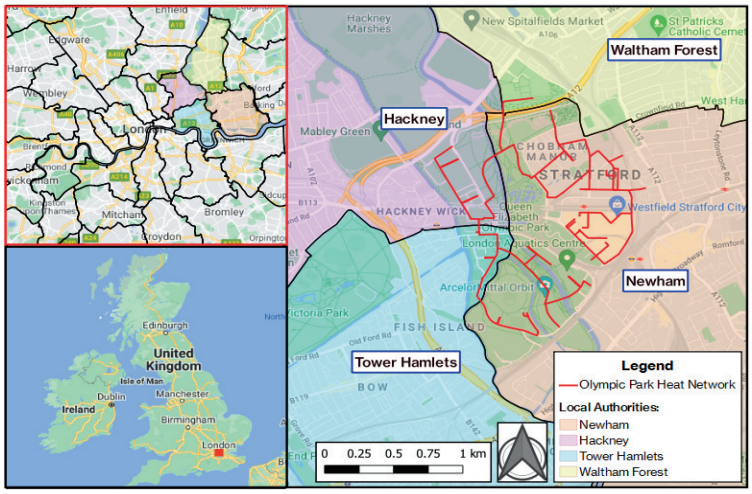
DEPARTMENT OF SCIENCE, TECHNOLOGY,
ENGINEERING AND PUBLIC POLICY

Enabling and improving cross-authority collaboration on infrastructure to better meet local energy needs

Urban Low Carbon Heat Networks



5

STEaPP Working Paper Series

Cover Image: A map of the heat network in the Olympic Park District Energy Scheme (OPDES). Image created by the authors of the report using data from the London Heat Map: https://www.london.gov.uk/what-we-do/environment/energy/london-heat-map

Research Project Team Members and Report Authors:
Marc Farre Moutinho, Alexandros Gregoriades, Jose Villacres Lozada, James Atkinson, Zi Huang, Xiyu Tang

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Any questions or feedback about the content of this report is welcome and can be addressed to its authors, who can be reached at the following e-mail addresses:

Marc Farre Moutinho – marc.moutinho.11@ucl.ac.uk

Alexandros Gregoriades – alexandros.gregoriades.17@ucl.ac.uk

Jose Villacres Lozada – jose.lozada.20@ucl.ac.uk

James Atkinson – james.atkinson.20@ucl.ac.uk

Zi Huang – zi.huang.19@ucl.ac.uk

Xiyu Tang – xiyu.tang.20@ucl.ac.uk

Contents

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5

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Executive Summary

Climate policy in the UK has become increasingly ambitious in recent years, particularly in view of the central government's commitment to making the UK carbon net zero by 2050. Local government has been an active contributor to this policy shift, with over 300 local authorities (LAs) to date having declared climate emergencies, often accompanied by local net-zero targets of equal or even greater ambition than those of the central government.

The decarbonisation of heat stands out as a significant challenge in meeting local energy needs and climate goals. On top of being one of the greatest contributing factors to national greenhouse gas (GHG) emissions, comprising over a third of the total, the characteristics of heat in the UK create unique difficulties to achieving low carbon transitions in this field of energy.

A combination of different solutions will be required to address the urgent and challenging task of decarbonising heat, and low carbon heat networks are often put forward as a key part of the solution for urban areas. As heat network development accelerates across the country however, reaping the greatest benefits from these networks will likely involve maximising their size to increase efficiencies and capitalising on waste heat sources by matching them with local pockets of heat demand. Given the relatively small size of some urban LAs in the UK, developing heat networks in these ways may well require building them across LA boundaries.

Heat is difficult to transport over long distances, giving it an inherently localised quality as an energy source and creating a strong rationale for heat networks to be developed as a decentralised energy technology. The local responsibilities already held by LAs put them in a good position to lead decentralised heat infrastructure development in this way, including across their borders. Moreover, the greater agility LAs display in responding to local needs combined with greater expertise of those needs themselves are qualities that offer advantages in local infrastructure development.

Despite the growing relevance of cross-border heat networks and the potential of LAs to address them, there are currently very few cases of such networks in the UK. The evidence suggests that this is because of a variety of issues that raise barriers to neighbouring LAs initiating and sustaining the cross-authority collaboration required to deliver those networks. Figure 1 shows how these issues can be grouped into four main themes.

Inherent Difficulties of Heat Networks	Heat networks are already a challenging piece of infrastructure to deliver within a single LA, never mind across LA boundaries. Inherent difficulties include high financing requirements, physical obstacles, navigating technical standards, procuring long-term supplies of heat, securing a customer baseload, and finding partners who can build large networks. Even when LAs are eager to pursue heat networks, these challenges raise barriers to cross-authority collaboration because they understandably deter LAs from engaging their neighbours in an attempt to keep their projects as simple as possible and maximise their chances of successfully delivering them.
Awareness	LAs can be unaware of opportunities for viable cross-authority heat networks involving their local area. This lack of awareness can be explained if a LA has not conducted sufficient heat mapping of its territory (or lacks the data to do so) but may also stem from the perception that the best conditions for heat networks lie at the geographic centre of LAs rather than near their borders. Either way, it presents additional barriers as neighbouring LAs who are unaware of opportunities will see no rationale to begin collaborating.
Resources	LAs can lack the resources necessary to initiate and sustain cross-authority collaboration on heat networks. This resource gap refers to both human resources (such as in-house expertise, internal 'champions', and capable external delivery partners) and financial ones (such as the funding required to staff the human resources as well as pay for the delivery of the infrastructure itself). These issues can act as barriers to cross-authority collaboration by reducing the ability of LAs to collaborate even when there is a viable opportunity for a cross-border heat network.

Alignment	There are several issues that can create misalignment between LAs and hinder cross-authority collaboration on heat networks. These issues can be technical, such as when networks are built to different technical standards in neighbouring LAs, making it difficult to interconnect them across their boundaries. More often though the issues relate to governance, such as differences between LAs in political priorities and planning policies that are difficult to reduce because of misaligned policy, planning, and election cycles. With little policy from the central government mitigating these issues, agreement on the governance of potential cross-authority heat networks becomes hard to achieve. All these factors raise further barriers to cross-authority working by eroding the motivation of neighbouring LAs to initiate and sustain such collaboration.

Figure 1 – Main Themes of Barriers to Cross-Authority Collaboration on Heat Network Development

Issues within these four themes are deeply interrelated. For example, resources in the form of in-house expertise and funding can support heat mapping activities and improve awareness of cross-authority opportunities. Similarly, policy misalignment between neighbouring LAs can lead to differences in the level of funding allocated to heat network development and limit the resources available for cross-authority collaboration. The interrelations between these issues indicate that any attempt to reduce the barriers to cross-authority collaboration will require addressing multiple themes simultaneously.

Setting aside the inherent difficulties of heat networks and focusing on issues specific to cross-authority collaboration, Figure 2 outlines three sets of recommendations that LAs should pursue to reduce the barriers to cross-border heat network development.

Long-Term Action	Short-Term Action	Collaboration Opportunities and Formats
Lobby the central government and relevant devolved governments to create overarching frameworks for heat network development that mandate the exploration of cross-border opportunities and provide the resources to do so. Shaping existing policy initiatives taking place across the UK (particularly relating to heat zoning) would be an efficient way of catalysing the necessary frameworks.	*Engage with existing organisations already looking at heat network development to get cross-authority collaboration on their agendas and leverage their resources to facilitate collaboration.* Making use of these organisations as platforms to find and discuss specific cross-border heat network opportunities would allow neighbouring LAs to begin collaborating on those opportunities.	*When contemplating cross-border heat network development, consider the opportunities and formats for collaboration identified by this report as a starting point to initiate collaborative efforts and further mitigate key issues.* Considering formats such as formal partnerships and joint ventures can act as a starting point for discussions between neighbouring LAs who want to act on a cross-border opportunity.

Figure 2 – Key Recommendations for Enabling and Improving Cross-Authority Collaboration on Heat Network Development

Acronyms and References

ADE	Association for Decentralised Energy
APSE	Association for Public Service Excellence
BEIS	Department for Business, Energy & Industrial Strategy
CCC	Climate Change Committee
CHP	Combined Heat and Power
DSO	Distribution System Operator
EfW	Energy from Waste
EV	Electric Vehicle
GHG	Greenhouse Gas
GHNF	Green Heat Networks Fund
GLA	Greater London Authority
HNDU	Heat Networks Development Unit
HNIC	Heat Networks Industry Council
IPCC	Intergovernmental Panel on Climate Change
LA	Local Authority
LDA	London Development Agency
LEP	Local Enterprise Partnership
LGA	Local Government Association
LHEES	Local Heat and Energy Efficiency Strategy
LLDC	London Legacy Development Corporation
NGO	Non-Governmental Organisation
Ofgem	Office of Gas and Electricity Markets
OPDES	Olympic Park District Energy Scheme
REHVA	Federation of European Heating, Ventilation and Air Conditions Associations
SAP	Standard Assessment Procedure
SPV	Special Purpose Vehicle
UK	United Kingdom
UKDEA	United Kingdom District Energy Association

References to literature or documents are made using footnotes with citations in the APA referencing style. References to primary data gathered for the purposes of this project are indicated by square brackets with numbers corresponding to the code numbers of the relevant data subjects. Please see the Methodology section and Appendix A for further details.

References to specific pieces of information outlined elsewhere in this report may contain hyperlinks to the relevant section for ease of navigation.

List of Figures

All figures are of the authors' own making unless referenced otherwise.

1. Introduction

I. Context and Research Problem

Legislative and Policy Context

The 2015 Paris Agreement, whereby 196 countries adopted greenhouse gas (GHG) reduction commitments to mitigate climate change,[1] has become a cornerstone of climate policy around the world in recent years, with significant implications for energy generation, distribution, and consumption. The recent IPCC special report, which calls for net zero emissions by 2050,[2] only adds to the urgency to bring about transformational change within energy.

The UK is no exception to the above, having passed legislation in 2019 setting out a target of reaching net zero emissions by 2050.[3] Moreover, local government in the UK has also been an active participant in this respect, with Bristol City Council in 2018 becoming the first local authority (LA) in the country to declare a climate emergency. Since then, over 300 more LAs have followed suit, accompanied by a host of local net-zero targets of equal or even greater ambition than those of the central government.[4]

Energy and Heat Context

In meeting climate goals set out by all levels of government, the decarbonisation of heat stands out as a significant challenge. A 2018 estimate by the UK government singled out heat as the largest contributing factor to UK GHG emissions (amounting to as much as 37% of the total) and recognised the uniquely difficult challenges of decarbonising this area. Some of the most salient ones include meeting the relatively high demand for heat in the UK, the substantial disruption to consumers posed by heat infrastructure transitions, and how the diverse range of heat applications makes it unlikely a single technology will be able to meet all needs.[5]

Considering the challenges posed by the transformation of heat in the UK, low carbon heat networks have been put forward as an integral part of the solution. In areas of high building density, they can be more promising than alternative solutions for individual buildings (such as domestic heat pumps). While hydrogen stands out as another alternative it still faces a long path to technological maturity and likely cannot be scaled up quickly enough to meet the urgent need to decarbonise heat in its entirety. Heat networks are currently at a higher level of technological maturity and can be applied to reduce the carbon footprint of heat more quickly.[6] Given these advantages, the central government has put forward strategies in which heat networks will deliver anywhere between 17-24% of the UK's heat needs by 2050 (up from the 2% they currently deliver) and many LAs are including the technology in their climate plans.[7]

What are heat networks?

Also known as district heating, heat networks consist of a system of insulated pipes that take heat generated from a central source and distribute it to the buildings connected to the network. The central source can take a variety of forms, as shown by Figures 3, 4, and 5 below, but depending on the chosen technology it can reduce the carbon intensity of heating buildings in its network relative to conventional systems such as individual gas boilers. This is particularly true of densely populated and built-up urban areas, where a heat network of a given size can more efficiently reach many more buildings than in rural areas where building density is normally lower [6, 28, 52, 55].

1 (Paris Agreement, 2015)
2 (IPCC, 2021)
3 (The Climate Change Act 2008 (2050 Target Amendment) Order 2019,2019)
4 (Climate Emergency UK, 2021)
5 (BEIS, 2018)
6 (CCC, 2020)
7 (BEIS, 2017)

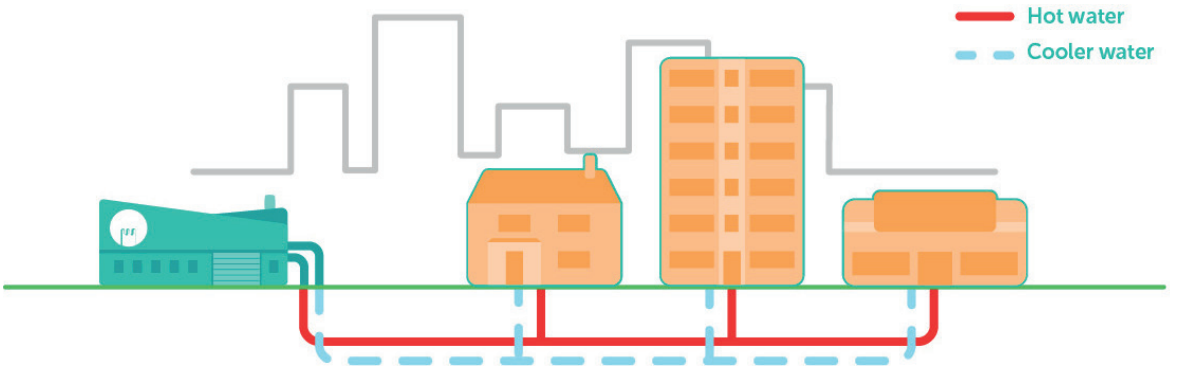


Figure 3 - Heat Network Diagram (Source: Energetik - https://www.energetik.london/how-it-works/community-heat-networks)

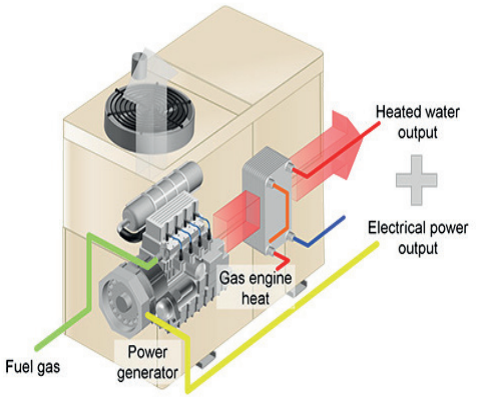


Figure 4 - Gas CHP Unit Diagram
(Source: Yanmar - https://www.yanmar.com/global/energy/cogeneration_systems)

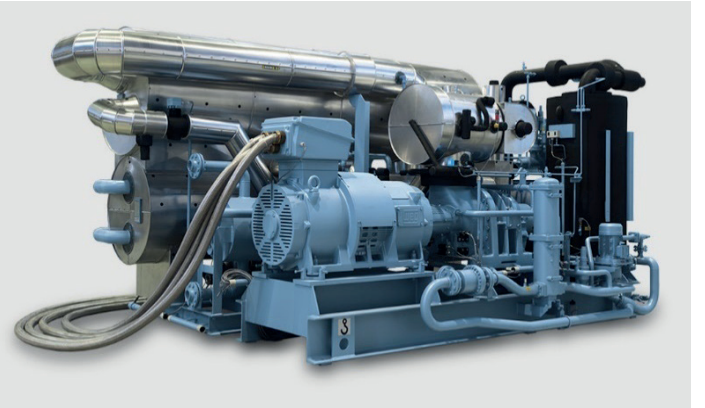


Figure 5 - Industrial Heat Pump
(Source: GEA - https://www.gea.com/en/products/refrigeration-heating/heat-pumps/index.jsp)

Heat Networks Context

The physical and economic obstacles to transporting heat over very long distances underpin the inherently localised nature of heat as an energy source and highlights why heat networks lend themselves to being developed as a decentralised energy technology. Because of this, local government can play a significant role in driving forward heat network deployment and it possesses certain strengths that could help it in doing so.[8] For example, given its responsibility for its immediate territory, local government can sometimes act with greater agility and take more initiative in addressing local needs than national government bodies. Moreover, being closer to their local needs often means local government possesses unique expertise of those needs and the conditions required to meet them [52, 88]. Although organisations such as the Energy Hubs are working on heat network planning, the absence of any organisations that are formally responsible for this planning at a national, regional, or local level (in the way that National Grid and the various DSOs hold this responsibility for the electricity system, for example) showcases the role LAs could take.

There are a few factors to consider for heat networks to deliver the greatest carbon savings and other benefits. For one, maximising for size (given technical and economic limits) allows heat networks to best capitalise on economies of scale and efficiencies [55, 88]. Additionally, matching local sources of heat with nearby demand makes the most efficient use of this energy source. Given that the size of LA territories can

8 (Evans, 2020)

be relatively small in parts of the UK, maximising for size or matching heat supply with demand might well mean building heat networks across LA boundaries. This sets the problem that the report seeks to address: *how to enable and improve the cross-authority collaboration that will become necessary as heat network deployment accelerates.*

There are signs that the relevance of this problem is already becoming apparent. A number of proposed heat networks in London follow routes that would cross LA boundaries,[9] including the planned East London Heat Network which is currently at a stage where it requires the approval of four borough councils.[10] Both within and beyond London, developers and operators of heat networks (be they public or privately-owned) have indicated aims to expand existing networks in ways that would necessitate cross-authority collaboration [1, 6, 56, 88]. The development of heat zoning policy across the UK that could make heat networks mandatory in certain areas further highlights the relevance of this problem.

These signs have been detected by private companies,[11] NGOs,[12] and even local government itself,[13] who have all recognised the importance of ensuring smooth cross-authority collaboration where it is needed. Yet despite the impending relevance of the problem, there are very few academic and grey literature studies on the topic. Research has certainly been conducted on the role of local government in energy[14] and even on inter-authority collaboration on energy,[15] but not on *cross-authority energy infrastructure development* specifically. It is this gap in the research which this report seeks to cover.

II. Definitions

The subject matter of this report addresses concepts and terms that could be interpreted in a variety of ways. For clarity and consistency, three of the most central terms are defined below, with additional important ones explained as necessary throughout the report.

Local Authorities

The organisation of local government in the UK is complex, with a variety of tiers, administrative divisions, and jurisdictional responsibilities to consider.[16] Broadly speaking, this report focuses on the higher tiers of LAs, defining them as those *whose powers are exceeded only by the central government in Westminster, the devolved governments of their respective nations, and by the combined authorities of which they may form a part.* These types of authorities were selected because they currently or may potentially possess the necessary powers for collaboration on heat infrastructure, such as powers to plan, own, and operate heat networks, while remaining local enough in scope to preserve the qualities of initiative and local expertise mentioned previously. Examples of the types of LAs in question are displayed in Figure 6 below according to their respective nation.

Nation	Relevant Types of Local Authorities
England	Local authority districts (i.e. unitary authorities, metropolitan districts, non-metropolitan districts and London boroughs)
Scotland	Council areas
Wales	Unitary authorities
Northern Ireland	Local government districts

Figure 6 – Types of Local Authorities within the Research Scope

9 (GLA, n.d.)
10 ('Developing a Clear Vision for Zero Carbon Heating in East London', 2020)
11 (Arup, 2011)
12 (Energy Charter Secretariat, 2006)
13 (GLA, 2014)
14 (Webb et al., 2017)
15 (Adam, 2018)
16 (ONS Geography, 2019)

Local Energy Infrastructure

For the reasons outlined earlier in this Introduction, *low carbon heat networks* are the type of local energy infrastructure that have formed the focus of this report. This definition is not unproblematic though, as the ongoing debate on the green credentials of different technologies has and continues to shift perceptions of what constitutes a 'low carbon' heat network. For example, networks powered by gas CHP were once widely considered to be a climate-friendly alternative to individual gas boilers. In recent years though, gas CHP has fallen out of favour in comparison to potentially lower carbon technologies such as heat pumps and waste heat recovery [6, 28, 52, 55, 56]. While being conscious of this debate, the definition of low carbon heat networks adopted by this report is technology agnostic. This is because even though certain technologies are losing their green credentials, existing heat networks (either proposed or completed) can offer insight into cross-authority collaboration regardless of the technology they used. The lessons drawn from these cases can thus still improve collaboration when future networks are developed using lower carbon or zero-carbon alternatives.

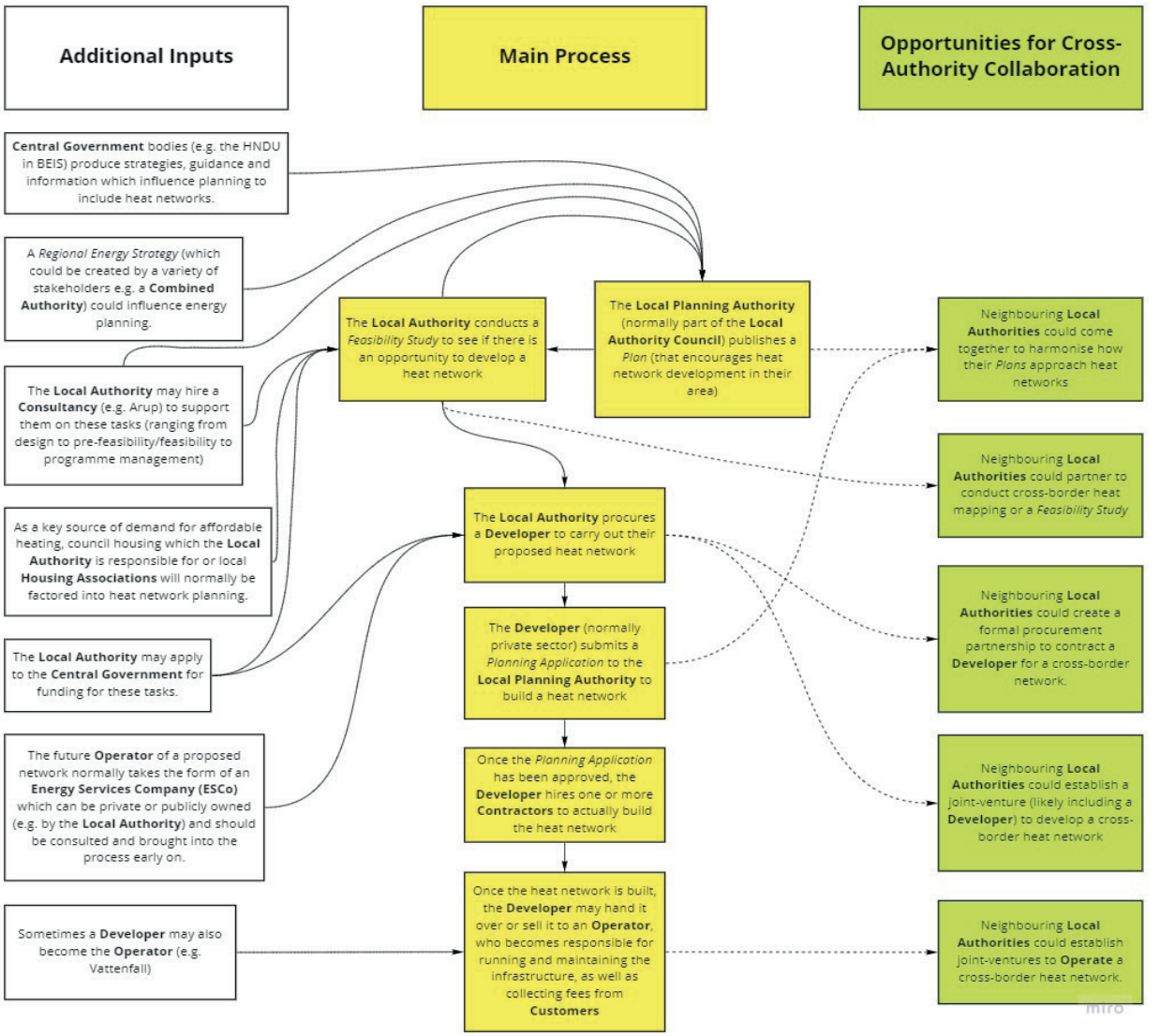


Figure 7 - LA-Led Heat Network Development Process

Cross-Authority Collaboration

If energy infrastructure development is understood as a process, the complex web of actors involved quickly becomes apparent. Heat networks in the UK are no exception, as shown by Figure 7 above which provides an overview of how the relevant actors interact with one another in the common scenario whereby an LA takes the initiative in developing a network [1]. The chart depicts the process within an English metropolitan district (or equivalent) in which there is only a single tier of local government.

Looking at the chart, cross-authority collaboration could have several meanings. It could refer to collaboration that seems 'vertical' in appearance, such as between LAs and central government agencies. The same could be said of more 'horizontal' types of collaboration, such as those between non-public actors based in neighbouring LAs. Due to the time and resource constraints of this research project, this report focuses solely on horizontal collaboration between neighbouring LAs as a means of drawing meaningful insight into this type of interaction.

Within the scope of collaboration between LAs however, this report defines collaboration quite broadly. As shown by the green boxes in Figure 7, there are hypothetically numerous ways in which LAs could work together on cross-boundary heat networks. As such, cross-authority collaboration is defined as *when two or more LAs actively work together to advance the development of heat networks across their shared borders.* The ultimate scope of this report is the barriers to LAs initiating and executing collaborative initiatives such as the hypothetical examples depicted in the chart, and what could be done to overcome those barriers.

III. Research Questions

The following research questions were developed to guide the research behind this report and structure its findings. Since the questions were formulated at the beginning of the research process, they are necessarily broad. As the research progressed, its scope eventually narrowed to heat networks specifically.

1. What are local energy needs in the UK?
2. Can cross-authority infrastructure help to meet local energy needs?
3. Are there existing cases of attempted or complete cross-authority energy infrastructure projects?
4. If cross-authority infrastructure can help to meet local energy needs, why has it been successful or unsuccessful? If it has not even been attempted, why is that?
5. What solutions could be put forward to enable and improve cross-authority collaboration on local energy infrastructure?

Although parts of the answers to Questions 1 and 2 are already visible in this Introduction, they are addressed more fully in the Analysis section of this report. The Analysis and Discussion sections also outline the answers to Questions 3 and 4, while Question 5 forms the basis of the Recommendations of this report before it reaches its Conclusion.

2. Methodology

I. Literature Review Summary

The process of literature review identified a paucity of research on cross-authority collaboration on energy infrastructure in the UK. To begin with, in preparation for the research that would underpin this report, some members of the project team applied the principles of systematic review (such as methodological process, rigour, and transparency) to conduct individual literature reviews on the topic. Although these were not intended as full systematic reviews, they offered the first signs that little had been written about the topic.[17] Data gathering for this report began with a literature review conducted collectively by the project team. The review was organised along the lines of the project's five research questions and refined over time to focus on specific urban centres in the UK that the topic would be most relevant to. A degree of 'snowballing' was employed as any relevant literature that was found was often used as a guide to further resources.[18] Although the overall process of literature review confirmed that little has been written about the topic, it did produce some useful insights. For one, studies had been carried out on cross-authority collaboration on energy infrastructure in geographies other than the UK,[19] suggesting international comparisons as a worthwhile avenue of future inquiry.

More importantly, although there is sparse literature on cross-authority collaboration on energy infrastructure, there is large volume of research on inter-organisational collaboration more generally. This includes a substantial body of literature on theories and conceptual frameworks that can be used to understand this sort of collaboration.[20] These theories and frameworks informed the analytic approach used in the research underpinning this report, particularly ideas around how collaboration should be understood in at least two parts: 1) the *antecedents* which set the conditions for collaboration, and 2) the *contingencies* that affect the process of collaboration itself once it has begun. The following conceptual map drawn by Wassmer et al. (Figure 8 below) to chart factors affecting environmental collaborations between different types of organisations was particularly useful in this respect and the data analysis methodology outlined later in this section draws on many of the concepts contained in the map.[21]

II. Primary Data Gathering

In light of sparse literature and existing data on the topic, the research behind this report focused significantly on the gathering and analysis of primary data. A mixed methods approach was used, targeting both qualitative and quantitative data, to draw on the unique value of both types.

Sampling Strategy

Due to the sparsity of existing literature and data on the topic, it was decided that key stakeholders in heat network development in the UK would be the best sources of data. A purposive sampling strategy was employed, whereby stakeholders were identified as potential data subjects and contacted based on the relevance of their professional experience to the topic. The sampling strategy also sought to achieve representation of a variety of stakeholder types, as shown by Figure 9 below. This was to ensure that the resulting data reflected the topic from a variety of perspectives and offered the most complete picture of the subject matter. However, some priority was given to local government stakeholders given their centrality to the topic.

There was an inevitable degree of convenience sampling too, as the ultimate sample of data subjects was also determined by the pool of stakeholders who were findable, reachable, willing, and able to participate. In practice this led to a degree of 'snowballing' in sampling as well, including getting referrals from data subjects and the research project partner. Willingness and ability to participate are important to note, as the data subject recruitment process required informing them of exactly how their data would be securely handled and obtaining their

17 (Gough et al, 2013)
18 (Moutinho, 2021)
19 (Magnusson, 2011)
20 (Bryson et al, 2006)
21 (Wassmer et al, 2014)

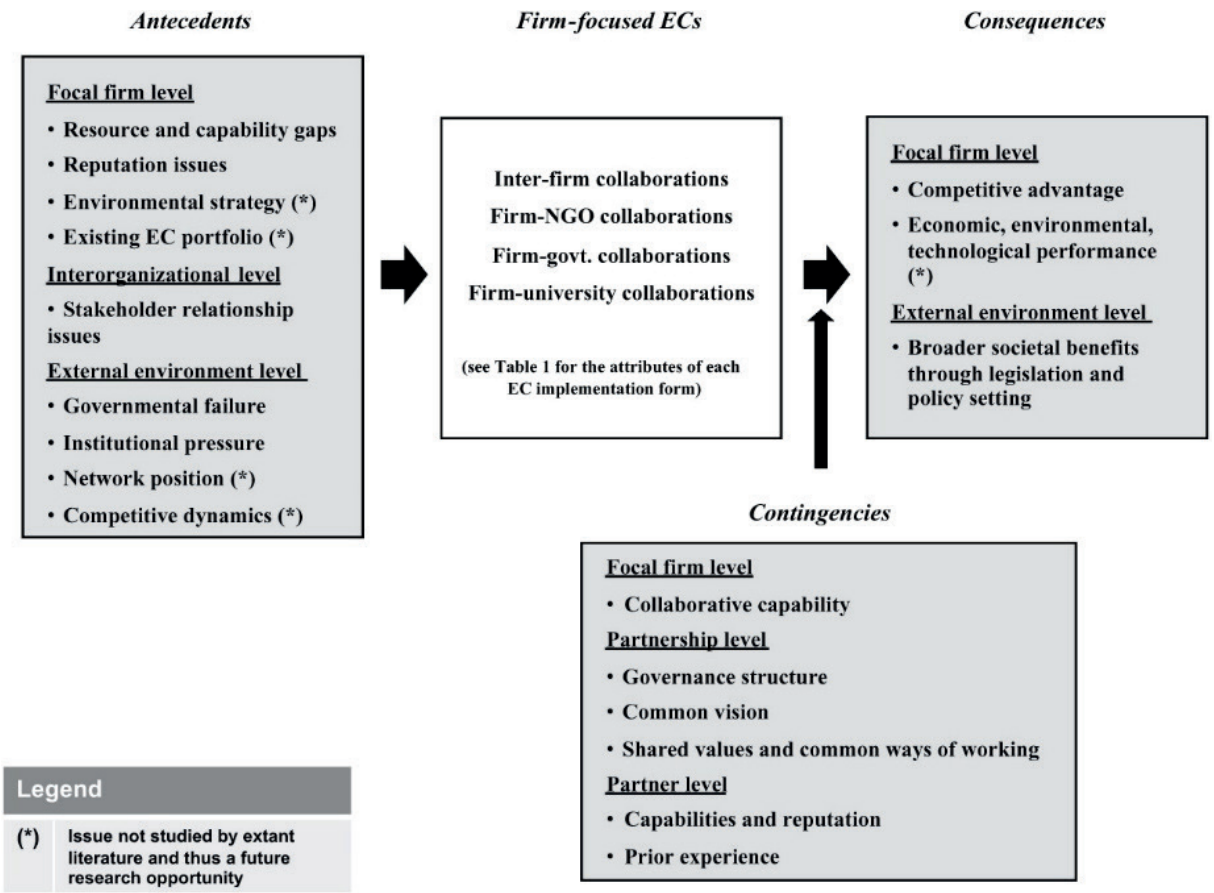


Figure 8 - Conceptual Map for Understanding Environmental Collaborations (ECs) (Source: Wassmer et al., 2014)

consent to this. A total of 20 data subjects were interviewed. See Appendix A for a full summary of the data subjects who formed part of the research.

Data Gathering

The interviews that were arranged with each data subject were designed to gather both qualitative and quantitative data. For the initial qualitative component, a semi-structured approach was used. Each interview followed a standard set of questions outlined in an interview guide (see Appendix D) to create consistency between interviews, but also gave the interviewers license to carry out more free-flowing questioning. This semi-structured approach was motivated by recognition of the different experiences of each data subject, the unique insights from which might not captured in a rigidly structured interview.

Following the qualitative section, the interview process concluded by asking data subjects to express their level of agreement with four statements about the topic (see Appendix D). This level of agreement was recorded on a Likert Scale ranging

Local Government	Business	Associations	Central Government	NGOs	Total
7	4	4	4	1	20

Figure 9 – Overview of Research Data Subjects and Stakeholder Categories

between 1 and 10, enabling the insight of data subjects to be captured quantitatively as well. This data gathering process was purposefully conducted at end of interviews so prior qualitative discussion would allow data subjects to gather their thoughts and give more representative scores of their agreement with the statements. Interviews lasted between 30 minutes to just over 60 minutes and each was recorded and transcribed.

III. Data Analysis

Qualitative Coding

Once the interview transcripts had been cleaned to make them legible and usable, qualitative coding was used to begin the analytic process. The approach to coding contained both deductive and inductive elements.[22] The approach was in large part deductive, as the conceptual frameworks described in the Literature Review Summary were drawn on to create a coding scheme focused on broad themes that affect both the *antecedents* (conditions) and *contingencies* (processes) of cross-authority collaboration on energy infrastructure development. The scheme could then be applied to the transcripts to identify data points relating to those themes.

Coding Scheme Themes

- **Local Energy Needs** of LAs
- **Inherent Difficulties** of developing heat networks
- **Awareness** of opportunities to develop cross-authority heat networks
- **Resources** to initiate and sustain cross-authority collaboration on heat networks
- **Alignment** between neighbouring LAs on initiating and sustaining cross-authority collaboration on heat networks

However, the approach to coding was inherently inductive too, as the final themes selected for the scheme were shaped by issues that had emerged recurrently throughout the data gathering process. Moreover, a final **Uncategorised** theme was added to the scheme to allow interesting data points to be coded for consideration even if they did not fall neatly into one of the other themes. See Appendix C for the details of how the scheme was applied. Lastly, the coding process involved each transcript being reviewed by two researchers. The first would be responsible for fully coding the transcript, while the second acted as a reviewer to help reduce the inherent subjectivity of the task.

Qualitative and Quantitative Analysis

After all the qualitative codes had been aggregated, content analysis in the form of thematic analysis was employed to draw out the key issues in the topic and structure answers to the research questions. This was accompanied by some simple statistical analysis of quantitative data gathered from the interviews, effectively the visualisation of the mean average level of agreement with each of the four statements. To provide a basis for deeper discussion, the thematic analysis was followed by an issue mapping exercise designed to draw out the interconnections between the myriad issues identified by the analytic process.

Formulating Recommendations

With the analytic findings in mind, derivative ideation was employed to generate proposals that built on existing ideas and activities and could help address the issues raised by the analysis.

22 (Asher Consulting, n.d.)

3. Analysis

This section summarises the main findings of the quantitative and qualitative analysis carried out on the primary data. The mean average results of the quantitative survey questions are presented in Figure 10 below and picked up on in the more in-depth summary of the thematic analysis that follows. The findings are structured in accordance with project's Research Questions outlined in the Introduction.

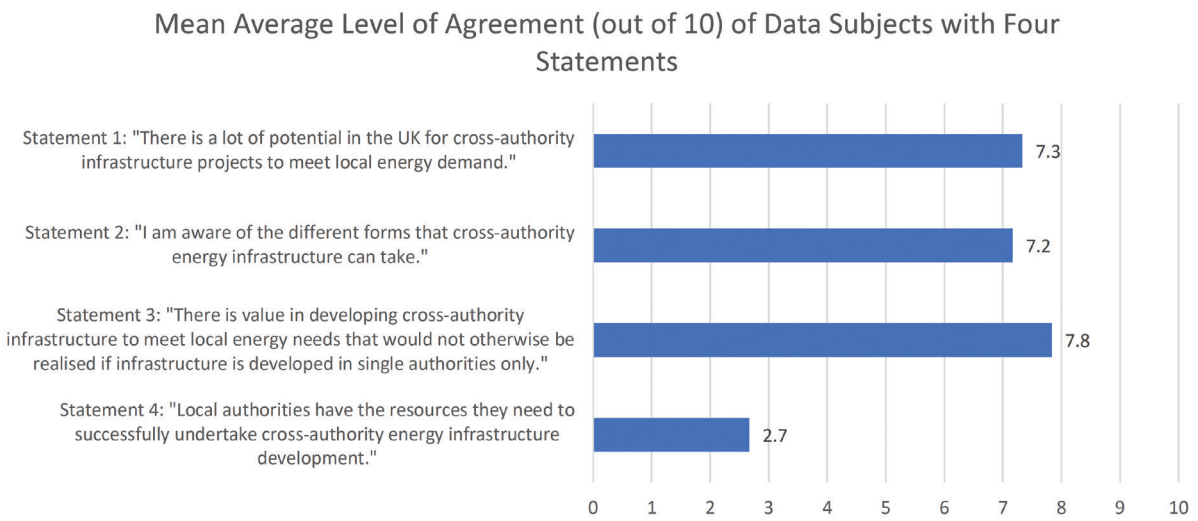


Figure 10 – Statistical Analysis of Quantitative Data

Research Question 1: What are local energy needs in the UK?

This question is addressed primarily from the point of view of organisational stakeholders such as government bodies and businesses, with an emphasis on the perspectives of LAs. Although the point of view of consumers is not addressed explicitly, this is not to say it is not important, but simply beyond the scope of this research project. Although many of the needs outlined below are also concerns at the national level, they constitute distinctly local needs as well because of how many LAs have made commitments to address them at the local level.

Concerning LAs, several interviewees stressed that local energy needs are context-specific and vary between different parts of the UK [18, 22, 72, 88]. However, as suggested by the Introduction of this report, there was a broad consensus among them that **decarbonisation** stood out as the primary local energy need, with each interviewee raising that need in one way or another and some placing emphasis on the decarbonisation of heat and buildings in particular [38, 55, 72].

At the same time, many interviewees mentioned additional energy needs that are also common to many local areas. These needs are considered by many LAs to be of vital importance and must be balanced alongside or integrated into decarbonisation imperatives. Some clear examples include:

- **Upgrading** and **retrofitting** existing (aging) infrastructure [1]
- Ensuring the **cost-efficiency** of energy supplies for taxpayers and consumers [1, 6, 11]
- Combatting **fuel poverty** [1, 11, 38, 55]
- Using energy to stimulate **economic development**, regeneration, and job creation [1]

Research Question 2: Can cross-authority infrastructure help to meet local energy needs?

Interviewees tended to show high levels of agreement with Statements 1 and 3 (the average mean scores being 7.3 and 7.8, respectively) suggesting an affirmative answer to this question. Low carbon heat networks offer excellent examples of why.

The UK emits significant amounts of waste heat that could be put to good use,[23] particularly in cities like London [52, 88]. Types of waste heat sources include transport systems such as the London Underground (see Figure 11 for an example), or waste processing facilities such as incinerators or EfW plants. Those sources may not be co-located with heat demand however, and there may well be greater demand situated in a neighbouring LA. In these situations, capturing that waste heat and channelling it to the adjacent LA via a cross-authority heat network could be a compelling option for meeting local energy needs around reducing the carbon footprint of heat.

Even where they may be no opportunities to neatly match waste heat generation in one LA with demand in another, arguments revolving around economies of scale nonetheless create a rationale for cross-authority heat networks. Echoing points raised in the Introduction of this report, heat networks should be maximised within technical and economic limits to produce the largest efficiencies and deliver the greatest carbon savings and other benefits [55, 88].

Low carbon heat networks demonstrate that cross-authority energy infrastructure can indeed help to meet local energy needs, but it bears mentioning that this point can also be made looking at other types of technology. Another relevant technology that was raised by interviewees was EV charging infrastructure, which can also be developed by two or more LAs to meet local energy needs. The Go Ultra Low West project taking place in the West of England Combined Authority area is a prime example of this [86, 87]. While recognising other technologies, the potential of low carbon heat networks makes them a worthwhile energy infrastructure around which to set the scope of this report and explore issues of cross-authority collaboration.

Research Question 3: Are there existing cases of attempted or complete cross-authority energy infrastructure projects?

Given the relatively high mean level of agreement with Statements 1 and 3, it was quite striking that many interviewees suspected that there would be cases of cross-authority heat networks in the UK but could not claim to be aware of any specific examples when asked [5, 11, 18, 22, 38, 56]. Heat networks that cross LA boundaries appear then to be very rare. The few clearest cases of attempted or complete cross-authority heat networks identified by this research project are summarised in Figure 12 below. For maps and additional detail on the cases, please see Appendix B.

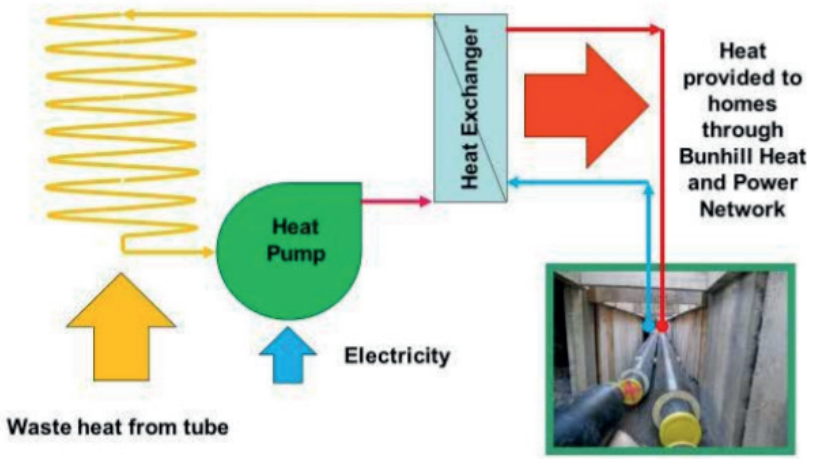


Figure 11 – Diagram of Waste Heat Recovery in the Bunhill Heat and Power Network (Source: Islington London Borough Council - https://www.energyadvice.islington.gov.uk/wp-content/uploads/2020/03/Bunhill-Heat-and-Power-Network-brochure.pdf)

23 (Tolvik Consulting, 2021)

Network Name	Relevant LAs	Notes
London Thames Gateway Heat Network	• Hackney Borough Council • Waltham Forest Borough Council • Tower Hamlets Borough Council • Newham Borough Council • Barking and Dagenham Borough Council • Greenwich Borough Council • Lewisham Borough Council • Southwark Borough Council	At their peak, plans for the network proposed developing infrastructure in all the LAs mentioned left. The project was ultimately abandoned in 2011/2012.
Olympic Park District Energy Scheme (OPDES)	• Hackney Borough Council • Waltham Forest Borough Council • Tower Hamlets Borough Council • Newham Borough Council	Developed for the 2012 London Olympic Games and remains operational.
Lee Valley Heat Network	• Enfield Borough Council • Haringey Borough Council • Hackney Borough Council	Launched in Enfield in 2013, the network is operational and continues to grow. Long-time plans to extend it into Haringey and Hackney have yet to come to fruition.
Bristol Heat Priority Area	• Bristol City Council • South Gloucestershire Council • Bath and North East Somerset Council	An area demarcated by Bristol Council that extends beyond its borders but nominally requires any heat networks developed therein to connect to existing networks in the area. Unclear if this has actually led to cross-authority connections into any of the neighbouring LAs.
Nine Elms Heat Network	• Wandsworth Borough Council • Lambeth Borough Council • Vauxhall Borough Council	Led by Wandsworth Council and is currently under construction, with planned extensions into Lambeth and Vauxhall.

Figure 12 – Cases of Cross-Boundary Heat Network Plans and Projects in the UK

Although there are valuable opportunities for cross-authority heat networks, and that they are likely to become more apparent as heat network deployment advances, for now they remain uncommon. This rarity raises the question of whether cross-authority collaboration on heat networks is even being explored and initiated in the first place, never mind the issues that such collaboration may encounter once it is underway. Returning to the conceptual frameworks raised in the Methodology section, this suggests that there are issues with the *antecedents* of collaboration as much as the *contingencies* of collaboration itself.

Research Question 4: If cross-authority infrastructure can help to meet local energy needs, why has it been successful or unsuccessful? If it has not even been attempted, why is that?

The answer to this question contains the findings of the content analysis, structured according to four themes of the original coding scheme.

I. Inherent Difficulties of Heat Networks

This theme brings together issues that reflect how heat networks are a challenging piece of infrastructure to develop in themselves, a characteristic that can deter LAs from pursuing them within their own local area,[24] let alone in collaboration with a neighbouring LA. The issues of this theme particularly affect the *antecedents* of collaboration, as they can compel LAs and their development partners to reduce the number of parties involved in a heat network project (including neighbouring LAs) in a bid to simplify the project and increase the prospects of successful delivery.

	Issues	References
1	**Financing** • The high costs of developing heat networks can make them unattractive to LAs whose budgets are often stretched. • Accessing capital to finance a heat network requires identifying and making a good business case, which can be difficult even where a network might be technically feasible. • Financing is available from the central government (e.g. HNIP) for a variety of development activities (ranging from feasibility studies to capital expenditure) where the business case can be made, but that financing can be difficult to apply for and use (e.g. short time windows to apply for and spend grants).	[5, 10]
2	**Physical Barriers** • Geophysical conditions such as terrain can make heat networks challenging to build. • Existing infrastructure can create physical complications (e.g. disruptions caused by running heat pipes under railway lines or retrofitting them to existing housing stock).	[1, 5, 10, 11, 18]
3	**Technical Standards** • A general lack of mandatory technical standards means heat networks can be built to different technical specifications. Technical incompatibility between two networks can make interconnection a non-starter, even when they sit within the same LA. • Rising environmental performance standards (e.g. SAP emissions standards) can make some heat network technology unviable.	[10, 11, 38, 52, 72]

24 (Quantum Strategy & Technology, 2021)

4	**Customer Baseload** • Securing a sufficiently large baseload of customers to make a heat network economically viable can be difficult. • Even if a suitable baseload exists, obtaining buy-in from potential customers can be challenging, particularly given cultural preferences for solutions that offer the customer greater individual control over their heating (namely individual gas boilers).	[6, 62]
5	**Heat Supply** • The stable, long-term supplies of heat needed by heat networks can be challenging to find or develop. • Where a substantial waste heat source exists, it can be difficult for public actors to procure it because it is virtually impossible for them to meet public procurement requirements around opening a competitive tender for that heat.	[5, 52]
6	**Development Market** • The market for heat network design and construction services remains underdeveloped in the UK, meaning companies capable of delivering large networks are few in number. • Although new housing developments are much easier candidates for heat networks than existing housing stock requiring disruptive retrofits, housing developers are generally averse to including heat networks in their plans due to their inherent difficulties.	[1, 10, 11]

Figure 13 – Issues Affecting Cross-Authority Heat Network Development relating to the Inherent Difficulties of Heat Networks

II. Awareness

Even if the inherent difficulties of heat network development can be overcome, neighbouring LAs may not be aware of opportunities for cross-border networks. The theme of awareness raises issues that also mostly affect the *antecedents* of collaboration, because if two LAs are not aware that there is an opportunity to develop a heat network across their borders, they are unlikely to initiate a collaboration in the first place.

	Issues	References
1	**Awareness of Opportunities** • It is uncommon for LAs to have conducted the sort of comprehensive heat mapping that reveals heat network opportunities. • Even where heat mapping has been carried out by an LA, it may not have necessarily looked beyond its boundaries for cross-authority opportunities.	[1, 6, 10, 11, 55, 56 ,72, 76]

2	**Data Gaps** • Even where the financial and human resources have been assembled for heat mapping, finding or generating the necessary data (e.g. heat consumption/demand data) can still be very challenging.	[11, 76]
3	**Perception of Opportunities** • Heat networks are best suited to areas with high building density, which are normally situated at the centre of LAs rather than on their borders. This geographic pattern means that LAs understandably may not even contemplate the possibility of developing a heat network at their border and beyond.	[5, 22 ,52, 56]

Figure 14 – Awareness-Themed Issues Affecting Cross-Authority Heat Network Development

III. Resources

In a scenario where neighbouring LAs are aware of a cross-border heat network opportunity, they may nonetheless struggle to start and sustain collaboration because they lack the capacity to do so. Issues under the theme of resources undoubtedly affect heat network development in general, not only cross-authority cases. However, insight gathered from interviewees suggested that the resources required to develop a cross-authority heat network would be an order of magnitude larger than those needed to develop a network of the same size within a single LA. Combined with the very low mean average level of agreement of interviewees with Statement 4 (a score of 2.7), the data suggested that the ways in which resources affect both the *antecedents* and *contingencies* of collaboration merited special attention.

	Issues	References
1	**Internal Expertise** • Funding constraints mean LAs often lack permanent staff dedicated to energy issues, including exploring and sustaining heat network collaborations. • Even in LAs where there is enough resource to staff energy officers, they are often stretched across a broad range of responsibilities (from paying the LA's own energy bills to addressing fuel poverty). The result is that those officers may not be able to focus on heat network development and cross-authority collaboration. • The process of heat network development, although long, means internal expertise is deeply valuable to an LA that is undertaking a project, but may be deemed too expensive to retain once the project is complete. • An LA may be able to bring in internal heat network experts, but collaboration would be greatly facilitated if there was a level of heat network 'literacy' in important non-energy departments (e.g. legal, procurement e.t.c.).	[1, 5, 6, 10, 28, 56, 59, 72, 76]
2	**External Expertise** • The implications of an underdeveloped market for heat network design and construction services are exacerbated for cross-authority projects. This is because such projects are likely to be large-scale, meaning the LAs involved cannot rely on a competitive market with plenty of options to meet their needs.	[38, 59, 72]

3	**Initiative** • Given the non-statutory status of energy, whether resource is allocated to energy and heat networks is often related to whether the LA has internal stakeholders who are willing to 'champion' the issue and make it a priority. These stakeholders can be officers within the LA, but more senior stakeholders (particularly elected officials) are often vital in advancing heat network projects within and across its borders.	[1, 5, 10, 31]
4	**Funding** • The statutory requirements of LAs relating to energy only go as far as supplying energy to their own estate. This means that once budget has been allocated towards statutory duties like waste management and social care, there is often little left over for the LA to spend on energy programmes. The non-statutory status of energy means that spending on energy is often quick to dry up in the event of budget cuts. • Besides the implications for Internal Expertise mentioned above, funding issues mean LAs often cannot rely on their own financial resources to bear the capital expenditure required for cross-authority heat network development.	[1, 5, 10, 11, 18, 22, 38, 52, 55, 59, 76]

Figure 15 – Resource-Themed Issues Affecting Cross-Authority Heat Network Development

IV. Alignment

Even if neighbouring LAs can marshal the resources to initiate and sustain a collaboration over a viable cross-border heat network, issues of alignment between the participating LAs can become obstacles. Much like resources, issues relating to this theme can affect the *contingencies* upon which collaborative processes depend but can also shape the *antecedents* in ways that deter the LAs from even initiating a collaboration in the first place.

	Issues	References
1	**Physical and Technical Compatibility** • While one LA may have the physical foundations for a heat network (e.g. heat supply or demand) located near its border, its neighbour may not have the physical foundations on its side of the border to match and create a valuable opportunity for both parties. • Problems of technical incompatibility affecting the interconnection of adjacent heat networks may be exacerbated in cross-authority scenarios by some of the Policy alignment issues below.	[5, 22 ,52, 55, 56]

2	**Policy & Governance** • Differences between the ownership/management/governance of networks across neighbouring LAs can make interconnecting those networks across their shared border difficult. A related issue is how to address the ownership/management/ governance of a network once it has extended out of its original LA and into a new one. • There is little policy from the central government setting out a plan for heat network development across the UK and the role of LAs therein, much less any policy encouraging LAs to collaborate on the topic. • Political differences between neighbouring LAs may make it harder to collaborate and can even encourage competition. All the interviewees referenced right pointed out that this need not necessarily refer to party political differences, but even simply disagreements over policy priorities. • The legal responsibility LAs have to their own residents means they understandably focus on their own jurisdiction and cross-authority collaboration doesn't always enter their mindset. • Varying planning policies across neighbouring LAs can affect their willingness to prioritise coming together on a cross-border infrastructure project like a heat network. At worst, housing developers, who are generally averse to building heat networks to begin with, play the planning policies of different LAs off one another to secure the easiest conditions for development and avoid building heat networks altogether. • Planning and policy cycles are rarely aligned between LAs, making it hard for neighbouring LAs to find the right time window to come together and collaborate on projects. • Election cycles can cause people and priorities in LAs to shift, making it hard to create the long-term stable ground which heat network collaboration would require.	[1, 5, 10, 11, 18, 22, 38, 52, 55, 72]

Figure 16 – Alignment-Themed Issues Affecting Cross-Authority Heat Network Development

4. Discussion

Systems Thinking and the Issue Space

Already during the data gathering process it was anticipated that many of the issues drawn out in the thematic analysis would be interrelated. These inferences were supported by a few interviewees, who underscored the importance of a systems approach to any energy-related topic [18, 52, 72]. It was further emphasised that considering issues in isolation would lead to an oversimplified and unrealistic understanding of the issue space. Systems thinking can act a language through which the complexities and associations of large strategic problems such those addressed by this report can be better communicated.[25]

By drawing on ideas from the field of systems dynamics, including the principles of its analytic methods such as casual loop diagramming and systems mapping,[26] this section explores the connection between the various issues identified. Figure 17 below is not exhaustive in that is does not address every single issue raised in the earlier Analysis section. Rather, it is intended to draw attention to the issues, and groupings of issues, that are most interrelated. The arrows indicate an increase of the factor that the arrow originates from and the colour signals whether that will support or oppose the recipient factor. The colour of the boxes denotes the themes into which the issues fit.

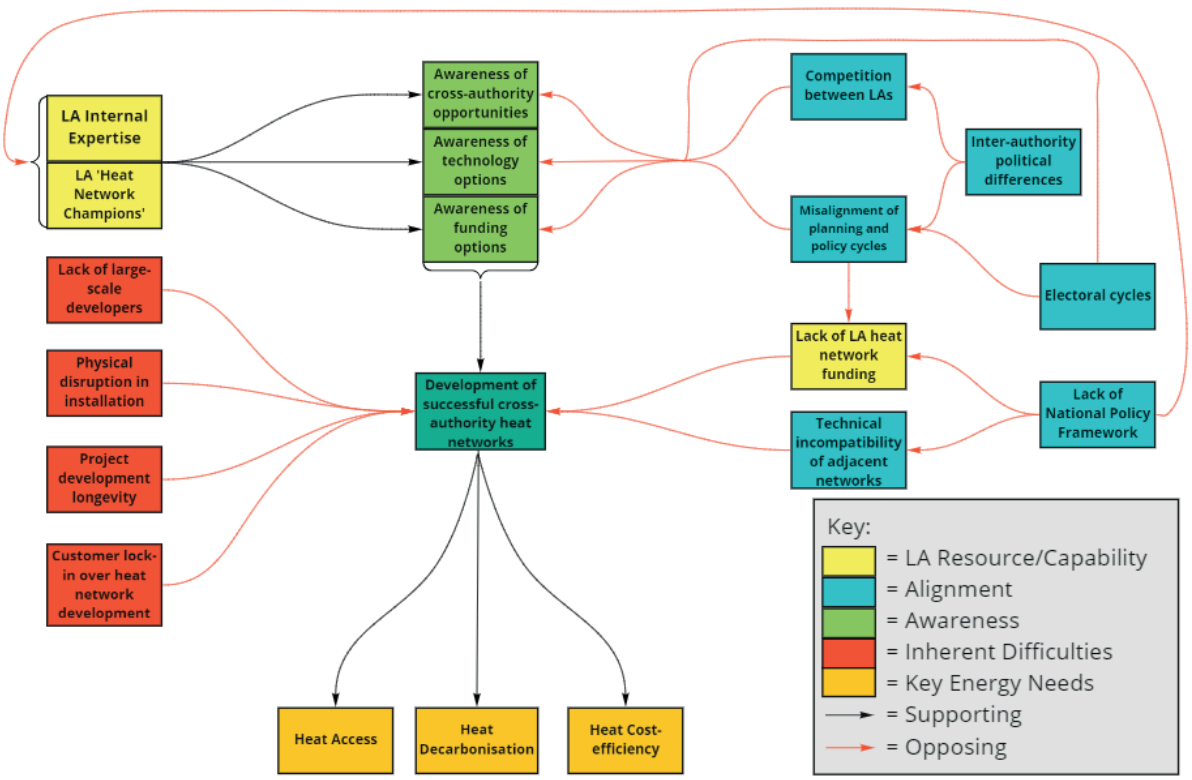
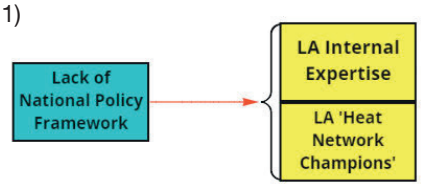
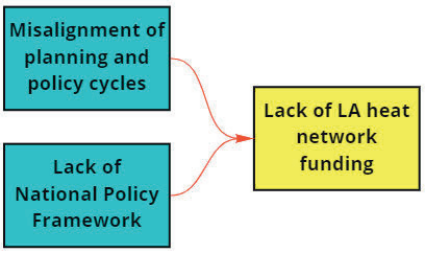
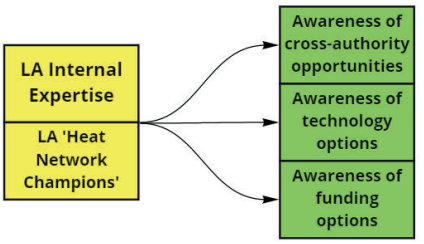
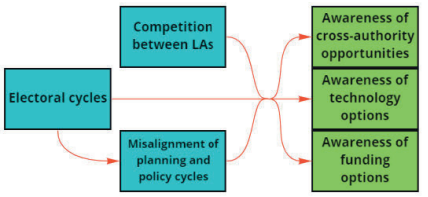


Figure 17 - System Map of the Relationships between Issues that Affect the Development of Successful Cross-Authority Heat Networks

25 (HM Treasury, 2020)
26 (Kim, 1999)

Key Issue Interrelationships

Issue Relationship	Relationship Explanation
1) 	In the absence of a mandate for LAs to decarbonise heat, many have scaled back relevant programmes due to budget cuts [5, 6]. Human resources have been preserved for or diverted towards their statutory duties. Therefore, there is a lack of policy drivers in place to make a step change in LA resource allocation to heat decarbonisation and cross-authority heating projects [22].
2) 	A similar relationship applies to the allocation of funding for cross-authority heat network capital expenditure, as without a national policy framework to mandate and support investment, the capacity of LAs to invest in such projects is lacking [11, 55]. It has also been noted that the misalignment of working cycles between LAs and central government often mean the former struggle to prepare applications for funding support when it becomes available [10]. These relationships, alongside the previous Relationship 1), show how alignment issues can impact other resource related issues.
3) 	Resource factors impact awareness in various ways. With dedicated in-house expertise generally lacking across LAs, awareness of the opportunities for cross-authority heat networks, along with viable technology options, is harder to achieve [10, 56]. This can manifest as a lack of awareness in relation to the landscape of nearby projects and the technical feasibility of connecting adjacent networks [10]. Finally, without internal expertise, local authorities are more likely unaware of potential avenues for funding [10].
4) 	These same awareness issues can further be impacted by multiple alignment factors. As business cycles (e.g. planning cycles, budgetary cycles) can easily misalign between local authorities, time windows for collaborative working are often limited [5, 10, 38]. These short windows reduce chances for LAs to become aware of opportunities for cross-border collaboration. Electoral cycles limit these chances further by creating a need to reinform possibly uninformed incoming councillors [5, 11]. These awareness factors can be worsened by a competitive mindset sometimes held between LA that engenders a reluctance to consider collaboration [5, 6].

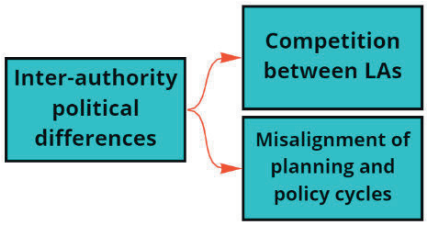
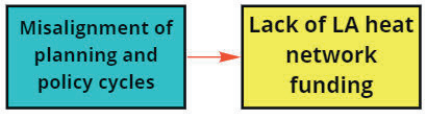
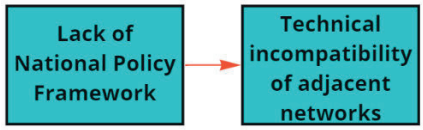
5) 	Political differences between adjacent councils can make them reluctant or even unwilling to work with each other [1, 5]. Political differences can foster inter-authority competition and further misalign planning cycles by reducing communication between those councils.
6) 	The issues raised in Relationship 2) could be exacerbated by misalignments in working cycles between LAs, in addition to their own misalignments with central government. A cross-authority heat network project may well require multiple LAs to collaborate on the preparation of grant applications. If one of the LAs involved is not in a position where it can prepare its part, funding for the overall project may prove elusive [10]. In this sense, this alignment issue impacts funding as a resource for cross-authority heat networks.
7) 	There is a present risk that developers of adjacent networks are not aligned as technical compatibility is not mandated under any national framework [10, 11]. Incompatible networks are more challenging to integrate with one another, limiting future network expansions and therefore reducing opportunities to capitalise on economies of scale.

Figure 18 – Key Issue Interrelationships Affecting Cross-Authority Heat Network Development

Implications for Recommendations

The interrelated nature of the issue space makes it clear that untangling and tackling issues in isolation is unlikely solve the overarching problem. Rather, proposed solutions should seek to tackle as many of the themes and issues as possible simultaneously. Moreover, interventions should generally look to affect the conditions and processes of collaboration over time, giving ample opportunity for monitoring, evaluation, and modification.[27] In sum, interventions should look to constructively change the issue space and system overall.

27 (Madden & Ohlson, 2020)

5. Recommendations

Research Question 5: What solutions could be put forward to improve cross-authority collaboration on local energy infrastructure?

By way of an answer to the final research question, this section proposes recommendations primarily with LAs in mind while recognising the variety of stakeholders involved in the topic. In effect, the recommendations relate to what LAs can do to help themselves as well as influence other stakeholders like central government and business to improve the conditions for initiating and sustaining cross-authority collaboration in heat network delivery.

Although the inherent difficulties of heat network development are an obstacle to cross-authority collaboration, there is already literature dedicated to addressing these issues.[28] For example, the challenge of securing customer baseloads is certainly connected to the lack of heat network regulation in certain parts of the UK. If market regulation were introduced to create consumer protections (either via an existing agency such as Ofgem, or a new independent body), it would no doubt improve consumer confidence in heat networks and facilitate getting buy-in from customers to form a baseload for a network.[29]

These recommendations seek to address the issues that are more unique to cross-authority heat network development. Due to the breadth and depth of the relevant issues, addressing them all fully would likely involve investigating topics well beyond heat network development. These recommendations focus instead on coherent and practical sets of action that LAs can take to overcome barriers to cross-authority collaboration on heat networks. Continuing the systems approach of the previous section, the proposed recommendations are designed to address multiple themes and issues simultaneously and create the greatest positive change to the overall issue space.

I. Long-Term Action

LAs should lobby the central government and their respective devolved governments to create overarching frameworks for heat network development that mandate the exploration of cross-border opportunities and provide the resources to do so.

Nation	Current/Upcoming Policy
England	Zoning Strategy
Scotland	Secondary Legislation for the Heat Networks (Scotland) Bill and LHEES Pilot Schemes
Wales	Regional Energy Planning

Figure 19 – Relevant Ongoing Energy Policy Development Initiatives

The central government and devolved governments around the UK already have ongoing policy development initiatives around energy planning that cover heat network deployment, as listed in Figure 19 above. Many of these initiatives consider ‘zoning’, which is the process of designating specific types of infrastructure for a given ‘zone’ according to its characteristics. For example, it is more likely that urban areas with high building density would be zoned for heat networks, while less built-up areas might be zoned for individual domestic heat pumps.

It would be advisable for LAs to capitalise on these ongoing initiatives by lobbying to shape their development in ways that improves conditions for cross-authority collaboration. Some of the specific requests LAs could make and how they could affect the themes explored thus far are as follows.

28 (Quantum Strategy & Technology, 2021)
29 (Heat Trust, 2019)

Statutory Duties for Heat Mapping and Zoning (Awareness)

- **LAs could advocate that upcoming policy should create statutory requirements for them to conduct heat mapping and zoning within and beyond their individual boundaries, thereby improving their awareness of cross-border heat network opportunities.**
- **A similar outcome could be achieved by directly requiring LAs to collaborate on heat mapping and zoning across larger areas beyond their individual jurisdictions. Combined authorities could be responsible for this where they exist.**

These recommendations have particular relevance for English LAs. In 2020, the central government committed to implementing LA zoning in England by 2025,[30] and a consultation on this policy is imminent [55]. While proposals on this policy have been put forward by stakeholders in the heat network sector,[31] there is uncertainty about the final form that a zoning strategy could take. However, among the interviewees who raised this topic, there was a consensus that that while there should be a clear framework at the national level, the actual execution of zoning should be left to LAs to better capitalise on their local expertise [31, 59]. If the government's zoning strategy eventually takes this form and LAs are to be given responsibility for zoning anyway, then the recommendations above on expanding that responsibility to consider cross-border heat networks becomes highly advisable.

Support for the Fulfilment of New Statutory Duties (Resources)

- **LAs should advocate that any new duties placed upon them because of new heat network policy should be accompanied by the funding needed for them to carry out those duties. This would improve LAs' access to the resources needed for cross-authority heat network development.**

The LHEES pilots in Scotland offer a useful basis for this recommendation. At the conclusion of the second phase of pilots, where numerous LAs made their first attempt at developing these new heat strategies, there was broad support among the LAs involved for making the future development of LHEES a statutory duty. However, the participants also made clear that fulfilling this duty effectively would benefit from additional resources, such as having officers within their LA dedicated to the task.[32]

The LHEES pilots showcase the importance of internal expertise and highlight how heat network development frameworks should offer this resource to LAs. This was a recurring point among interviewees, who stated that LAs would rather have more internal expertise among their own staff [1, 5, 6, 10, 28, 56, 59, 72, 76]. The ultimate outcome of this recommendation should not be that LAs end up with sufficient internal expertise to replace expertise they have typically drawn from external organisations like consultancies. Rather, greater internal human capital would help LAs become more 'intelligent customers' when working with external experts and obtain greater value from their services.

In any case, requests for support to be included in upcoming heat network policy should also make clear that support should be available for the full range of activities that LAs should be required to undertake. For example, the new GHNF Transition Scheme supports low carbon heat network development in England, but only in the form of financing for commercialising pre-identified opportunities.[33] For LAs to fulfil requirements that would identify cross-authority opportunities in the first place, additional funding may be needed for activities such as heat mapping, zoning, and feasibility studies. LAs could advocate that pools of funding available from existing relevant bodies, such as the HNDU, could be expanded for these purposes, or new sources of funding be created.

30 (BEIS, 2020)
31 (ADE, n.d.)
32 (Wade & Webb, 2020)
33 (BEIS, 2021)

Frameworks for Zoning and Heat Network Deployment (Alignment)

- **LAs should advocate that these upcoming policies mandate heat networks under the right conditions, which would help bring neighbouring LAs into alignment on heat networks and cross-authority opportunities.**
- **The request above could go one step further by mandating the development of cross-authority heat networks specifically where they are shown to offer greater value than developing separate networks. This could involve requiring new networks to connect to nearby existing ones, even if there is a LA boundary between them.**
- **LAs should also advocate that zoning frameworks set out technical standards for the heat networks they mandate.**
- **LAs could further advocate that zoning frameworks should set out requirements for community consultation to form part of the zoning process.**

If previous recommendations are intended to give LAs new duties to map and zone for heat networks (along with the resources to do so), then this package of requests is intended to remove alignment barriers to collaboration when cross-border opportunities are discovered. If zoning creates a mandate for specific types of energy infrastructure to be developed where they are most suitable, heat network development should take place where it is most appropriate (particularly for new build domestic and commercial properties), even if it is across LA boundaries and requires collaboration.

Zoning frameworks should specify the technical standards for heat networks to be developed where zones dictate. This would reduce the risk of networks being developed in adjacent LAs that then turn out to be technically incompatible and unable to interconnect in the future. This would also help harmonise LA procurement standards with regards to heat network services and would create simplified and clearer conditions for authorities to collaborate.

The final point about community consultation requirements is an important one, as it could help mitigate misalignment between LAs caused by political differences and electoral cycles. If LAs consult their residents as part of their zoning, it creates the opportunity to educate residents on technologies such as heat networks and get buy-in to their deployment. If residents on both sides of an LA boundary express support for a heat network, it creates a democratic mandate to develop one and creates alignment between the relevant LAs on doing so. This mandate can create a stable basis of alignment even in the face of political differences on other issues and changing priorities brought on by election cycles.

In sum, the recommendations for long-term action involve LAs bringing the aforementioned requests together when lobbying the central and devolved governments on their ongoing policy initiatives around energy planning. This lobbying should ideally result in stronger overarching frameworks for heat network development. These frameworks should evolve over time to account for technological and policy developments; a responsibility that could be assigned within BEIS or to a new independent body altogether. Regardless of future updates however, the frameworks should provide better and more stable conditions for cross-authority collaboration on heat networks.

II. Short-Term Action

LAs should engage with existing organisations already looking at heat network development to get cross-authority collaboration on their agendas and leverage their resources to facilitate collaboration.

Although the recommendations made thus far have the potential to drive significant improvement, those changes would likely only be felt in the long-term. Many of the ongoing heat network policy initiatives that could be influenced to produce the frameworks needed for cross-authority collaboration may require years to be completed. For example, the deadline for the central government to fulfil its commitment on zoning in England is as far away as 2025. The following short-term actions constitute recommendations for what LAs can do immediately to begin improving cross-authority collaboration in the interim while higher-level frameworks are developed.

These recommendations revolve around existing organisations that are partially or wholly focused on heat network development. The organisations below already offer support to LAs as part of their activities

and some were set up for the express purpose of doing so. Some organisations have small costs associated with their support (such as membership fees) while other are entirely free to use.

Organisation	Resources
Energy Hubs	Offer technical advice.
Heat Networks Delivery Unit (HNDU)	Part of BEIS, offers advice and funding for pre-commercialisation activities.
UK District Energy Association (UKDEA) Local Authorities Forum	Political advocacy and information-sharing platform.
Energy Systems Catapult	Offers planning guidance (especially its Local Area Energy Planning methodology) and other resources.
Centre for Sustainable Energy	Support for community-led energy projects.
Association for Public Service Excellence (APSE) Energy	Part of the APSE, offers resources of its own and acts as a platform for information sharing.
Heat Networks Industry Council (HNIC)	Represents relevant stakeholders in conducting advocacy towards government.
Association for Decentralised Energy (ADE)	Political advocacy and information-sharing platform.
Local Government Association (LGA)	Political advocacy and information-sharing platform.

Figure 20 – Existing Organisations Active in Heat Network Development

It would be advisable for LAs to make the most of these existing resources by getting cross-authority collaboration on the agendas of these organisations. Some of the specific ways in which LAs could engage and how they could affect the themes explored thus far are as follows.

Identifying Cross-Authority Opportunities (Awareness)

- **LAs should inform these organisations of their heat network plans, allowing them to develop a better strategic overview of heat network development across the UK. With this overview, these organisations would be better able to spot opportunities for cross-authority heat networks and improve the awareness of the relevant LAs about those opportunities.**

The GLA is a good example of an organisation that is already performing this function. Due to its strategic overview of all the boroughs of London, it acts as a city-wide repository of knowledge on heat network development plans. That way, when the GLA is approached by a borough council looking to pursue heat networks, it can point the council to networks in neighbouring boroughs that could offer opportunities for cross-border interconnection [6].

Research on Cross-Authority Collaboration (Resources)

- **LAs can tap the resources of these organisations by asking them to investigate the topic of cross-authority collaboration on heat network development. These organisations could investigate the topic in a general sense or apply their resources to exploring concrete opportunities presented to them by LAs.**

To make up for the shortfall in internal heat network expertise they often experience, LAs can engage with these organisations to expand the pool of resources they can assemble for exploring the topic. Organisations like the Energy Hubs, HNDU and the Energy Systems Catapult already work with LAs on activities such as heat mapping and feasibility studies. This recommendation would be to simply expand the scope of their support to consider cross-authority opportunities.

Information-Sharing Forums (Alignment)

- **LAs can use these organisations as networking platforms and forums for building consensus around the importance of cross-authority collaboration and how to achieve it. A space for inter-authority dialogue on these subjects could help drive the alignment needed for cross-authority projects to proceed when opportunities arise.**

Acting as platforms and forums, these organisations could foster alignment in a variety of ways. As a venue for consensus-building, they could bring neighbouring LAs together in agreement on the importance of cross-authority collaboration on heat networks despite political differences they may have. This would likely lead to greater harmonisation of planning policy between those LAs and lay stronger foundations for cross-authority heat networks.

As a dedicated space for dialogue, these organisations could also create a window of opportunity for neighbouring LAs to discuss heat network plans and counteract the effects of misaligned planning and policy cycles. This could in turn set up the vital discussions on the ownership, management, and governance structures of potential cross-boundary networks; the outcomes of which could be disseminated among LAs in the pursuit of best practice for these issues.

In sum, the recommendations for short-term action involve LAs engaging with existing organisations to leverage them as a resource for improving cross-authority collaboration on heat networks. The organisations mentioned as part of this section will be better equipped to respond to some recommendations than others, but their current work on heat networks makes them an ideal place for LAs to start.

III. Collaboration Opportunities and Formats

LAs contemplating cross-border heat network development should consider the opportunities and formats for collaboration identified by this report as a starting point to initiate collaborative efforts and further mitigate key issues.

Given that cross-authority collaboration on heat networks is rare and the issues analysed in this report strongly affect the *antecedents* of collaboration, the recommendations presented thus far correspondingly focus on improving the conditions for collaboration. However, while there is a clear need to enable and so increase the 'quantity' of collaboration, it would be remiss to neglect the *contingencies* and 'quality' of that collaboration when it does occur.

Where the conditions are favourable and neighbouring LAs find themselves able and willing to collaborate on a cross-border heat network project, this final set of recommendations is intended to offer ideas to those LAs on possible opportunities and formats for collaboration. By making suggestions on what LAs can work together on and how, these recommendations are designed as a starting point to inspire discussions on how they can proceed. Moreover, the opportunities and formats have been proposed on account of how they can modify the effect of certain issues, thereby further reducing barriers to collaboration and improving the quality of the process.

In the Introduction of this report, Figure 7 depicts heat network development as a process and points to opportunities along that process through which neighbouring LAs could collaborate. Those opportunities have been isolated in Figure 21 (below) and form the basis of the following recommendations. Each opportunity is accompanied by different formats the collaboration could take (in **bold**) and how they combine to further mitigate the issues raised in the Analysis section.

1: Neighbouring LAs could establish **formal partnerships** or simply have **informal discussions** to reach agreement on how to prioritise heat networks in their respective planning activities. This would improve policy *alignment* between those LAs, making it easier to start projects where there is a good business case and reducing the ability of developers to play the planning policies of neighbouring LAs off

1: Neighbouring **Local Authorities** could come together to harmonise how their *Plans* approach heat networks

2: Neighbouring **Local Authorities** could partner to conduct cross-border heat mapping or a *Feasibility Study*

3: Neighbouring **Local Authorities** could create a formal procurement partnership to contract a **Developer** for a cross-border network.

4: Neighbouring **Local Authorities** could establish a joint-venture (likely including a **Developer**) to develop a cross-border heat network

5: Neighbouring **Local Authorities** could establish joint-ventures to **Operate** a cross-border heat network.

Figure 21 – Opportunities for Cross-Authority Collaboration on Heat Network Development

one another in a bid to skirt heat networks altogether.

2: Neighbouring LAs could partner to carry out cross-border heat mapping or feasibility studies to raise their *awareness* of possible heat network opportunities. The LAs could **share staff** or **jointly commission** a consultancy for the task, pooling and making better use of their *resources*.

3: Neighbouring LAs could use **formal partnerships** to build on the ideas in Opportunity **1** and create agreement on what they would expect heat network developers to deliver and harmonise the procurement standards they would use to select prospective developers. This could create better technical *alignment* between the LAs by ensuring networks developed in their respective areas meet the same technical standards and are easier to interconnect across boundaries as a result.

Opportunities **4** and **5** are best discussed together because of how the format of a **joint venture** can be used to act on both in a way that addresses thorny issues of *alignment* relating to how cross-border heat networks should be governed, owned, and operated. Figure 22 below illustrates how this format can address these issues.

In this hypothetical scenario, a **special purpose vehicle (SPV)** is created to develop, own, and operate the cross-border network. Having these responsibilities fall to a single entity is important, as this allows it to take decisions more quickly and act with greater agility in the everyday management of the network [88]. However, as the **SPV** is a **joint venture** co-owned by the relevant LAs, they remain closely involved in the governance of the network. Using **steering committees**, for example, the LAs can regularly adjust the long-term strategy and direction of the **SPV** to ensure it continues to meet their energy needs.

Although the research underpinning this report found no examples of this format applied to heat networks specifically, the use of joint ventures to enable cross-authority collaboration on energy infrastructure is not without precedent. The NESS Energy Project in Aberdeen, for example, is a joint venture involving three neighbouring councils to deliver an EfW plant that will serve all three LAs [76]. A similar model could conceivably be applied to future heat networks.

Additionally, the experiences of existing cases of cross-authority heat networks highlight reasons

to encourage LAs to explore joint ventures as a format for collaboration. Both the Thames Gateway Heat Network and the OPDES in London were cases in which a single entity took the leading role in developing the cross-border heat network and coordinating the relevant LAs (the LDA and the LLDC, respectively). However, this model did not guarantee smooth cross-authority collaboration, as the level of support for the projects could vary widely between the participating LAs [52]. A joint venture, conversely, could shift this leading role to the LAs themselves. By transferring this responsibility to the participating LAs, the format of a joint venture could create a greater sense of project ownership among the LAs and help drive the alignment needed to see the cross-authority heat network through in the long-term.

These recommendations of opportunities and formats for collaboration will not be equally relevant in every case and neighbouring LAs are advised to consider which ones would best suit their specific context. Similarly, they are not exhaustive, and there may well be other opportunities and formats for collaboration that arise when heat networks are explored. Rather, this final set of recommendations are intended as a basis for initial discussions between neighbouring LAs, who can use the ideas they contain to initiate and lay the foundations for smooth cross-authority collaboration on heat networks.

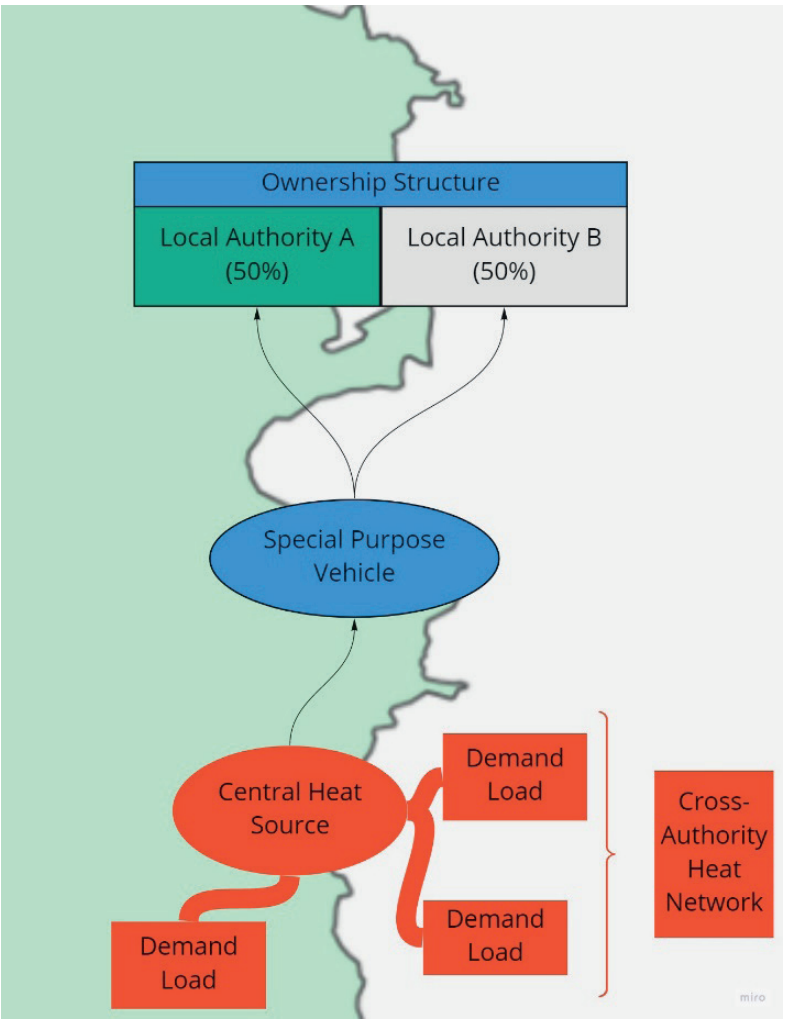


Figure 22 – Schematic of a Cross-Authority Heat Network managed through a Joint Venture

6. Conclusion

Although the detail presented in previous sections adds valuable nuance, the key findings and insights of this report can be summarised as follows.

- Low carbon heat networks are an integral solution for meeting local energy needs in the UK, particularly around reducing GHG emissions from heat.
- Capturing the greatest benefits from heat networks, by maximising their size or matching heat supply with demand, will likely involve developing them across LA boundaries.
- LAs are well-positioned to lead on heat network development, including the necessary cross-authority collaboration.
- Despite this potential and a growing need for cross-authority collaboration, there are very few cases cross-border heat networks in the UK. Evidence suggests LAs face barriers to even initiating cross-authority projects, as well as sustaining and completing them.
- Many of these barriers have to do with 1) the inherent difficulties of developing heat networks, but themes which are more specific to cross-authority collaboration itself relate to 2) awareness of opportunities, 3) the resources to find and act on those opportunities, and 4) the alignment needed between LAs to form the necessary basis for collaboration.
- Recommended action which LAs can take to improve the conditions and processes of cross-authority collaboration could include:
  - In the long term, lobbying the central government and their respective devolved governments to create overarching frameworks for heat network development that mandate the exploration of cross-border opportunities and provide the resources to do so.
  - In the short term, engaging with existing organisations already looking at heat network development to get cross-authority collaboration on their agendas and leverage their resources to facilitate collaboration.
  - For LAs contemplating cross-border heat network development, considering the opportunities and formats for collaboration identified by this report as a starting point to initiate collaborative efforts and further mitigate key issues.

While this report aims to provide comprehensive coverage of its topic, the time and resource constraints that placed certain limitations on the underlying research should be addressed. The most significant constraints relate to the reliance of the research on gathering new primary data for analysis. In view of a lack of literature and existing data on the topic, the research was dependent on the accessibility, availability, and willingness of relevant data subjects. More time and greater access to a wider pool of these subjects may well have opened new analytic possibilities. For example, interviewing additional data subjects who were familiar with the cases of cross-boundary heat networks mentioned by

this report may have generated the data needed for more in-depth case study analyses. Similarly, a larger sample size could have offered better opportunities for quantitative analysis, such as getting a better picture of what proportion of LAs have conducted heat mapping, for example.

Putting data subject issues aside, time constraints placed additional limitations of their own on the analytic process. More time would have allowed for the application of more sophisticated analytic methods to the data at hand. Methods that were considered but ultimately could not be used included adding layers to the thematic analysis (such as cross-referencing qualitative codes with stakeholder categories to understand if certain issues were more salient from certain perspectives) and employing the Delphi technique to generate and evaluate recommendations.

The limitations of the research used to compile this report already suggest possible next steps for future research on this topic. Moreover, the research process itself identified numerous additional avenues of inquiry. These avenues offer valuable routes to expand on the topic of this report, and so bear mentioning as potential future research subjects. The first builds directly on the proposed recommendations. While being the product of a reasoned methodology, a logical next step would be to further test their potential effectiveness with methods of *a priori* evaluation and further refine them if necessary.

A second avenue of future inquiry could involve expanding the scope to other types of energy infrastructure. While the characteristics and projected future developments of heat networks make them a natural candidate for a study on cross-authority collaboration, this report points out that other types of energy infrastructure such as EV charging systems may also be relevant candidates. Given the highly interrelated nature of energy system components, it may be worth taking a systems approach to future inquiry rather than focusing on any one type of infrastructure in isolation.

As mentioned previously, there is also a large body of existing literature on inter-organisational collaboration, which includes research on cross-authority collaboration in sectors other than energy. A worthwhile third avenue of inquiry would be to investigate how this research can be brought to bear on the topic at hand, particularly how solutions for improving cross-authority collaboration in other areas could be adapted for issues in energy.

Lastly, an avenue for future inquiry that has already received some mention could involve international comparative study. A recurring point of many interviewees was that the UK has far less experience with heat network development than some European countries, drawing attention to countries such as Denmark, the Netherlands, and Austria as having particularly successful cases of municipal urban heat networks (especially in their respective capital cities) [1, 55]. Researching these cases would enable better understanding of the degree to which cross-authority collaboration played a role in their development and what measures were taken to improve it.

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Appendices

Appendix A – Data Subject Summary

Figure 23 below displays information according to the wishes of the data subject to whom it belongs. Where a data subject requested that a certain piece of information about them be anonymised, that information is presented in a more generic form and signalled by *italics*.

Please note Data Subject 53 agreed to participate but requested that none of their information feature in this report. Their knowledge was used to guide the research underlying the report, but none of their insight features in the final version.

Code Number	Category	Relevant Current/Former Position	Relevant Current/ Former Employer
1	Business	*Manager*	*Heat Network Developer*
5	Association	Head of APSE Energy	APSE
6	Local Government	*Former Officer*	GLA
10	Central Government	Technical Manager	South West Energy Hub
11	NGO	Chief Executive Officer	Energy Action Scotland
18	Business	Founder	Quantum Strategy and Technology
22	Central Government	*Manager*	*LEP*
28	Local Government	Sustainability, Air Quality and Energy Lead	Camden London Borough Council
31	Association	*Officer*	ADE
38	Local Government	Principal Officer, Carbon Management	Glasgow City Council
52	Local Government	Former Head of Energy Supply	LDA
53	-	-	-
55	Central Government	Head of Heat Networks Policy	BEIS
56	Business	*Engineer*	*Heat Network Operator*
59	Association	*Officer*	ADE
72	Central Government	Government and Regulator Senior Relationships Manager	Energy Systems Catapult
76	Local Government	*Officer*	Aberdeen City Council
86	Local Government	*Officer*	Bristol City Council
87	Local Government	Investment Programme Manager	Bristol City Council
88	Business	*Manager*	*Heat Network Operator*

Appendix B – Case Maps and Notes

London Thames Gateway Heat Network

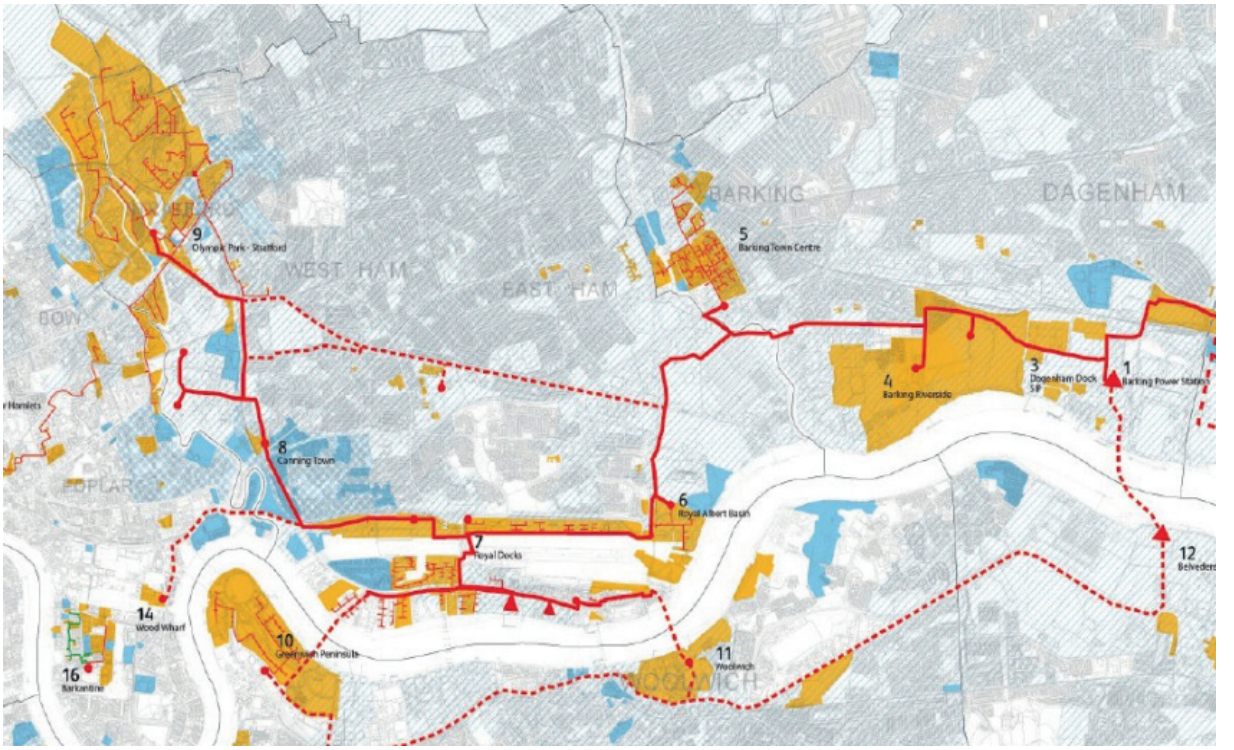

Figure 24 - Map of the London Thames Gateway Heat Network (Source: REHVA - https://www.rehva.eu/fileadmin/Publications_and_resources/EUSEW_2014/Peter_North_London_GLA_Brussels_Part_1.pdf)

The case of the London Thames Gateway Heat Network is a good example of how the **inherent difficulties of heat networks** can frustrate cross-boundary project development, even independently of any issues in cross-authority collaboration specifically. Figure 24 above depicts the proposed layout of the network, but the plans to take it forward were abandoned primarily because of problems in securing long-term heat supplies.[34]

However, this is not to say that the cross-authority collaboration that did take place in the early stages of the project was smooth. One interviewee who was closely involved in the case throughout its duration pointed out that levels of support for the project varied widely among participating LAs. Although the driving force behind the project was the LDA, the interviewee added that it should have done more to secure buy-in from relevant LAs from the very beginning. Lessons drawn from the case included the idea that future projects could employ governance arrangements in which the LAs themselves took the leading role. These arrangements could enable greater sense of ownership among participating LAs, thereby improving **alignment** between them and facilitating cross-authority collaboration [52].

34 (North, 2013)

Olympic Park District Energy Scheme (OPDES)

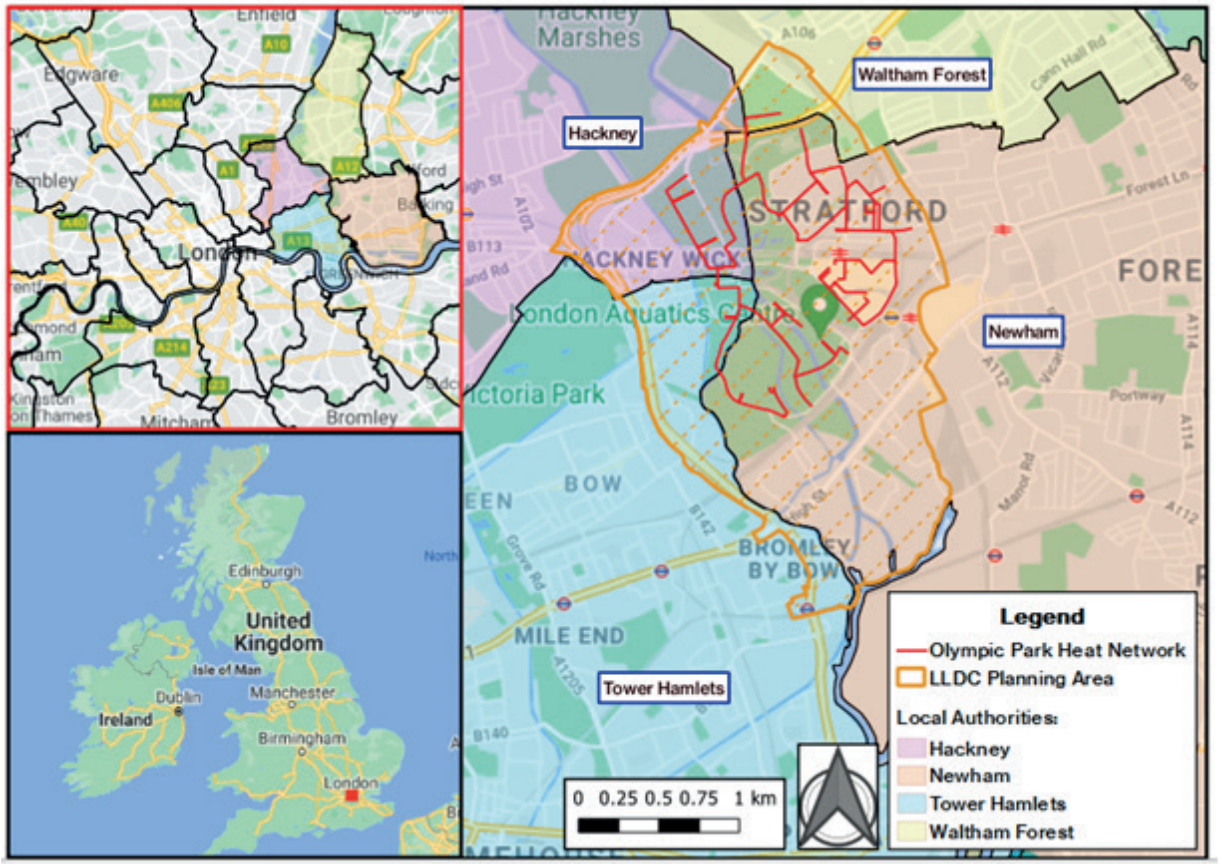

Figure 25 - Map of the OPDES (Adapted from LLDC Source Material - https://www.queenelizabetholympicpark.co.uk/planning-authority/planning-area-map)

The case of the OPDES showcases how cross-authority heat networks can come to fruition when sufficient **resource** is made available. In this case, resource became available because the heat network was part of wider efforts to prepare the area for the 2012 London Olympic Games. These efforts included the creation of a new planning authority, the Olympic Park Legacy Company (now the LLDC), whose jurisdiction is outlined in Figure 25 above and whose purpose it was to facilitate development in the area (including the OPDES).

One interviewee familiar with the project explained that the LLDC (and its predecessor) had been fundamental in coordinating the LAs that fell into its planning area and streamlining planning requirements for the OPDES [56]. However, further research is needed to understand the perspectives of the relevant LAs on the matter. Much like the London Thames Gateway Heat Network, the OPDES is another example of a cross-authority project where the driving force from the public sector took the form of a single overarching entity, rather than being led by the LAs themselves. Moreover, the establishment of the LLDC and its predecessor meant four LAs were effectively required to surrender planning authority over parts of their local areas to another organisation. This raises questions around the degree of **alignment** between those LAs, how much they genuinely collaborated with one another, and if alternative formats might be more suitable for future cross-authority heat network development.

Lee Valley Heat Network

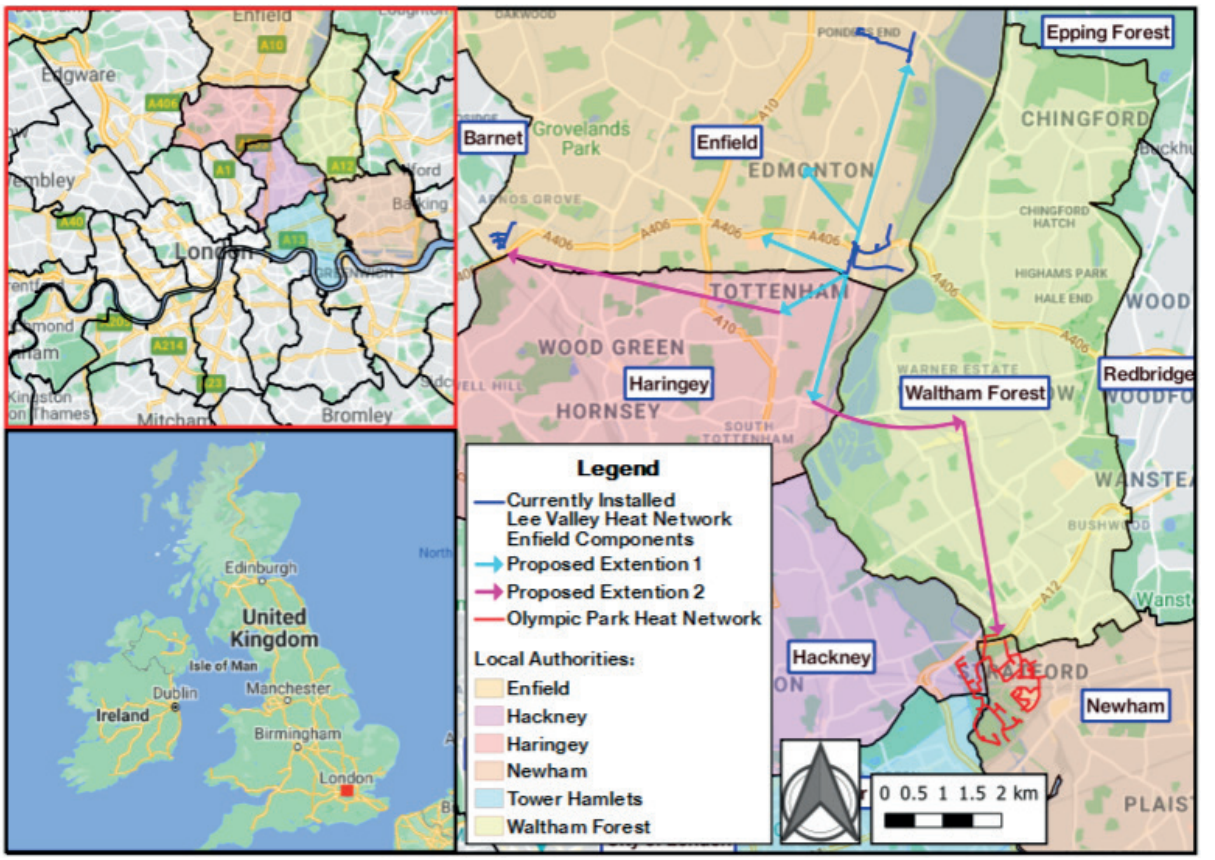

Figure 26 - Map of the Lee Valley Heat Network (Adapted from Energetik Source Material - https://www.energetik.london/how-it-works/enfield)

The case of the Lee Valley Heat Network illustrates issues of **alignment** in action and how they can create persistent barriers to cross-authority collaboration. Feasibility studies for the network were first undertaken in 2011, and one interviewee who is familiar with the project explained that even in those early days there were plans and discussions to build a network that crossed the boundary between the Boroughs of Enfield and Haringey in particular [88]. However, as shown by Figure 26 above, 10 years on and network development has remained within the borders of Enfield.

The interviewee attributed the development trajectory of the Lee Valley Heat Network primarily to issues of alignment. Differences in the business and planning cycles of Enfield and Haringey Councils narrowed time windows in which to progress discussions on cross-authority collaboration, and shifting political priorities in both LAs meant one was rarely in a position to move forward at the same time as the other [88]. Although cross-border extensions of the current network are on the horizon, the time it has taken to reach this point highlights the significance of alignment-related barriers.

Bristol Heat Priority Area

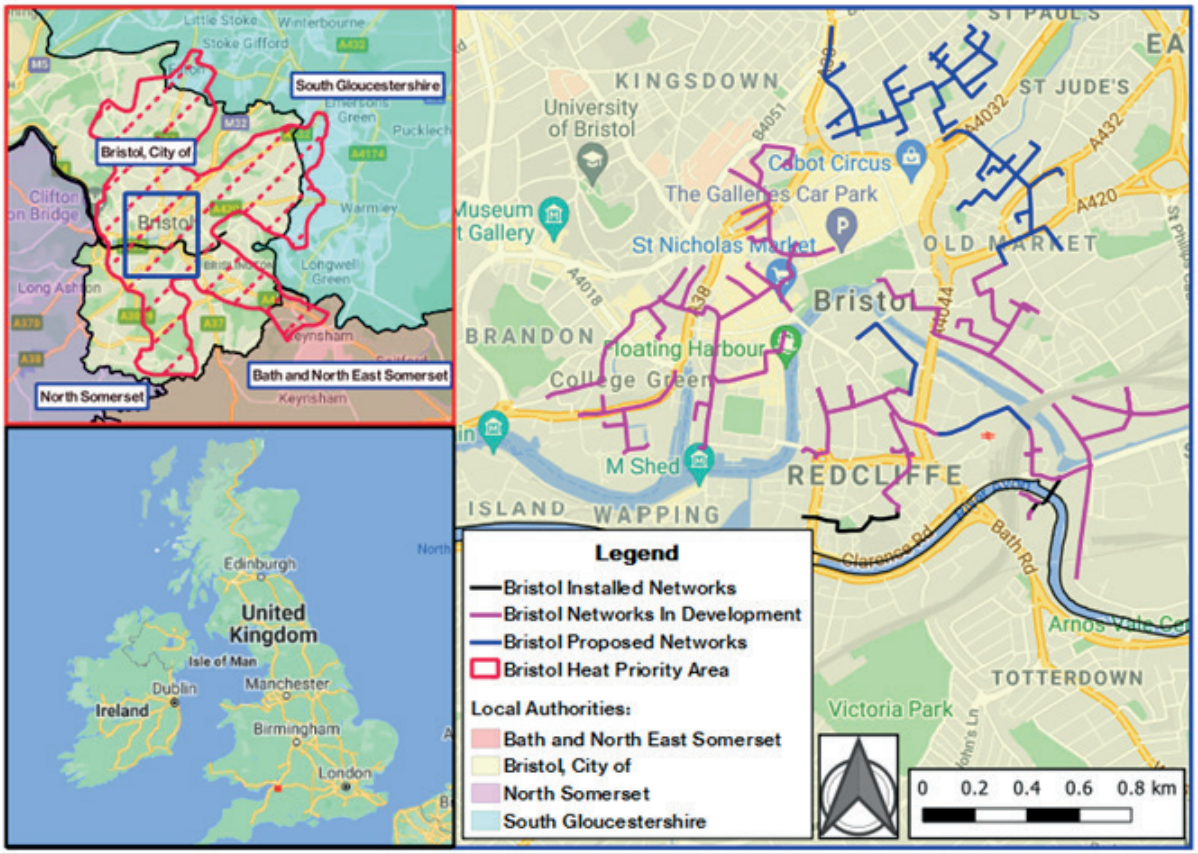

Figure 27 - Map of the Bristol Heat Priority Area (Adapted from Energy Service Bristol Source Material - https://www.energyservicebristol.co.uk/business/heat-networks/)

Although Figure 27 above shows that the Bristol Heat Priority Area may not cover any cross-authority heat networks at the present, it merits further research as a potential example of the positive outcomes of improving **awareness** of cross-authority opportunities. Created by Bristol City Council, the Priority Area is intended to encourage the connection of new heat networks developed within its boundaries to existing networks in the area. The Priority Area extends into neighbouring LAs, suggesting that the process of designing the area recognised that there would be value in developing heat networks that crossed LA boundaries.

The Bristol Heat Priority Area offers a vision of what the Long-Term Action recommended by this report intends to achieve. By creating frameworks with a mandate for neighbouring LAs to carry out heat mapping and zoning beyond their borders, they would be much more likely to become aware of the possibilities of cross-authority heat networks and of the opportunities to collaborate on them. These activities may well result in zones reminiscent of the Bristol Heat Priority Area, creating requirements to develop heat networks even if it means building them across LA boundaries.

Appendix C – Qualitative Coding Scheme

Figure 28 represents the scheme used to code qualitative interview data gathered for the purposes of this report. The themes and their definitions were informed by the conceptual map (particularly concepts relating to the *antecedents* and *contingencies* of inter-organisational collaboration) taken from Wassmer et al., represented by Figure 8 in the Literature Review Summary of this report. Specific links between those concepts and the themes or definitions of the scheme are outlined accordingly.

In terms of how the scheme was applied, researchers from the project team would use the definitions to identify and code text from interviewee transcripts relating to the various themes. All the codes for each theme were then aggregated together in one place in preparation for further analysis.

Theme	Definition	Links to Conceptual Map
Local Energy Needs	Any reference to an interviewee's mention of the needs and goals of LAs with regards to their local energy systems.	**Antecedents** • Environmental strategy
Inherent Difficulties	Any reference to an interviewee's mention of the general challenges of developing heat networks and their causes (such as physical obstacles, financial hurdles, and technical requirements).	N/A (this theme was developed to capture issues in heat network development that were not unique to cross-boundary cases)
Awareness	Any reference to an interviewee's mention of LAs' level of awareness of opportunities to collaborate on cross-boundary heat networks in their local area, including causal factors and solutions for improvement.	**Antecedents** • Existing EC portfolio
Resources	Any reference to an interviewee's mention of LAs' resource-base (comprising human and knowledge resources as well as financial ones) for cross-authority collaboration on heat networks, including causal factors and solutions for improvement.	**Antecedents** • Resource and capability gaps **Contingencies** • Collaborative capability • Capabilities and reputation • Prior experience

Alignment	Any reference to an interviewee's mention of factors affecting the degree of alignment between LAs needed for cross-authority collaboration on heat networks, including solutions for improvement.	**Antecedents** • Reputation issues • Stakeholder relationship issues • Governmental failure • Competitive dynamics **Contingencies** • Common vision • Governance structure • Shared values and common ways of working
Uncategorised	Any reference to an interviewee's mention of an interesting point that does not fall directly into one of the preceding themes but nonetheless merits further consideration.	This theme was created in part because of the recognition that the preceding themes did not reflect all the concepts from the map, and that interviewees could raise points that may not neatly fit into a framework derived from the map.

Figure 28 – Qualitative Coding Scheme

Appendix D – Interview Guide

1. Interview guide purpose

This interview guide is used to illustrate the design of the interview including interview purpose, objectives, time, personal information and outlines.

2. Interview design

Based on our project details, the interviews should focus on the cross-authority collaboration on energy infrastructure. The data from these interviews will be gathered via audio-visual recordings and will then be transcribed by the interviewer(s). It will be the responsibility of the interviewer(s) to immediately and securely store any data recordings they make. If possible and/or desirable, two interviewers should carry out each interview.

Interviews would be in form of person-to-person online meeting (via MS Teams) and should last between 30 and 60 minutes.

3. Interview structure

Thanks for your time for this interview. Your personal data will be collected and safely stored at UCL. We'll start with your personal information and then the specific questions about your ideas of cross-authority collaboration in energy infrastructure.

Category	Number	Question	Note
Personal Details	1	What name do you go by/how would you like to be addressed?	
	2	Who is your employer?	
	3	What is your job title?	
	4	What professional experience do you have with energy infrastructure development? What organisations have you worked with in that field?	e.g. private or public sector

Geography Info	1	In what parts of the country have you had experience in?	
	2	What did you consider to be local energy needs of the areas you worked in?	
	3	What were the challenges of meeting those local energy needs?	
Qualitative Questions	1	Do you have experience with cross-authority energy infrastructure development?	
	2	If the answer to 1 is Yes, what were the challenges of the project and how were they addressed?	
	3	If the answer to 1 is No, is that because you have declined to advance projects of that type, or because you have not yet been able to launch one? Please elaborate in either case.	
Quantitative Questions		On a scale of 1 to 10 (1 being completely disagree to 10 being completely agreement), how would you score your level of agreement with the following statements?	
	1	“There is a lot of potential in the UK for cross-authority infrastructure projects to meet local energy demand.”	
	2	“I am aware of the different forms that cross-authority energy infrastructure can take.”	
	3	“There is value in developing cross-authority infrastructure to meet local energy needs that would not otherwise be realized if infrastructure is developed within single authorities only.”	
	4	“Local authorities have the resources they need to successfully undertake cross-authority energy infrastructure development.”	