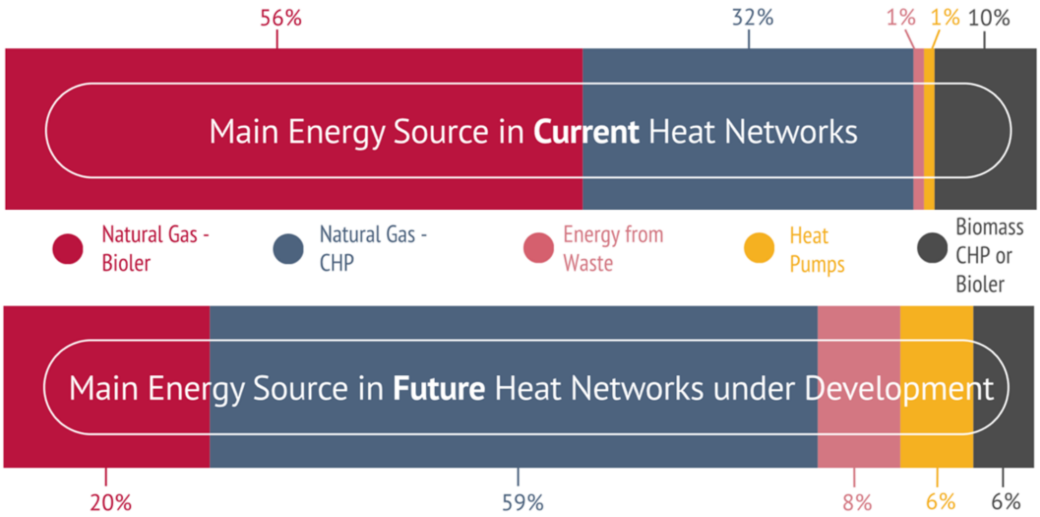

Figure 1-Main energy source in current and future heat networks in the UK [11]

2.1.2. London

London, like many other cities, relies heavily on fossil fuels for energy and therefore has a high level of carbon emissions. To reduce these emissions, London has set ambitious goals for the expansion of district heating networks, aiming to have 15% of the city's heat demand met by renewable and district heating sources by 2030. This goal is driven by the need to reach zero carbon by 2030, with district heating networks being considered a crucial part of net-zero plans [15]. The London Plan is encouraging the development of smaller heat networks on new developments, with the potential for these to be connected to more extensive district-wide networks in the future. Some district-wide heat networks are being developed through the Mayor's Decentralized Energy Enabling Project (DEEP), but the current development rate is insufficient to meet the 2050 zero-carbon target [16].

London boasts the highest number of heat networks in the United Kingdom, accounting for approximately 30% of the total documented heat networks in the country. Of these networks, 80% are classified as small communal networks, while the remaining 20% are district heating systems [17]. According to data collected by DESNZ, there are an estimated 4,000 heat networks present in London boroughs [17], as shown in Figure 2. The highest concentration of these networks can be found in the central area of London, particularly in the Westminster region. Several district heating projects are already providing low-carbon heat to homes and buildings. One notable example is the Bunhill heat network, which uses excess heat from the London Underground to heat over 1,350 homes and community buildings in Islington [18]. In addition, several new district heating projects are in the works, such as the Riverside heat network, which is expected to provide up to 30 MW of heat for approximately 10,500 homes in the London Borough of Bexley and the Royal Borough of Greenwich [19]. However, despite the high number of heat networks in London, it is essential to note that most of these networks are communal systems with a small number of consumers connected. Additionally, these networks are estimated to meet only 4% of London's heat demand [17].

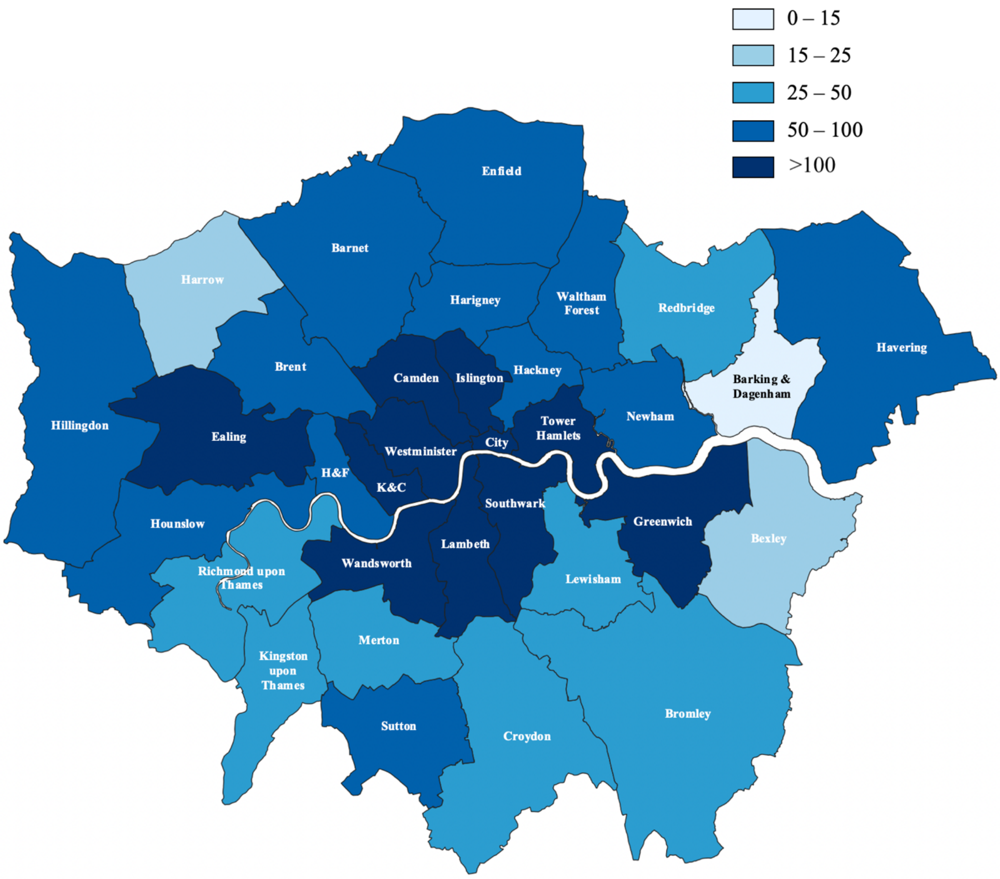

Figure 2-Visual representation of the number of heat networks in London boroughs

3.0 Barriers to the development of DH in the UK

Heat networks have the potential to provide a more efficient and sustainable source of heat for buildings in the UK. However, the development of these systems has been limited by a number of barriers. One major barrier is the high upfront capital costs associated with building heat networks, as well as the ongoing maintenance and operational expenses required to ensure their long-term viability [20]. Additionally, regulatory and policy frameworks can present challenges, as heat networks often require a complex web of approvals and permissions from multiple levels of government [21]. Another barrier is the difficulty in identifying and securing adequate heat sources, which can be a challenge in urban areas where space is limited [22]. Moreover, public acceptance and understanding of heat networks may be limited, which can make it difficult to secure the necessary support and funding for their development [23]. Another often-overlooked barrier is the lack of documentation and misclassification, which can lead to delays and confusion, hindering the progress of projects and initiatives. These barriers, among others, have hindered the widespread adoption of heat networks in the UK, but ongoing research and development efforts are aimed at addressing most these challenges and enabling their wider deployment.

While the need to decarbonise the heating sector in the UK has been well-documented in the literature [24] [23] [25] [23], and the challenges associated with this goal have been thoroughly analysed [26] [27] [28], national and international efforts to achieve this target have lagged behind. In this paper, we aim to address this gap by focusing on an often-overlooked barrier to heat network development: the lack of comprehensive and accurate documentation and classification of these systems.

3.1. Lack of documentation in the UK databases

It is common for databases to have incomplete or inconsistent coverage, particularly when it comes to data on complex systems like heat networks. Despite the existence of a number of databases that contain information on heat networks in the UK, such as DESNZ, the Heat Network Delivery Unit (HNDU), the Heat Trust, the Greater London Authority (GLA), and E.ON, there is still a lack of comprehensive documentation in many cases.
Despite extensive research conducted on the number of heat networks in the UK and London, obtaining an accurate comparison with documented figures has been challenging due to inconsistent and incomplete data on these systems. The findings suggest a lack of comprehensive and standardized data collection methods, which hinders the evaluation of the effectiveness and impact of heat networks on reducing carbon emissions. Heat networks can be owned and operated by a variety of entities, including utility companies, local governments, and private companies. As a result, it can be challenging to accurately document the number of heat networks that are in operation. Many heat networks may not be well-documented or may not be officially recorded with any agency, which can hinder efforts to accurately count these systems. For instance, in 2015, DESNZ, formally known as the Department of Energy and Climate Change (DECC), estimated that there were 4,000 heat networks in London, of which 800 were district heating schemes [17]. However, after conducting a thorough investigation, it was discovered that the available and documented data of heat networks in London did not exceed 50% of the estimated number from 2015 [17]. This suggests that the actual number of heat networks in London may be significantly higher than what is officially recorded, highlighting the need for improved documentation and registration of these systems.

One of the challenges of working with incomplete or inconsistent data is that it can be difficult to get a clear picture of the current state of the systems being studied. This can make it difficult to identify trends or patterns, or to draw meaningful conclusions from the data [29]. It can also hinder efforts to develop and implement effective strategies for improving the performance of heat networks towards the decarbonization targets.

To address these issues, it is necessary to invest in improving the documentation and data management practices for heat networks in the UK. This could involve standardizing the way data is collected and recorded or developing more robust systems for tracking and analysing the data over time. Ultimately, the goal would be to create a more comprehensive and reliable dataset that can be used to inform policy decisions and support the wider deployment of heat networks in the UK.

3.2. Misclassification in the UK databases

The classification of heat networks as either communal or district can depend on various factors, including the specific regulatory framework that applies to the system, the size and scope of the network, and the type of customers it serves. In some cases, heat networks may be classified as communal systems if owned and operated by a local government or community organisation. These systems may serve a specific group of customers within a defined geographic area, such as public buildings or residential properties. On the other hand, heat networks that are owned and operated by a private company may be classified as district systems. These systems may serve a larger geographic area, often covering multiple communities, and may serve a range of customers, including residential, commercial, and industrial properties. Classifying heat networks as either communal or district systems is not always straightforward. It can depend on various factors, such as the lack of clear definitions or guidelines for distinguishing between the two types of heat networks or because of incorrect or incomplete information in the databases that track these systems. As a result, the classification of these systems is inconsistent and can vary depending on the specific characteristics of the network.

Table 1 provides a comparison of different definitions of "district heating" and "communal heating" as used by various organizations. It can be observed that there is a lack of consistency in the definitions being used. It is important to note that the definitions of district and communal heating vary widely and may be used differently by different organizations, leading to confusion and inconsistency in the way these terms are used. Furthermore, it appears that some of the sources in the table provide two inconsistent definitions for heat networks. It is important to note that these inconsistencies may be due to different definitions being used by different departments or divisions within the same organization, or to changes in definitions over time. According to the analysis conducted, it was discovered that most UK-based organizations use the definition of heat networks provided by DESNZ as the standard. However, it was also found that this definition is inconsistent with the definitions used in other reports by DESNZ. According to data from the Heat Network Planning Database (HNPD) document [30], some district heating schemes in the UK are connected to only one building, even though DESNZ defines a district heating network as requiring connection to more than one building.

The inconsistency in the categorisation of heat networks can have several negative impacts. Firstly, it can hinder the ability to accurately evaluate the scale and extent of various heat networks, or to compare the performance and efficiency of different systems. Secondly, it can make it challenging to design and implement policies or initiatives that aim to promote the wider adoption of heat networks, as it may be unclear which systems are eligible for specific incentives or subsidies. These issues underscore the importance of clear and consistent definitions in the field of heat networks, as they can affect the accuracy and comparability of data and research, as well as the effectiveness of policies and programs.

To address issues of misclassification and inconsistency, it is necessary to establish clear definitions and guidelines for distinguishing between communal and district heat networks, and to ensure that the data on these systems is accurate and up to date. This should involve conducting more detailed analysis of the available data and working to improve data management practices to ensure that the information is consistent and reliable.

Table 1-Comparison of different definitions of "district heating" and "communal heating" as used by various organisations

	Heat Network Types		References
	Communal	**District**	
DESNZ	One building	More than one building	[31]
	One building with less than ten customers	More than one building **or** one building with more than ten customers	[32]
Office for Product Safety & Standards (OPSS)	One building	More than one building	[33]
Boiler Guide	1-2 Buildings	a much larger scale, with properties often miles apart being serviced by the same HN	[34]
CIBSE	One building	More than one building	[35]
	One building **and** more than one customer	More than one building **and** more than one customer	[36]
Evinox Energy	One building	More than one building	[37]
Heat Trust	One building	More than one building	[38]
Switch2	One building **or** include small heat networks that connects to a couple or more buildings within the same site.	Large scale networks, usually within cities, connecting communal heating schemes together.	[39]
WWF	No Difference		[40]
Energy Saving Trust	1-2 Buildings	a much larger scale, with properties often miles apart being serviced by the same HN	[41]
HELEC	No Difference		[42]
SP Energy Network	1-2 Buildings	a much larger scale, with properties often miles apart being serviced by the same HN	[43]
Finn Geotherm	No Difference		[44]
TheGreenAge	1-2 Buildings	a much larger scale, with properties often miles apart being serviced by the same HN	[45]
Colloide	One or a few local buildings	Large-scale generation than Communal	[46]
Clean Energy Wire	One or a few local buildings	NA	[47]
Celsius	Part of a district heat network (communal district heating network)	Large scale networks	[48]
ADE	Part of a district heat network (Secondary heating network)	Primary heating network	[11]
	One building	More than one building	[49]

3.2.1. Potential Implications on Policy

Misclassifying heat networks can have significant implications for policy decisions related to decarbonising the heating sector. Inaccurate or incomplete data can result in policy decisions that do not reflect the characteristics of different types of heat networks, leading to suboptimal outcomes. For instance, if policy decisions are based on inaccurate data, there is a risk that funding, and support could be misdirected towards less efficient and less effective types of heat networks. This can result in higher consumer costs and a slower transition to low-carbon heating.

In the UK, heat zoning policy aims to create low-carbon heating zones, where district heating networks play a central role in achieving this goal [50]. However, misclassifying communal heating networks as district heating networks may lead to a false sense of progress in achieving heat zoning targets, as these networks have limited potential for decarbonisation. This may result in the allocation of resources towards less efficient and effective policies, which can slow down the transition to low-carbon heating.

The misclassification of heat networks can also have implications for the UK's Future Homes Standard, which aims to ensure that all new homes are built with low-carbon heating systems and have high energy efficiency standards[51]. If the wrong types of heat networks are prioritised for investment and support due to misclassification, it could promote less efficient and less effective heating systems in new homes. This could result in new homes not meeting the standards required by the Future Homes Standard and, therefore, not contributing to the UK's decarbonisation targets[52]. Furthermore, misclassifying heat networks may give policymakers a false sense of progress towards achieving standardization when this may not be true. Such a misclassification could lead to less effective policies, ultimately hindering the transition to low-carbon heating in new homes. Hence, it is imperative to develop new criteria that can accurately and reliably differentiate between different types of heat networks, addressing the aforementioned issues and enabling more informed policy decisions.

3.2.2. Potential Implications on Decarbonisation Targets

The current classification system for district and communal heating networks lacks standardisation, resulting in confusion and inconsistencies in data collection and classification.

In categorisation, it is crucial to consider the significant differences between district and communal heating networks. District schemes have more potential for efficiency, lower costs, and more significant renewable energy integration opportunities. Therefore, these schemes are crucial for achieving decarbonisation targets, as they can utilise waste heat, improving energy efficiency using otherwise wasted heat. On the other hand, communal systems often have space limitations and other constraints that limit their expansion potential, making them less effective at meeting the heat demands of a growing population.

Communal systems also face limitations in terms of energy efficiency and cost-effectiveness. They require a high upfront capital investment and may not achieve the same efficiency level as larger district schemes.

It is important to note that district schemes are considered the primary focus in the heat network market in Europe, leading the way in reducing carbon emissions and improving energy efficiency [53]. In contrast, the UK only meets 3% of its heat demand through heat networks [6]. Therefore, the UK should follow Europe's lead in prioritising large-scale district heating networks, which can only be achieved by precisely differentiating between the two types of heat networks.

It is crucial to properly differentiate between district and communal heating networks in categorisation to avoid misallocated funding and insufficient infrastructure hindering progress towards decarbonisation goals. Therefore, a more precise and reliable categorisation criterion is essential to ensure efficient, cost-effective, and sustainable heat networks that meet the UK's ambitious 2050 targets for net-zero emissions.

4.0 Development of a new heat network categorisation criteria

This paper presents a new categorisation criterion for heat networks to provide clear definitions and guidelines for distinguishing between communal and district heat networks. To develop this system, a detailed analysis of available data on heat networks was conducted, which allowed for identifying key characteristics and features that differentiate communal and district heat networks. The new categorisation system, which considers these differences, provides a framework for accurately classifying heat networks based on their specific features and characteristics. It is believed that this system will be helpful for researchers, policymakers, and practitioners working in the field of heat networks, as it offers a clear and consistent way to distinguish between these two types of systems.

4.1. Methodology

The methodology employed in this study, as illustrated in Figure 3, involved a comprehensive analysis of data on heat networks from various sources, including regulatory agencies and academic literature. Figure 4 presents the sampling data that was used in this analysis, which was classified by data source and type of heat network. Data processing techniques, including data cleaning and extrapolation of missing values, were used to gain insights into the characteristics of district and communal heat networks. The data for this study was presented in the form of infographics and applied to a London case study, which represents the diversity and complexity of heating systems. This approach facilitated a comprehensive analysis and interpretation of the data and the creation of a useful classification system for heat networks.

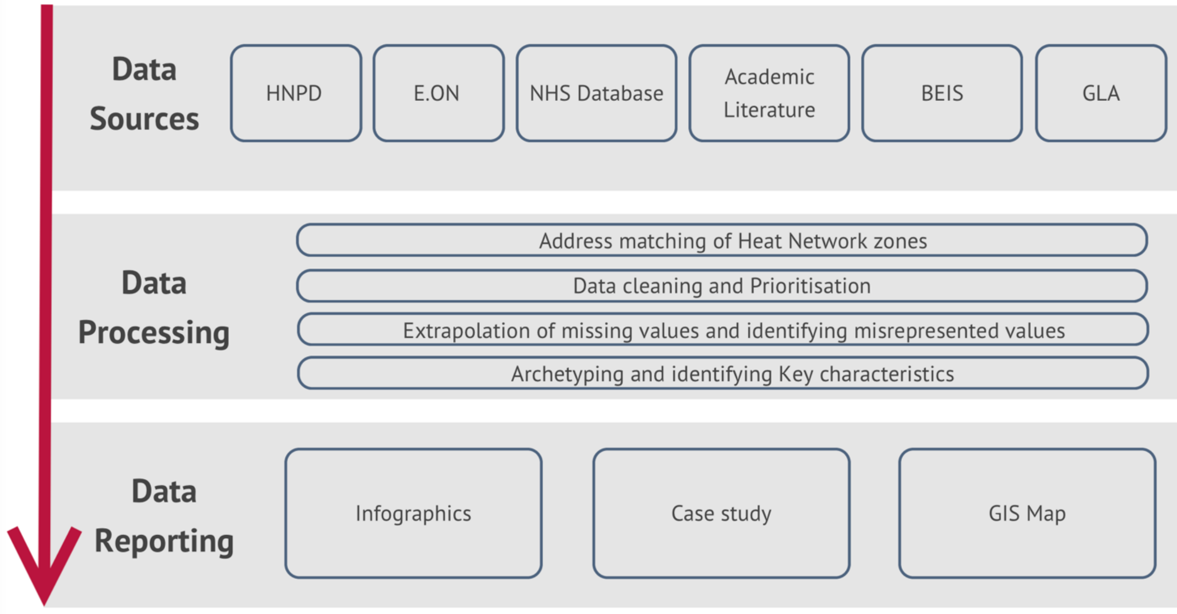

Figure 3-Methodological Framework for the Study

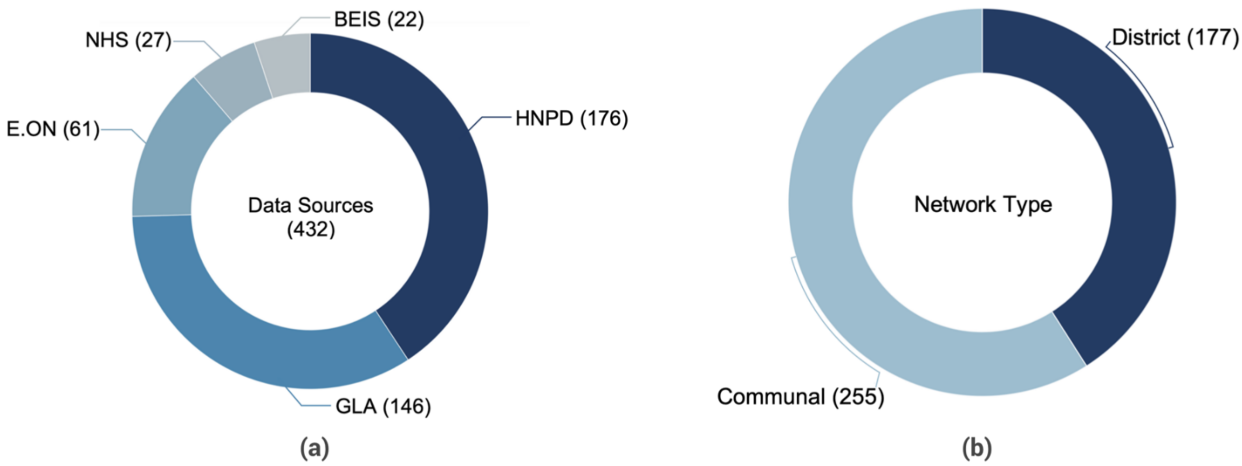

Figure 4- Sampled data utilized in this study, classified by (a) data source and (b) type of heat network

4.2. Results and Discussion

Upon conducting a thorough analysis of the available data, several prominent trends and patterns emerged. Upon further investigation, it became evident that these trends had significant ramifications for the research problem being addressed. It is worth noting that communal and district heating networks share some similarities, as they both involve the distribution of heat from a central source to various buildings or dwellings via a network of pipes. Nonetheless, the data analysed in this study highlighted key differences between communal and district heating networks, as depicted in Table 2 using statistical measures such as mean, standard deviation (St Dev), and range. The presented data were carefully analysed, and any outliers were removed to accurately represent the findings of this study. Upon further examination, as illustrated in Figure 5, it became clear that, using the current categorisation, these two types of networks overlap in some of their key properties, including electric and thermal capacities, the number of buildings and customers connected. This overlap makes it difficult to clearly distinguish between the two systems based solely on these characteristics. The analysis also revealed that some networks labelled as communal were connected to multiple buildings, despite the sources' own definition stating that a communal heat network should be connected to only one building. Furthermore, it was noted that there exists a gap in the categorisation systems being utilised, as small heat networks that are undergoing expansion are sometimes classified as district networks and other times as communal networks. This inconsistency impairs the ability to accurately assess the scale and extent of various heat networks or to compare the performance and efficiency of different systems.

Table 2-Key differences between communal and district heating networks

	Heat Network Type					
	Communal			District		
	Mean	St Dev	Range	Mean	St Dev	Range
Thermal Capacity (kW_{th})	1313	3344	100 ~ 17600	9189	14440	142 ~ 87000
Electric Capacity (kW_e)	2192	7321	20 ~ 69000	1488	4402	40 ~ 35000
Number of buildings connected	1	1	1 ~ 8	9	19	1 ~ 131
Number of Customers connected	99	142	1 ~ 740	418	539	1 ~ 2800
Geographical scope	Localised area (i.e., Neighbourhood/city block)			City/ region/ neighbourhood		
Infrastructure	Less complex and extensive infrastructure (i.e., small network of pipes)			More complex and extensive infrastructure (i.e., central heating plant and a large network of pipes)		
Customer Demographics	Buildings are often owned by single entity			Buildings are often owned by various entities		

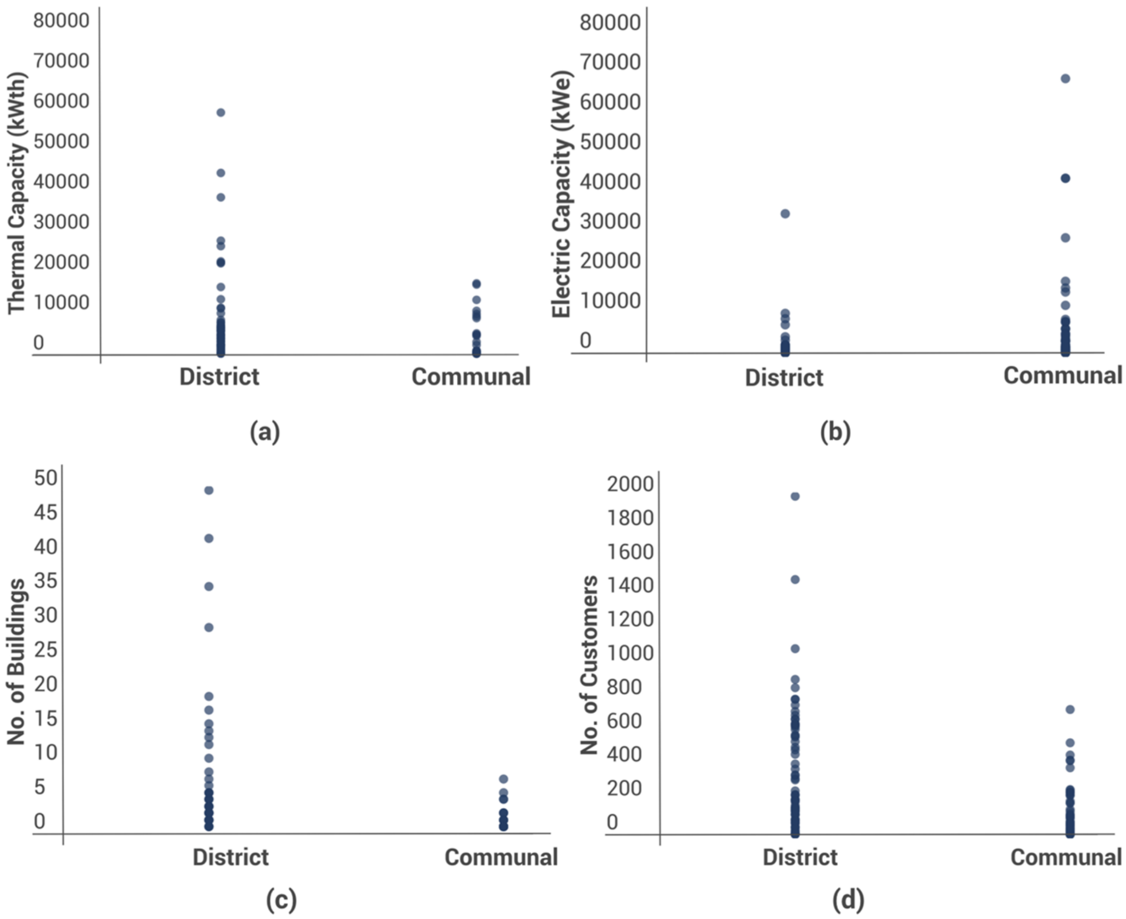

Figure 5-District and communal network insights based on (a) thermal capacity (kWth), (b) electric capacity (kWe), (c) number of buildings connected, and (d) number of customers connected.

The analysis conducted in this study considered key characteristics and features that may differentiate communal heat networks from district heating networks. It was found that using the number of buildings connected to a heat network as the only difference between these two types of networks is not reliable and leads to significant inconsistencies in different data sources. Instead, it is proposed that using specific properties that must be met for a network to qualify as either communal or district heating can provide a more consistent and reliable means of categorisation. Based on the analysis of available data, it was observed that considering the ownership type of the buildings connected to heat networks is one of the main properties that should be considered. Therefore, a new criterion for classifying heat networks is proposed to accurately account for these differences and provide a framework for categorising heat networks based on their specific features and characteristics. This new criterion is outlined as follows (see Figure 6):

District heating network:

To qualify as a district heating network, the following criteria must be met:

- The network must serve a city or region/neighbourhood.
- It must be connected to multiple buildings.
- The connected buildings must be owned by multiple entities.

Communal heating network:

To be classified as a communal heating network, the following criteria must be satisfied:

- The network must serve a localized area.
- The connected buildings must be owned by a single entity..

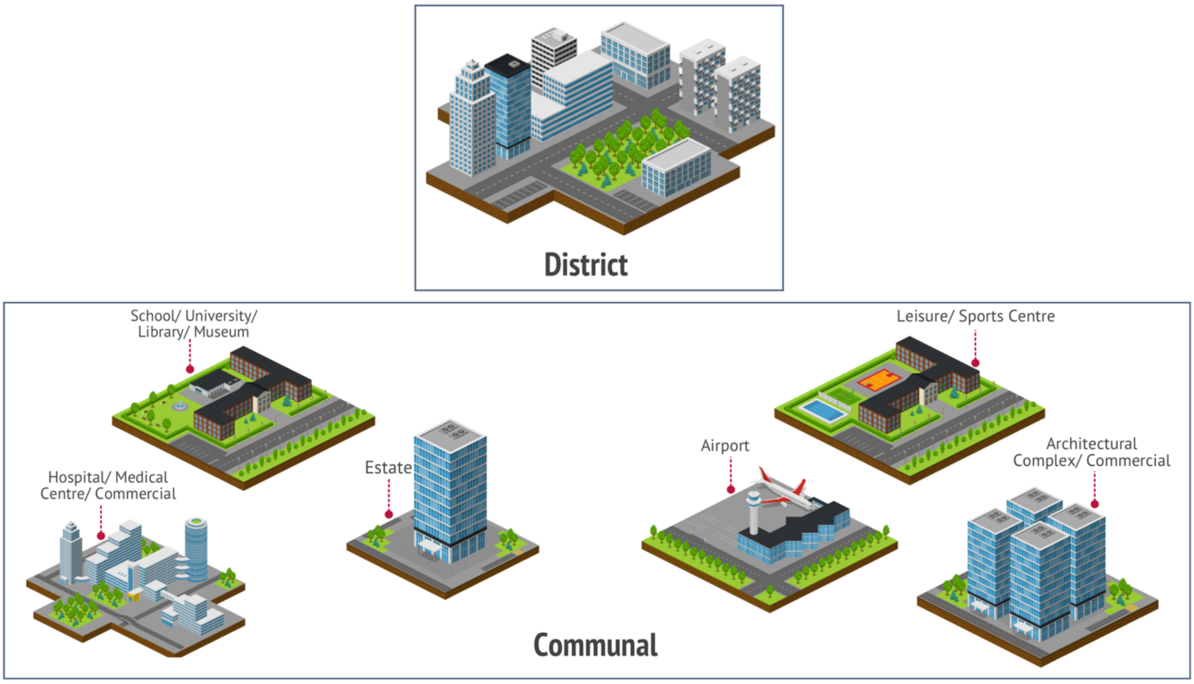

Figure 6-Infographic illustrations of communal and district heating network

4.3. Benefits of the novel heat network categorisation criteria

Accurately categorising heat networks is essential for research purposes and informing policy decisions that can help drive the transition to low-carbon heating in the UK. Implementing this new categorisation criterion provide a precise and reliable way to distinguish between the different types of heat networks. The new criteria consider specific properties that must be met for a network to qualify as either district or communal heating, resulting in a more consistent and reliable means of categorisation. By focusing on the ownership type of buildings connected, the new criteria provide a more accurate and robust framework for categorising heat networks based on their scope, number of buildings connected and ownership. This approach helps to address inconsistencies in different data sources, which can be a significant problem for policymakers and researchers seeking to understand the heat network landscape. The suggested criteria provide a precise definition of district and communal heating networks, thereby minimizing the risk of misidentifying them. Overall, the new categorisation criteria have the potential to support more effective policymaking, planning, and decision-making in the heat network sector, ultimately contributing to the decarbonisation of the energy system.

5.0 London Case Study

A case study of heat networks in London was conducted, using a sample of 432 networks which represents approximately 11% of the total number in the city [17]. The sample was chosen through a systematic selection process that aimed to include a diverse range of properties and network characteristics present in the city. The selection was also based on a concentration of networks in the boroughs of Westminster and Southwark, as illustrated in Figure 7, to ensure that the sample was representative of the wider network distribution across the city. The sampling data used in this study, shown in Figure 8, was classified by data source, type of heat network, and heat source. This sample was then refined using the proposed categorisation criteria for heat networks to accurately classify each network as communal or district based on their specific features and characteristics. This allowed for a comprehensive assessment of the current state of heat networks in London and the identification of any gaps or inconsistencies in the data.

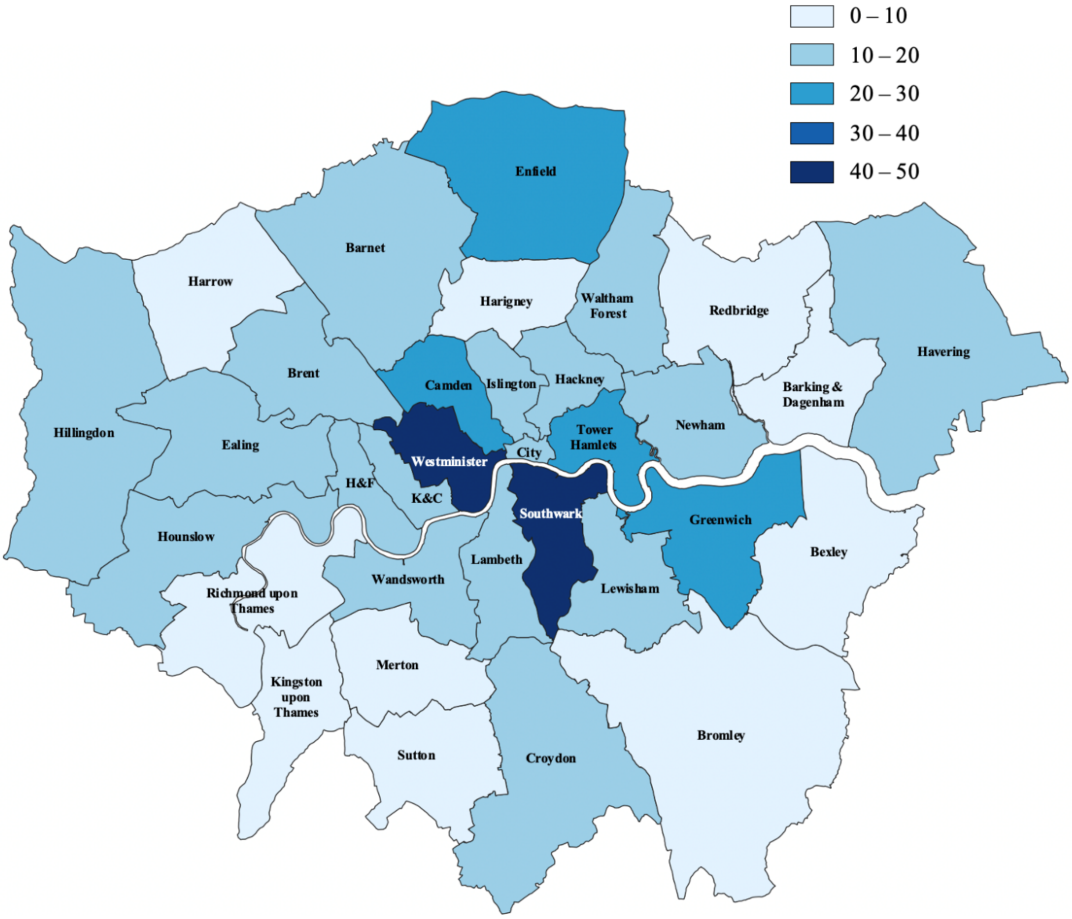

Figure 7-Visual representation of the sampled number of heat networks in London boroughs

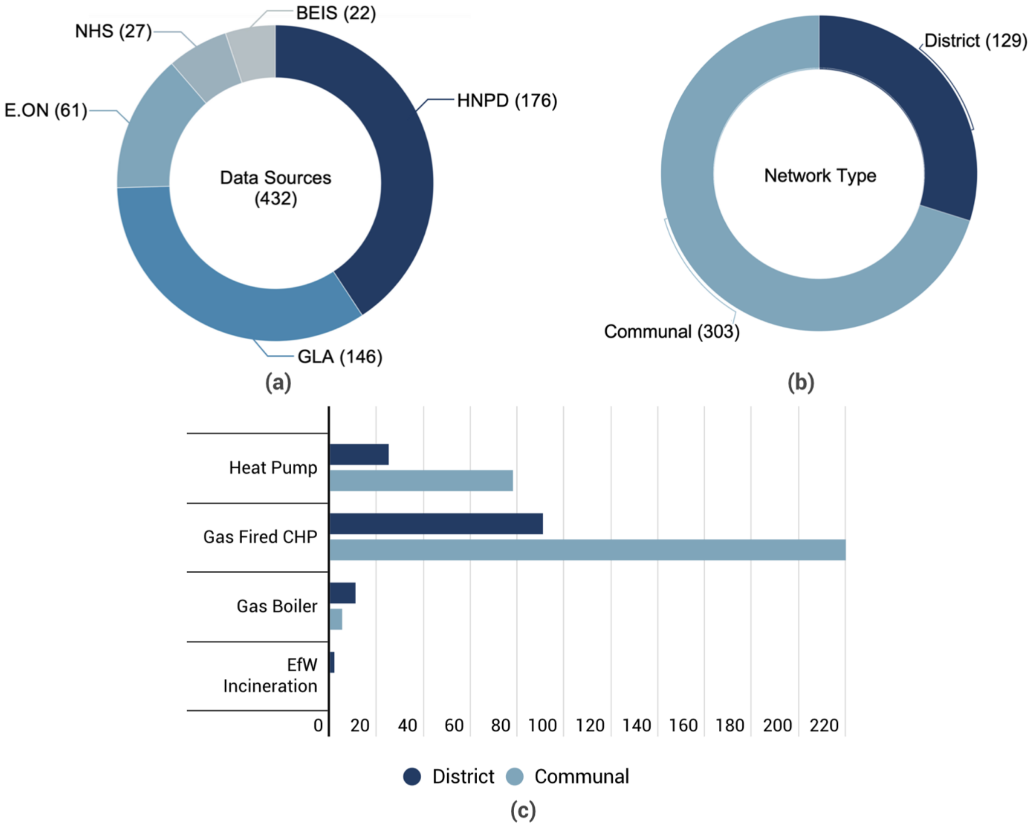

Figure 8- Sampled data utilised in this case study, classified by (a) data source, (b) type of heat network and (c) heat source.

The case study results demonstrated that using specific properties, such as size, ownership entity, and service area, influenced distinguishing between communal and district heating networks. By applying these criteria to the sampled data, the study identified many networks that had been misclassified, providing evidence of the importance of accurate categorisation. For instance, it was discovered that, under this proposed system, approximately 27% of the district heating networks should have been categorised as communal networks due to their small size, single ownership entity, and service to mainly small hospitals or leisure centres. Misclassification of these cases can lead to ill-informed policy decisions that could have significant implications for decarbonisation and energy efficiency targets. For instance, classifying the Princess Royal University Hospital's Endoscopy Building as a district heating scheme rather than a communal one could lead to erroneous conclusions about the potential for decarbonisation [54]. This is because the ownership of the energy centre, which serves only the hospital, makes it more appropriate for a communal scheme classification. This misclassification could also lead to complications in integrating with the hospital's existing system, resulting in a loss of effort and time. Similarly, the heat network serving the Hounslow Civic Centre has been classified as a communal heating network despite serving multiple buildings owned by different entities [54]. Misclassifying these heat networks may give policymakers a false sense of progress towards achieving decarbonisation. Such a misclassification could lead to less effective policies, ultimately hindering the transition to low-carbon heating in new homes. Hence, it is imperative to differentiate between different types of heat networks accurately and reliably. The proposed criteria provide a clear and consistent

means of identifying the correct classification for these heat networks, essential for ensuring accurate and reliable data for decision-making and policy development.
Despite the high number of heat networks in London, most communal systems serve a relatively small number of consumers. This study highlights the importance of accurately categorising heat networks to understand the landscape and make informed decisions about their development. In addition, the increase in the number of district heating networks in the UK requires careful consideration of system scale. While smaller heat networks may appear to have the potential to contribute to district heating, there are challenges to their integration into larger systems. Misclassifying small-scale systems as district networks can limit future expansions, increase costs, and reduce efficiency. Therefore, it is recommended that future district heating networks should primarily consist of large-scale systems, which can provide increased efficiency, lower costs, and higher potential for renewable energy integration.

6.0 Conclusions

Heat networks have been identified as critical in the UK's efforts to transition to low-carbon communities and meet its net-zero emissions targets by 2050. While the country has made progress in developing heat networks, there are still barriers to their wider adoption. One significant barrier is the lack of comprehensive and accurate documentation and classification of these systems. The potential implications of the current categorisation of heat networks on policy and decrabonisation targets were discussed, emphasising the need for accurate classification to inform policy decisions and support the development of low-carbon heat networks in the UK. This paper presents a new categorisation criterion for heat networks that aims to provide clear definitions and guidelines for distinguishing between communal and district heat networks, which will aid in improving documentation and registration of these systems and support the development of low-carbon heat networks in the UK. A case study of heat networks in London was conducted using a sample of 432 networks representing approximately 11% of the total number in the city. This sample was then sorted using the proposed categorisation criteria to accurately classify each network as communal or district based on their specific features and characteristics. The potential implication of misclassified heat networks was highlighted through examples of misclassified networks, showing the pressing need to use more reliable criteria. The proposed categorisation criterion for heat networks can serve as a reliable and consistent method for distinguishing between communal and district systems. Researchers, policymakers, and practitioners can make informed decisions about developing low-carbon heat networks in the UK by accurately classifying heat networks based on their specific characteristics and features. It is crucial to note that, as the government has a significant role in expanding and implementing heat networks in the UK, it must invest in improving the documentation and data management practices for these networks. This could involve standardising how data is collected and recorded or developing more robust systems for tracking and analysing the data over time. Ultimately, the goal would be to create a more comprehensive and reliable dataset that can be used to inform policy decisions and support the broader deployment of heat networks in the UK.

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