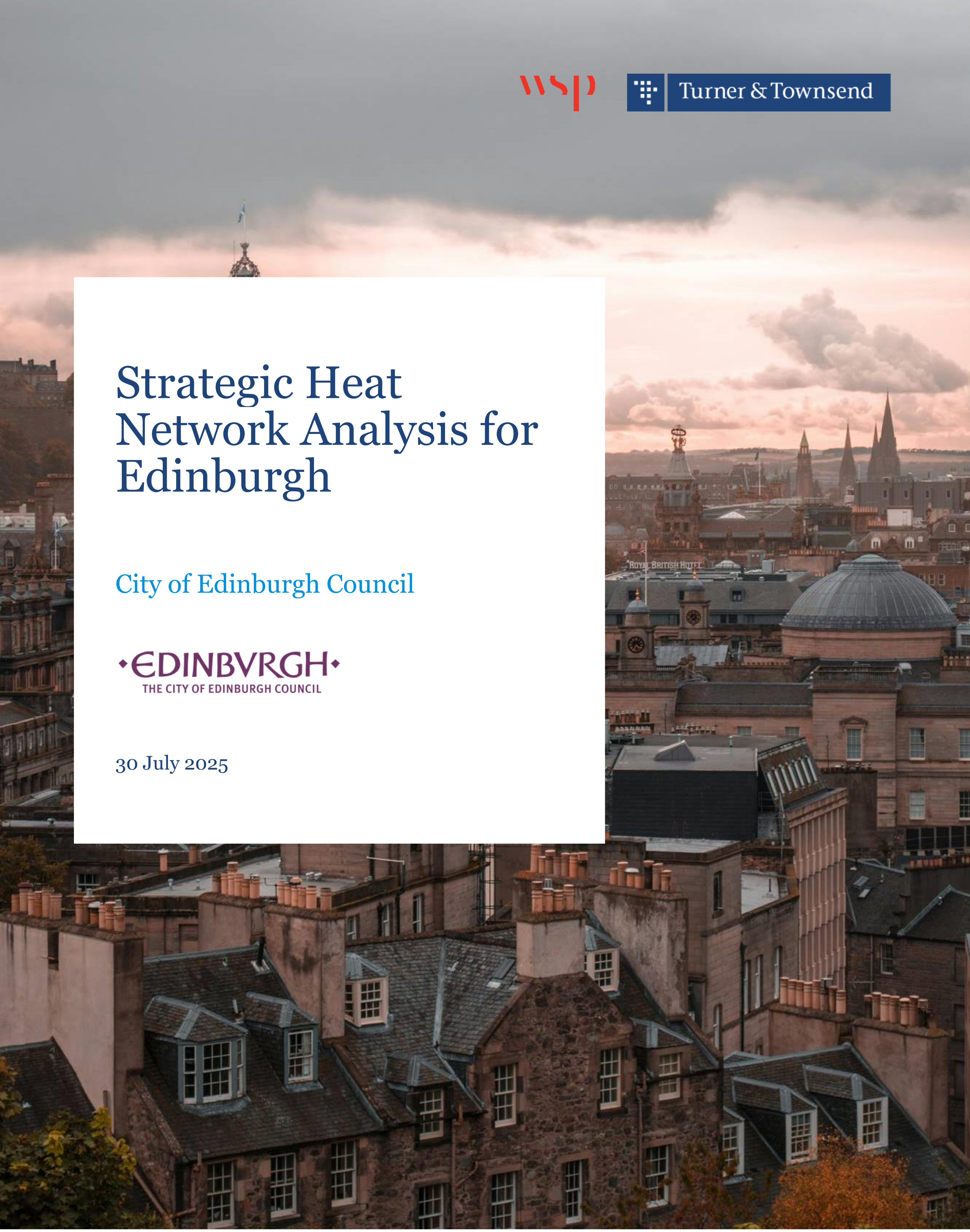


# Strategic Heat Network Analysis for Edinburgh

City of Edinburgh Council

30 July 2025

We transform together.

# Contents

| Rev | Status | Originators | Approved | Date |
|---|---|---|---|---|
| 6.0 | Final | Hassan Waheed, Jess Grant, Calum Mehay, Max Leeson, Tim Rippon, Eve Nicholson, Chris Forster, Ellen Potter, Ian Brocklebank | Hassan Waheed | 30/07/25 |

# 1. Executive Summary

*We propose the development of a city-wide heat network across 11 prospective heat network zones in Edinburgh, covering 67% (3.5 TWh) of Edinburgh's total annual heat demand and becoming available for connection to approximately 178,000 properties. Our feasibility review indicates that heat networks can deliver low carbon heat at a competitive cost, particularly with the grant funding currently available. We recommend a phased delivery strategy. This involves the continued development of the Granton heat network and starting two additional 'Gateway Zones' – first in Northeast Edinburgh and subsequently in Southeast Edinburgh – which have access to scalable low carbon heat sources. We recommend expansion from these zones into the city centre and western Edinburgh. The city-wide heat network can be supplied by developing several large-scale heat sources serving up to ten zones via spinal routes, and multiple small-scale heat sources supplying zonal networks. Altogether, this infrastructure represents total capital investments exceeding £1.5bn over the coming decades, supporting low carbon skills and jobs across the region. We have identified this to be the most practical way for providing the lowest cost low carbon heat to decarbonise Edinburgh's buildings and help reduce fuel poverty. We found strong backing for a major heat network rollout via engagement with potential customers, investors/developers, public bodies, utilities, regulators and the national Heat Network Support Unit (HNSU).*

## 1.1 Context

The City of Edinburgh Council is advancing its proposals for a city-wide heat network (or 'network of networks'). The Council proposed a potential city-wide heat network in its 2023 Local Heat and Energy Efficiency Strategy (LHEES), a statutory document which defines how Edinburgh will decarbonise its built environment and tackle fuel poverty.

This analysis progresses the LHEES work via four objectives:

- Investigate available **heat sources**.
- **Update zones**.
- Conduct a **feasibility review** of these zones.
- Provide an indication of possible **spinal routes** to supply heat to these zones via large-scale primary heat sources.

The Council appointed Turner & Townsend and WSP to conduct this study. The results underpin the Council's current working strategy to develop of heat networks, solidifying the intentions for heat networks as a utility-scale generational investment for Edinburgh.

Several policy drivers are backing heat network developments in Scotland. The primary driver is the Heat Networks (Scotland) Act 2021, with further updates expected in the upcoming Heat in Building Bill and the heat networks regulatory regime. While there are several outstanding uncertainties on policy specifics, we consider their progress to be encouraging on the whole. This has allowed us to take an optimistic view for our analysis.

Edinburgh already has dozens of small-scale heat networks. The Council is also actively procuring a heat network for its major development at Granton Waterfront. Midlothian Council are expanding and operating heat networks proximate to Edinburgh's boundary while East Lothian Council also develops its heat network plans. Our analysis builds on these efforts to support scale and opportunities for collaboration.

## 1.2 Heat sources

We appraised all current heat sources before prioritising potential sources for our analysis of heat supply. This assessment included greenspaces, water bodies, waste heat, mines, and other sources. We categorised selected sources into two types:

- **Primary** (city-scale) heat sources are major strategic heat assets which could potentially supply heat for multiple zones and are suited to supply a spinal route.
- **Secondary** (zonal-scale) heat sources are those which could cover part or most of the heat demand for a zone.

We identified eight potential heat sources:

**Primary heat sources**

Port of Leith sea source heat pump

Cockenzie sea source heat pump

Monktonhall Colliery ground source heat pump

**Secondary heat sources**

Sewer source heat

Millerhill Recycling & Energy Recovery Centre

Seafield Waste Water Treatment Works

North British Distillery

Closed loop ground source heat pumps

This list is not exhaustive as new sources may arise and others may become more viable, like waste heat from data centres and hydrogen.

## 1.3 Updated zones

The Edinburgh LHEES identified 17 prospective heat network zones. We utilised various data sources and methods to consolidate these into 11 refined zones, shown in Figure 1. We developed these with due regard to heat demand, constraints, fuel poverty, and stakeholder input. This refinement intended to provide more robust prospective zones with a clearer view of the opportunity.

They consolidate most original zones into larger, more commercially attractive investment opportunities, follow more strategic boundaries, better reflect physical constraints, and offer a more even distribution of heat demand across major zones. This reflects stakeholder input calling for larger zones with a clearly defined delivery strategy.

The updated zones represent an overall annual heat demand of 3.5 TWh[1] from 177,944 potential loads (i.e. buildings), and an anchor load[2] annual heat demand of almost 1 TWh from 515 potential loads. This represents 67% of overall heat demand and 84% of anchor load heat demand in Edinburgh.

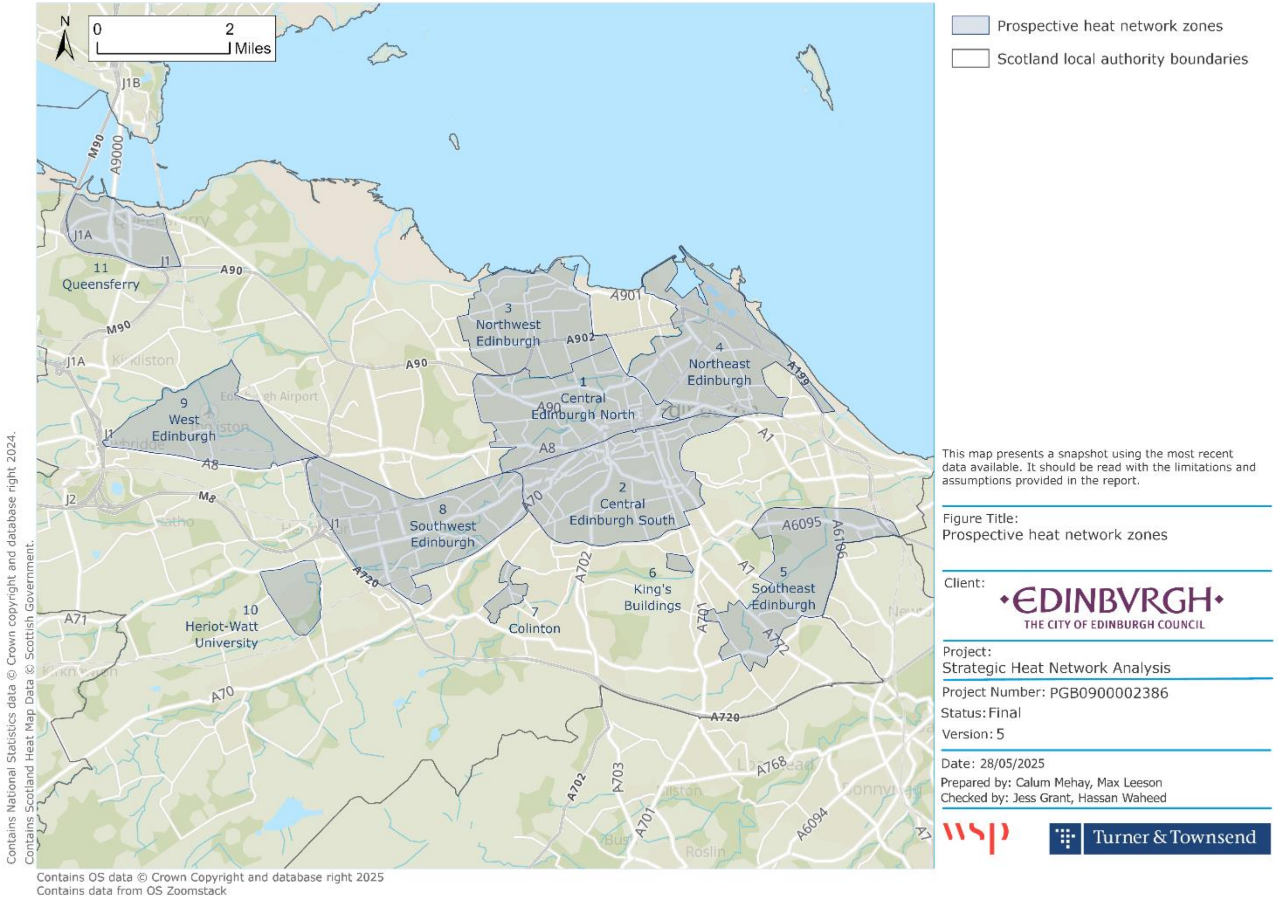
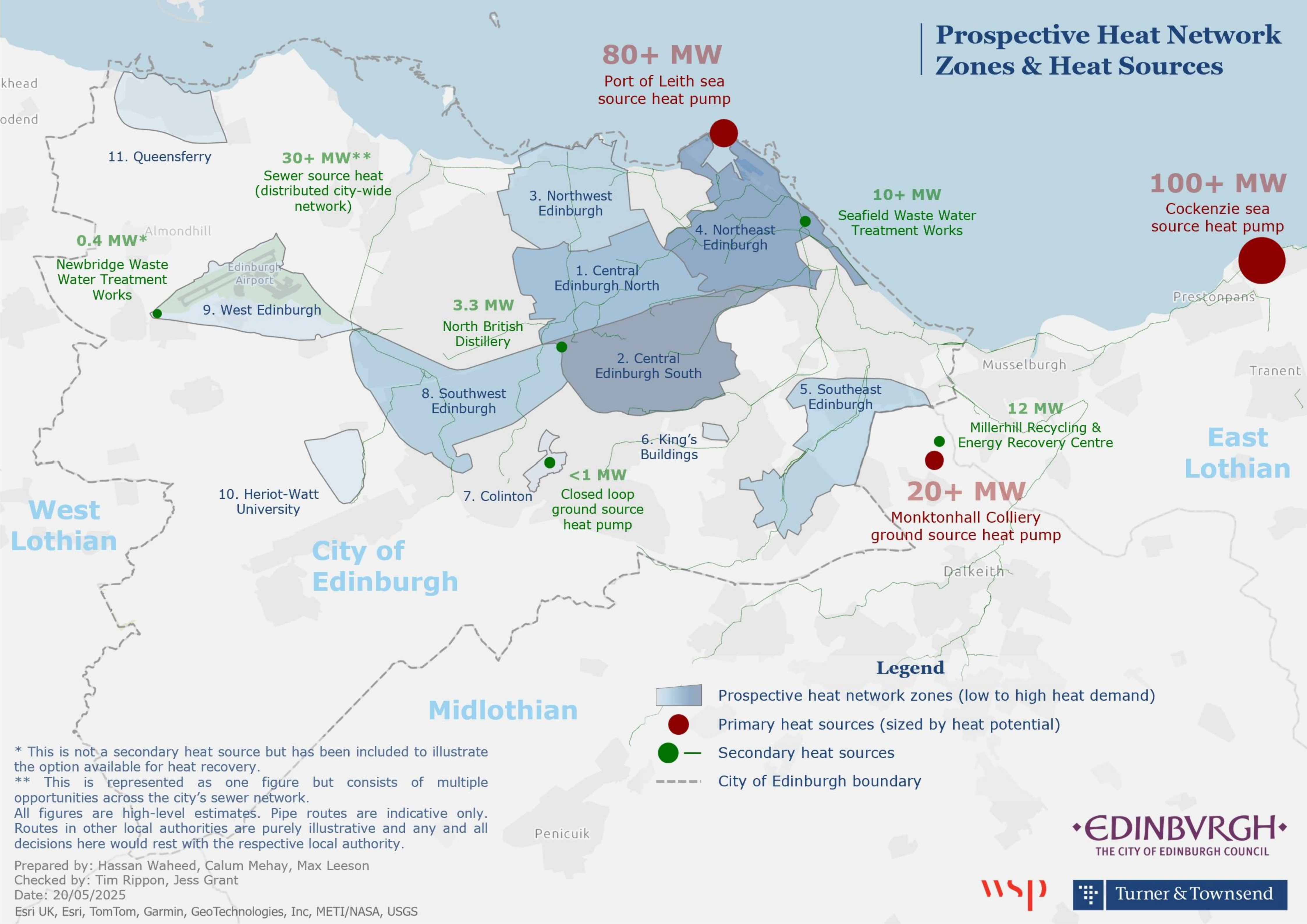



*Figure 1: Prospective heat network zones for the City of Edinburgh.*

The zones provide clarity on leadership and roles, identifying the party primarily responsible for leading heat network development in each zone and the role of the Council and other stakeholders. However, we do not consider our outputs to be designation-ready zones at this stage. They may well be suited to designation after the regulatory environment has been created and it supports the zones as we defined them. Equally, they may require modifications depending on central government decisions on any number of the upcoming regulations. In the following page, we present the zones and heat sources.

[1] This equates to 3,503 GWh, 3.5 million MWh, or 3.5 billion kWh. The mean annual heat demand of Scottish homes heated via mains gas is 12,354 kWh.

[2] Defined as loads with total annual heat demand exceeding 500 MWh/year.


Prospective Heat Network Zones & Heat Sources
80+ MW
Port of Leith sea source heat pump
100+ MW
Cockenzie sea source heat pump
30+ MW**
Sewer source heat (distributed city-wide network)
10+ MW
Seafield Waste Water Treatment Works
0.4 MW*
Newbridge Waste Water Treatment Works
3.3 MW
North British Distillery
12 MW
Millerhill Recycling & Energy Recovery Centre
20+ MW
Monktonhall Colliery ground source heat pump
<1 MW
Closed loop ground source heat pump
1. Central Edinburgh North
2. Central Edinburgh South
3. Northwest Edinburgh
4. Northeast Edinburgh
5. Southeast Edinburgh
6. King's Buildings
7. Colinton
8. Southwest Edinburgh
9. West Edinburgh
10. Heriot-Watt University
11. Queensferry
Edinburgh Airport
Almondhill
Musselburgh
Prestonpans
Tranent
Dalkeith
Penicuik
West Lothian
City of Edinburgh
Midlothian
East Lothian
Legend
Prospective heat network zones (low to high heat demand)
Primary heat sources (sized by heat potential)
Secondary heat sources
City of Edinburgh boundary
* This is not a secondary heat source but has been included to illustrate the option available for heat recovery.
** This is represented as one figure but consists of multiple opportunities across the city's sewer network.
All figures are high-level estimates. Pipe routes are indicative only. Routes in other local authorities are purely illustrative and any and all decisions here would rest with the respective local authority.
Prepared by: Hassan Waheed, Calum Mehay, Max Leeson
Checked by: Tim Rippon, Jess Grant
Date: 20/05/2025
Esri UK, Esri, TomTom, Garmin, GeoTechnologies, Inc, METI/NASA, USGS
EDINBVRGH
THE CITY OF EDINBURGH COUNCIL
wsp
Turner & Townsend

## 1.4 Spinal route

Edinburgh's heat demand far exceeds what is readily available from local heat sources. Much of the low carbon supply for zonal heat networks needs to be imported. Air source heat pumps (ASHPs) are an attractive low carbon technology for energy centres, but the scale required comes with challenges such as grid upgrade costs, a lack of space for large ASHPs arrays in or near zones, noise, and the unsuitability of central Edinburgh for large-scale industrial energy installations.

Therefore, we have carried out high-level analysis to illustrate how it might be feasible to transport heat from further afield into the zones, and whether that heat could be economically attractive.

We suggest two spinal routes to be able to collect heat from all three primary heat sources, to serve up to ten zones, and to avoid crossing railway lines wherever possible. This route is expected to evolve significantly over time following more detailed analysis.

The Northern Spinal Route could serve three zones from Port of Leith sea source heat pumps. The Southern Spinal Route could serve up to seven zones from Cockenzie sea source heat pumps and Monktonhall Colliery ground source heat pumps. The concept spinal architecture is presented in Figure 2 and the route is presented in the following page.

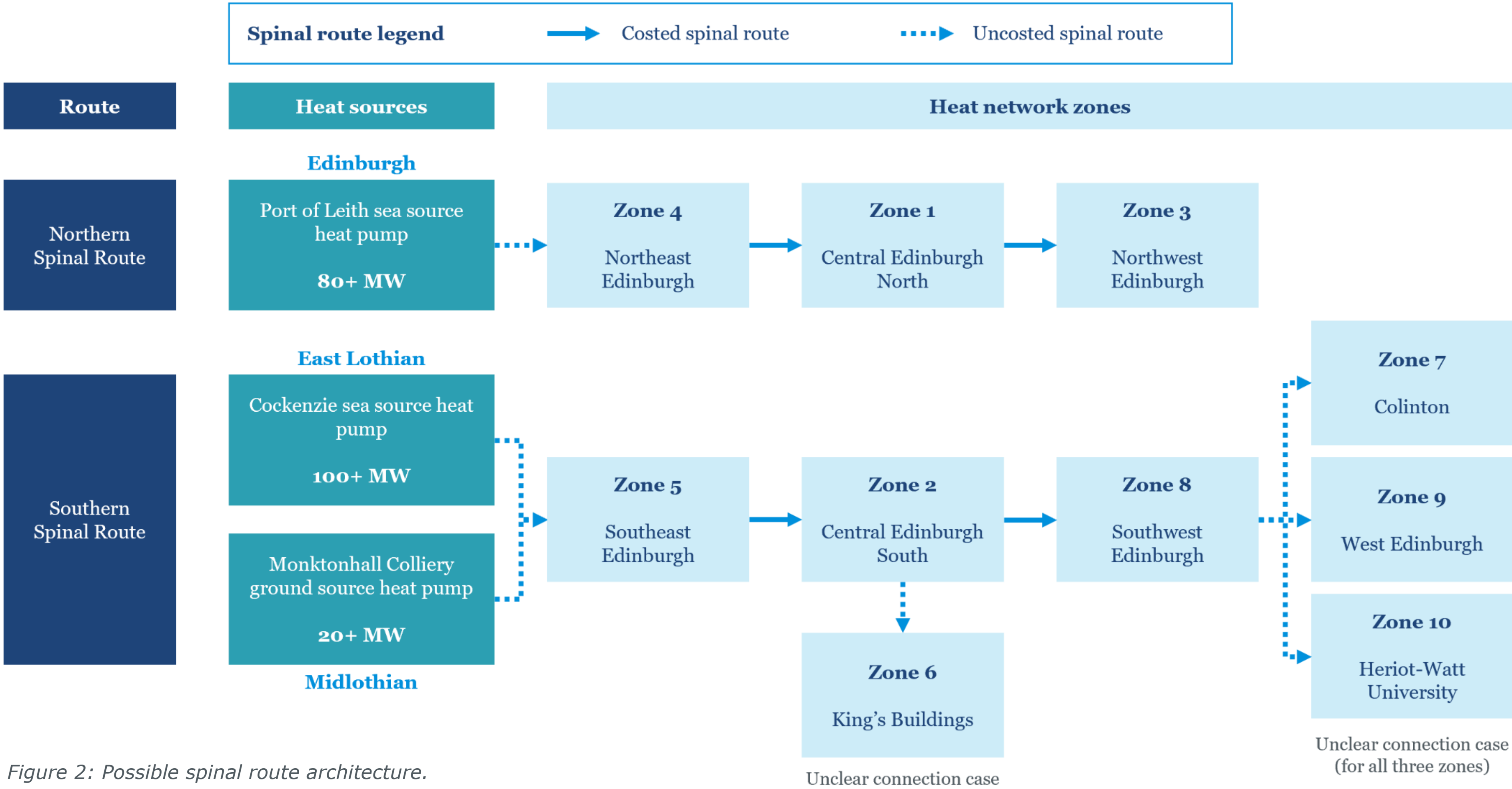
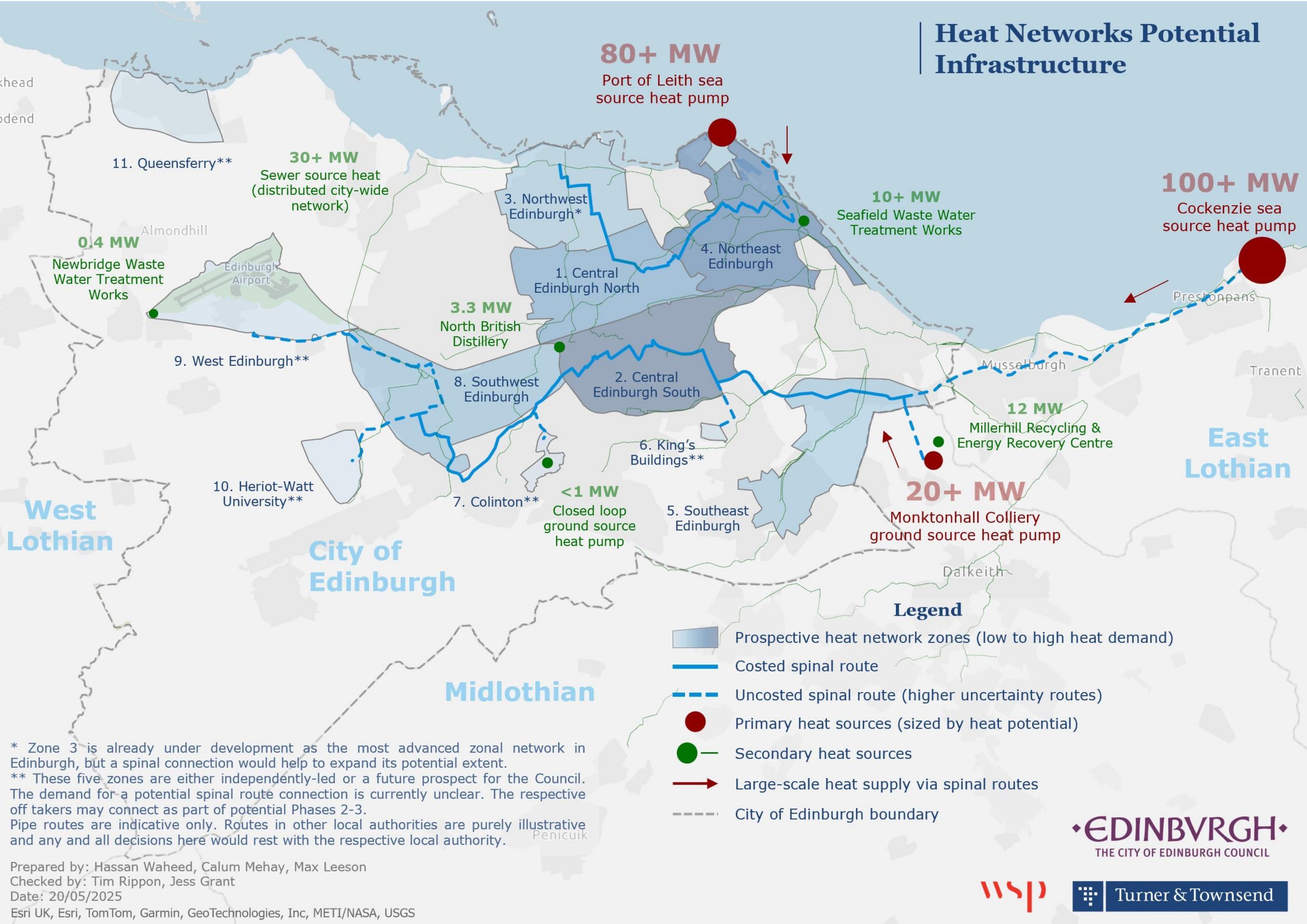



*Figure 2: Possible spinal route architecture.*

# Heat Networks Potential Infrastructure




* Zone 3 is already under development as the most advanced zonal network in Edinburgh, but a spinal connection would help to expand its potential extent.
** These five zones are either independently-led or a future prospect for the Council. The demand for a potential spinal route connection is currently unclear. The respective off takers may connect as part of potential Phases 2-3.
Pipe routes are indicative only. Routes in other local authorities are purely illustrative and any and all decisions here would rest with the respective local authority.

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## 1.5 Feasibility review of zones

We carried out a high-level feasibility review of several heat network zones. This process involved developing a heat load profile for the anchor loads in each zone, energy modelling to estimate energy centre primary plant requirements and a zonal heat network route connecting all anchor loads. This enabled initial cost models to be developed, and basic economic viability tests applied.

We carried out a levelised cost of heat (LCOH) assessment (Table 1). LCOH is the average cost of heat per kWh over the system's lifetime, including capital, operation, maintenance and fuel costs. LCOH is not a heat tariff but can help compare the cost of alternative methods of energy production.

| Zone number & name | LCOH (p/kWh) – 50% grant | LCOH (p/kWh) |
|---|---|---|
| Zone 1 – Central Edinburgh North | 12.3 | 16.7 |
| Zone 2 – Central Edinburgh South | 11.1 | 14.6 |
| Zone 4 – Northeast Edinburgh | 13.2 | 19.6 |
| Zone 5 – Southeast Edinburgh | 10.2 | 13.3 |
| Zone 7 – Colinton | 14.6 | 21.3 |
| Zone 8 – Southwest Edinburgh | 12.8 | 17.6 |
| Zone 11 – Queensferry | 13.8 | 20.8 |
| **Total** | **N/A** | **N/A** |
| Building-level ASHP counterfactual | 15.6 | |

*Table 1: LCOH across all zones assuming current maximum level of grants for heat networks, compared with individual ASHPs.*

Our analysis is high-level and indicative, relying on several assumptions where real-world conditions could not be fully accounted for. A key limitation is that zonal networks are modelled using theoretical ASHP-based energy centres, without factoring in heat from a spinal route due to data gaps and scope limitations. Incorporating spinal heat could significantly improve feasibility. Additionally, our analysis uses only anchor loads, excluding other potential connections, which could raise or lower the LCOH based on factors such as heat density and connection costs. Outputs should be refined through detailed feasibility studies.

An example anchor network (*Zone 1 – Central Edinburgh North*) is presented in Figure 3. In the following page, we provide an overview of the potential £1.5bn capital investment opportunity for heat network infrastructure, across three phases.

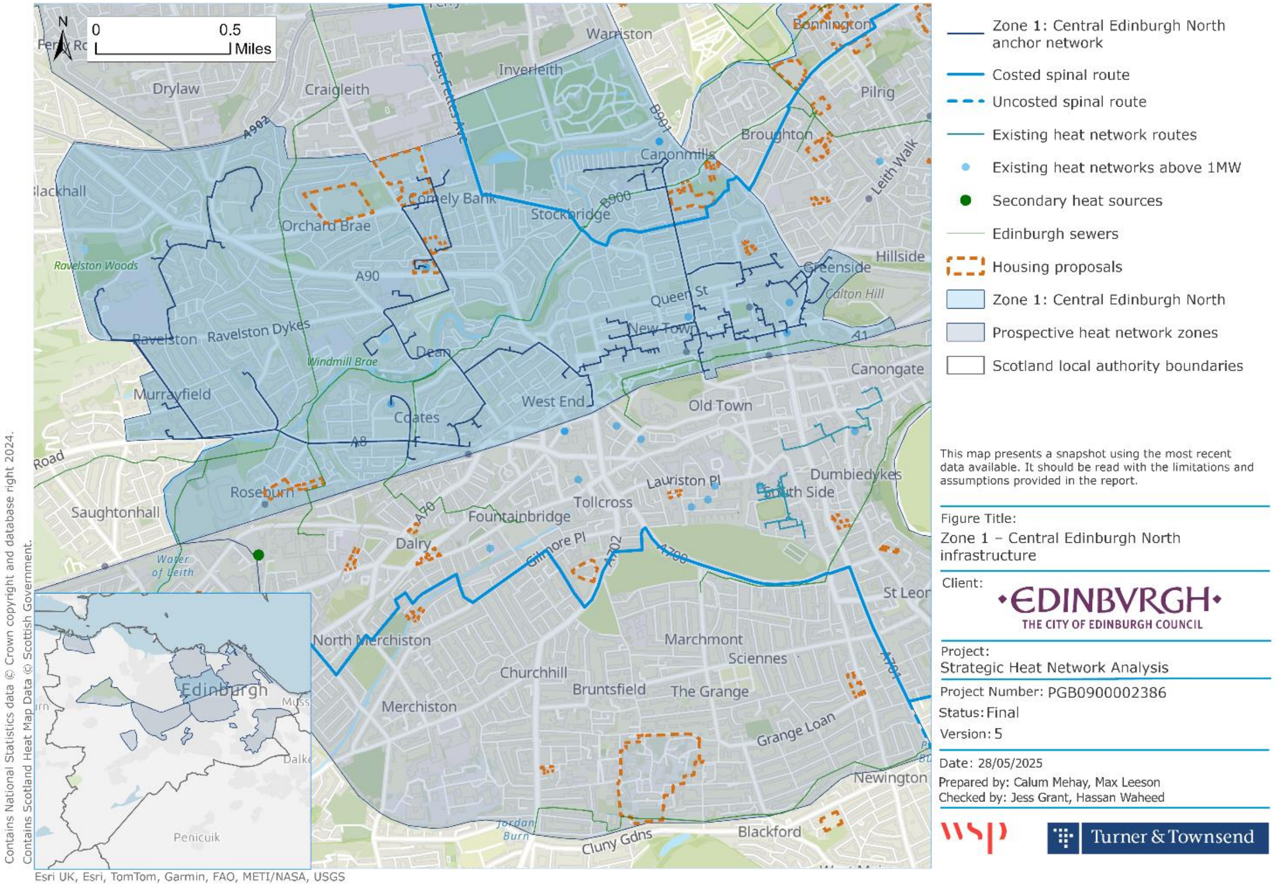
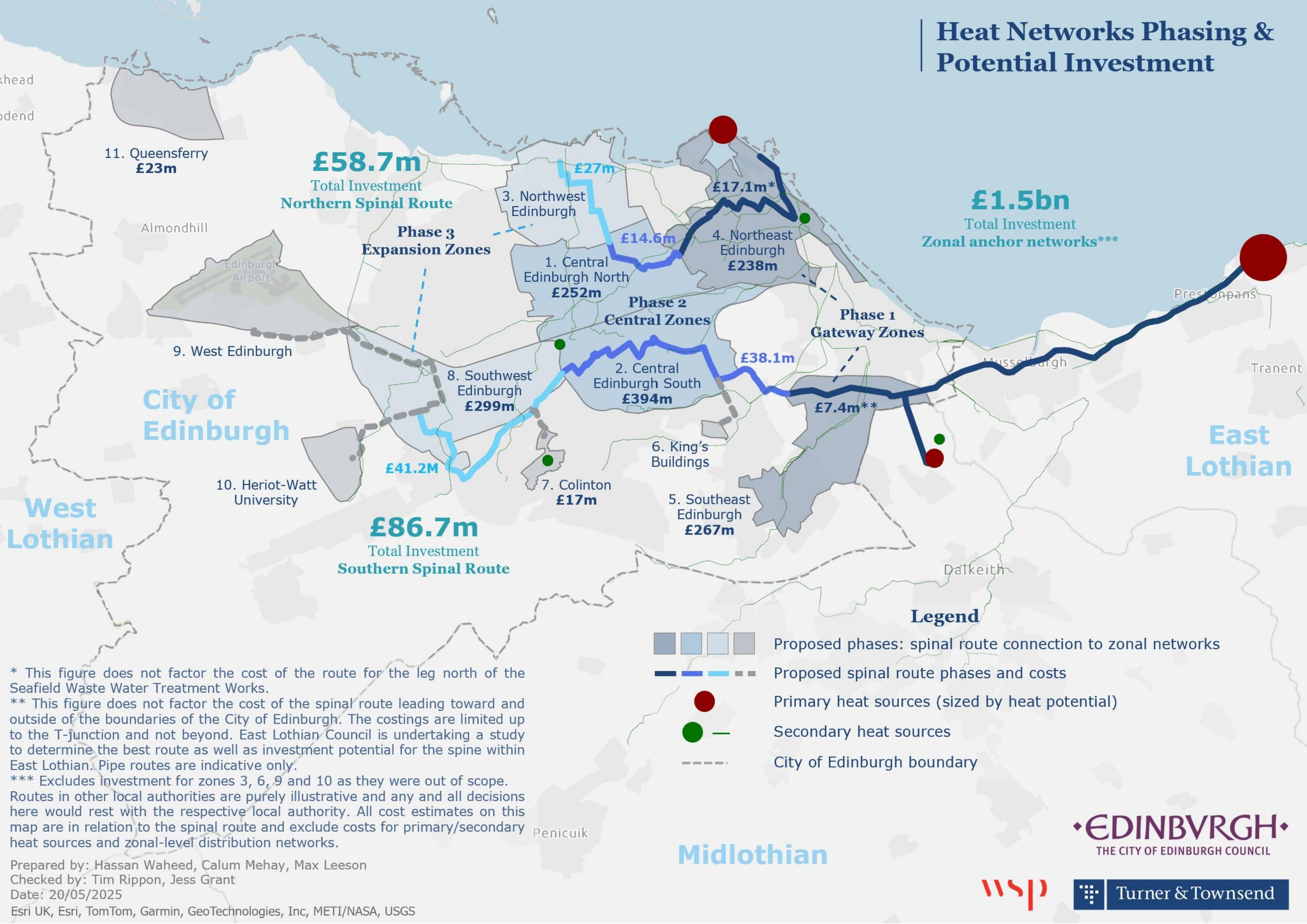



*Figure 3: Anchor network example: Zone 1 – Central Edinburgh North*

# Heat Networks Phasing & Potential Investment




* This figure does not factor the cost of the route for the leg north of the Seafield Waste Water Treatment Works.
** This figure does not factor the cost of the spinal route leading toward and outside of the boundaries of the City of Edinburgh. The costings are limited up to the T-junction and not beyond. East Lothian Council is undertaking a study to determine the best route as well as investment potential for the spine within East Lothian. Pipe routes are indicative only.
*** Excludes investment for zones 3, 6, 9 and 10 as they were out of scope. Routes in other local authorities are purely illustrative and any and all decisions here would rest with the respective local authority. All cost estimates on this map are in relation to the spinal route and exclude costs for primary/secondary heat sources and zonal-level distribution networks.

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## 1.6 Delivery strategy

### 1.6.1 Strategic energy assets

We consider large-scale primary heat sources and spinal routes as critical infrastructure to fully deliver a city-wide heat network. Further, we also think this approach can drive down the cost of heat for Edinburgh's customers relative to low carbon counterfactuals. This can be achieved by developing primary energy sources into strategic energy assets using one or more of the following approaches:

- At a basic level, a greater scale of electricity demand will allow these sites to negotiate cheaper electricity tariffs.
- A primary heat source could attract a private wire connection to renewable energy sources (e.g. offshore wind). This would provide significantly cheaper electricity than is available via the grid.
- Large-scale heat storage will introduce significant flexibility, allowing storage to be charged from cheap off-peak and private wire electricity when these are available. Heat can be used when electricity costs are high. Storage also provides system resilience and helps to balance the grid. Different forms of storage can help to offset the financial impact of heat demand peaks across the short (hours to days), medium (weeks) and long term (seasonal).
- Economies of scale could allow developers to achieve cost reductions through efficiencies in heat generation equipment, operations, and procurement.
- Other innovative ways to reduce costs and leverage the unique role of primary heat sources include using combined heat and power plants as, backup, peaking assets and export electricity as a revenue stream.

### 1.6.2 Role of the Council

The Council has multiple statutory obligations which make it the *de facto* coordinator of heat networks in Edinburgh. Its role in administering the city make it a critical partner from a practical perspective. Its actions influence investment intent in a major way, and its decisions define how, where and when developments can happen. Thus, the Council is central to strategic heat network development. We make the following recommendations for progressing with these plans:

- Launch the heat network delivery programme originally envisaged in the LHEES. It should address the decisions, responsibilities and plans deferred within the Edinburgh LHEES. It should include the recommendations of this analysis and be structured to manage the Council's role in/with the selected delivery model. The programme should have clear milestones and time-bound actions to achieve these.
- Engage the HNSU to seek funding for personnel and other means of increasing capacity and skills. This will help progress further studies as well as develop the functions required for the programme.
- Continue engagement with key partners across the public sector, including NHS Lothian, Universities, and other public bodies to solidify support and foster collaboration.
- Decide the preferred delivery model as soon as possible, with details on its implementation across zonal and spinal networks, and primary and secondary heat sources. This will set the foundation for large-scale heat network development.
- With HNSU support, expand the dialogue with East Lothian Council and Midlothian Council to coordinate approaches to analysis, development, financing, and operation of primary heat sources and a spinal route across the region.
- Comply with anticipated Ofgem regulations to support a clear and fair heat price which benefits both developers and customers.

In addition, we make these recommendations in relation to the objectives of this study:

- Heat sources: develop plans to utilise viable primary heat sources, prioritising the Port of Leith sea source heat pumps, with a coalition of partners and continue collating data on secondary heat sources.
- Zone refinement: consider developing pilot zones to test incoming regulations and align to LHEES activities.
- Zone feasibility: prioritise a detailed feasibility study for *Zone 4 – Northeast Edinburgh* followed by *Zone 5 – Southeast Edinburgh*, with support from the HNSU. These should consider, both, primary heat sources and spinal routes alongside secondary heat sources.
- Spinal route: update spinal route(s) based on the most viable route options, constraints and opportunities to deliver heat at scale and cost-effectively.
- Stakeholder engagement: develop a clear strategy which identifies who, when and why the Council will engage on each of the preceding four areas of work.

# 2. Glossary

## 2.1 Abbreviations

| | |
|---|---|
| ASHP/GSHP/WSHP | Air/ground/water source heat pump |
| BAR | Building Assessment Report |
| CAPEX | Capital Expense |
| CHP | Combined Heat and Power |
| CIBSE | Chartered Institution of Building Services Engineers |
| CIBSE CP1 | CIBSE Code of Practice 1 (Heat Networks Code of Practice) |
| COP | Coefficient of Performance |
| DAC | Dry Air Cooler |
| DNO | Distribution Network Operators |
| ECCI | Edinburgh Climate Change Institute |
| EfW | Energy from Waste |
| GIS | Graphical Information System |
| GSP | Grid Supply Point |
| GW / GWh | Gigawatt / Gigawatt-hour |
| HNSU | Heat Network Support Unit |
| IRR | Internal Rate of Return |
| kW / kWp / kWh | Kilowatt / Kilowatt peak (used for solar PV capacity)/ Kilowatt-hour |
| LCOH | Levelised Cost of Heat |
| LDP | Local Development Plan |
| LHD | Linear Heat Density |
| LHEES | Local Heat and Energy Efficiency Strategy |
| MEL | Midlothian Energy Limited |
| MW / MVA / MWh | Megawatt / Megavolt-ampere (used in electrical capacity ratings) / Megawatt-hour |
| NHS | National Health Service |
| OFGEM | Office of Gas and Electricity Markets |
| OPEX | Operating Expense |
| OS | Ordnance Survey |
| RERC | Recycling and Energy Recovery Centre |
| REPEX | Replacement Expense |
| RFI | Request for information |
| SFT | Scottish Futures Trust |
| SGN | Scotia Gas Networks |
| SHM | Scotland Heat Map |
| SPEN | ScottishPower Energy Networks |
| TW / TWh | Terawatt / Terawatt-hour |
| WWTW | Waste Water Treatment Works |
| ZWS | Zero Waste Scotland |

## 2.2 Terminology

| Term | Definition |
|---|---|
| Anchor load | A large, consistent source of heat demand within a heat network, providing a reliable heat load and, by extension, income stream, increasing the economic viability of the heat network. |
| Coolth | In contrast to heat, coolth is the transfer of cooling as a commodity or service. Networks may offer 'coolth' or cooling services to off-takers in the same way as they offer heat. |
| Coefficient of performance (COP) | The power output by a system relative to the power input – in this case, heat output relative to electricity input. A higher coefficient of performance represents a more efficient (and thus cost effective) system. |
| Delivery model | The ownership structure which governs the development, finance and operation of a heat network. |
| (Extreme) Fuel Poverty | A household is in fuel poverty if, in order to maintain a satisfactory heating regime, total fuel costs necessary for the home are more than 10% (20% for extreme fuel poverty) of the household's adjusted net income (after housing costs), and if after deducting fuel costs, benefits received for a care need or disability and childcare costs, the household's remaining adjusted net income is insufficient to maintain an acceptable standard of living. |
| Heat network | Distributes heat from a central network to multiple buildings through pipes. |
| Heat network zone | Areas where the Council considers there to be high potential for a heat network to be a viable decarbonisation option. These indicative zones form the evidence base on which the Council can formally designate heat network zones, enabling regulatory powers to be exercised to support heat network development and expansion. |
| Heat source | Any natural or human made process which can provide thermal energy. Low carbon heat sources provide this energy without direct greenhouse gas emissions, often using electricity to abstract thermal energy. |
| Levelised Cost of Heat (LCOH) | LCOH is the average cost of heat per kWh over the system's lifetime, including capital, operation, maintenance and fuel costs. LCOH is not a heat tariff but can help compare alternative methods of energy production. |
| Linear heat density (LHD) | LHD is defined as the annual heat load per meter of heat network pipe (kwh/m/year). It is an approximate measure of the demand a heat network would be able to service for a fixed length of pipe. This is an industry standard metric used to assess the commercial viability of a heat network based on the heat sales for a capital cost. It can be derived by dividing the total heat demand by the total length of pipe for a potential area of study. The higher the LHD, the higher the likelihood of financial viability. |
| Local Heat and Energy Efficiency Strategy (LHEES) | Documents produced by Scottish local authorities that set out how an entire area's built environment will reach net zero, and how poor energy efficiency will be removed as a driver for fuel poverty. These include approaches to decarbonise buildings (both on-gas and off-gas); investigating the potential for heat networks; tackling poor building energy efficiency, especially where this is a driver for fuel poverty; and considering how to overcome challenges associated with mixed-tenure, mixed use and historic buildings. |
| Off-taker | A heat network customer which is supplied by the network. |
| Spinal route | A large transmission mains pipe transporting heat from a major source to a heat substation, often over a long distance. |

## Acknowledgements

We are grateful to Kyle Drummond and Hilary Blackman at the City of Edinburgh Council for their unwavering support and guidance on this work.

We are thankful to Kira Myers at the Edinburgh Climate Change Institute for sharing insightful data for our analysis, Morten Jordt Duedahl at the Danish Board of District Heating for his advice and materials, and all the stakeholders we engaged for their input.

We thank colleagues at the Heat Network Support Unit for their reviews, constructive challenge, and valued feedback.

# 3. Introduction

*In line with its legal duties, the City of Edinburgh Council in 2023 prepared a Local Heat and Energy Efficiency Strategy (LHEES) to assess the infrastructure and building upgrades needed to decarbonise Edinburgh's built environment. As part of the Edinburgh LHEES, the Council investigated the potential for heat networks within the Edinburgh local authority area. It demonstrated the potential for a city-wide heat network (or 'network of networks') which could decarbonise a substantial portion of the city's buildings and help alleviate fuel poverty. Subsequently, the Council (with support from the national Heat Network Support Unit (HNSU)) appointed Turner & Townsend and WSP to carry out strategic analysis to further assess the feasibility of heat networks in Edinburgh. This report presents the findings of our work.*

## 3.1 Rationale for this work

As part of the Edinburgh LHEES, the Council proposed a programmatic approach to delivering heat networks. It set an ambition to develop a *heat network delivery framework* which in turn would define a *heat network delivery programme*. The framework included a key task to refine the heat network zones identified in the Edinburgh LHEES and carry out a feasibility review of these zones. This would provide a better indication of the heat demand which could be economically supplied by a heat network and help to improve the deliverability of zones. The Council also identified the need to better understand the available heat sources and potential routes to supply this to customers via the city-wide heat network. The Council subsequently secured funding from the HNSU to further progress this analysis.

## 3.2 Objectives

To address these gaps, the Council outlined four key objectives which this work covers:

- An audit and analysis of low carbon heat sources in and around Edinburgh, giving a deeper understanding of the available heat supply. This covers key information on each source, including location, availability and heat potential. It considers sources in Edinburgh as well as the most significant sources in neighbouring local authority areas. We cover this in section 7.
- Refinement of the prospective heat network zones developed as part of the Edinburgh LHEES. The refinement is based on practical, commercial, strategic, regulatory, stakeholder and other considerations to delivering heat networks. It sets the basis for these zones to be later designated in line with the Heat Networks (Scotland) Act 2021, whether as they stand at present or with further refinements the Council and key stakeholders would deem suitable. We cover this in section 8.
- A high-level feasibility review of the refined prospective heat network zones. The feasibility review is a middle ground between the high-level zoning (carried out in the Edinburgh LHEES) and a detailed feasibility (which the Council may instruct for discrete zonal networks and/or spinal routes following this work). We present a summary of the feasibility analysis in section 9, with the feasibility review of each refined zone covered in 12.1. This work involved:
    - Hourly heat demand profile of each zone, based on Scotland Heat Map data and supplementing with real energy use data where available via stakeholder engagement.
    - Constraints analysis for each zone.
    - An indicative anchor network pipe route following the optimal path between anchor loads while considering constraints which would add cost or disruption.
    - A high-level technoeconomic assessment of each zone, with an estimation of the CAPEX and levelised cost of heat (LCOH). This articulates a basic investment proposition for each zone highlighting the feasibility and attractiveness of the opportunity.
- Identification of the optimal route for a spinal pipe serving a city-wide heat network or linking multiple networks. There are significant limitations for generating all of the heat required by the major zones from within or near to the zonal boundaries in an economical or practical way. This raises the need to potentially import this heat from into zones via a spinal pipe. This also opens up the possibility to source heat from large-scale sources, including from outside Edinburgh, which capture economies of scale and transmit this via the spinal pipe to various zones. We cover this in section 10.

Together, these four objectives form the technical foundation for delivering heat networks in Edinburgh, outlining how the Council can progress development. They also cover a major part of Action 22 in the Edinburgh LHEES Delivery Plan.

The Edinburgh LHEES and subsequent developments (discussed in 4.2) helped transition the approach to heat network planning from project scale to zonal scale. Our work aims to further shift the approach from zonal scale to 'utility scale' planning. A public utility is a regulated, reliable service considered to be fundamental to the region. It is provided through major physical infrastructure which is required to cost-effectively deliver the service to a substantial part of the population in an equitable way. This transition in approach to thinking about heat networks calls for maximising their extent while taking account of barriers from a technical, economic and strategic perspective. A utility-scale lens helps to establish investor confidence in Edinburgh's heat networks, helping them become a major generational infrastructure investment opportunity.

Executing at this scale requires close collaboration with partners across the sectors and supply chains. To this end, the Council tasked us to carry out an extensive stakeholder engagement exercise as part of this work. This was to gather information and gauge interest and perspectives on how heat networks should be developed. This involved engagement with potential developers, heat customers, waste heat providers, utilities, public bodies, designers and many others. The topics covered each of the four objectives above.

This engagement and collaboration also allowed us to align the analysis with the major future energy and net zero infrastructure transitions. This includes consideration for making best use of and aligning with energy generation, grid, storage and other infrastructure. In turn, it positions the city's heat networks as a core part of the next generation of the region's energy infrastructure, working in harmony with and enabling a just transition to net zero.

A key part of the just transition is ensuring the benefits of these networks are realised fairly by the city's residents, businesses and other organisations. In particular, this includes households in fuel poverty and extreme fuel poverty. Addressing fuel poverty is among the two most important priorities of the Edinburgh LHEES, alongside the other priority of improving energy efficiency and decarbonising heat. Bringing the lowest cost low carbon heat to fuel poor homes wherever possible is central to the Council's approach to achieving these priorities. We therefore considered areas of fuel poverty and social housing as a key part of the analysis, in addition to exploring methods to achieve the lowest cost of heat.

## 3.3 Scope

The Council's intention behind this project was to develop a strategic pathway to a city-wide heat network of the greatest viable extent. This is a crucial step before progressing with detailed feasibility, business case and procurement for future heat network projects. As part of its programmatic approach, the Council first needed to understand and develop a clear approach, highest value projects and an investment pipeline. This forms the basis for the *heat network delivery programme*, helping to plan, define and select projects as well as inform how these should be progressed and in what sequence (Figure 4). Without this strategic analysis, it would be challenging to identify projects, and the benefits, long-term value and strategic fit of each project would be unclear and with potentially greater project risk. Progressing with a lack of strategic coordination could also result in stranded assets or competing interest, potentially hampering developments or possibly jeopardising them altogether.

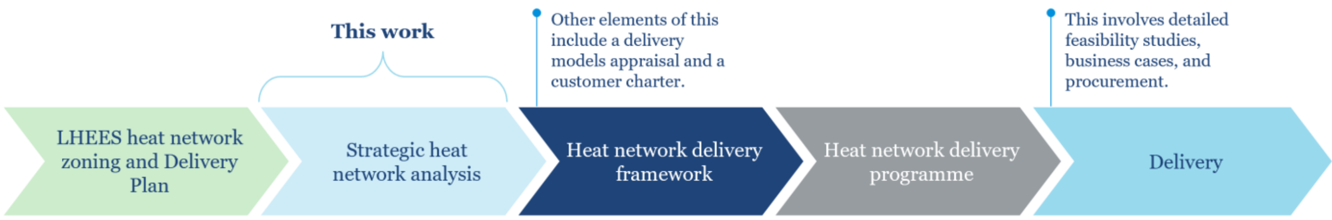


*Figure 4: The pathway to city-wide heat networks for Edinburgh as defined within the Edinburgh LHEES Delivery Plan.*

Recognising the compressed timeframes and limited resources involved, this work should be read with the following limitations in mind:

- The outputs of this analysis are indicative only and not intended to permanently fix plans under any of the four objectives of the analysis. They are an initial exploration with potential changes likely where new information is uncovered or if circumstances change.
- The purpose of the analysis was to define an overarching technical approach for the city's heat networks. The analysis is intended to aid in setting the Council's strategy and guiding the Council's

heat network delivery programme. We were unable to define details which normally fall within the remit of a detailed feasibility study. Deeper investigations will be required to take forward most technical findings of our work.

- This analysis is desk-based only at this stage; no site visits, surveys or audits were conducted.
- Due to limited timeframes, we focused on priority scenarios, options and possibilities for analysis of all four objectives. More scenarios may need to be explored in subsequent phases of the pathway highlighted in Figure 4.
- The timeframe and resources also afforded only limited opportunities to gather real world data. Therefore, the analysis relies on a significant amount of modelled and benchmark data.
- This analysis is aligned to the CIBSE CP1 Heat Networks Code of Practice. However, owing to the nature and scope of the project, the analysis does not constitute a detailed CP1 feasibility. We prioritised alignment to objectives 2.1, 2.2, and 2.5 in line with the Council’s guidance.

# 4. Context

## 4.1 Policy drivers

This section explores the current, incoming and potential future policy drivers which are linked to heat network development.

### 4.1.1 Current policy drivers

There are several policy drivers making heat networks a primary component of the Council's decarbonisation efforts. Chief among these has been the Local Heat and Energy Efficiency Strategies (LHEES) Order, which has triggered the initial heat network zoning investigations that has led to this work. Multiple other policies also play an important role; we define each of these policies and how they relate to heat networks we are exploring in this work Table 2.

| | |
|---|---|
| Heat in Buildings Strategy (2021) | The Heat in Buildings Strategy (2021) is the principal document setting out the Scottish Government's approach to decarbonising Scotland's building stock. It sets out the key challenges based on a national analysis of the built environment and proposes the actions which will be required to reach net zero as part of a just transition. Among the principal actions is the development of heat networks via several policy levers, funding schemes, programmes, regulations, and investments. |
| LHEES Order 2022 | This is a Scottish Statutory Instrument (secondary legislation) which places a duty on all Scottish local authorities to produce an LHEES. The LHEES should cover delivery planning for decarbonisation and energy efficiency improvements for domestic and non-domestic properties across the whole local area. Heat networks are identified as a key consideration for LHEES planning. The Council developed initial heat network zone prospects as part of the Edinburgh LHEES analysis. The Edinburgh LHEES also investigated these zones with respect to the potential for use of waste heat or renewable heat, presence of potential anchor loads, existing infrastructure in the area, potential to address fuel poverty, potential to contribute to national targets on heat demand, and potential for public buildings to connect to the heat network. This was in keeping with the requirements of the Heat Networks (Scotland) Act 2021. |
| Heat Networks (Scotland) Act 2021 | The Act provides a regulatory framework for the development, delivery and operation of heat networks as infrastructure investments. As a primary legislation, it reinforces the central role of heat networks by enshrining targets of 2.6 TWh of heat output by 2027 and 6 TWh of heat output by 2030 to be delivered via heat networks. It also sets the foundations for rules on licencing, consenting, permitting, transfers/conferrals, and designation of heat network zones. The Act places a duty on local authorities to review heat network zone potential in their areas at five-year intervals (practically, this is aligned to the development and publication of LHEES). Local authorities must also collate building assessment reports (BARs), a mandatory requirement on all public bodies. BARs provide detailed energy use information, allowing an assessment of high-level connection potential for public buildings. |
| Fuel Poverty (Scotland) Act 2019 | The Fuel Poverty (Targets, Definition and Strategy) (Scotland) Act 2019 was a key legislation which defined fuel poverty and set statutory fuel poverty targets at a national and local level. The Act requires that by 2040 no more than 5% of households in Scotland are in fuel poverty, no more than 1% of households in Scotland are in extreme fuel poverty, and the median fuel poverty gap of households in Scotland in fuel poverty is no more than £250 (in 2015 prices). These targets are defined at a local authority-level, hence apply to the City of Edinburgh Council. The Act also establishes other interim targets, priorities and actions for government. Fuel poverty has subsequently become a key driver for local and national policies, including for LHEES and heat network development work. |

*Table 2: The key heat network development policy drivers.*

### 4.1.2 Emerging regulations

We are in the midst of an evolving policy landscape with various emerging changes and expected shifts. Therefore, we expect these drivers to impact heat network development in addition to the existing regulations.

#### 4.1.2.1 Heat in Buildings Bill

The Scottish Government has concluded consultations on proposals for a forthcoming Heat in Buildings Bill. This is expected to be introduced into parliament later in 2025 and progress many of the legislative and regulatory commitments made by the Heat in Buildings Strategy into a comprehensive legislative package. The proposals for the Bill were initially introduced as part of the consultation but are now under revision by Scottish Government, citing the need for a more a risk-averse approach to fuel poverty. This is largely with reference to homeowners and likely in reference to requirements for decarbonising heat supply within a given timeframe following the purchase of a home. Details on specific changes to regulatory levers have not yet been released. However, the following proposals were originally tabled in relation to heat networks (many of which may still be considered given they do not directly impact on household decarbonisation decisions):

- A requirement for heat network operators to generate most of their energy from renewables or bioenergy by 2045.
- A requirement for all public buildings to decarbonise earlier by the end of 2038, with a connection to a heat network being a primary way in which they can achieve this[3]. The government intends to consult on a separate potential duty for public bodies to connect buildings they own to a heat network where one is available.
- A requirement for all non-domestic buildings to decarbonise by 2045, with a connection to a heat network being a primary way in which they can achieve this[3].
- A local authority could require the occupier of a non-domestic building to provide information about unused heat (or 'waste heat') on their premises. Further, where economically viable, the occupier could be required to supply their unused heat to a heat network.
- A local authority or the Scottish Government could require developers to connect new buildings in a heat network zone to connect to a heat network.
- A requirement for all domestic buildings to decarbonise by 2045, with a connection to a heat network being a primary way in which they can achieve this[3], and an earlier requirement for properties meeting certain triggers such as transfer of ownership or the change of a main heating system at the end of life[4].
- A local authority could require a building owner within a heat network zone to end the use of a polluting heating system with a minimum notice period after a heat network becomes available. The building owner could comply to this by installing their own clean heating system or connect to the heat network[5].
- In relation to the previous provision, a temporary exemption for decarbonising buildings within a heat network zone until a heat network is available, whereupon the building owner would be required to install their clean heating system or connect to a network. This approach is in contrast with properties outside of a heat network zone, which may be required to decarbonise earlier (for example at point of purchase).

These regulations will aim to facilitate the transition of the Scottish built environment to net zero, and many are geared toward giving heat networks the best possible chance at success. The Bill intends to give local authorities powers to drive uptake and equip developers with certainty to invest in heat networks.

Despite the delay and some remaining uncertainty, the continued commitment has encouraged us to take an optimistic view for our analysis, recognising that should these powers fall within the gift of the Council it will

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[3] The requirement to decarbonise a property is not in itself an action to support the development of a heat network. However, in practice, making connection to a heat network as viable way to meet regulations helps to attract customers to what might be the most financially attractive way to comply.

[4] The Scottish Government has referenced these earlier triggers as the reason for the revisions to the Bill as they could place added costs for homeowners, potentially exacerbating fuel poverty. Alternative proposals or changes/removal of these proposals have not been clarified.

[5] This provision could also be under revision as it originally applied to all buildings (domestic and non-domestic), but this is not currently clear until more information is released.

make heat network development more viable. It also has the potential to facilitate a more ambitious scope and scale of heat networks.

#### 4.1.2.2 Energy Act 2023

Heat networks have hitherto not been a fully regulated market, with past gaps in consumer protection which other energy markets have, lower certainty for investors, and undetermined roles and functions for regulatory bodies among other challenges. The Energy Act includes a framework for the development and regulation of heat networks. Many of its provisions are similar in topic to those of the Heat Networks (Scotland) Act 2021 but the Scottish and UK Governments have avoided legislative conflicts across English and devolved approaches.

The Energy Act defines England's[6] approaches to zoning, zoning methods, the role of local authorities, the consenting approach and other matters already covered for Scotland under the Heat Networks (Scotland) Act. The Scottish counterparts to these provisions remain withing Scottish devolved competence.

However, there are certain powers reserved by the UK Government, and the Energy Act establishes provisions for these at the UK-level:

- The UK Government defined Ofgem as the regulator for heat networks in England, Wales and Scotland, and the Utility Regulator as the regulator for heat networks in Northern Ireland. In Scotland, Ofgem will serve as the Scottish licencing authority as defined by the Heat Networks (Scotland) Act.
- The UK Government set the basis to develop secondary legislation governing the regulatory regime for heat networks.

Following the appointment, Ofgem has consulted on:

- Consumer protections: this covers Great Britain-wide standards for fair prices and transparent information for consumers, protections for consumers in vulnerable circumstances, a high quality of service, minimum standards, carbon limits, and sequencing regulations. It also covers how Ofgem will govern licencing regimes, including market step-in rights and rights.
- Authorisation and regulatory oversight over heat networks: this covers monitoring, audit, compliance and enforcement of authorised persons. This includes the activities to be regulated, models for governing the parties responsible for heat networks, the roll-out of the regulatory regime, registration and compliance processes, monitoring compliance against regulations, and enforcement actions against serious cases of consumer detriment, harm to the market, habitual non-compliance or other poor conduct.
- Fair pricing protections: ongoing consultation on proposals for pricing protections via a 'fair pricing framework', rules on redress, benchmark methods to compare pricing and identify disproportionate prices, price transparency, excess profit monitoring, and enforcement details. Notably, the proposals do not include direct price regulations (e.g. price caps or excessive profit regulations) in line with the UK Government's position; however, this will be kept under review.

At the time of writing, we await further details from Ofgem on the draft regulations covering the first two consultations; further, the outcome of the third consultation will not be clear until after it is concluded in July 2025. These details will help to determine investment, development, timescales, and consumer engagement with heat networks. As such, the analysis we have carried out is largely agnostic to these developments due to the uncertainty associated with the pathway that Ofgem and the UK and Scottish Governments may select. This is a major limitation for the Council, as the optimal strategy could change considerably depending on the regulatory regime.

#### 4.1.2.3 Scotland's regulatory regime

The Heat Networks (Scotland) Act and the Energy Act collectively provide the primary legislative foundations for developing and regulating heat networks. However, regulations are required to give effect to the provisions of the Acts.

The Heat Networks (Scotland) Act defines that one **licence** will be required per organisation to be eligible to operate heat networks in Scotland. This licence could be accompanied by conferred powers to aid the

[6] The Energy Act also includes Wales but does not apply powers for zoning methods and some other aspects of heat network development in the same way as it does for England (or for that matter for Scotland with reference to the Heat Networks (Scotland) Act). The Welsh Government will review the outputs of the Local Area Energy Plans to identify opportunities for zonal planning in Wales and thereafter make a decision on whether the zoning powers in the Energy Act are required in Wales.

development of a network, including wayleave rights, land acquisition powers, road works and surveying rights. The rationale for licencing is to ensure that only financially stable and qualified operators are able to build and operate heat networks. The licensees will need to operate heat networks in a way that is able to support a just transition, contribute to greenhouse gas targets, and support fuel poverty reductions.

Further, the Act also stipulates that a **consent** will be required to build and/or operate a heat network (in addition to a licence), and consents will apply to discrete new schemes. A consent could be granted by the Scottish Government, or by a local authority should the government appoint it as a consenting authority.

The Act also establishes a **permitting** function to award developers with exclusive rights to develop networks within a heat network zone. This is intended to provide developers with long-term certainty of the customer base available to them, attracting investment, reducing risk and encouraging expansion of networks.

Currently, the Act only provides the legal basis for regulation and there remains substantial work on developing a full regulatory framework which will give effect to these provisions; and at the time of writing no consultation on the proposed regulations has taken place.

Consumer Scotland will also play a key role by researching and advocating for improvements on behalf of consumers nationally. Furthermore, Advice Direct Scotland is the official, government-funded source of free, impartial advice for heat network consumers in Scotland, aiming to provide access to clear guidance and support to heat network customers. We anticipate these consumer advocacy bodies, Ofgem and the Scottish Government will collaborate to deliver on a framework for the most advantageous combination of quality and cost for consumers, catalysing the development of heat networks at pace and scale.

### 4.1.3 Conclusions on policy drivers

#### 4.1.3.1 Regulatory uncertainties

This three-pronged system (i.e. licences, consents, and permits) could provide ample leverage for the Scottish Government and local authorities to facilitate rapid development of large networks. However, much of the regulatory process, roles, timeframes, activities, and other details are yet to be defined by the Scottish Government. Without these details it is currently unclear how utility scale heat networks can be planned and delivered, how network connections will be made and managed at this scale, and how heat networks will be governed as a utility. This uncertainty makes investment decisions uncertain which in turn has introduced multiple uncertainties and assumptions into our analysis.

One example of an uncertainty is the potential expansion of existing networks. The policy position is clear in that existing operators will not initially require a consent to continue operating their existing heat networks. However, the implications of these operators expanding their networks is unclear as the Heat Networks (Scotland) Act also requires a consent to be required for extensions but does not define what constitutes an extension (a matter for secondary legislation). What type of expansion and at what point in that expansion would a licence and appropriate consents become mandatory[7]? An expansion by an operator to connect an existing or new building which is a part of their estate is unlikely to be a trigger as it would be disproportional. However, an extension of an existing heat network to one or multiple other off-takers might be an appropriate trigger, and so might other arrangements with a zonal network operator entailing some form of interface with the existing network or energy centre.

In this regard, stakeholders expressed hesitation when we fielded proposals on expanding their existing heat networks to serve additional users, integrating them into zonal networks as heat suppliers, or increasing their energy centre capacities to improve wider zone viability and routing. This reluctance caused challenges for our analysis, including with existing, proposed and in-development networks from a route planning perspective.

Another example of an uncertainty is the viability of modifying zone boundaries and how this would work with consents and permits already issued to heat network operators. It is unclear what processes or rules would need to be put in place to allow for extending or reducing zone boundaries[8]. For example, without a fair

[7] The Heat Networks (Scotland) Act makes two provisions that we consider to be relevant here. First, it introduces the possibility of exemptions for a consent (section 19). This is complicated by further limitations to this exemption but, in principle, this may be available to grant in the appropriate instances. Second, it provides the consenting authority with powers to make the consent subject to conditions or limitations it considers appropriate (section 24). Both of these provisions could allow for a governance framework which sets clear network extension rules; however, it is expected that the Scottish Government will lead on defining these.

[8] The Heat Networks (Scotland) Act includes provisions for making variations to zone boundaries (section 51) but a process, triggers, reasons and implications of this on other aspects of the Act (consents and permits) are all not understood. The Act includes compensation for revocation of a consent (section 32) or permit (section 61), but secondary regulations are to determine compensation circumstances, calculations, and procedures. Further, it is not clear whether a variation to the zone

process it could be considered anti-competitive to extend zone boundaries if private operators are involved, especially when there are two or more licensees with discreet networks and permits for their respective zones adjacent to the area in question.

In another related case, if there is an economic, policy, or strategic cause, areas of one zone may need to be transferred to another neighbouring zone. In both these cases, it is not yet clear whether what process the authority would follow to ensure a fair modifications process, or even what factors it must consider for designating zones in the first instance[9]. This caused challenges for us when deciding zone boundaries, especially where there was not a particularly compelling case, or it was unclear which zone would have the strongest case for an area along two zone boundaries. This is expected to play out over time, with network expansion across the zones and the practical learnings from that helping to shape how the network grows over time. Only then would service gaps and the need to resolve these arise.

Another example of uncertainty is the exact privileges of a zonal permit. Where a heat network operator within a zone is unable to supply heat to an area, or unable to do so in an economical way, there may be other operators who could achieve this. These could be a licensee with the right capability and/or capacity to deliver this, an existing legacy heat network operator within the zone who could extend their network, or an operator with a permit for the neighbouring zone who could cross the boundary to reach the area with their network. In all these instances, parties other than the permit holder would be in a strong position to service an area of the zone. There would be a case for intra-zonal and inter-zonal play to encourage competition, perhaps by issue of another permit if this is viable[10].

This created challenges for us in deciding the extent and reach of zones. Our scope did not cover a thorough buildability analysis for networks across each zone to determine the most viable boundary. Further, there are other factors such as constraints, heat sources, heat demand and development sites which complicate this decision. However, without further clarity on permit privileges, even detailed feasibility analysis may not be able to determine the most appropriate boundaries as there may be other policy and strategic considerations.

Another example of uncertainty is the relationship and viability for a bulk heat supplier (i.e. the entity which owns a cross-zonal spinal pipe) and a supply company (i.e. the entity which supplies heat for the last mile to the customer) to operate within the same zone. The mechanics of this are currently not addressed by any primary or secondary legislation. Large-scale developments will require clear rules to govern these two types of entities, providing clear processes and requirements for the appropriate consents/permits, well-defined powers and privileges for both entities within zones, prioritisation of activities and roles, and mechanisms to resolve conflicts. In the absence of this regulation, we had to largely disregard the potential regulatory gaps and challenges in the way of our zonal refinements and zonal and spinal routing. We had to assume that regulations would allow for the selected technoeconomic approach, rather than the preferable approach of aligning our analysis to regulatory requirements.

These are only a few examples which help us demonstrate the uncertainties we faced as part of our analysis. There are many other major and minor considerations which the regulatory regime would need to resolve[11]. In light of these challenges, we do not consider our outputs to be designation-ready zones at this stage. They may well be suited to designation after the regulatory environment has been created and it supports the zones as we defined them. Equally, they may require modifications depending on central government decisions on any number of the uncertainties explored in this section.

#### 4.1.3.2 Anticipated updates

The licensing regime will be Ofgem-led with some local authority input, where required. However, local authorities could have a more significant role in permitting and consenting heat network operators within their areas. It is currently unclear whether the Scottish Government will confer these powers to local authorities and, if it does, how these will play out at the local and national levels. The Scottish Government is yet to issue

for which an operator has a permit would constitute a revocation of the permit or no change, as there is no mechanism for modifying a permit.

[9] The Heat Networks (Scotland) Act indicates a possibility for the Scottish Government to produce guidance for local authorities on designating and varying zones (section 54). This would add much needed clarity for setting and changing boundaries.

[10] Part 4 of the Heat Networks (Scotland) Act highlight the basics of permits but does not delve into the detail of their relation to zones. It does not determine the number of permits per zone, nor the conditions, privileges, limitations or other aspects of the permit.

[11] A full assessment of the implications of Heat Networks (Scotland) Act and regulatory regime on our work was out of scope.

a joint consultation with Ofgem covering the licencing, consenting and permitting regime under the Heat Networks (Scotland) Act.

Further primary legislation in the form of the Heat in Buildings Bill may provide more levers to help network viability and expansion. Future and existing primary legislation is a welcome foundation for helping develop heat networks. However, the Council's decisions on heat networks are heavily reliant on the emerging regulatory regime. This is required to enable the Council to understand how it will develop and procure zonal-scale networks at a more practical level. This is critical given the potential scale of these heat networks, the central importance of heat networks as a decarbonisation route for a large part of Edinburgh, and the potential role for heat networks to help alleviate fuel poverty. Without clear regulations, it is unlikely that the Council can begin a city-scale project as there is limited certainty for:

- Developers: the risks of investment and return without certainty on a customer base, rights required to build the network, and the rules.
- Off-takers: lacking confidence in the process, pricing, quality, and transparency, all leading to currently uncertain consumer and public trust in heat networks.

Our analysis is currently based on the premise that competent regulations will be introduced in a timely manner, allowing the scale of the ambition to be realised. The analysis also considers that powers will be conferred to the Council to make (or that the Council will be able to request) permits and consents, allowing it to guide developments at the city, zonal and local scale. This includes the Council having authoritative decision-making powers for defining technical specifications regarding the heat networks which are built.

## 4.2 Progress to date

### 4.2.1 Edinburgh LHEES

Heat networks have been an area of investigation for the Council for many years, including as part of its Granton and BioQuarter development plans (discussed further in 4.2.2). The priority, scope and scale of heat networks has increased for the Council following the initial zoning analysis carried out in 2023 as part of the Edinburgh LHEES. That analysis followed the Zero Waste Scotland (ZWS) LHEES Methodology. It drew mainly from Scotland Heat Map (SHM) datasets, along with Council and other datasets. These datasets provide modelled heat demand estimates, information on existing heat networks, locations and sizes of potential heat sources and other supporting data to aid the zoning exercise.

The process of generating Edinburgh LHEES heat network zones involved a multi-point radii buffering method to identify clusters of buildings which have sufficient heat demand and are close together to be viable for a heat network. This GIS-based analysis relied on a combination of anchor loads and linear heat density (LHD) values to develop various sizes of buffers around properties to form clusters of heat demand[12]. These indicated the locations where heat networks are the most viable, providing the foundations for developing zones. Further analysis involved the assessment of the following factors to inform the shapes of the zones:

- Local Development Plan sites which covered growth and regeneration areas.
- Ongoing or past heat network feasibility studies.
- Constraints such as rivers, rail, major roads, topography, and other physical barriers presenting a challenge to the extent of zones.
- Heat density raster (a map layer from the SHM dataset which provides a 'heat map' (shaded matrices) of heat demand) to capture areas of high heat density near the boundary.
- Available heat sources proximate to the zones.

This analysis resulted in the identification of 17 prospective heat network zones with an annual total estimated heat demand of 3.7 TWh for all ~88k buildings within the zone (Figure 5 and Table 3). This included 1.4 TWh of demand from 545 anchor loads with heat demand exceeding 500 MWh/year[13]. The analysis adopted a positive outlook on heat networks, positioning them as a central strategy for meeting the Edinburgh LHEES twin objectives of decarbonising the built environment and reducing fuel poverty.

[12] The Council used the LHD value of 8,000 kWh/m/year for zones closer to the city centre and 4,000 kWh/m/year for zones in the suburban areas and the periphery of the city boundary. The analysis used a minimum of two anchor loads with demand of 500 MWh/year or more to prioritise clusters.

[13] These figures were based on modelled data and should be read as estimates. They also do not account for the potential future heat demand which could be created by new developments or expansions, or reduced heat demand as a result of energy efficiency upgrades or change in building purpose.

As the analysis was high-level, the Edinburgh LHEES Delivery Plan included an action to develop a heat network delivery programme to further investigate the feasibility of the zones and refine them with respect to deliverability. The programme would seek to use this analysis to help define the Council's strategy for heat networks. This action has been fulfilled through our work, presented in this report.

The Edinburgh LHEES Delivery Plan also set out an action to conduct options appraisal of delivery models and vehicles for supporting the roll-out of heat networks in Edinburgh. This has also been completed separately to our work, although we draw on this work to inform our analysis.

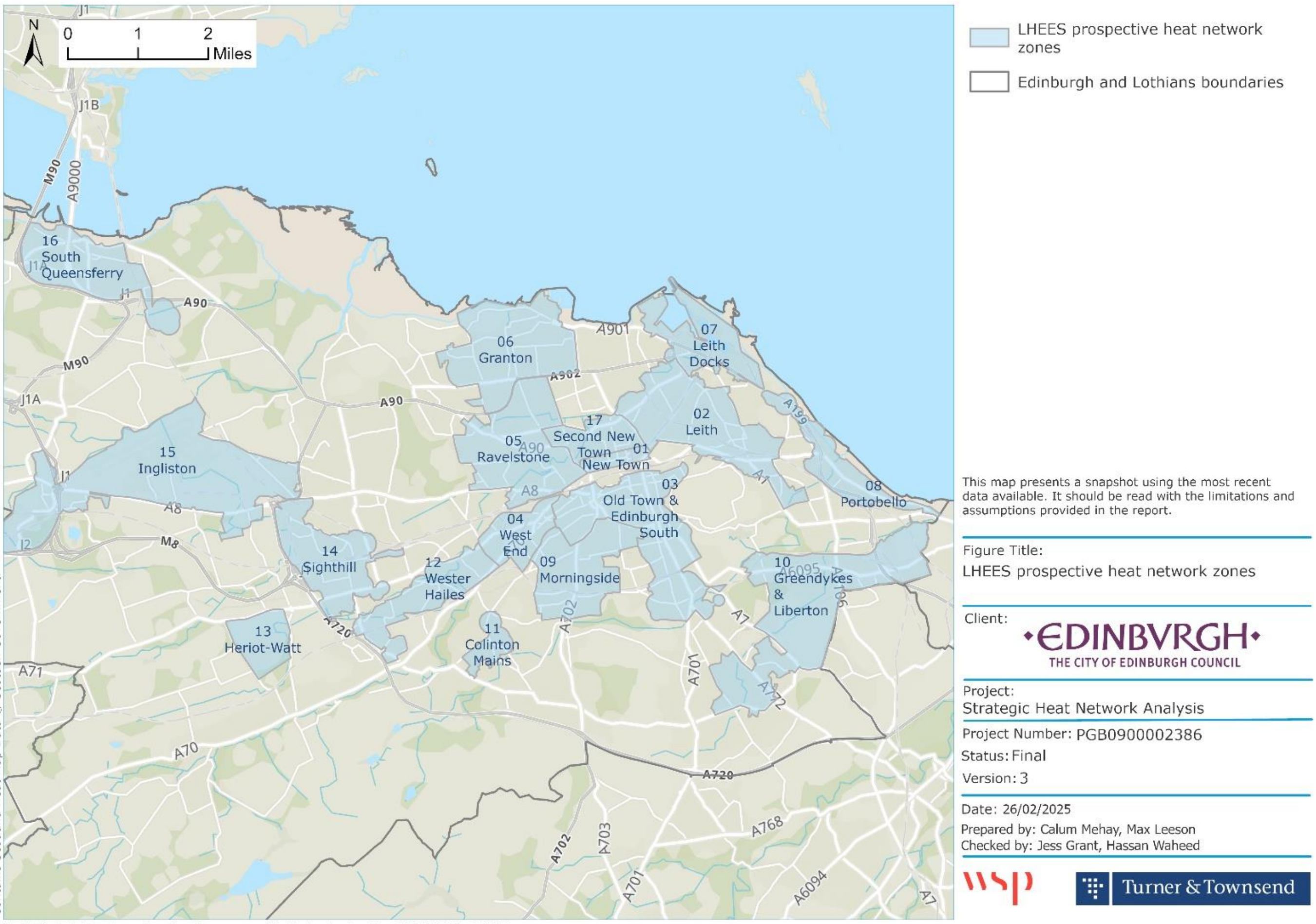




*Figure 5: Prospective heat network zones developed by the Council as part of the Edinburgh LHEES.*

| # | Zone Name | Buildings | Total heat demand (MWh/year) | Anchor loads | Anchor load heat demand (MWh/year) |
|---|---|---|---|---|---|
| *01* | New Town | 1,560 | 112,025 | 37 | 37,554 |
| *02* | Leith Walk | 15,149 | 439,127 | 43 | 46,915 |
| *03* | Old Town & Southside | 12,736 | 706,174 | 149 | 275,744 |
| *04* | Gorgie & Dalry | 3,846 | 630,021 | 14 | 514,898 |
| *05* | Craigleith | 7,589 | 287,103 | 33 | 83,148 |
| *06* | Granton | 8,425 | 190,383 | 26 | 35,142 |
| *07* | Leith | 2,047 | 119,369 | 32 | 44,238 |
| *08* | Portobello & Seafield | 2,975 | 88,143 | 10 | 10,145 |

| # | Zone Name | Buildings | Total heat demand (MWh/year) | Anchor loads | Anchor load heat demand (MWh/year) |
|---|---|---|---|---|---|
| *09* | Morningside | 7,306 | 283,938 | 17 | 54,218 |
| *10* | South East Edinburgh | 8,422 | 187,528 | 38 | 56,369 |
| *11* | Colinton Mains | 312 | 11,675 | 5 | 5,389 |
| *12* | South West Edinburgh | 4,214 | 119,474 | 27 | 32,068 |
| *13* | Heriot-Watt | 80 | 68,751 | 17 | 62,927 |
| *14* | Sighthill & Gyle | 2,148 | 138,136 | 45 | 73,652 |
| *15* | Ingliston | 614 | 90,287 | 34 | 62,153 |
| *16* | South Queensferry | 4,253 | 75,742 | 8 | 12,627 |
| *17* | Second New Town | 6,284 | 185,446 | 10 | 11,924 |
| | **Total** | **87,960** | **3,733,322** | **545** | **1,419,111** |

*Table 3: The 17 Edinburgh LHEES prospective heat network zones.*

### 4.2.2 Pre-capital developments

There are several major local developments, covering new housing, business facilities, research and education facilities and other classes. As recognised in the Edinburgh LHEES, new developments often provide the best opportunities for developing networks. There is a lack of inertia against change which is typically faced in already developed areas where there is typically limited or no appetite for disruption and existing utilities and heating systems. A development site requires substantial work (digs for utilities, foundations, landscaping, etc) providing an easier opportunity to install infrastructure with far lower cost and disruption, clearer and lower risk investment opportunity, more certainty in heat sales agreements (i.e. heat networks as the primary/only heating system) and other factors which contribute to heat networks as a preferred option. In this regard, the Council has been actively progressing several heat network opportunities as 'low regrets' initiatives prior to and in parallel with the Edinburgh LHEES analysis and continuing alongside our analysis and into the future.

This has been a fruitful endeavour, putting the Council on the front foot with several projects in the pipeline alongside an advantageous position of being experienced and prepared for scaling these efforts. We have assessed the progress and nature of all these developments and have fully incorporated them into our analysis. We summarise them in the following subsections.

#### 4.2.2.1 Granton Waterfront

The Granton development has been a major regeneration project for Edinburgh, providing substantial housing and other amenities for a new town on the coast. The energy options appraisal identified the potential for a heat network as an attractive lowest cost low carbon heating option. The Council invested significant time and resources to fund a feasibility study, technical design, and a business case, arriving at a concession model[14] as the preferred delivery route for the planned network. In 2024, the Council tendered for and appointed Vattenfall Heat UK Limited as proposed concessionaire on a two-stage process in December 2023. The initial pre-development stage is currently underway with a view to concluding with a final investment decision (on entering into a concession agreement to develop the scheme) in the second half of 2025. Initial routing and energy centre plans for the Granton heat network have been completed and these are incorporated in our analysis (Figure 38 in section 8.3 visualises this).

The Granton heat network is the most mature Council-led strategic heat network project in Edinburgh.

[14] A concession model is based on a concession agreement, meaning a private sector-led venture is appointed to develop and operate the scheme albeit with some contractual levers at the Council's disposal. These levers help the Council safeguard off-takers and ensure fair price for heat, fair rules for connection/disconnection, reinvestment and other considerations.

#### 4.2.2.2 BioQuarter

Edinburgh BioQuarter is a proposed major development in southeast Edinburgh being led by the BioQuarter Partnership comprised of the Council, NHS Lothian, Scottish Enterprise, and the University of Edinburgh. The development is focused on health innovation and life sciences, with proposals for over two million square feet of commercial space, alongside 2,000 homes. The development also has a sustainability strategy requiring all new buildings to decarbonise by 2030 and for all remaining buildings to decarbonise by 2040. Existing buildings at the development include the Royal Infirmary of Edinburgh, the Chancellor's Building (home of the University of Edinburgh Medical School), and multiple other education, research, and commercial facilities. The strategy for progressing the BioQuarter development is currently being reviewed by the Partnership.

Recognising the potential for a heat network to supply low-cost heat and aid in decarbonising the buildings, the Partnership commissioned a heat network feasibility study. This study suggested a fourth-generation heat network and district cooling network. It pointed to the Millerhill energy from waste (EfW) plant nearby in Midlothian as a major source of heat for this network.

The Council has recognised there is a potential cross-boundary role for Midlothian Energy Limited (MEL), a joint venture between Midlothian Council and Vattenfall. MEL is actively developing a heat network at the Shawfair development in Midlothian close to BioQuarter. This network is powered by a new energy centre, and it is also surrounded by two potential major sources of heat:

- Millerhill EfW plant, which MEL is planning to utilise as the main heat source for their ongoing network under development.
- Mine workings at Monktonhall Colliery and across the area, which MEL is considering as a major source of heat for a potential larger heat network(s).

As part of the Edinburgh LHEES analysis, BioQuarter as well as the surrounding areas were included within a much larger prospective heat network zone, *Zone 11 – Southeast Edinburgh*. This zone also covered Fort Kinnaird retail park and the neighbourhoods of Newcraighall, Craigmillar/Niddrie, Gilmerton and Gracemount.

#### 4.2.2.3 Gracemount

In 2022, the Council identified a cluster of closely placed buildings that it owns in Gracemount, south Edinburgh, as a potential discrete heat network opportunity. A heat network was considered as a means to cost effectively decarbonise these buildings as well as a nearby NHS medical practice. Additionally, since the heat demand is based on public buildings, most of which are Council-owned, the opportunity could provide a potential developer with certainty of demand. This could make it attractive for the developer as well as the public bodies involved. The Council commissioned a feasibility study to assess heat network options and costs. The analysis found the preferred heating system to be a ground source heat pump with an electric boiler peaking plant as well as thermal storage.

The next step for the Council was to develop a business case for a Gracemount heat network. The area was subsequently incorporated within *Zone 11 – Southeast Edinburgh* alongside BioQuarter as part of the Edinburgh LHEES heat network zoning analysis. The Edinburgh LHEES consolidated Gracemount with other local heat network plans and helped the Council consider the role, fit and priority of this scheme within the wider potential zonal network as well as withing the context of city-wide heat network roll out. Plans for a standalone Gracemount heat network have since been parked in favour of a potential zonal network encompassing the area (or at least until the extent and viability of the zonal network is established).

#### 4.2.2.4 Seafield

The Council is master-planning a major redevelopment of Seafield, northeast Edinburgh, under the project designation Seafield Regeneration Area (SRA). The SRA aims to provide a variety of housing types, a community hub, a new primary school, and mixed-use and commercial facilities. As per current building standards, all new homes in Scotland require a clean heating system to attain a building warrant. In practice, in most circumstances this means that homes must have an electrified heating solution (e.g. a heat pump) or be connected to a heat network.

Equally, the Council prioritised net zero, focusing on efficient buildings powered by renewable heating. The Edinburgh LHEES considered the SRA as part of the heat network zoning analysis, and this area was incorporated into the Edinburgh LHEES *Zone 9: Portobello & Seafield*. The Council subsequently tasked the architect to consider heat networks as the preferred heating solution within the masterplan. The masterplan identifies the Seafield Waste Water Treatment Works (WWTW) as the potential heat source.

There is sufficient land for a potential energy centre along with a safeguarded indicative pipe routing to capture the low-cost heat from the WWTW. The development is currently undergoing its third round of consultation, with planning applications and a delivery strategy as the next step. A detailed feasibility is envisaged to support further development of the heat network scheme.

#### 4.2.2.5 Other developments

There are several ongoing heat network developments in Edinburgh which have seen limited involvement from the Council. These have become relevant to track in recent times due to the Council's role under the Heat Networks (Scotland) Act as well as heat network plans under the Edinburgh LHEES. As such, the Council keeps a record of various developments across the city. Among these, the most prominent are the Edinburgh Airport heat network and expansions to the University of Edinburgh's heat networks.

### 4.2.3 Delivery models

The Edinburgh LHEES put forward a major ambition for heat networks but also recognised the need for significant work to develop a delivery vehicle to build and operate these networks. In general, heat network delivery models can be viewed along a spectrum ranging from public-led to private-led, with hybrid approaches in the middle. Selection of a preferred model depends on multiple factors; however, three factors play the biggest role in this decision: risk, return, and control. The selection of a delivery model depends mainly on the suitable balance of the appetite across these factors for the decision-maker. This range is illustrated in Figure 6. The Scottish Futures Trust (SFT) has produced a detailed analysis of delivery models, including identification of models which would best suit heat network delivery in Scotland[15].

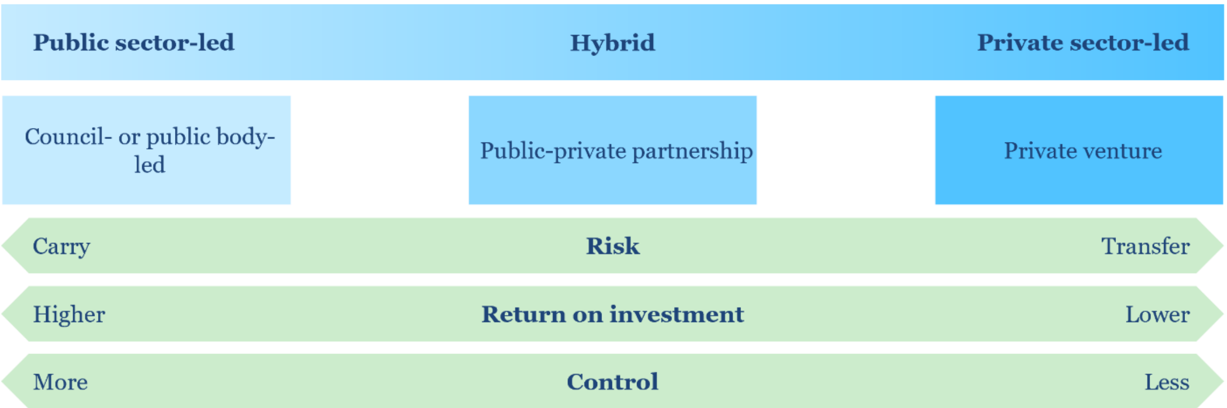


*Figure 6: A high-level summary of three heat network delivery model types and the factors from the Council's perspective. In practice, there are several mainstream delivery models and many other specialised delivery models across the spectrum beyond these three.*

The Council has commissioned analysis aimed at carrying out an options appraisal of delivery models[16] as a workstream in parallel to our work. This analysis considered options along the spectrum and shortlists three recommended options for the Council to explore further:

- A service concession (private sector-led).
- Council minority joint venture with minority stake (hybrid).
- Council-led joint venture with a 50:50 partnership (hybrid).

This selection can be challenging as preferences across all factors may not align, often leading to a compromise on one or two factors in favour of preferences for a priority factor. This is further complicated where a long-term decision needs to be made which also covers heat networks across the entire jurisdiction, as is the case for Edinburgh. Making a decision of this magnitude is required as soon as possible if the Council is to set the foundations for large-scale developments.

The lack of clarity on a specific model has proven challenging for our work. The type of delivery model has a major bearing on how the Council's city-wide heat network strategy should be shaped, including how the zones and spinal route are developed and delivered.

[15] Scottish Futures Trust (2024). Heat Networks Delivery Models.

[16] Brodies LLP (2025). Edinburgh Heat Network Delivery Model: Legal Options Appraisal

For example, a joint venture with a private sector partner (hybrid model) could put the Council in a flexible position, meaning it can plan and deliver networks across zones in the manner which best aligns with its goals. The heat network zones would serve more as a regulatory instrument, and the extension, reduction, reshaping and designation of the zones would serve largely as delivery and planning tools. The Council would have the option to adapt zones with relative ease and without developer resistance as it would only be reshaping zones that it would be delivering heat networks in eventually. This would mean our analysis should focus on zone development to aid a delivery plan, without the need for careful consideration for exact long-term boundaries. In this regard, zone locations, shapes and number of zones could be considerably different.

On the other hand, a private sector-led approach involving multiple providers would require the development of a fair and competitive market environment. The approach to defining zones would entail spreading the risk and opportunity in a fair manner, meaning developers have ample opportunities across the city, attracting investment and interest from various types of parties. To provide investors with certainty, the Council would likely need to fix zonal boundaries and routing plans to be bounded by these.

Before doing this, the longer-term implications of the shape, size and other aspects of zones would have to be studied. This is because it would not be straightforward to alter zone boundaries or zonal/spinal routes once developers have been granted a permit for a zone (once the permitting regime comes into effect). Therefore, our analysis has to reflect the need for these zones to form the basis of a heat network market, and for the boundaries to be considered on account of fairness of risk and opportunity, competition, attractiveness for investment (return on investment), and deliverability and practicality (routing, energy centre location and sizes, availability of land, constraints and barriers, and connection-ready anchor loads and off-takers).

Further, without clarity on the delivery models it is also unclear how the Council might procure. For example, if the private-led approach is selected, then should the Council procure just one developer at a city-scale, offer multiple zones at once, or procure one zone at a time[17]? Or should the Council potentially procure for multiple types of delivery models[18]? These questions raise similar issues to those explored above. They also raised another challenge in that it became difficult for us to develop strategies on how networks should be phased at the zonal scale or city scale.

The Council is expected to select its preferred delivery model in 2025-2026. It is worth noting that this selection is likely to determine any involvement of and role for Energy for Edinburgh Limited, the Council's dormant energy services company. Once the selection process has concluded, it will contribute to completing Action 22 of the Edinburgh LHEES Delivery Plan. More specifically, this work covers the first action in Phase 1 of the *heat network delivery framework*: an options appraisal of delivery models and vehicles.

We consider the need for further work to marry the findings of this work with that of the selected delivery model(s) to refine the strategy further. This will allow the Council to move onto procurement and delivery.

### 4.2.4 Public sector efforts

The Council has collaborated closely with relevant public bodies in and around the city to coordinate a shared public sector approach to support heat network roll out. This includes the coordination of a unified approach to heat network development within Edinburgh as well as collaboration with neighbouring local authorities.

It is important to note that Edinburgh already has many operational heat networks. The largest heat network operator in Edinburgh is the University of Edinburgh which owns and operates four heat networks within the city, exclusively serving University buildings:

- Holyrood heat network
- George Square heat network
- Pollock Halls heat network
- King's Buildings heat network

#### 4.2.4.1 Net Zero Edinburgh Leadership Board and Edinburgh Climate Change Institute

The Net Zero Edinburgh Leadership Board comprises a partnership of the Council, NHS Lothian, the University of Edinburgh, Edinburgh Chamber of Commerce, ScottishPower Energy Networks (SPEN) and SGN. This group has been leading on wider net zero activities under the Net Zero Edinburgh umbrella, including energy master

[17] This highlights the added complexity of the procurement scope. The delivery model type is one dimension, whereas the scope of the procurement is an added dimension which further raises uncertainties.

[18] Note that the Granton heat network has already been procured as a concession (private sector-led). It is unclear how the Council will choose to fit this within future delivery model selection, should that be a significantly different approach.

planning, data sharing and dissemination, and developing a coordinated approach to decarbonisation and climate adaptation.

As one of its workstreams, the board commissioned the Edinburgh Climate Change Institute (ECCI) to carry out high-level GIS analysis on heat network potential in Edinburgh. This work has involved network route mapping and other pieces of analysis. The outputs and many of the datasets behind this have been shared with us by the ECCI to support our analysis.

ECCI has also been playing a key role in consolidating various visions of heat networks at the local and regional levels. This has included tracking Edinburgh LHEES; local authority activities, plans and analysis; progress made by other public bodies; and private sector visions. This has culminated in a detailed online GIS dashboard[19] and a high-level map of possible ways to power heat networks in the region (Figure 7).

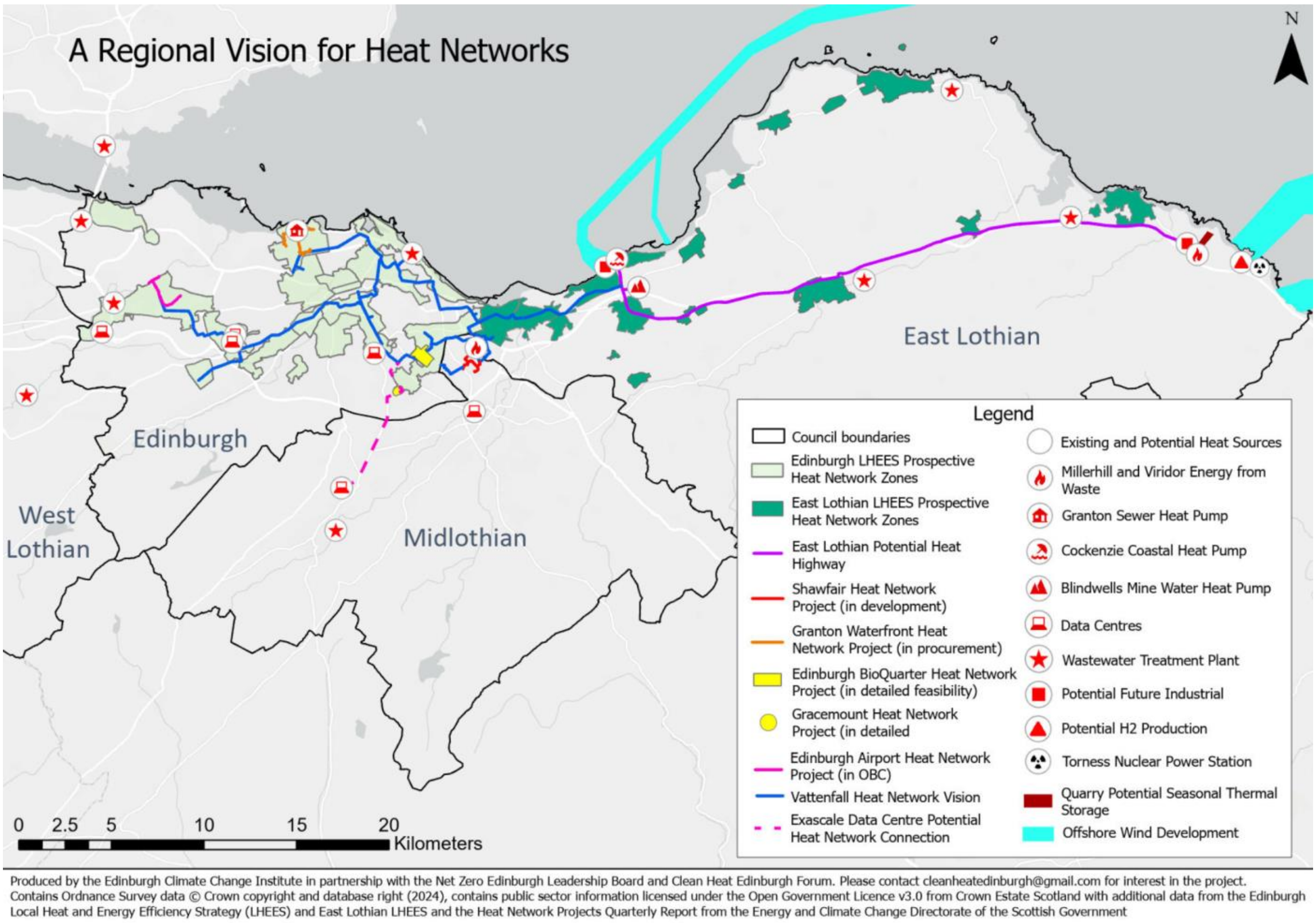


*Figure 7: High-level mapping of the various heat network visions for Edinburgh and Lothians brought together.*

### 4.2.4.2 Partnering with other local authorities

The LHEES Order requires all Scottish local authorities to develop and maintain their LHEES and the Heat Networks (Scotland) Act similarly requires all local authorities to conduct analysis on potential heat network zones. Therefore, East Lothian Council, Midlothian Council and West Lothian Council have also carried out this analysis via their own approaches.

The approaches taken by each local authority differ. Consequently, the scope, size and nature of heat network strategies across the local authority areas are also unique. While they share some similarities (e.g. they all aim to identify areas of high heat demand density), there are differences which should be considered before local authorities can develop a common view of the heat supply and demand across the region.

These differences can be considered in two terms: technical differences and strategic differences. The **strategic differences** can be considered as the key policy, economic and delivery decisions:

[19] ECCI (2025). Climate Action Map.

- Scope: not all heat network zones have been developed with the same set of vision of scale; for example, Edinburgh has focused on an expansive network with the greatest possible extent that is economically attractive, but Midlothian has focused solely on zones around selected public buildings.
- Key objectives: some core objectives for heat networks are not shared; while there is general agreement on developing heat networks where they provide the lowest cost of clean heat, there are multiple other factors at play across the local authorities including fuel poverty, community ownership, economics, income generation, inward investment, employment and other policy objectives.
- How heat networks will be delivered, including the timeframes, delivery models, their relative importance as a decarbonisation strategy and other factors.

The **technical differences** relate to how zones have been generated (i.e. the methodologies) all the way down to specific plans and specifications of networks. While these are important in practical terms, they are addressable relatively easily should the local authorities be strategically aligned in a timely manner:

- LHD and anchor load criteria used to develop buffers which inform the boundaries and hence the typical heat demand and attractiveness of a zone.
- The additional factors used in informing zone boundaries (constraints, LDP sites etc.).
- The nature of heat supply and transmission.
- The nature and likely future specification and scale of local networks and spinal route plans.

The three neighbouring local authorities shared the initial zones developed as part of their LHEES for our analysis. These are displayed in Figure 8.

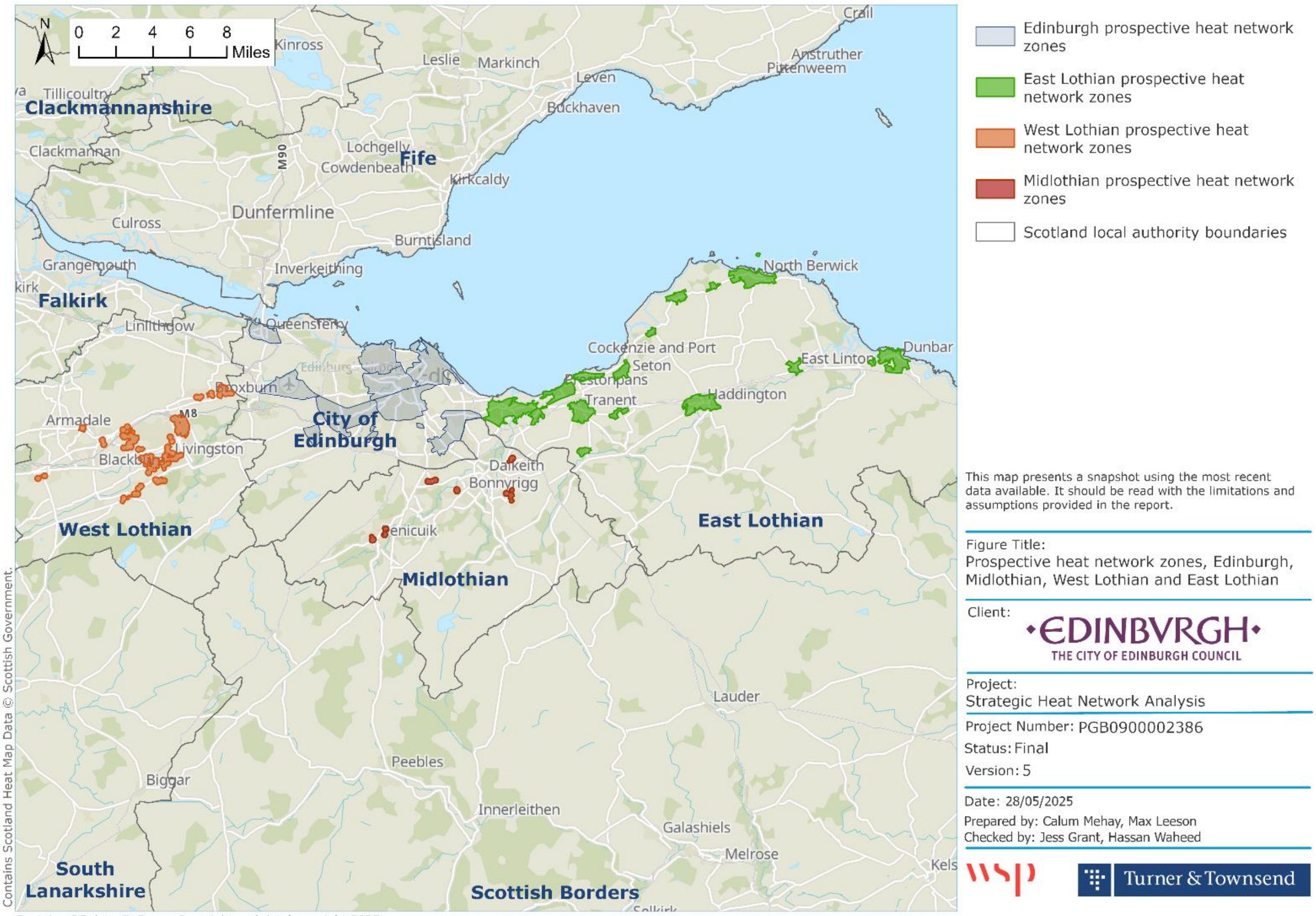




*Figure 8: Prospective heat network zones across Edinburgh and the Lothians. We have used the updated zones for Edinburgh produced through our analysis (discussed in section 8). Zones across other local authorities may also be outdated at the time of reading. Readers should refer to local authority LHEES and any subsequent publications for the most accurate view of the zones. While a neighbouring local authority, Scottish Borders heat network zones have not been included as none are close to Edinburgh's zones or any material level of heat demand in Edinburgh.*

There has been recent heat network planning in East Lothian and heat network planning and developments in Midlothian. Much of this also involves Edinburgh as the natural epicentre of heat demand in the region. These local authorities recognise the potential to supply heat to Edinburgh, a role which the Council is receptive to given to scale of potential heat that the city may require. The relevant developments are discussed in the following sections 4.2.4.3 and 4.2.4.4.

### 4.2.4.3 Midlothian heat network developments

Midlothian Council's joint venture with Vattenfall, Midlothian Energy Limited (MEL), is responsible for heat network activity within the Midlothian local authority area. MEL has developed a heat network with the aim of supplying 3,000 properties at the new town of Shawfair. This uses the waste heat from the Millerhill Recycling and Energy Recovery Centre (RERC) EfW plant. The heat available is approximated at 20 MW, but the network is expected to utilise only up to 8 MW with 12 MW still remaining. MEL has positioned to be able to supply this excess heat to the existing and new buildings at the Edinburgh BioQuarter development as well as across the southeast Edinburgh area. This could become a potential cross-boundary heat network (and heat network zone).

Zero Waste Scotland (ZWS) has also investigated southeast Edinburgh with respect to cross-boundary heat networks in 2022. It also focused on the Millerhill Recycling and Energy Recovery Centre as a heat source and utilised the LHEES methodology (as described in 4.2.1) to identify a cross-boundary zone across Edinburgh, Midlothian and East Lothian. This identified two cross-boundary zones. This work was not intended as an LHEES output but rather a demonstrator of possibilities where local authorities can collaborate to leverage heat from a low-cost heat source for demand across boundaries.

Following heat network developments at Shawfair, Vattenfall has also produced a vision of a cross-boundary heat network which would link into Edinburgh's plans for a heat network around BioQuarter. This proposes delivering excess heat from the Millerhill Recycling and Energy Recovery Centre, which is beyond what is required at Shawfair, to BioQuarter and potentially other areas in southeast Edinburgh (Figure 9).

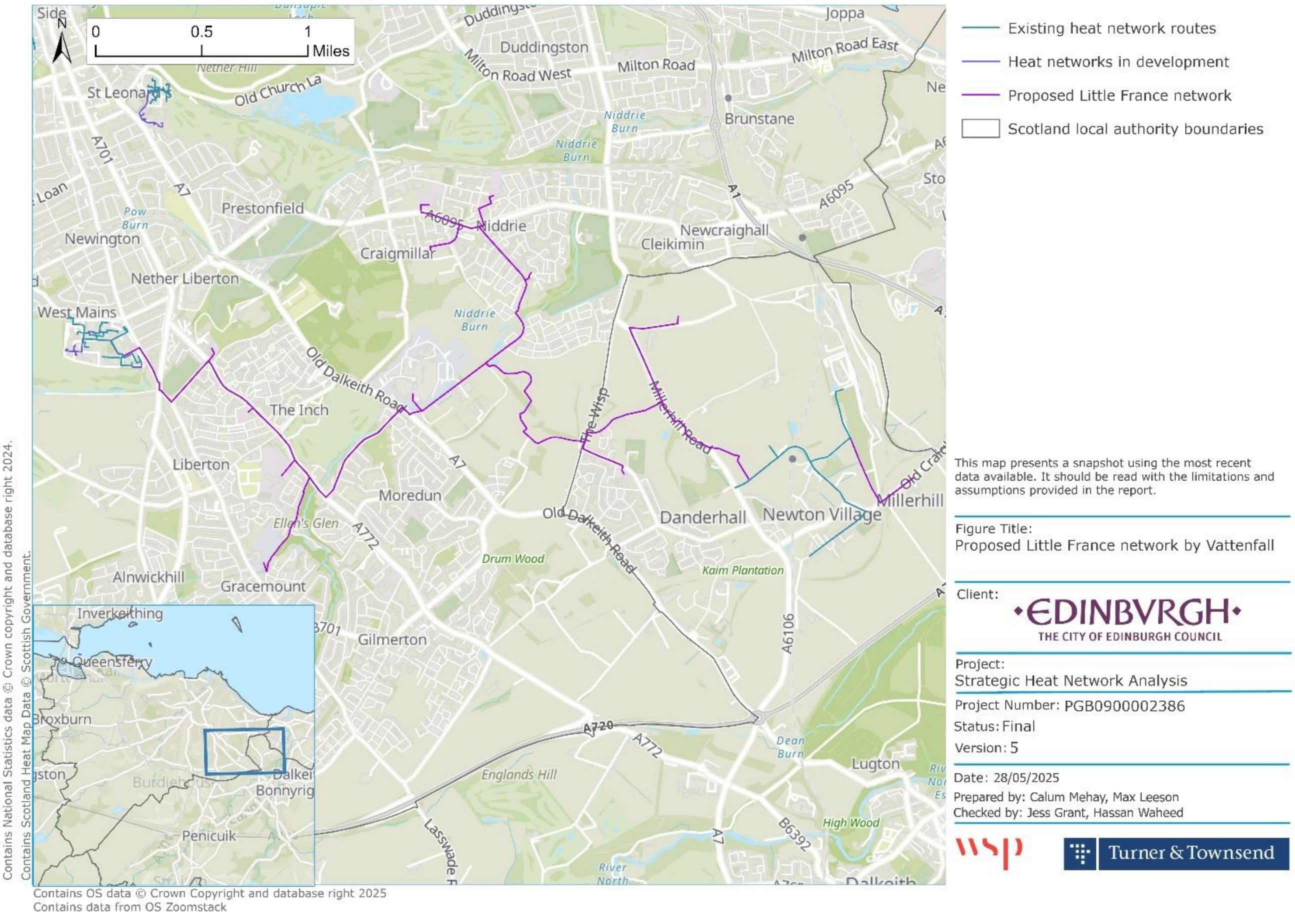


*Figure 9: Vattenfall's vision of the potential extent of their heat network, crossing over from Midlothian into Edinburgh.*

#### 4.2.4.4 East Lothian heat supply planning

East Lothian has multiple major current and potential future energy assets which are of interest to the Council. These include offshore wind landing at multiple points across the coast, major grid infrastructure assets (especially surrounding the decommissioned Cockenzie Power Station), Dunbar Energy Recovery Facility (a Recycling and Energy Recovery Centre operated by Viridor), mine workings, quarries and other potential heat generation and storage assets. The heat potential of these is substantially greater than the heat demand for future heat networks within East Lothian. Many of these assets could theoretically be developed into strategic energy assets to export large volumes of heat to Edinburgh in an economical way (see Figure 7).

This is of interest to both local authority areas as Edinburgh lacks many of these assets but has major heat demand for which it needs a low-cost low carbon heat supply, while, conversely, East Lothian lacks the heat demand to make full use of these assets but could benefit economically by supplying heat to Edinburgh.

A community-led study has been commissioned to study a potential spinal route which connects these strategic energy assets to the heat demand in Edinburgh. This study is expected to provide detailed analysis of the options, the capital cost, the price at which heat could viably be supplied, and potential ways in which this project could be developed.

# 5. Methodology

*This study involved a mixed methods approach, with each of the four objectives requiring a unique approach to the analysis. In addition, stakeholder engagement also required its separate method. This resulted in five discrete methodologies for this project. However, these were all intertwined as the activities and analysis ran in parallel and fed into each other. This section presents these methods in brief, which each of the following 5 sections covering the respective methods in detail.*

## 5.1 Summary of methods

Stakeholder engagement was unique in that it was the only element with a heavy focus on a qualitative approach. The remaining four methods are mostly quantitative, and each reflects an objective of this study. A high-level summary of these methods is provided in Table 4 and illustrated in Figure 10.

| Objective | Methodology type | Methodology description |
|---|---|---|
| **Stakeholder engagement** | Qualitative | We developed a stakeholder engagement strategy which defined six steps to carry out the engagement. We:<br>1. Mapped the Council's strategic drivers for engagement.<br>2. Identified the key stakeholder types and the specific organisations.<br>3. Analysed each stakeholder with respect to interest, influence and position in relation to the Council's heat network delivery programme.<br>4. Developed sector and stakeholder-specific engagement plans.<br>5. Engaged via the appropriate channels.<br>6. Reviewed and analysed themes to report back to the Council and HNSU as well as inform our analysis. |
| **Heat sources audit** | Quantitative | The heat source audit method was intended to capture all possibilities and thereafter refine these down to the most relevant sources for the Council's strategic aims. We:<br>1. Developed a longlist of all potential heat sources.<br>2. Shortlisted sources using a multi-criteria assessment agreed with the Council; this focused on larger sources which could support the development of zonal networks and a spine to transmit bulk heat to these zones.<br>3. Developed profiles for all shortlisted sources to make the final selection of the sources to take forward and whether these would be suitable for zones or the spinal routes. |
| **Zone refinement** | Quantitative | We began with Edinburgh LHEES zones as the starting point and carried out four key steps iteratively until we arrived at updated zones the Council approved and the HNSU agreed with. We:<br>1. Established a data source hierarchy.<br>2. Updated heat demands of anchor loads.<br>3. Aligned boundaries to the Council's strategic rationale for developing heat networks.<br>4. Limited the boundaries where there were physical barriers based on a constraints analysis. |
| **Feasibility review of zones** | Quantitative | We carried out the feasibility review in broad accordance with the CIBSE Code of Practice for Heat Networks (CP1). The scope and timeframe were limited to considering anchor loads only, thus all feasibility review outputs are based on this assumption. We: |

| Objective | Methodology type | Methodology description |
|---|---|---|
| | | 1. Developed total energy load profiles for the heat networks within each zone using typical 24-hour heating and hot water profiles for the building types.<br>2. Used these to develop heat pump-based energy centre configurations, arriving at gross internal area and simplified costs.<br>3. Used a Steiner tree algorithm (which finds the optimal route to connect anchor loads based on specified parameters) along with an engineer-led refinement to generate network routes.<br>4. Carried out economic analysis considering the cost of generation only (excluding revenues and phasing) covering CAPEX, REPEX, maintenance costs, and fuel costs to arrive at total CAPEX and LCOH for each zone. |
| **Spinal routing** | Quantitative | We initially developed the rationale for a spinal route, testing the need and benefit of it using heat demand figures, heat supply figures from secondary heat sources, stakeholder insights, and detailed discussions with the Council. We established a technical as well as strategic need for a spine to be able to deliver the networks of the required ambition. Using the primary heat sources developed as part of the audit and the refined zones, we:<br>1. Defined an indicative spinal architecture serving all relevant zones, including phases and hydraulic configuration.<br>2. Developed spinal routing with consideration to heat supply, heat demand and constraints.<br>3. Costed the routing and carried out a high-level calculation to establish how much cheaper the spinal heat would need to be (the margin) to offset the additional cost of the capital for the spine over its lifetime. |

*Table 4: A summary of the methods used in this study.*

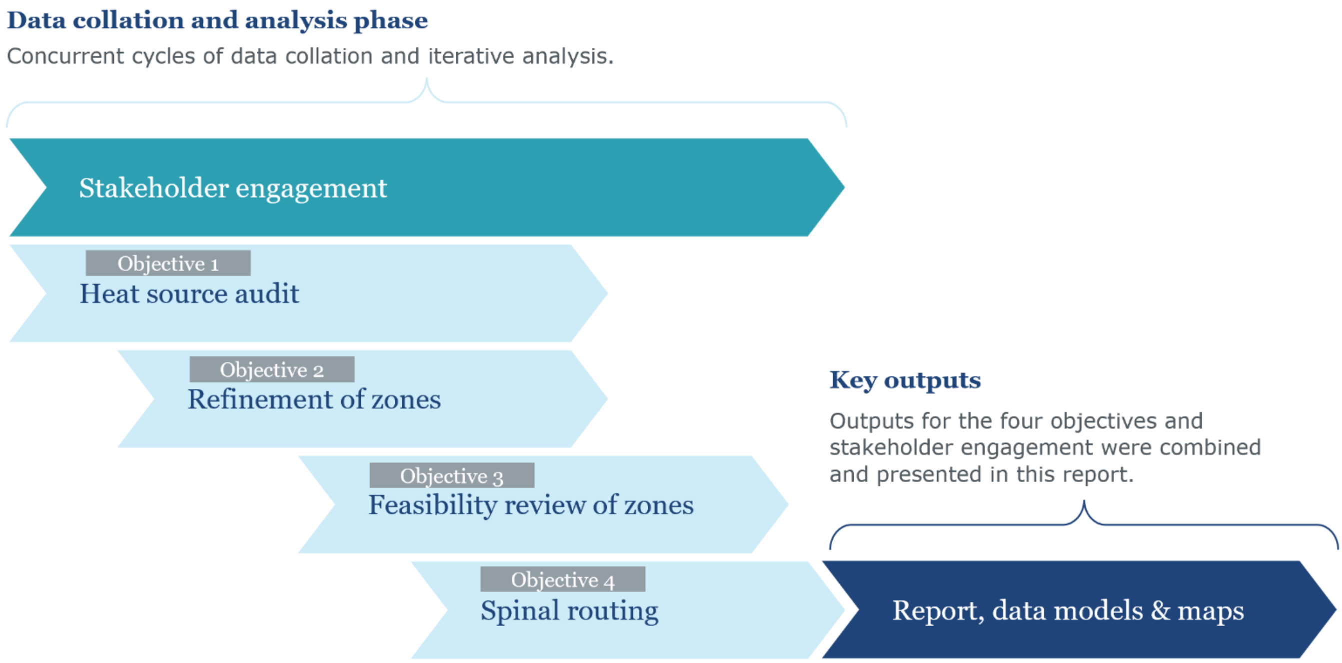


*Figure 10: Our broad methodological process.*

# 6. Stakeholder engagement

## 6.1 Approach to stakeholder engagement

The Council has been engaged with public and private organisations within and surrounding the Edinburgh local authority area. Historically, this engagement entailed gathering input for the various discrete heat network projects being developed, mostly on a project-by-project basis (see 4.2.2). The Council undertook engagement at a more strategic level as part of the Edinburgh LHEES heat network zoning activities. This involved taking on board feedback on the initial draft zones and proposals for a city-wide heat network from regulators, public bodies, and other key stakeholders in the city.

The Council also carried out an open public consultation on the Edinburgh LHEES, generating significant interest. In particular, the ambition and scope of the city-wide heat networks was welcomed. However, given the time and resource constraints as well as scope of proposals, the stakeholder engagement and public consultation carried out as part of Edinburgh LHEES did not involve segmentation and strategic engagement based on sectors.

Our analysis progresses these proposals toward tangible opportunities. Since this study shapes the Council's approach to heat networks in a significant way, it was important to reflect more granular stakeholder data and feedback within strategic and technical outputs. We resolved to capture feedback from a broad range of stakeholder types and in as much depth as possible. We developed a stakeholder engagement strategy to help deliver this engagement. Building on the engagement conducted under the Edinburgh LHEES, this strategy defined a six-step stakeholder engagement process (Figure 11).

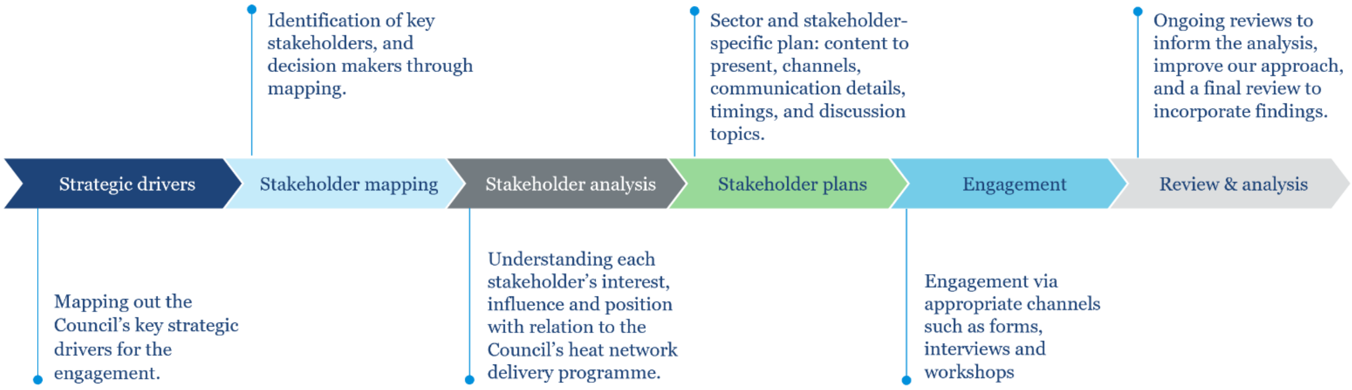


*Figure 11: Our six-step stakeholder engagement process for this project.*

These steps are covered in the following subsections.

### 6.1.1 Strategic drivers

As part of setting the strategic drivers, we identified five elements of interest to the Council. These were based on the overarching project objectives (see 3.1) as well as the HNSU's funding guidelines:

1. **Anchor loads:** gather energy use data and raise positive awareness as a potential first contact. This included gathering Building Assessment Reports (BARs)[20], half-hourly meter data where available, and higher-level heat demand and heating system data in the absence of the preceding two.
2. **Waste heat sites:** gather waste heat data, including total recoverable energy, constraints, and ability to supply.
3. **Gather other heat use and heat source data** in alignment with BARs, including constraints, heating system lifecycles, interest in joining, waste heat potential, and heat use characteristics (to validate the heat network technology/generation).
4. **Collate other useful data on heat network development**, including existing or planned heat network routes, energy centre sizes and locations, land availability for energy centres, planned future energy demand and energy-related investments.

[20] A BAR is a statutory report completed by a property owner or operator and submitted to the local authority. It covers information on the property with respect to heat network connection viability and attractiveness. Core aspects include location, property details and descriptions, heat demand, heating system details, and existing heat network connections.

5. **Engage on wider heat network delivery considerations** to build into our analysis for most favourable outcomes, including investor outlook, regulator concerns and alternative approaches.

The drivers were developed to gather as much data as possible on heat demand, possible heat supply and network development considerations to maximise uptake.

### 6.1.2 Stakeholder mapping, analysis and plans

The development of heat networks requires the necessary support and engagement with a wide range of stakeholders. We identified seven stakeholder segments which would address all five drivers and provide the support required to progress this analysis as well as the Council's wider heat network development programme. Each group, and therein each stakeholder was listed and analysed within a stakeholder register with respect to their motivations, interest and importance. These are summarised in Table 5.

| Stakeholder segment | Description | Purpose of engagement |
|---|---|---|
| Potential off-takers[21] | Domestic or non-domestic properties connected to the network, including public, private or third sector. | To capture real-world data on energy use, temperature requirements, seasonality of demand and waste heat availability. |
| Local authorities and government | Central government bodies and neighbouring local authorities. They play a key role in the planning, regulation, development and in some cases funding of heat networks. | To establish fundability and national policy-alignment as well as to understand regional and national options to delivery of heat network. |
| Project developers | Commercial heat network owners and operators who are expected to take projects and/or zones from early stages of inception to full roll out and commercial operation. | To identify and define developers' perspectives on investing into, developing, and operating heat networks in the city. |
| Designers, contractors and technology providers | Organisations which design and construct energy centres, heat generating plant and the heat network infrastructure and connections to heat loads. | To gather wider views on the analysis, including considerations on strategy, technical approach and technology considerations. |
| Key utility companies | Organisations which provide energy supplies to a heat network's energy centre(s). | To identify barriers and opportunities to deploying various heat sources and to assess grid constraints, timelines for key upgrades, and availability of waste heat. |
| Waste heat providers | Organisations which can deliver a reliable, long-term and cost-effective supply of heat to a heat network. | To identify the key sources of available waste heat which could be captured at low cost. |
| Statutory and non-statutory regulators | National, regional and local level bodies which ensure the project complies with relevant laws and regulations, as well as meeting environmental standards during construction and operation. | To identify barriers and potential to various heat sources and development of heat networks across the city. |

*Table 5: The seven stakeholder segments, a description of each segment, and the primary purpose of engaging them. Many organisations fell into more than one stakeholder segment. In this case, we covered engagement across all segments relevant to them via a single engagement.*

We also identified other valuable stakeholders such as the ECCI (to gather data and align our analysis), and Council officers (to gain feedback on our analysis and insight into regional and national options). These do not fit within the above segment and therefore we engaged with these stakeholders in a tailored way.

[21] Off-takers are the heat customers within a heat network. They purchase heat or coolth from the network (and in fifth generation heat networks can also supply this to the network)

### 6.1.3 Stakeholder engagement, analysis and review

We sent out tailored communications to all identified stakeholders in phases, totalling approximately 150 organisations and individuals. This included Request for Information (RFI) forms, online surveys and video calls. Progress on responses and information received was continuously monitored by our stakeholder management team. Follow-up communications were sent on two occasions to ensure recipients had a chance to respond before the deadline.

We held semi-structured interviews with several types of stakeholders, including potential off-takers (with a focus on large anchor loads and large estate operators), local authorities and government, project developers (including existing heat network operators), key utility companies, and regulators. For each of these groups, we developed a semi-structured topic guide focusing on the areas most relevant to the stakeholder type. We captured minutes from these interviews and, alongside data from forms, used thematic analysis to draw out key themes.

The datasets provided by stakeholders were included within our technical analysis. We analysed the surveys and meeting discussions to draw out key insights and collate overall themes, trends and outliers. This informed our evidence-based approach to the technical analysis on heat sources, zone refinement, zone feasibility reviews and spinal routing. The qualitative findings are presented below in section 6.2.

We reviewed and reported findings to the Council as well as the HNSU on a periodic basis. Following the conclusion of all engagements, we presented summary findings to the Council and HNSU.

It is critical to understand that the stakeholder engagement was not just an isolated one-off exercise, but rather intended to help establish the foundations for ongoing stakeholder relationships with the Council. Therefore, the content and discussion topics helped to garner interest with key stakeholders, and we also maintained a dialogue to allow the Council to continue the engagement following the publication of this work. The stakeholder engagement strategy also defined guiding principles for the stakeholder engagement process. These principles enabled us to carry out a fruitful engagement process and also helped to cultivate or reaffirm relationships on a longer-term basis:

- Engage early and explain the reason for engagement.
- Make asks clear and concise.
- Provide useful and targeted information about the analysis we are undertaking.
- Provide equal opportunities to inform and influence the outputs (being fair, inclusive and representative).
- Build trust and confidence in the process.

This process also helped to spread awareness of the Council’s ambitions and thinking in ensuring a just transition from project based to zonal and city-scale heat network development and decarbonisation.

## 6.2 Stakeholder engagement - key themes

As expected, there were varying levels of response from stakeholder groups. Project developers and large estate owners were the most engaged; those who already had a vested interest (commercial or otherwise) in the development of heat networks. We were able to engage all relevant local authorities and central government bodies, key utility companies, and statutory and non-statutory regulators. Despite multiple communication attempts, off-takers and waste heat providers were less responsive. Similarly, technology providers also had lower levels of engagement, possibly due to the early stage of the project.

We reached out to over 150 stakeholders through various means and gathered detailed insights and information via interviews with 25 key stakeholders. These insights are summarised in the following themes.

### 6.2.1 Support for heat networks

There was unanimous support for heat networks across all stakeholders, with no indications of opposition or resistance to the concept. Moreover, the scale and ambition of heat networks was also similarly welcomed. All stakeholders saw benefits for Edinburgh, its residents and businesses. Off-takers were particularly positive and supportive about low carbon heat networks coming to the city. This was coupled with the positive outlook on heat networks displacing the need for other potential challenging infrastructure constraints associated with decarbonisation. This included utilities as well as off-takers identifying issues with bringing sufficient grid capacity to the dense areas of Edinburgh and being able to find the space for individual building-level heat generation assets (e.g. heat pumps). Heat networks were seen as a potential solution to this challenge, especially where the heat could be supplied in a cheap way and without the need for major capital expenditure on part of individual organisations.

Existing seeds of opportunity were highlighted by stakeholders, naming developments at Edinburgh Airport, Granton Waterfront, and BioQuarter. These were considered as key opportunities to help build the momentum for heat networks in Edinburgh. Further, multiple stakeholders mentioned that they were aligning to the Edinburgh LHEES and heat network zones. This included the Edinburgh LHEES feeding into their strategy developments, decarbonisation planning and potential capital investments that they aim to make. However, there remained some level of hesitancy to commit based on the regulatory uncertainties (some of which we highlight in 4.1.3.1) and pending decisions the Council and government must take (this is discussed further in 6.2.2).

Furthermore, existing heat network operators were either open to or invited the opportunity for a third-party zonal-scale developer linking to their network. This could involve integration/expansion of existing networks into a wider zonal-scale network, purchasing heat from a zonal and/or spinal network, or even willing to field propositions for a full take over (buying out) the existing network[22]. The benefits for off-takers could entail tapping into low-cost heat supply from a zonal- or city-scale heat network with potentially lower overall OPEX and REPEX[23]. However, stakeholders highlighted the potential risk in this transfer was losing control of setting the heat tariffs. Transferring partial or full control of existing heat network assets to a zonal operator was not in the interests of all existing heat network operators; to some their heat networks are a critical part of their organisation.

### 6.2.2 Uncertainty of development

While there was widespread support for heat networks there was also some scepticism on whether a city-wide heat network will come to fruition in time for their individual estate requirements. For example, if a key fossil fuel plant is expected to come to end of useful life and/or an organisation's decarbonisation commitments are achievable through a heat network connection. This reservation was raised in large part by organisations which have net zero targets and statutory or non-statutory decarbonisation commitments[24]. Whether and when heat networks will come forward could mean potential off-takers would have to move earlier with individual systems[25]. For existing heat network operators, this means progressively integrating low carbon heating into energy centres rather than waiting for a zonal network to supply bulk low carbon heat to them. These stakeholders recognise that these steps are incremental and there may be internal constraints on space and/or grid capacity within current energy centres. However, they believe that actions within limitations are at present more certain than a city-wide heat network. That being said, some existing operators are designing their new energy centres and configuring existing ones with space for future expansion or connection to a zonal network.

For some developers, the uncertainty also meant that they have resolved to progress with their localised heat network plans and individual building heat pump projects[26], choosing to consider integration with city-wide or zonal-scale plans in the future should it be viable and attractive.

With the ongoing reviews of energy market pricing, some potential off-takers were also unclear how heat will be priced before and after potential electricity price changes. There was apprehension that they would lose out by connecting to a heat network if an individual decarbonisation solution becomes more economical (should there be energy market reforms to this effect and the heat network tariff did not align to this shift[27]). The long-term nature of being locked into a heat network was a potential concern without assurances on a fair price of heat. Developers recognise that a key learning for building out low carbon heat networks has been the need for robust transition arrangements from gas-based pricing to other forms of pricing geared toward renewable energy sources.

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[22] Stakeholders highlight that operating a heat network is a complicated and resource-intensive endeavour. At times, it may require capacity and skills that they do not possess internally. A buy-out to a more well-established and resourceful entity may provide a better outcome for all parties. The subsequent possibilities could include integration of the network route into a zonal route where technically viable or running it as a standalone network alongside the zonal network.

[23] REPEX could be lower where the existing network reduces or eliminates the need for their own heating plant as it relies on the zonal operator to provide heat.

[24] This included potential statutory commitments as part of the upcoming Heat in Buildings Bill (see section 4.1.2.1).

[25] The Heat in Building Bill proposals recognised this potential issue and made provisions for exemptions on statutory deadlines for decarbonisation where buildings are within a heat network zone. The Scottish Government recognises the need to give buildings the chance to connect to a network on advantageous grounds. However, this does not factor challenges in aligning network connection with capital planning/budgets, end of heating system life, the need to demonstrate early action on commitment, and the uncertainty of a network reaching the building at the expected time.

[26] We did not speak with housing or commercials developers which were not engaged in network developments but presume they would progress with individual heat pump plans.

[27] This consideration is expected to fall under the remit of Ofgem as the regulator.

Despite welcoming the notion of a city-wide heat network, existing communal and heat network operators expressed uncertainty around integration of their networks to it. There was uncertainty around cost of a transition, especially regarding potential loss in their own revenues from ceasing to operate combined heat and power (CHP) systems. They highlighted the cost of heat would have to be highly competitive for them to purchase bulk heat for their own networks. Generally, existing heat network operators and off-takers at large expressed the need for assurance and safeguards on pricing. For now, existing operators are focusing on investing in their own assets where the business case is viable but remain receptive to a third-party supplier entering the picture.

Further, while there was a positive outlook on heat networks helping to limit grid upgrades in dense urban areas and aiding in stabilising the grid, stakeholders also highlighted current grid constraints for energy centres which have to compete with ever-increasing demand on the grid. Some developers are considering moving toward on-site renewable energy generation to alleviate the pressure. However, this also presents challenges in the form of the limited space available and comparably high energy demands of a heat network. Where there are renewable generation aspirations, these are relatively limited or available only in rare cases for smaller heat networks. However, stakeholders highlight substantial work being undertaken to resolve the grid constraints via multiple approaches:

- Major infrastructure upgrades are a key part of this. Stakeholders recognise that ultimately the grid requires substantial reinforcements in nodes of high demand, such as energy centres and pumping stations, and this needs to be expedited. The work being undertaken to address this was highlighted[28].
- Wind farms onshoring near or within Edinburgh presents another major opportunity to directly utilise renewable energy (e.g. via private wire arrangements) and couple it with storage to overcome grid constraints, provide demand reduction services to the grid, and take advantage of a potentially economical cost of electricity.
- Improvements also include various flexibility schemes. For example, it is possible now to have flexible grid offers in Edinburgh that account for different import capacities during the daytime and nighttime hours (e.g. 1 MVA during day but 7 MVA during the night).

Another area of uncertainty highlighted by stakeholders was the practical challenges and constraints of developing the network. Edinburgh has a dense urban environment, existing buried utility infrastructure constraints, historical architecture and conservation requirements, and potential archaeological artefacts. The main cost of a heat network is usually delivering the pipes in the ground, and these constraints could hinder infrastructure development. One stakeholder pointed to the Edinburgh Trams project as a useful source of lessons on managing development risks associated with delivering major infrastructure.

### 6.2.3 Heat supply

Stakeholders were relatively aware of the substantial heat demand that exists, and how this makes heat networks an attractive option from the demand perspective. However, they were less clear about the heat supply available to reliably and economically service the demand. Developers highlighted the need for clear identification of specific heat sources as a critical step to understand how heat will be supplied. For them, this was a core part of the commercial viability of heat networks.

Stakeholders made references to heat supply at various scales and in different configurations. We have categorised these into two types:

- Primary heat sources: stakeholders referred to large-scale heat sources which could transmit heat into multiple zones across the city, possibly from outside Edinburgh's boundaries.
- Secondary heat sources: stakeholders highlighted the need to identify significant sources within each zone which could supply as much of the heat demand locally as possible.

These sources are also not communicated as mutually exclusive, both types of sources were not mentioned by each stakeholder. However, there was a common view of the need for heat sources to be of a sufficiently large scale to enable the development of the networks as intended.

Some developers indicated that starting with a small (seed) heat network in a city centre location and building outwards can be a workable option, but it would be fraught with a dearth of sufficient heat supply to match the total zonal demand. Further considerations in cities like Edinburgh are high levels of listed and pre-1919 buildings which could be challenging to supply with the sufficient temperature of heat from *in situ* low carbon

[28] There are several grid supply point (GSP) upgrades planned, including the GSP in Currie by an additional 30 MVA and the GSP in Sighthill by an additional 40 MVA.

sources. Limited availability of space to generate this volume of heat would potentially require a heat transmission pipe bringing heat from sources outside the city at sufficient grade and scale.

Off-takers and existing heat network operators stressed that heat network temperature is particularly important – many buildings operate on a relatively higher bracket of temperature (e.g. 80ºC supply and 60ºC return) they would require supply from third parties at that level to avoid existing buildings requiring updates. Some other specialist requirements would also need to be factored, such as hospitals and their various uses of heat demand.

Stakeholders highlighted specific heat sources and their merits:

- The potential for sewer source heat, with reference to it being deployed at Granton Waterfront.
- Seafield Waste Water Treatment Works (WWTW) and Newbridge WWTW
- The Millerhill Recycling and Energy Recovery Centre (RERC)
- Potential sources in East Lothian
  - Offshore wind onshoring at Cockenzie
  - Dunbar Energy Recovery Facility
- Hydrogen (discussed below)

Alongside heat sources, some highlighted the value of thermal storage as a vital component to be able to help manage peaks and take advantage of dynamic electricity prices as well as grid services.

There were competing views on the role of hydrogen for decarbonising heat in buildings. Most stakeholders who commented were of the view that electrification is likely the more viable option, whether at individual or heat network scales. A minority stated the key role a potential future supply of green hydrogen could play, but recognising the hurdles which need to be overcome[29]:

- Increasing the supply of green hydrogen (grey and blue hydrogen are not viable low carbon options for Edinburgh's heat networks).
- Hydrogen to become price competitive.
- The need to factor the cost to install new pipe infrastructure for hydrogen.
- Uncertainty given a pending UK Government decision in 2026 on the role of hydrogen.

These stakeholders stated that even if hydrogen does not play a role in building-level systems, it could play a role in supplying energy centres. They cite the increased viability of a bulk supply pipeline routed to an energy centre in a suitable location.

### 6.2.4 Developer and investor confidence

All heat network developers we engaged were optimistic about their ambitious plans for heat networks in the UK. Some stated that they are hoping to develop (or are developing) city-scale networks in various cities. These involve expanding existing networks, interconnecting networks or utilising a spine to serve multiple networks (a 'network of networks'). They view Edinburgh as a potential opportunity for such a development.

Noting their optimism, some developers were eager to see larger zones than those represented in the Edinburgh LHEES. One comment even entailed all zones being consolidated into one zone of the multiple constituent phases which could be used to procure a single developer in a concession-style arrangement. On the other hand, some developers were explicit about the need to have multiple potential operators with coverage over equivalent zones, although these would also indicatively be large zones[30]. The suggestions were to have equal and fair commercial opportunity across the zone, with one zone not being significantly more attractive than another. Developers also wanted to see clarity on network route options for the zonal networks, as well as a viable initial 'day one' network with an aggressive rollout plan.

Another topic related to the size of zones were direct comments on the Council's role in establishing a competitive and fair market for developers. There were questions about how the Council could encourage competition by making room for multiple operators with multiple networks in the city vying for customers. This

[29] We consider and further explore these factors as part of our assessment on hydrogen in 7.2.8.

[30] None of the developers indicated, explicitly stated or framed their views in the context of small zones. Rather, most of their views aligned to the need for larger zones which covered substantial parts of the city.

included the ability to allow cross-zone developments and competition[31]. Ultimately, multiple developers wanted to see room for multiple networks and network operators around the city working in competition.

Some developers we engaged were already present or are establishing themselves in Edinburgh, while the remaining either have heat networks in Scotland or in the UK. For those with an Edinburgh presence, their key interest is in the potential of zones (whereby their current or planned networks could expand to other areas within the zone). They seek clarity on the scope and future potential of their current development in the context of a refined zone. Their stated ambition was to then size energy centres, review heat sources available, and other aspects of infrastructure investment to be able to evolve into a zonal network.

However, not all developers were interested in expansion; these were the operators focused solely on their own estates. They did, however, consider acting as heat suppliers to a single third party (in a business-to-business relation) which would subsequently supply heat to individual off-takers. This would reduce their operation risk as well as potentially avoid the various regulatory thresholds which Ofgem might introduce[32]. These operators recognised that this would provide additional revenue as well as an impetus to invest in additional capacity. Based on these viewpoints, we consider there to be currently two key types of developers emergent in Edinburgh:

- Suppliers: developers who aim to develop a network and supply heat to customers; a traditional heat network developer.
- Asset-based: developers who do not wish to supply heat directly to off-takers but are interested in supplying heat to a supplier.

Regardless of the type of developer, many stressed the need for more assurance on connection certainty. Guaranteed connections with large heat loads were seen as a major aspect of enabling investment. This was considered by some as the most important enabler of developing a network.

Developers also raised the importance of government funding as a key enabler. Without funding, developers are currently finding it challenging to meet their internal investment hurdle rates to take schemes forward[33]. They assess the level of government funding required to make a project viable in relation to project scale, risk and return, noting that the level of funding will typically also impact the investment potential.

Another limitation developers highlighted was the uncertainties and risks involved with cross-local authority collaboration. Zones across local authorities and the differing approaches to delivery may make it more challenging to supply heat from another local authority. In particular, it is noted that Midlothian Council has already procured a joint venture model. This could make a strategic spinal pipe less certain, especially when a developer invests into assets in one local authority with hope of supplying heat into another, either through a spinal pipe or with longer term expansion plans for their zonal network[34].

This stakeholder engagement exercise was welcomed by many developers, but some wanted more engagement from the Council with the market. They wanted more clarity on the technical and delivery approach, including further information on heat network zones and delivery models. They also highlighted the need to have potential energy centre locations along with estimated capacities of heat sources[35].

[31] This is a contentious issue as it touches on potential limits of the way zoning could come to be seen in Scotland. In general, zoning is meant to help engender a favourable regulatory environment to aid the development of heat networks. This includes mandates to connect, rights to develop infrastructure, and clearer regulations for operators among other elements. There is a further interpretation of the purpose of zoning which holds that a zone would also be allocated to one developer (i.e. there would be one anchor network operated by a single entity). This could encourage investment by providing security of demand to a developer. The opposing interpretation is allowing multiple entities to develop networks within a single zone to safeguard against loss of investment interest, driving down costs, and helping maximise the extent of the network. Our analysis has adapted the former view of one anchor network per zone for practical reasons (we cannot foresee the potential number of networks within, the Council has not signalled intent on the number of operators per zone should it receive these powers, nor has the Council selected the delivery models(s)). The challenges of regulation and delivery models play into this, discussed in 4.1.3.1 and 4.2.3, respectively.

[32] This is speculative. It is unclear whether or what regulatory threshold tests Ofgem will introduce and how these will affect existing operators as well as bulk heat suppliers.

[33] Investors may set a desirable annual return rate target for their investment, meeting which is a prerequisite for committing to a project. Generally, if schemes do not meet investor expectations it becomes challenging to attract capital.

[34] We consider this to be a low to minimal risk. First, this assertion implies that local authorities do not collaborate. In the case of Edinburgh, there is close collaboration on areas of common interest with the Lothians. Further, the HNSU and wider Scottish Government policy is supportive of this collaboration and could facilitate further should it be required. Finally, the Heat Networks (Scotland) Act already makes provisions for two or more local authorities designating a heat network zone. This recognises the vital role of local authorities in collaborating to deliver strategic networks which benefit both areas.

[35] This is commercially sensitive information, and the Council has opted not to release this part of our analysis at this stage.

Further to this, some suggested that the Council could develop an engagement and communication plan on heat networks to aid in more effective engagement. This was mentioned in relation to developers and wider supply chain market as well as businesses and the public at large. Clear communication could help build community support for heat networks by helping to explain what they are, how they work and their benefits. Developers pointed out that understanding heat networks can be difficult, so it is important for the Council to lead on this communication.

Developers also emphasised that there is more that the Council could do to make investment into Edinburgh compelling. They cited the deferment of many of the decisions, responsibilities and plans within the Edinburgh LHEES and the current pending status of these[36]. Some stated that this raises uncertainties, increasing risk and reducing the attractiveness of investment into Edinburgh. They remarked that other emergent opportunities in England are potentially more compelling due to stronger market conditions and funding regimes. This alternative, coupled with the ongoing uncertainty on Scottish policies and legislation, could eventually discourage investment into Edinburgh's heat networks. However, this was a minority view, and many developers did not make similar claims.

Finally, developers compelled the Council to take a more active and leading role[37] in encouraging heat network development. They expressed the importance of a coordinated approach, led by the local authority, which provides clear support. This ranges from the strategy and communication on heat networks all the way down to providing clear access to routes for pipes and making their own buildings available for connection.

## 6.3 Conclusions on stakeholder engagement

Stakeholder engagement continued throughout the study, and we captured, analysed and discussed these insights with the Council on a regular basis. Insights were also summarised for the HNSU, helping gather input on how we should utilise these for our approach to the analysis. We worked with the Council to agree on the key factors which would shape our analysis across the four key objectives. The relevant factors and our actions to address them are summarised below, ordered by the four key themes.

- **Support for heat networks** (section 6.2.1) added confidence to heat networks as the most viable solution for decarbonising the zoned areas of Edinburgh. Stakeholder comments on expanding zones to the greatest economically and practically viable extent helped shape the boundary refinements to be larger more attractive investment opportunities. These factors are discussed further in section 8.2.
- Concerns around the **uncertainty of development** (section 6.2.2) informed our feasibility review of zones to help clarify the investment attractiveness of zones (section 9). Further, we propose a clear strategy for phasing the spinal route which would spur the development and/or expansion of zonal networks (section 11).
- Calls for clarity on **heat supply** (section 6.2.3) informed our heat sources audit whereby we highlight both primary and secondary heat sources. Our work demonstrates what the most practically and economically viable heating solution to support a city-wide heat network could be. This is detailed in section 7. We also detail how the primary heat sources would potentially interface with a spinal pipe to deliver large-scale bulk heat to Edinburgh, leveraging economies of scale, flexibility and grid balancing, heat storage, renewables and other techniques to drive down the cost of heat (section 7.2)
- **Developer confidence** (section 6.2.4) comments on shaping large zones as a substantial and attractive opportunity were also incorporated into our zoning refinements. Further, requests to make the zones as equal as possible were considered to the greatest practical and strategic interest to the Council. While the zones could not be equalised (e.g. constraints, technoeconomic analysis, and many other factors prevented this in a real world context) we endeavoured to balance all of the major zones to be attractive in their own right (we discuss zoning boundaries in 8.2). We also detail the potential heat demand within a zone, heat demand from anchor loads and proposed anchor network for the key zones, all to help address the most important consideration highlighted by developers: the lack of uncertain anchor load off-takers.

[36] Much of this has been on the basis of funding constraints as well as pending updates from the Scottish Government and regulatory bodies on the upcoming regulatory regime.

[37] This should not be interpreted as a comment on a suggested delivery model. It is a wider comment about the important and leading role of the Council in helping to develop and operate networks.

# 7. Heat sources audit

## 7.1 Our approach to the analysis

The first objective of our analysis was to carry out a desktop audit of all potential heat sources within and around Edinburgh, giving a deeper understanding of heat supply. The audit aimed to identify the key sources of relevance to the scope and scale of the networks by considering the relationship between heat supply and heat demand. We used a 3-step process to profile the most relevant heat sources. This is illustrated in Figure 12 and detailed in the following subsections.


*Figure 12: This process aimed to qualify and profile all relevant heat sources in accordance with the technical and strategic requirements. Primary and secondary heat sources are discussed further in section 7.1.3.*

### 7.1.1 Develop a longlist

The Council placed a strong focus on understanding the potential of waste heat, given this can be an economic enabler for heat networks. This also aligns to stakeholder recommendations (section 6.2.3). Many of the available waste heat sources in the city have already been identified via previous Scottish Government-funded ClimateXChange research on waste heat sources for heat networks across Scotland[38]. These are mapped in Figure 13.

We identified further waste heat sources and other sources (not from waste heat) through stakeholder engagement (see section 6.2.3), desktop research, Scotland Heat Map (SHM) datasets, sources had already been discovered as part of the Edinburgh LHEES development, and other data (e.g. Mining Redemption Authority and Scottish Water Horizons). We also engaged closely with East Lothian Council and MEL to understand potential heat source of scale within their areas which they would be interested in putting forward for consideration.

Several major sources were added from this discovery in recognition that Edinburgh is the centre of a service-based economy with a potential lack of heat sources matching the level of its heat demand. Therefore, it was critical to consider the need to transmit bulk heat from the edges of the city and/or from neighbouring local authorities. This was also in line with stakeholder views (section 6.2.3).

The longlist included any potential heat source, taking a technology-agnostic approach to heat supply. We considered all sources equally at this stage, allowing for a balanced judgement of their merits in line with the profiling criteria[39] agreed with the Council:

- Greenspaces and geological sources (locations suitable for ground source heat pumps)
- Waste heat sources in the city:
  - Waste Water Treatment Works
  - Sewer source heat pumps
  - Distilleries
  - Data centres
  - Other waste heat sources, including supermarkets, bakeries, electrical substations, landfill, and other manufacturing process.
- Waste heat sources in other local authority areas:

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[38] Sinclair, C & Unkaya, G (2020). Potential sources of waste heat for heat networks in Scotland. ClimateXChange.

[39] This is described in 7.1.3

  - Millerhill Recycling and Energy Recovery Centre
  - Hillwood Asphalt Plant
  - Dunbar Energy Recovery Facility
  - Torness Nuclear Power Plant
- Mine workings in Edinburgh and surrounding areas
- The Firth of Forth and other major watercourses (sources suitable for sea/water source heat pumps)
- Hydrogen

These heat sources were catalogued with the data available on key parameters for each, such as location and heat supply potential.

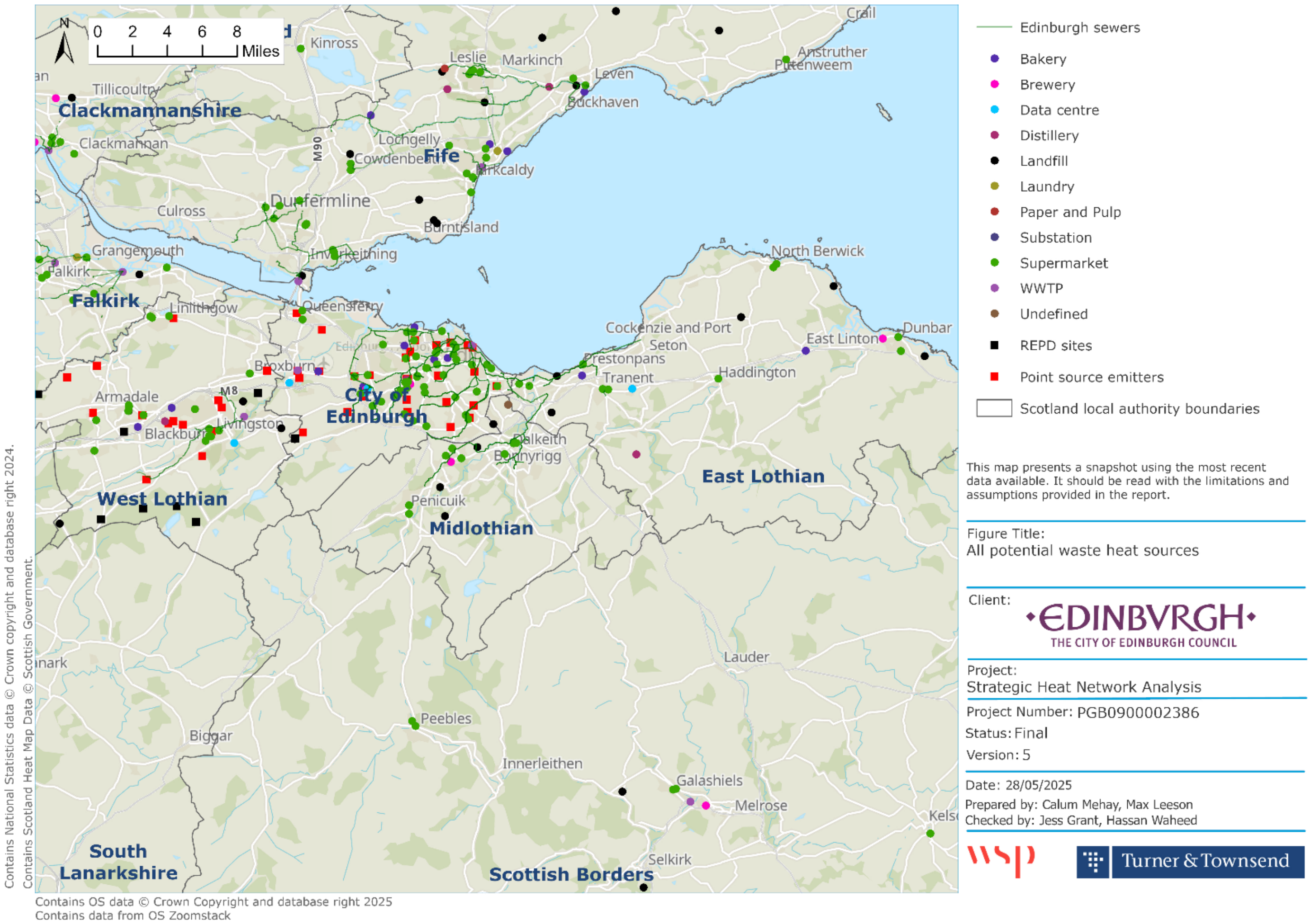


*Figure 13: All potential waste heat sources in the region, based on the ClimateXChange research dataset. Note that these sources are only mapping waste heat. This dataset is also five years old and thus does not cover recent relevant sources.*

### 7.1.2 Shortlist using multi-criteria assessment

In the context of the city-wide heat network, we shortlisted primarily larger scale heat sources. These would be at least large enough to serve a significant proportion of the heat demand within the relevant heat network zone. This was mainly due to the economic and practical advantages of connecting a few large heat sources, as opposed to many smaller heat sources. In general, we removed almost all sources which were below 1 MW in heat potential[40]. This set the basis for our shortlist.

In addition to this, we also considered the location of each source with respect to the heat network zones. This was a function of the heat supply available, the heat demand from relevant zone(s) and the distance between

[40] Smaller sources should be reconsidered at detailed feasibility stage as it will not face similar scope constraints.

the two. The greater the distance from centres of heat demand, the larger the source needs to be for there to be an economic case for it to be utilised over closer sources.

Finally, we tested the viability of sources via local knowledge from the Council as well as stakeholders. We qualified all sources based on alignment with the evidence provided within these discussions.

Once a shortlist was agreed with the Council, we assessed this for data gaps and accuracy. For this analysis, we were interested in at least a high-level heat potential and a high-medium-low rating of extraction costs. We drew on past project experiences as well as Council and stakeholder feedback to aid in filling these gaps.

The shortlist of sources is presented in Figure 14.

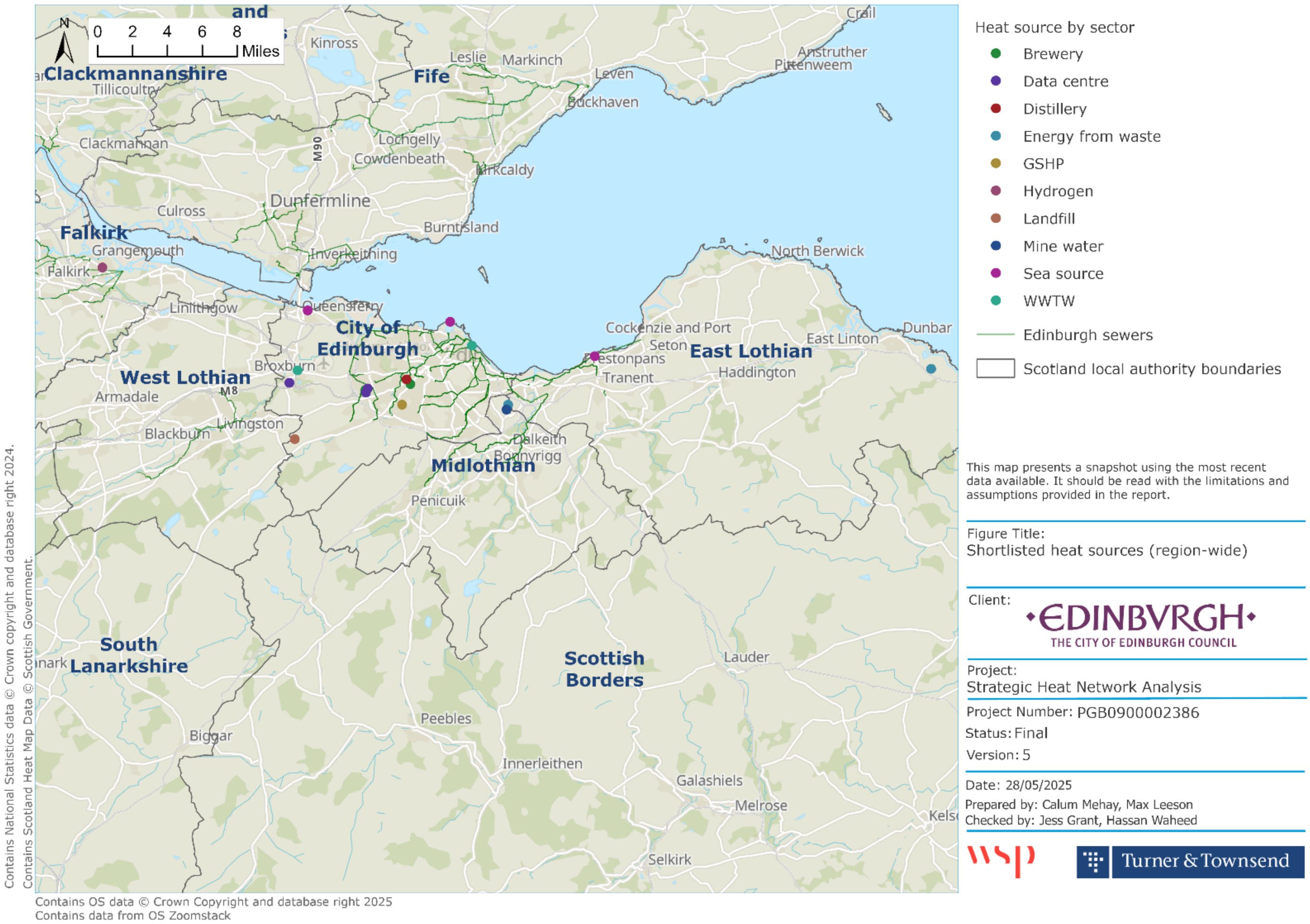


*Figure 14: Shortlist of heat sources, covering waste heat as well as other sources. Scottish Water Horizons provided maps and flow rates for their main trunk sewers throughout the city.*

### 7.1.3 Profiling heat sources and final selection

To appropriately assign sources to relevant use, we categorised them into two types.

- Primary (city-scale) heat sources are major strategic heat assets which could potentially supply heat for multiple zones and are suited to supply a spinal route.
- Secondary (zonal-scale) heat sources are those which could cover a substantial part or most of the heat demand for a zone.

While heat demands differ for each zone, this generally means that sources of at least 20 MW or more are primary and anything less than this is considered as secondary. Additionally, in general, primary sources can be outside or (in principle) at a distance of several miles from zones whereas secondary sources are expected to be within or proximate to their respective zone.

We captured as much available information as possible for each source, targeting all of the following data points to aid our analysis:

- Owner

- Location
- Use potential
- Annual supply potential (MWh)
- Recovery medium
- Temperature range
- Seasonal variation
- Indicative availability (on a technical/commercial basis)
- Indicative cost

We considered the above information alongside the various potential configurations for each heat source. This was in an effort to find the best technological and economic fit with the Council's city-wide heat network plans. For example, we considered multiple abstraction techniques to recover waste heat as well as both main ground source heat pump system types.

Altogether, the information helped us to assess the pros and cons of each heat source in relation to the following criteria:

- Heat supply: total potential and reliability of supply.
- Economic viability: commercial considerations such as cost of abstraction, whether it would enable the business case.
- Technical fit: grade, potential flow temperatures and ability to integrate into network.
- Practical viability: distance from demand, owner and accessibility.

This resulted in further refinement to the most suitable primary and secondary heat sources. We applied rigorous methods to our analysis, but this is limited due to the scope and scale of this analysis. All heat sources and their potential should be qualified with further analysis at the detailed feasibility level.

Large-scale thermal storage plays a major role in the approach to our analysis. Storage can enable operators to take advantage of varying capacities to alleviate stress on the electricity grid, in doing so use time of use tariffs to drive down costs, and increase their capacity agreement headroom based on time of day among other benefits (discussed by stakeholders in 6.2.3). However, we were unable to explore thermal storage opportunities at this stage. This is because granular analysis is required at a detailed feasibility stage in terms of selecting heat sources, optioneering specific energy centre locations, agreeing on the extent of zones, and phasing of network development at the city- and zonal-levels. Only once these details are under investigation it would be valuable to consider thermal storage options vis-à-vis selected primary and secondary heat sources.

Finally, the use of renewable energy via private wire or mixed with onside generation alongside the energy centre can be highly advantageous. This can enable lower electricity costs via investments or power purchase agreements (PPAs), allowing the energy centre to offer a cheaper heat tariff. For example, Edinburgh Airport has an existing solar farm and battery storage system to supply the site. This could also be used to power the proposed energy centre, substantially lowering the operator's electricity costs.

We analysed potential renewable developments within Edinburgh but found no credible developments of sufficient scale. Due to the presence of the Edinburgh Airport, onshore wind turbines are generally not permitted in the Edinburgh local authority area. There is also a lack of land (at a suitable price) for viable large-scale solar farms. The Council is assessing options for solar at Hermiston Park & Ride with the intention to replicate this at other sites should it prove successful. However, the peak output at 460 kWp is not sufficient for this single site to warrant further consideration as a source of renewable energy for Edinburgh's heat networks at this stage[41]. The Council remains open to solar and potentially other technologies at its developments, including Seafield and Granton, and other areas of Edinburgh.

There is potentially a major role for offshore wind farms onshoring at the northern coast of East Lothian and possibly also Edinburgh in the longer term. These do present a significant opportunity, especially in conjunction with primary heat sources. We have considered these as part of the relevant primary heat sources. However, we have not quantified or modelled the interplay of private wire and energy centres largely because there is substantial further work required before concrete assumptions can be made. This should be addressed at detailed feasibility stage.

[41] This is more suited to investigation at a detailed feasibility stage as a potential private wire source to supply a portion of an energy centre's electricity demand.

## 7.2 Heat source profiles

This section details our findings for all heat sources shortlisted and thereafter profiled and selected to be taken forward as part of the zone refinement and feasibility review.

### 7.2.1 Summary of all heat source profiles

The largest heat sources potentially available within Edinburgh are:

- Surface water (Firth of Forth, optimally at Port of Leith as discussed below)
- Sewers (primarily the main trunk sewers)
- Waste water treatment works (WWTW) (principally Seafield WWTW)
- Distilleries also present a good opportunity for waste heat, such as the North British Distillery Company in Gorgie.

The largest heat sources potentially available from neighbouring local authorities are:

- Surface water (Firth of Forth, optimally at Cockenzie as discussed below)
- Mine workings (Monktonhall Colliery)
- Energy from waste (for now, Millerhill Recycling and Energy Recovery Centre as the most relevant given its proximity to some of Edinburgh's heat network zones)

Altogether, these comprise the heat sources with the most advantageous energy profile according to our multi-criteria assessment. All sources are described in Table 6.

| Heat source | Scale considered | Heat potential[42] | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| Cockenzie sea source heat pump | Primary | 100+ MW | Low | High[43] | East Lothian Council / SEPA | Yes |
| Port of Leith sea source heat pump | Primary | 80+ MW | Low | Medium | Forth Ports / SEPA | Yes |
| Sewer source heat pumps | Secondary[44] | 30+ MW | Low | High | Scottish Water Horizons | Yes |
| Open loop GSHP – Monktonhall Colliery | Primary | 20+ MW | Low | Medium | Midlothian Council / Mining Redemption Authority | Yes |
| EfW - Dunbar | Primary | 20+ MW | High | High[43] | East Lothian Council / Viridor | No |
| EfW - Millerhill | Secondary | 11.6 MW | High | Low | FCC Environmental / MEL | Yes |
| Seafield WWTW | Secondary | 10+ MW | Low | Medium | Scottish Water Horizons | Yes |

[42] Sources with a plus sign (+) in the heat potential denote a conservative estimate of the figure. In some cases, this figure could be substantially larger should these sources be investigated further.

[43] Note the 'High' cost here takes into consideration the length of pipework required to get the heat to the City of Edinburgh Council's local authority boundary.

[44] This is classed as a secondary source because the figure represents the aggregated potential of all abstraction from points throughout various zones in the city. Any single sewer source heat pump would be significantly smaller than 30 MW. More detailed analysis on specific size and location of sewer source abstraction should be determined via detailed feasibility, hence we are only able to provide an aggregated estimate.

| Heat source | Scale considered | Heat potential[42] | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| North British Distillery | Secondary | 3.3 MW | Low - Medium | Medium | North British Distillery | Yes |
| Closed Loop GSHP | Secondary | Up to 1 MW per site | Low | High | Relevant landowner | Yes – very small scale only |
| Newbridge WWTW | Secondary | 0.4 MW | Low | Medium | Scottish Water Horizons | No |
| Open loop GSHP | Secondary | Unknown | Low | High | Relevant landowner | No |
| Hydrogen | Unknown at present | Unquantifiable at present | Low or high grade[45] | High[46] | None at present[47] | No |

*Table 6: Potential heat source profiles summary sorted by heat potential (high to low). We either used heat potential figures provided by the relevant owner or made a conservative estimate of these based on past project examples.*

It is important to note that most sources which have not been taken forward in this study are not permanently ruled out. Rather, there have been multiple reasons for the current decision to exclude them from our analysis, including lack of clarity or information on the source or limited scale. The proposed energy centre configuration will allow for alternative heat sources to be connected in the future. Therefore, most sources are disregarded; rather, they are not being considered as a source for the starter networks.

Each source is profiled individually in the following sections.

### 7.2.2 Surface water sources

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **Port of Leith sea source heat pump** | Primary heat source | 80+ MW | Low | Medium | Forth Ports/SEPA | Yes |
| **Cockenzie sea source heat pump** | Primary heat source | 100+ MW | Low | High | East Lothian Council/SEPA | Yes |

*Figure 15: A summary of surface water heat pump heat profiles and selection.*

Surface water heat sources include rivers, lochs and the sea. The amount of heat that can be abstracted from small rivers and lochs is limited, especially during winter due to low temperatures and environmental protection considerations. Therefore, only the largest rivers or the sea can be considered for large-scale networks.

Water from the Firth of Forth could be used as a source of low-grade heat for a water source heat pump (WSHP). Water could be abstracted using either an open loop or closed loop system. The heat potential from the open sea could theoretically supply the heat for all heat network zones in Edinburgh. However, there are practical limitations based on availability of land, environmental and biodiversity considerations, electricity supply, design choices such as the spinal pipe route and capacity, and preference for other heat sources.

An open loop system pumps seawater via pipes to a heat pump, where the heat is extracted, and returns cooler water back to the source or other suitable discharge location.

[45] Low- or high-grade heat can be recovered from electrolysers. Combustion can generate high-grade heat.

[46] Currently over 20 p/kWh but expected to reduce over time.

[47] There is currently no large-scale commercial production in or around Edinburgh which could be considered in our profiling and selection process.

In a closed loop system, there would be no direct contact between the seawater and the heat transfer fluid (typically a water/brine mix). Instead, heat is transferred from the seawater to the heat transfer fluid via a heat exchanger (e.g. plate heat exchanger or submerged 'slinky' pipe arrays). In this configuration the unavoidable temperature drop across the additional heat exchanger results in a reduced temperature at the heat pump evaporator compared with an open-loop system. It is therefore envisaged that any surface water heat pump scheme at Edinburgh would preferably be of an open-loop configuration to allow higher heat pump efficiencies.

Considerations for an open loop-system include the location and design of the water abstraction and filtration works, which need to accommodate changes in water level, protect aquatic life, the environment and amenity, and prevent fouling and ingress of foreign bodies. It is likely to be more economic to address these issues on a large-scale scheme, favouring the Firth of Forth over rivers.

#### 7.2.2.1 Port of Leith sea source heat pump

With the Firth of Forth's ability to supply heat for very large-scale heat pumps, there is an opportunity to build a primary heat source within Edinburgh's boundary[48]. An obvious location for this is at the Port of Leith, where there is already a seawall and potential space to develop an energy centre and thermal storage, enabling it to serve as a scalable strategic energy asset. This is within the boundary of *Zone 4 – Northeast Edinburgh* and proximate to high levels of heat demand within this zone (which includes the anticipated Seafield Regeneration Area discussed in 4.2.2.4) and other nearby zones.

Other potential locations for using the Firth of Forth in Edinburgh or in neighbouring local authorities may surface if investigated beyond our high-level review. However, we are considering Port of Leith as a representative of this opportunity.

Whilst within a zonal boundary, a heat pump station at the scale we have considered is likely to be more suitable as a primary heat source serving several zones, as opposed to a secondary source supporting a single zonal heat network. For the purposes of this study, it has been assumed that an 80 MW heat pump could be built at the Port of Leith.

This figure is based on the anchor load heat demand requirements within the three proximate zones[49] which is not available from secondary heat sources. However, this could theoretically be much higher with the addition of further capacity. More analysis would be required to assess the true potential of this development. In our view, this should be the Council's priority primary heat source due to the expected heat potential and proximity of this source to major heat network zones.

In addition to the proposed water source heat pump at Port of Leith, the Firth of Forth could be used as a secondary heat source for zones on or near the coast. This is likely only beneficial for zones not served by the Port of Leith large-scale heat pump as it would not capture the same economies of scale and other benefits. For now, we consider *Zone 11 – Queensferry* to be the only location where a small standalone system could be fruitful.

#### 7.2.2.2 Cockenzie sea source heat pump

During our engagement, East Lothian Council referenced a potential large-scale water source heat pump (WSHP) plant in Cockenzie as a suitable source of large-scale heat generation. It could utilise the decommissioned Cockenzie Power Station site and infrastructure, which includes pipes for pumping seawater (previously used for cooling), an electricity substation, and availability of space.

If this infrastructure is fit-for-purpose, it would save significant capital costs and enable redevelopment of the site into a major low carbon strategic energy asset which could capture economies of scale. Additionally, a significant capacity of offshore wind is slated to onshore at Cockenzie. Utilisation of this electricity via a form of direct connection would also be theoretically possible, driving down the cost of electricity (the largest factor in the lifecycle cost of a heat pump). Further, the site has potential space for thermal storage, adding to the flexibility of balancing electricity supply and heat demand at scale[50].

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[48] There is also potential to develop multiple sites, but it is likely that fewer larger sites or one exceptionally large site will be more flexible and effective at capturing economies of scale. Although this is dependent on many factors, including demand, space availability, and grid capacity. A more detailed investigation will help determine the ideal set-up and phasing for primary sea-based heat source development for Edinburgh.

[49] These are *Zone 1 – Central Edinburgh North, Zone 3 – Northwest Edinburgh*, and *Zone 4 – Northeast Edinburgh*. These are based on our preliminary spinal route architecture discussed later in section 10. This is indicative only and likely subject to change as the approach to spinal route development matures.

[50] These aspects are further discussed in section 11.2 in relation to all primary heat sources.

This site has the potential to meet the heat demand of the surrounding areas of East Lothian, including the heat network zones in and around Musselburgh, close to the border of Edinburgh. However, there is significantly more potential at Cockenzie than can be utilised by East Lothian. This makes it attractive as a primary heat source for Edinburgh, with an ability to deliver a substantial portion of Edinburgh's heat demand.

While Edinburgh has access to the Firth of Forth, which should be prioritised due to proximity and likely lower cost, the abovementioned factors make Cockenzie an important consideration. This is because the advantages these potential benefits have over a new development nearer to the areas of highest heat demand (e.g. within Edinburgh) could outweigh the substantial cost and risks associated with the distance, potentially providing a competitive cost of heat.

We consider Cockenzie to be currently the largest potential heat source within a potentially accessible distance from Edinburgh, subject to further analysis. Owing to interest from, both, City of Edinburgh Council and East Lothian Council this has been allocated as a primary heat source suitable to supply a spinal pipe. A community-led group is analysing the potential to utilise Cockenzie and transmit this heat to Edinburgh. East Lothian Council has yet to clarify its formal position on these proposals.

For the purposes of this study, a high-level assumption of 100 MW has been taken as the amount of heat available from a large-scale plant. Similar to Port of Leith, this figure is derived from the relative deficit of supply for anchor load heat demands across the zones which were considered relevant[51] and high-level conservative estimates of site limitations.

A significant amount of further analysis beyond the scope and resources of this study is required to determine the optimal heat potential from Cockenzie required for Edinburgh and East Lothian. This would include studying many of the same considerations as highlighted for Port of Leith.

### 7.2.3 Ground source

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **Open Loop GSHP – Monktonhall Colliery** | Primary heat source | 20+ MW | Low | Medium | Midlothian Council/ Mining Redemption Authority | Yes |
| **Closed Loop GSHP** | Secondary heat source | Up to 1 MW per site | Low | High | Relevant landowner | Yes – very small scale only |
| **Open Loop GSHP** | Secondary heat source | Unknown | Low | High | Relevant landowner | No |

*Figure 16: A summary of ground source heat pump heat profiles and selection.*

Generally, there are two types of ground source heat systems, closed loop or open loop. These circulate a heat transfer fluid (usually water blended with anti-freeze or brine) at ambient temperatures (typically 4-15°C) between the ground and a ground source heat pump (GSHP). The heat pump boosts the heat temperature to supply the heat network.

There are further variations to these two types of systems. For our purposes, the most relevant one is a variation of an open loop system whereby mine water[52] is used instead of an aquifer. These three types of system are illustrated in Figure 17.

[51] These are *Zone 2 – Central Edinburgh South, Zone 5 – Southeast Edinburgh, Zone 6 – King's Buildings, Zone 7 – Colinton, Zone 8 – Southwest Edinburgh, Zone 9 – West Edinburgh,* and *Zone 10 – Heriot-Watt University*. These are based on our preliminary spinal route architecture discussed later in section 10. This is indicative only and likely subject to change as the approach to spinal route development matures.

[52] Mine water is water that collects in a mine. When decommissioned, a disused mine will flood over time as the water management systems used to keep a mine empty are paused and the voids created fill up. This water is warmed from natural geological processes and the temperatures typically remain stable throughout the year.

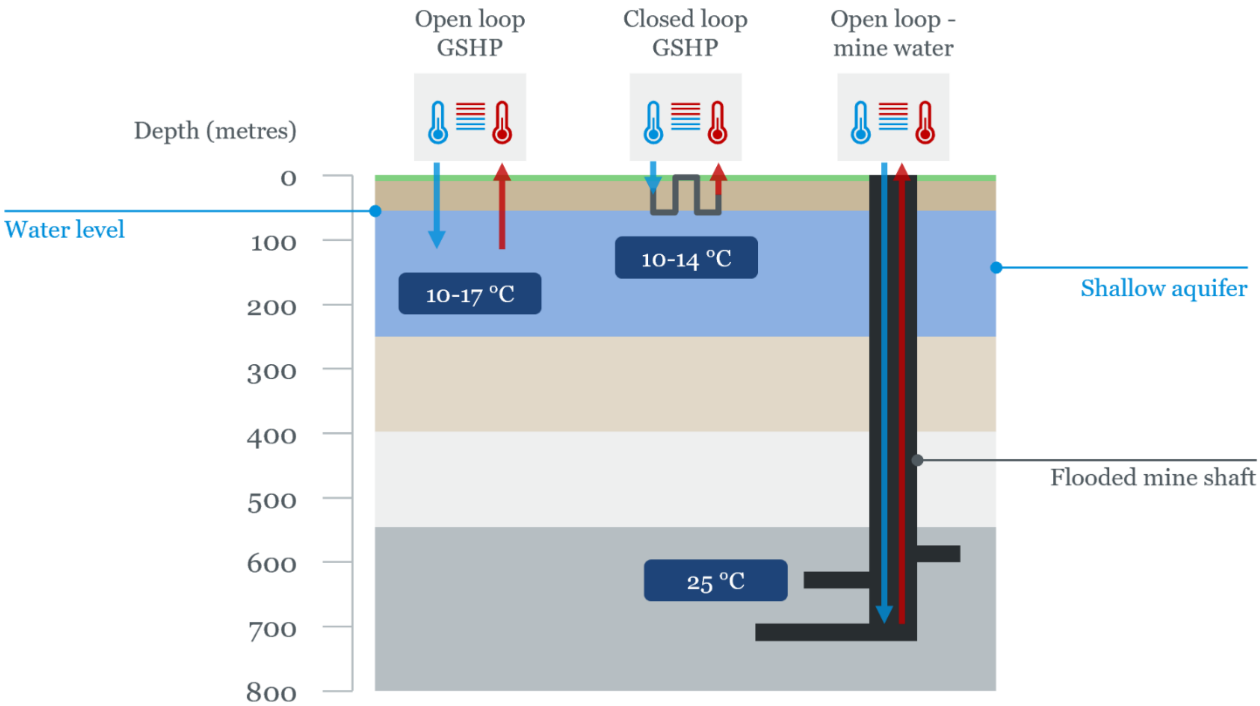



*Figure 17: An illustration of how ground source heat pumps function. Adapted from [British Geological Society](#).*

### 7.2.3.1 Closed loop systems

Closed loop systems do not abstract any ground water; they circulate the heat transfer fluid through pipes, usually arranged as an interconnected array of 'U-loops' which make up a ground collector array. Heat from the ground is transferred by conduction to the heat transfer fluid flowing through the pipes. The rate of heat extraction is limited by the rate of heat conduction, meaning very large arrays are required for high levels of heat demand[53].

The thermal mass of the ground ensures greater stability of temperature when compared to the external air as shown in Figure 18. This means that GSHPs can potentially achieve higher efficiency (CoP) during winter compared to an air source heat pump (ASHP). Greater depths of the borehole below surface result in progressively lower effect of seasonal temperatures on the ground temperature.

The heating capacity of a closed loop GSHP collector arrays depends on the 'recharge rate' of the ground. On very large-scale schemes, as would be required for zonal scale network in Edinburgh, there will be a requirement for balancing of the heat source to prevent uneconomical array sizes, i.e. equal abstraction and reinjection of heat across the year. Without heat reinjection, the ground temperatures will reduce over time, leading to

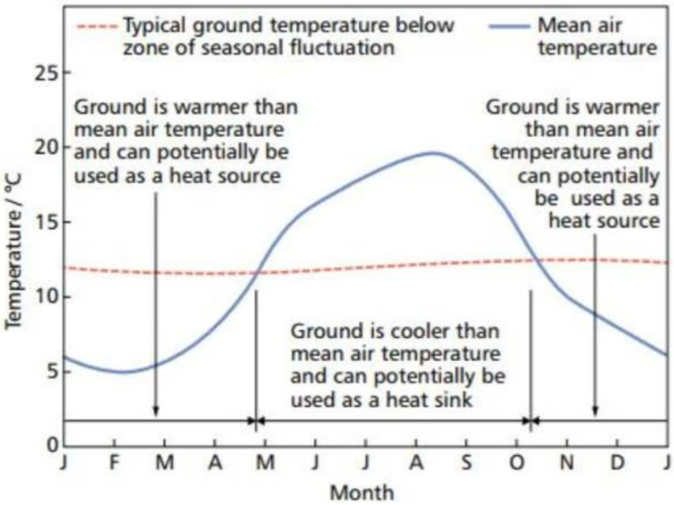



*Figure 18: Relationship between external air temperatures and ground temperatures (Preen & Powrie).*

[53] An average three-bed semi-detached home in the UK is roughly 100m$^2$; it would require land equivalent to 2.5 times its floor area (250m$^2$) to install a horizontal array. Even if scaled to the size of a very small heat network covering a few homes, this would mean thousands of square meters. This is impractical for heat networks in dense urban areas. Hence, these are more suited to individual systems or shared loop systems in domestic or small-scale non-domestic settings. Vertical systems are more expensive but also more space efficient. They require drilling 100-200m deep and one borehole is typically sufficient for a small domestic property. However, boreholes need to be placed 5-6 metres apart for meeting greater levels of demand efficiently. While this is feasible for a small-scale heat network in an area where land is available it becomes unfeasible if hundreds or thousands of properties and major anchor loads need to be supplied within Edinburgh's land-constrained circumstances. Both options may well be suited to areas of Edinburgh with more land availability and lower heat density; it is likely these systems are preferable over a heat network in these areas.

continued reduction in CoP and, eventually, freezing of the ground.

Typical capital costs for closed-loop heat recovery are multiple drilled boreholes to 100m+ depth, ground array to circulate around all boreholes, heat exchanger and pumping skids, and WHSPs to boost the temperature once in the energy centre.

Operational costs mainly consist of electricity for the ground loop circulation pumps and the heat pumps. Maintenance costs for the ground array are negligible, however, repairing leaks can be difficult.

Considering all of the above factors, it is not recommended to have large-scale (greater than 1 MW) closed loop GSHP schemes unless there is an option to reinject the heat back into the ground, such as through cooling heat rejection.

#### 7.2.3.2 Open loop systems

Open loop systems abstract low-grade heat (i.e. heat less than 100°C) from ground water, such as aquifers or mine workings, and then reinject the water back into the aquifer or mines[54]. The water is usually abstracted and then reinjected some distance away through a different borehole. However, it is possible to have abstraction and reinjection within the same borehole, but this can lead to performance issues. Similar to closed loop boreholes, thermal degradation of aquifer groundwater (and therefore reduction in heat pump performance) may occur due to the following:

- Hydraulic short circuiting (i.e. mixing of cold and warm water): this can be mitigated against by maximising the distance between abstraction and reinjection wells. The greater the distance, the less chance of thermal mixing.
- Lack of balance between naturally occurring heat flows within the aquifer and rates of heat abstraction: this must be mitigated by providing some measure of thermal recharge of the aquifer (e.g. cooling heat rejection during the summer).

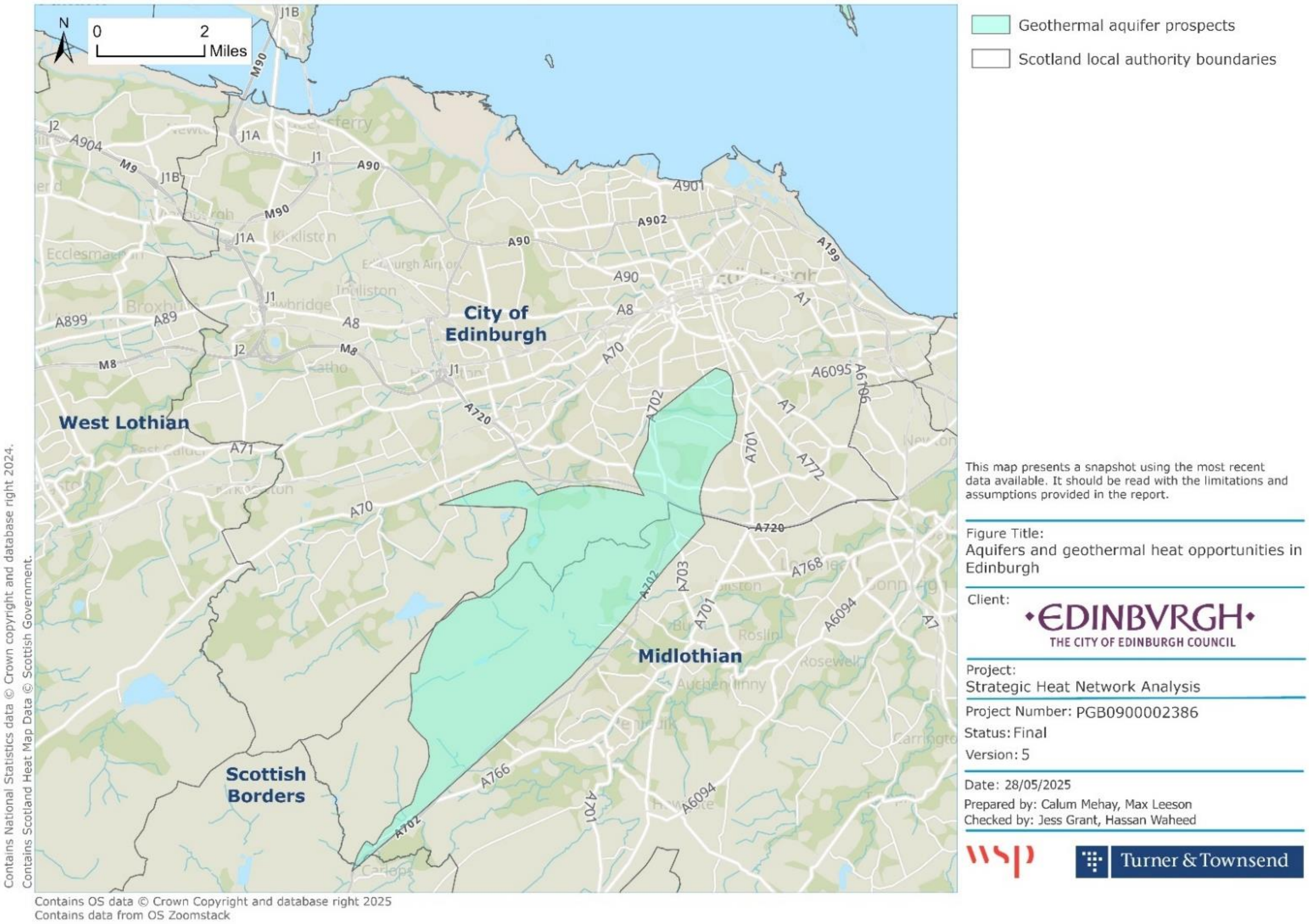



*Figure 19: There is limited potential for aquifer heat. This is not well-established and requires further study.*

[54] We cover mine water heat in more detail in 7.2.3.3.

The Edinburgh LHEES showed minimal aquifers within the city's boundaries, making them an unlikely source of heat for most of the heat network zones. This can be seen in Figure 19. However, this does not rule them out as a potential heat source for local networks around the Edinburgh and Midlothian border.

#### 7.2.3.3 Open loop GSHP – Monktonhall Colliery

The Monktonhall Colliery in Midlothian has deep mine workings and shafts which are now filled with water. Whilst not within the Edinburgh local authority area boundary (being located within Midlothian), this opportunity could hold potential as a primary heat source.

MEL is investigating the potential to use this mine water heat for the Shawfair heat network. If this resource has substantial heat potential, it could be suitable to supply heat to a substantial part of southeast Edinburgh. This was also investigated in 2003-2005 for potential heat network schemes but did not proceed due to lack of developer commitment.

The flooded water absorbs heat from the surrounding rock, making it a potential source of geothermal energy, albeit still low-grade heat. The water would need to be pumped to the surface, and then the temperature would need to be boosted via a heat pump to bring it up to a suitable temperature to serve existing buildings on a heat network.

Additional challenges with mine workings include finding a suitable discharge point to reinject the water without short-circuiting the natural flow, as flow patterns throughout the mines are often unknown. Further investigation is recommended to be carried out by Midlothian Council, plus engagement with the Mining Redemption Authority (MRA) (previously known as The Coal Authority). For the purposes of this study, it has been assumed that up to 20 MW of heat could be accessible from the mine workings based on previous studies of heat abstraction from Monktonhall[55]. However, this remains subject to further analysis.

The MRA carried out a high-level analysis of mine water opportunities in Edinburgh for the Council[56]. Assessment of the mine workings identified poor, and poor to moderate mine heat potential (for larger schemes) in the oil-shales in the western part of Edinburgh.

Assessment of the coal mine workings in the eastern part of Edinburgh identified what we consider to be poor to moderate mine heat potential for heating, cooling and storage. Existing MRA infrastructure (shaft, boreholes and discharges) within this area could potentially be used for mine heat schemes, though it is relatively limited in potential:

- Joppa discharge (estimated to be approximately 1 to 2.5 MW).
- Niddrie borehole (estimated to be approximately 0.7 to 1.5 MW).
- Potential for installing boreholes in the area could also be investigated with potential drilling depths between <10 and >800m.

We did not consider these opportunities to be sufficient to include in our analysis. However, we also do not recommend ruling these out entirely, as there is scope for these to be taken forward as part of a detailed feasibility.

### 7.2.4 Sewer source heat pumps

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **Sewer source heat pumps** | Secondary heat source | 30+ MW | Low | High | Scottish Water Horizons | Yes |

*Figure 20: A summary of sewer source heat profile and selection.*

Sewage or wastewater pipes can be used as a source of low-grade heat for a water source heat pump (WSHP). The principal method of extracting heat from the sewers is to abstract the raw wastewater through a connection point (a 'wet-well') connected to a sewer, and pump it through a special heat exchanger. This transfers heat from the wastewater to an intermediate water circuit which is connected to a WSHP. The WSHP raises the heat temperature to that required for the heat network. An illustration of the basic concept is provided in Figure 21.

[55] WSP (2003). Shawfair Mine Water Resource Project.

[56] Wyatt, L & Todd, F (2023). Edinburgh Mine Water Heat Opportunities. The Coal Authority.

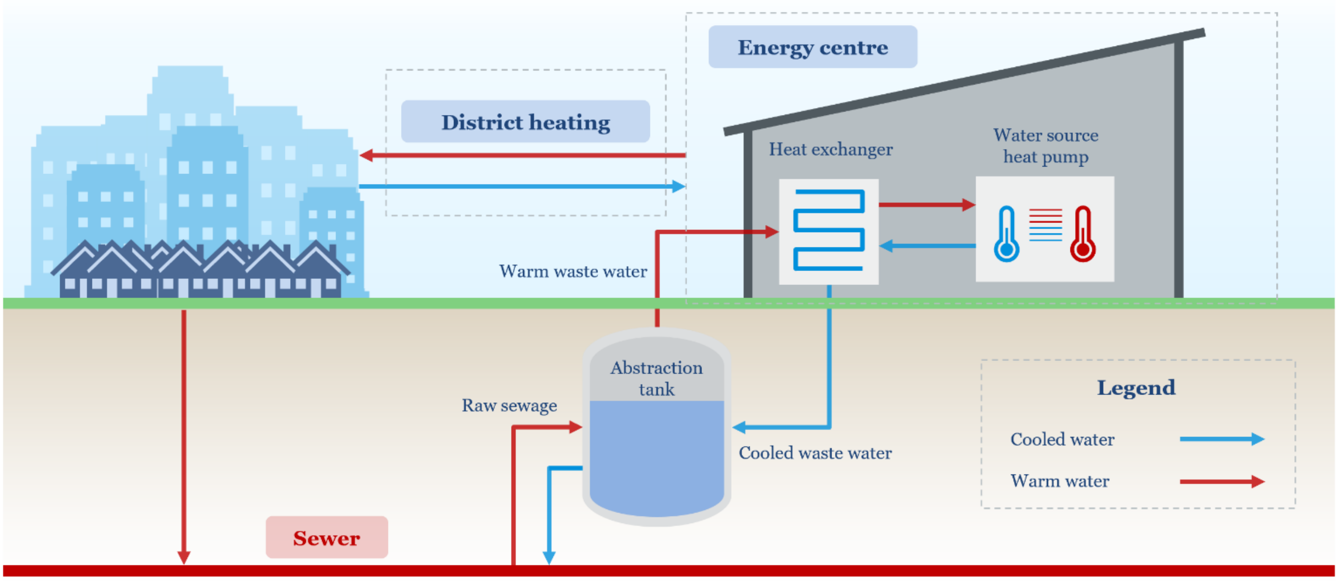



*Figure 21: An example of a sewer abstraction setup.*

After engagement with Scottish Water Horizons, the following was established:

- The average wastewater temperature is approximately 14 to 15ºC.
- We assume it is acceptable for heat abstraction to reduce the wastewater temperature by up to 5ºC.
- The same sewer can be tapped into multiple times to abstract heat along the heat network route if the demand continues to increase along the distance; the heat will recover with reasonable distances (a few hundred metres) due to additional inflows into the sewer.
- Scottish Water Horizons will charge approximately 0.5 p/kWh for the heat extracted. This is expected to rise with the consumer price index (CPI).
- Scottish Water Horizons provided maps and flow rates for their main trunk sewers throughout the city.

As the temperature of wastewater is expected to be slightly higher than other groundwater sources or river flow, heat pump efficiencies may be slightly improved when using this heat source.

There are several large trunk sewer mains running through each of Edinburgh's prospective heat network zones (defined in 8.3), meaning there is the potential for most zones to have several abstraction points each.

Capital costs incurred for developing a wastewater heat recovery scheme include the abstraction, filtration and heat exchange system, the heat pump and pipework to transfer heat into the energy centre. There is also a connection fee to access the heat, payable to Scottish Water Horizons. This connection fee will vary depending on the location and scale of the abstraction point.

Operational costs will include electricity for the abstraction pumps and filtration system, the intermediate circuit pumps and the heat pump. There will also be maintenance costs associated with the abstraction and filtration system, and the heat charge levied by Scottish Water Horizons. Indicative reported costs for high-grade heat delivered from a sewer water heat pump system are in the region of 10 p/kWh.

### 7.2.5 Waste water treatment works

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **Seafield WWTW** | Secondary heat source | 10+ MW | Low (c. 10°C) | Medium | Scottish Water Horizons | Yes |
| **Newbridge WWTW** | Secondary heat source | 0.4 MW | Low | Medium | Scottish Water Horizons | No |

*Figure 22: A summary of wastewater treatment works heat profiles and selection.*

Heat recovery from wastewater treatment works (WWTW) typically uses treated effluent on the outfall of the treatment works to avoid interference with the sanitation process. As with sewer heat recovery, effluent is abstracted from the outfall and pumped through a heat exchanger to transfer heat to an intermediate circuit to which water source heat pump(s) are connected. Although the temperature of the treated effluent may be slightly lower than the sewer water temperature, the effluent is virtually clear and requires far less filtration than raw sewage. This simplifies the equipment needed and reduces maintenance costs.

The capital cost incurred when recovering heat from a WWTW are pipework from WWTW to energy centre, heat exchanger and pumping stations at the WWTW and the energy centre, and WSHP to boost the temperature once in the energy centre.

Operational costs include electricity for the water abstraction and intermediate circuit pumps and for the heat pumps, and (lesser) maintenance costs. Scottish Water Horizons will also charge for heat abstraction from WWTW at a rate of 0.5 p/kWh for the heat extracted (at current values).

There are two main WWTW considered as heat sources for Edinburgh, Seafield and Newbridge. These are discussed in the following subsections.

#### 7.2.5.1 Seafield

The WWTW at Seafield is the largest in Scotland, processing over 300 million litres of wastewater every day. Whilst a heat recovery system is unlikely to be able to access the full 300 million litres a day, it still presents the largest opportunity for Edinburgh to be able to recover heat from a WWTW. The location of the Seafield WWTW is also advantageous, situated within *Zone 4 – Northeast Edinburgh* by the Port of Leith and proximate to substantial heat demand in the surrounding area which it could serve.

Our engagement with Scottish Water Horizons established the following points on the potential for heat recovery from Seafield WWTW:

- The conservative estimated heat supply is 10 MW, which we have used, though this could be much higher.
- A large expansion to the WWTW is anticipated to be needed by the mid-2030s.
- Seafield WWTW is currently under a public finance initiative (PFI) operation with Veolia until mid-2029; until that date modifications to the system would be unlikely to be considered, but a heat recovery system could be implemented afterwards.

Scottish Water Horizons also expressed a keenness to be involved in potentially supplying waste heat to a heat network. Given the scale of the plant as well as an early expression of interest, these are strong reasons for taking the heat from the Seafield WWTW forward in this study for consideration.

#### 7.2.5.2 Newbridge

The Newbridge WWTW is located immediately to the west of Edinburgh Airport and is significantly smaller than the Seafield WWTW. From the ClimateXChange dataset, we estimate the heat potential of Newbridge WWTW to be approximately 0.4 MW.

After engagement with Edinburgh Airport, it was found that analysis had been carried out by them on whether it would be suitable to serve a potential network at the airport. However, the airport concluded that Newbridge WWTW would be of too small a scale and too far away from their proposed energy centre location. Based on this, it would also be too small to consider any significant contribution to networks closer to the city centre thus it has been ruled out at this stage.

### 7.2.6 Energy from waste

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **EfW - Dunbar** | Primary heat source | 20+ MW | High | High | East Lothian Council / Viridor | No |
| **EfW – Millerhill** | Secondary heat source | 11.6 MW | High | Low | FCC Environmental / MEL | Yes |

*Figure 23: A summary of energy from waste heat profiles and selection.*

Energy from Waste (EfW) plants can serve heat networks by capturing and utilising the heat generated during the waste combustion process. This generated heat is used to drive steam turbines which generate electrical power, and the high-grade heat can be used for heat network temperatures of 80ºC+. Taking heat from an EfW might reduce the electricity output[57], as the energy is removed from the system part way through the electricity generation process. However, the reduction in electricity output is typically in the region of 1/6th to 1/5th of the heat used, so this can still be a valuable source of heat at higher temperatures than can typically be achieved with heat pumps.

There may also be potential for extracting low-grade waste heat (typically 25 to 40°C) from an EfW which does not impact upon the electricity production. In this case, the low-grade heat would supply a heat pump to boost the temperature to a useful level for a heat network.

One major difference between EfW and the remaining sources we have identified to be taken forward is that EfW is not a low carbon source of heat. Waste combustion results in emissions and thus may lead to challenges in Edinburgh's heat networks reaching net zero in the future. However, there is a pe case for this heat to be used as long as it is available:

- Firstly, EfW sources in and around Edinburgh produce waste heat for purposes unrelated to heat networks; a heat network has not been a determining factor in the form of waste processing being developed. Edinburgh heat networks using waste heat from an EfW is a consequential advantage.
- Second, EfW is a reliable and scalable source of heat which could be cost-effective for Edinburgh.

However, in the longer term, large-scale waste combustion contravenes the principles of a circular economy and is not aligned to the net zero commitments at national and local levels as described in the Edinburgh LHEES. Where this opportunity presents low-cost heat in the short term it also presents a risk of creating demand for waste combustion in the long term, as the availability of heat is tied to the EfW plant remaining open. We recommend the Council to utilise waste heat from existing EfW plants but avert long-term interdependencies between waste combustion and Edinburgh's heat networks.

We have identified two potential EfW sources.

#### 7.2.6.1 Millerhill

The Millerhill Recycling and Energy Recovery Centre EfW plant will supply low carbon heat to the Shawfair heat network, being developed by MEL. This EfW plant can output up to 20 MW of high-grade heat for a heat network. During our engagement with MEL, we learned about their expansion plans for the network within Midlothian. It has been calculated that 11.6 MW of the 20 MW capacity is remaining, which could contribute towards meeting the heat demand within the City of Edinburgh Council area.

The capital cost to receive heat from the Millerhill EfW plant would be the heat network pipe connection to Millerhill energy centre and heat exchanger interface. A commercial agreement with MEL would be needed to agree the heat tariff (pence per kWh) and any connection fee.

The use of low-grade waste heat from the Millerhill EfW plant to supply heat pumps has, to our understanding, not been explored yet. This might represent potential for further heat supply in the longer term.

#### 7.2.6.2 Dunbar

East Lothian Council has identified Dunbar Energy Recovery Facility EfW plant as a key waste heat source within their area. It is expected that at least 20 MW of heat could be available from it. East Lothian Council have indicated that the capacity could be much higher, considering it as a primary heat source. However, this is yet to be confirmed as East Lothian Council would need to engage with the operator, Viridor, to produce a feasibility study to quantify the waste heat which could be available.

A significant challenge with transporting heat from Dunbar to Edinburgh is the distance, with over 40 km of pipe trench required. This would come at considerable cost and there are practical constraints on the amount of heat that the EfW plant could supply. Due to the distance, it is not being considered further as a heat source for this study.

However, we do not consider Dunbar to be ruled out permanently. There is potential for major offshore wind farms to onshore their supply near the existing plant. Based on this supply, there are strategic developments around a potential hydrogen production facility. The Dunbar Cement Plant, generating waste heat, is also located nearby alongside a quarry in the process of being decommissioned, which could serve as potential thermal store. East Lothian Council has also fielded the option of installing large-scale electric boilers to

[57] An EfW plant will use a portion of the heat to generate electricity.

further bolster abilities to supply and store heat in response to surplus electricity supply from offshore wind farms.

The Council will continue to work with East Lothian Council to understand the potential of their waste heat opportunities and other heat supply opportunities from Dunbar.

### 7.2.7 Distilleries or breweries

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **North British Distillery** | Secondary heat source | 3.3 MW | Low – medium | Medium | North British Distillery | Yes |

*Figure 24: A summary of distillery and brewery heat profiles and selection.*

Distilleries and breweries have significant heating requirements during their production processes, making them a good potential for waste heat recovery. Heat can be recovered from the process cooling water, exhaust gases from boilers, or from hot air ventilation. The potential is location- and process-specific and in some cases the brewery or distillery may already be capturing waste heat and recycling it within their own process, which means that there is less available to supply external demands.

The North British Distillery is of a significant scale and has the largest waste heat potential from distilleries and breweries identified as part of the ClimateXChange data. It already supplies heat at 85ºC to the Council's 560-pupil Tynecastle High School, providing total duty heat and hot water demand. This is provided via a 1.5 MW standby heat exchanger at the distillery which connects to a heat exchanger in the school's boiler house and is managed via a sophisticated control system, all designed as part of the school's construction.

Capital costs incurred for accessing distillery heat would depend on the method of heat recovery but would be expected to include heat exchangers integrated into the distillery processes and pipework to deliver this heat back to a heat network energy centre. Heat pumps may also be needed to boost temperatures of low-grade sources. It is also possible that the distillery or brewery would charge to access the heat, either on a p/kWh basis, a connection fee, or both. The availability of the heat is also naturally tied to consistent distillery operation. Further engagement with the North British Distillery would be required for future feasibility studies.

Other distilleries and breweries within Edinburgh's boundary identified by the ClimateXChange dataset have been ruled out for this analysis as they are too small to have a significant impact on the heat network zones within the city. However, we do not consider these to be permanently ruled out for multiple reasons, such as their heat supply could have increased, or it could have previously been underestimated. Detailed feasibilities for respective zones should engage with these sites to accurately estimate the waste heat available.

### 7.2.8 Hydrogen

| Source | Scale considered | Heat potential | Heat grade | Abstraction cost | Owner(s) | Taken forward? |
|---|---|---|---|---|---|---|
| **Green hydrogen** | Unknown at present | Unquantifiable at present | Low or high grade[58] | High[59] | None at present[60] | No |

*Figure 25: A summary of green hydrogen heat profiles and selection.*

Hydrogen could be used as a fuel for boilers or a combined heat and power plant, displacing natural gas. However, whether there is any carbon reduction benefit of hydrogen as a fuel depends on how it is produced.

Currently, most hydrogen gas in the UK is produced through steam methane reformation. This process involves reacting natural gas with steam to generate 'grey' hydrogen. By incorporating Carbon Capture, Usage, and Storage (CCUS) technology, 'blue' hydrogen can be produced. The fertiliser industry also generates blue hydrogen by capturing the carbon dioxide ($CO_2$) by-product for use in the food and drink sector. Grey hydrogen provides no carbon savings, whilst the carbon benefits of blue hydrogen are not credible as it is lower carbon but not a net zero carbon fuel (it may not achieve a high enough storage

[58] Low- or high-grade heat can be recovered from electrolysers. Combustion can generate high-grade heat.

[59] Currently over 20 p/kWh but expected to reduce over time.

[60] There is currently no large-scale commercial production in or around Edinburgh which could be considered in our profiling and selection process.

efficiency, it involves an inefficient and costly process lifecycle, and methane extraction, processing and transportation still results in significant emissions). Both sources are contentious and could be seen as short-term means to introduce hydrogen infrastructure, but not as net zero energy solutions aligned with commitments set out in the Edinburgh LHEES.

Electrolysis is another method of hydrogen production, where electricity is used to split water into hydrogen and oxygen. When this electricity is sourced from renewable energy, such as curtailed wind generation, the result is 'green' or net zero carbon hydrogen. Although green hydrogen production is currently minimal in the UK, it has garnered significant attention due to its carbon saving benefits. The electrolysis process also generates significant waste heat which could in theory be recovered for a heat network. Additional methods for hydrogen production include:

- Thermochemical water splitting, which uses extremely high temperatures to separate water into hydrogen and oxygen.
- Methane pyrolysis, where heat is used to break down natural gas into hydrogen and solid carbon. This is part-way between green and blue hydrogen in terms of carbon benefit and is also only regarded as a transitional source.

As well as the production, additional cost and energy inputs are needed to compress and refrigerate (liquify) hydrogen for storage and distribution, which is why only green hydrogen offers any long-term benefit from cost and carbon perspectives.

We have identified four hydrogen projects near Edinburgh, all originating at Grangemouth, Falkirk:

- The Scottish and UK Governments have jointly proposed Project Willow, a multi-billion-pound investment plan to develop Grangemouth into an industrial hub for clean tech across nine possible investment areas covering wastes, bio-feedstock, and support for offshore wind. Among these proposals is a £250m scheme for replacing natural gas combustion with low carbon hydrogen produced from offshore wind power[61]. Project Willow has a £25m funding commitment from the Scottish Government in addition to a £200m commitment from the UK Government. However, the Project Willow report notes that if large volumes of hydrogen are required (Gigawatt scale), these will need to be produced elsewhere in Scotland and transported to Grangemouth.
- RWE, one of UK's leading energy developers, is progressing plans to develop a green hydrogen electrolysis plant at Grangemouth. RWE plans for initial capacity for up to 200 MWe producing up to 3.6 tonnes of hydrogen per hour by 2029, with ambitions for expansion to 600 MWe.
- Project Acorn[62] is a private sector-led proposal to produce blue hydrogen from natural gas in Scotland's central belt (primarily Grangemouth), transporting the emitted $CO_2$ via pipelines to St Fergus to be shipped 100km offshore and pumped under the North Sea. The Scottish Government has committed £2m to this project.
- While much of this activity signifies potential for large-scale production capacity, this needs to be transported closer to the heat demand in Edinburgh for use as a heat source. SGN has received Ofgem approval to do this by repurposing a 30km decommissioned pipeline which runs from Grangemouth to Granton. This trial would involve transporting 100% hydrogen sourced from INEOS facility in Grangemouth to test procedures, safety and practicality.

To be of direct use to a heat network, hydrogen would have to serve as a fuel for heat sources (e.g. boilers or CHP). At present there are significant unknowns related to the potential use of hydrogen within Edinburgh:

- Distribution and availability: initial roll-out of hydrogen distribution networks are likely to be focussed on serving industrial sectors with high heat demand in order to recuperate the infrastructure investment. It is not clear when, or even if, hydrogen networks will be built into city centre areas such as Edinburgh. Through stakeholder engagement we learned that even if networks were not built to the same extent as gas or water networks, hydrogen could be utilised in a bulk capacity at an energy centre where it is more viable to route a hydrogen pipeline to (e.g. at Granton). We consider this to be the method with the least friction.

[61] This is focused on using curtailed wind power, providing a means to store and diversify the uses of energy produced from intermittent wind. This is intended to reduce the burden on the grid and avoid curtailment of offshore wind farms when supply exceeds demand.

[62] A partnership of Storegga, Shell UK, Harbour Energy and North Sea Midstream Partners.

- Costs: without knowing the specific method of production and transportation to site (i.e. where and how it would get there), it is difficult to quantify a cost for hydrogen[63]. For it to be competitive with other heat source options, it would need to be available at under 7 p/kWh in the present day. According to the International Energy Agency, this might be possible but will require a major up-scale in the production of low-cost renewable electricity and electrolyser facilities. If this level of renewable generation does become available, then it would be significantly more economical to directly use as much of this as possible via heat pumps. Various other methods of thermal storage may also continue to be more economical than hydrogen. Hydrogen would have to become a highly competitive energy storage medium to be able to displace this role. Alternatively cheaper hydrogen may be imported. In the long-term, it may also be potentially viable for green hydrogen to serve as a back-up or as a fuel source for a peaking plant, eliminating the need for natural gas to enable a net zero heat network.
- There will likely be strong competition for green hydrogen from other energy users. Given the relatively limited scale and outlook on supply, industry may utilise most hydrogen produced. This may become more probable if more hydrogen demand arises from industrial and chemical processes where it has the strongest business case. For example, RWE's green hydrogen project at Grangemouth is expected to supply INEOS and the local industrial cluster to decarbonise industrial process emissions.
- The carbon saving potential of hydrogen can be marginal or negligible. Due to the inefficiencies of electrolysis, liquefaction and combustion, even at present green hydrogen does not deliver any carbon benefit compared to using renewable electricity to run heat pumps to generate heat directly. While green hydrogen may be viable, we do not consider that grey or blue hydrogen is a viable option for Edinburgh's heat networks on grounds of efficiency/cost and carbon. Grey hydrogen is, by definition, inconsistent with the LHEES net zero goals as the greenhouse gas emissions from its production are released into the atmosphere. Blue hydrogen involves the use of fossil fuels (primarily methane), with substantial emissions from aspects discussed above, and is therefore also inconsistent with the LHEES net zero goals. Additionally, CCUS for blue hydrogen has yet to prove its operational effectiveness at scale; it also adds substantial costs which are yet economically unproven.

Due to these uncertainties, we have not considered hydrogen as a heat source for heat networks within Edinburgh at this time. However, there will be an option to integrate green hydrogen in the future. Our approach to analysing heat networks is technology agnostic at present as well as for the long run. If and when green hydrogen becomes scalable, practical and economic, it could potentially serve a spinal network as a primary source and/or serve a main, peaking or back-up plant within energy centres as a secondary source.

### 7.2.9 Other sources of heat

#### 7.2.9.1 Hillwood Asphalt Plant

Heat recovery from asphalt plants is typically carried out with a heat exchanger utilising heat from the exhaust gases produced by the plant. This usually preheats the air to the dryers, helping to improve the thermal efficiency of the plant. This method could also be used to heat or pre-heat water for a heat network.

Hillwood Asphalt Plant is a small plant located south of Ratho. It is not located near any major sources of heat demand other than Edinburgh Airport, who have already established their own heat decarbonisation plans. It is unlikely that this plant will be able to serve another more distant heat network zone. Due to Edinburgh Airport's assessment and the small scale of the asphalt plant, it has not been considered further in this study.

#### 7.2.9.2 Biogas

The gases produced from landfill can be used to combust in either CHP engines or boilers. There are several landfill sites located around Edinburgh. However, the estimated waste heat output from these is low, and none are located close enough to any substantial heat demand to be of benefit to a potential heat network. As landfill of organic materials is being phased out, the landfill gas production is declining and will contribute less to energy generation. For these reasons, landfill as a waste heat source has been ruled out for this study.

Further, there have been suggestions of fully transitioning the gas grid from natural gas to biogas. However, these plans are yet unproven and unclear with respect to the practical viability and cost implications.

[63] While the projects described provide some early indications, the full details of production at scale are unknown. Therefore, the costs are currently unquantifiable in the way that they are for other more well-established heat sources.

#### 7.2.9.3 Data centres

Data centres can make excellent potential waste heat sources due to their constant rejection of low-grade heat. However, the estimated waste heat potential from existing data centres highlighted in the ClimateXChange dataset is deemed too low to have significant impact on the zonal scale networks. Therefore, heat from data centres has been excluded any further from this study.

It should be noted that early-stage proposals for the considerably large new Green Data Centre in *Zone 8 – Southwest Edinburgh* have received pre-planning approval. This and other opportunities should be considered as potential heat sources for any nearby heat network, with the integration of the waste heat recovery to be considered from the start.

#### 7.2.9.4 Supermarkets & bakeries

Supermarkets and bakeries have also been listed by the ClimateXChange dataset as large heat sources. However, these types of heat sources can be challenging to integrate as it can be costly to modify equipment to extract the heat. For this reason, these types of heat sources are not being considered as a heat source for zonal scale heat networks in this study.

#### 7.2.9.5 Electrical substations

Substation transformers are typically cooled via an internal oil circuit and then oil-to-air heat exchangers (radiators) with dissipation of the heat into the atmosphere by natural convection. This configuration makes efficient heat recovery difficult. Alternative oil-to-water heat exchangers do exist and would be better suited to heat recovery for use in a heat network system. In these systems, heat is transferred from the oil cooling circuit into a water circuit, which can then be used to supply a WSHP.

The cost of transformer modifications means this is only likely to be worth doing at a grid level (110 kV or 132 kV transformers). Even then, it is estimated that a peak offtake of 300-700 kW would be available per grid-level substation (based on previous projects). For the purposes of this study, this has been deemed not large enough and has not been taken any further. It should be noted that substation heat rejection may still be a viable option which can be assessed at the detailed feasibility stage.

#### 7.2.9.6 Torness Nuclear Power Station

Torness Nuclear Power Station is situated on the coast east of Dunbar, East Lothian. Nuclear power stations produce exceptional amounts of heat via nuclear fission and keeping them cool is critical to maintain safe operating conditions. Torness uses approximately 33 $m^3$/s of seawater to cool its two reactors with a combined capacity of 1,190 MW. Large volumes of heated seawater are then pumped back into the sea.

While at a substantial distance from Edinburgh, this may have been worthwhile studying due to the sheer waste heat potential. However, Torness is scheduled for decommissioning in 2030, thus we have not considered it further. EDF, the operator, has signalled extending this life further subject to plant inspections and regulatory oversight, but there is currently no declared policy intent from the Scottish Government.

## 7.3 Conclusions on heat sources audit

Our analysis considered all possible heat sources identified with support from the Council and stakeholder input. It is important to note that this analysis is a snapshot in time, avoiding any final conclusions on heat sources and remaining open to sources changing status or new sources emerging as circumstances change (data centres, industry etc.).

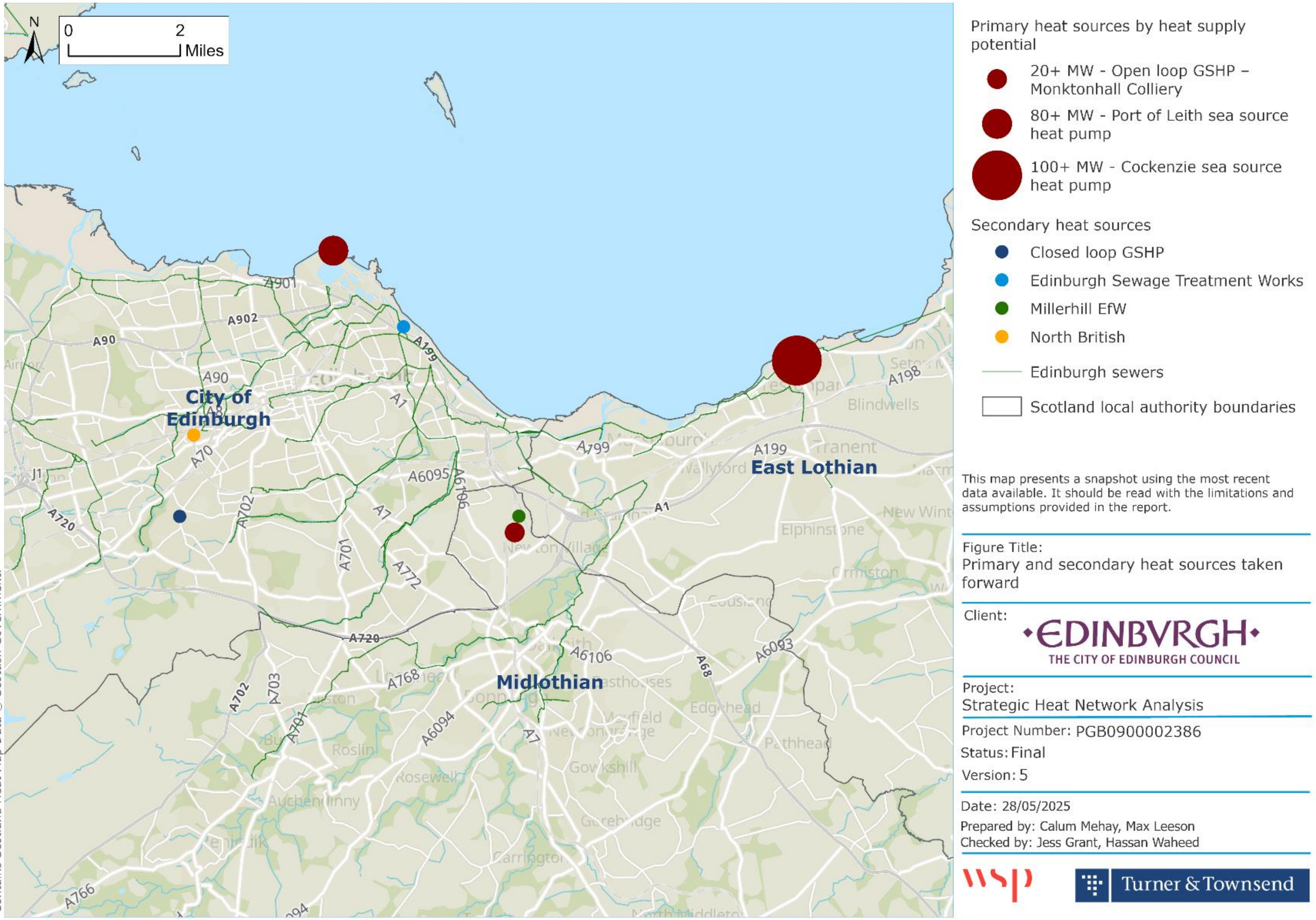
This analysis is also technology agnostic; as long as sources are in line with the LHEES net zero commitments we considered them. This reflects the fact that a heat network is, by nature, technology agnostic as any source or method could be used to heat the water in the pipes. Thus, we focused on factors which would determine the cost effectiveness and practicality of sources in our profiling. This resulted in three primary and five secondary heat sources being taken forward for further consideration at this stage. These are presented in Table 7 and Figure 26.

| Primary heat sources | Secondary heat sources |
|---|---|
| | Sewer source heat |
| Port of Leith sea source heat pump | EfW - Millerhill |
| Cockenzie sea source heat pump | Seafield WWTW |
| Open loop GSHP – Monktonhall Colliery | North British Distillery |
| | Closed Loop GSHP |

*Table 7: Primary and secondary heat sources considered for our analysis.*

We have not profiled air source heat pumps (ASHPs) within this section. This is because they are a highly versatile source not tied to a location; they can be used in many situations as a primary plant, supplementary, or back-up source. We utilise ASHPs extensively within our feasibility review and energy modelling (section 9).

*Figure 26: Map of primary and secondary heat sources taken forward for our analysis.*



# 8. Zone refinement

*The second objective of this analysis was to refine the Edinburgh LHEES prospective heat network zones with due regard to practical, commercial, strategic, regulatory, stakeholder and other considerations. This refinement intended to provide more robust prospective zones with a clearer view of the opportunity. We arrived at 11 prospective zones, presented in Figure 27. In general, they consolidate many of the previous zones into larger more attractive investment opportunities, follow more strategically planned boundaries, better reflect the constraints around the boundaries as well as within zones, and provide a more balanced split of heat demand across the major zones. This section details the process we followed to arrive at these zones. However, these zones should be refined further at detailed feasibility stage.*

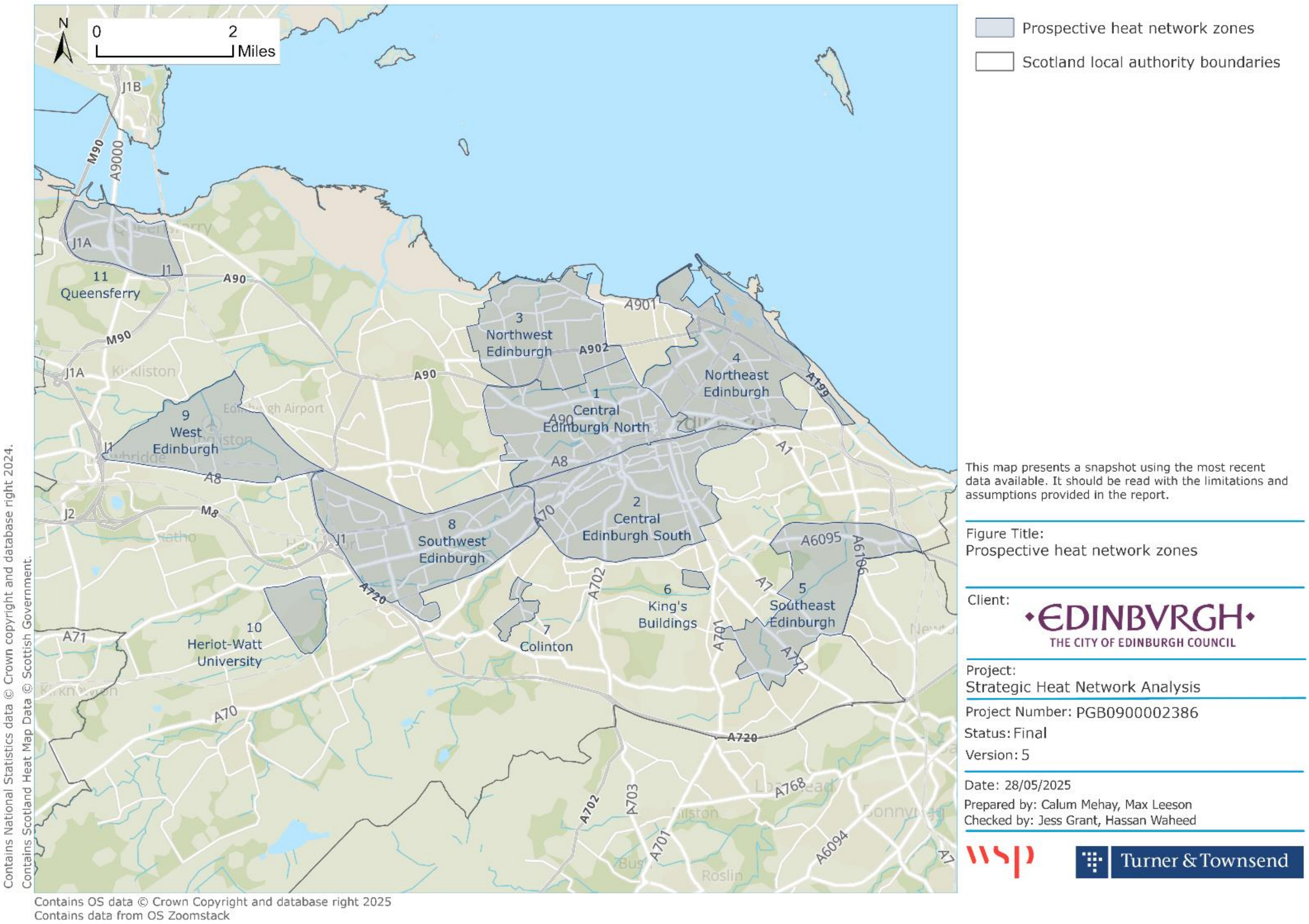



*Figure 27: Prospective heat network zones for the City of Edinburgh.*

## 8.1 Edinburgh LHEES potential heat network zones

The Council first formally conducted zoning as part of the Edinburgh LHEES, published in 2023. That exercise produced 17 zones across the local authority area.

The methodology utilised a linear heat density of 8,000 kWh/m/year for central Edinburgh and 4,000 kWh/m/year for areas outside of central Edinburgh to create buffer zones. The anchor load threshold of 500 MWh/year was used, along with a requirement for there to be at least two anchor loads to form prioritised clusters. These clusters were shaped by the key constraints to provide boundaries.

The resulting 17 zones had a total heat demand of 3.7 TWh for all buildings within the zone. This included 1.4 TWh of demand from 545 anchor loads with heat demand exceeding 500 MWh/year. Further details on the methodology, map of the zones and heat demands of the zones[64] can be found within section 4.2.1.

## 8.2 Refinement process

Our zone refinement method followed an iterative cycle of updates, starting from the Edinburgh LHEES zones and ending with the zones presented in Figure 27. Various processes and data sources fed into the refinement, including datasets compiled as part of the Edinburgh LHEES, insights and data collated via the stakeholder engagement, discussions with the Council's LHEES team and other officers, workshops with the Council and HNSU, and our analysis of these sources.

These sources became available at various points throughout the study; we collected several datasets from stakeholders at separate times. Likewise, our investigation of key topics with the Council progressively revealed information over the course of several months[65]. We made multiple rounds of refinements to the zones based on these updates until an agreed set of boundaries was approved by the Council and reviewed by the HNSU. To iterate the zones, we carried out four activities with multiple repetitions of the cycle (Figure 28).

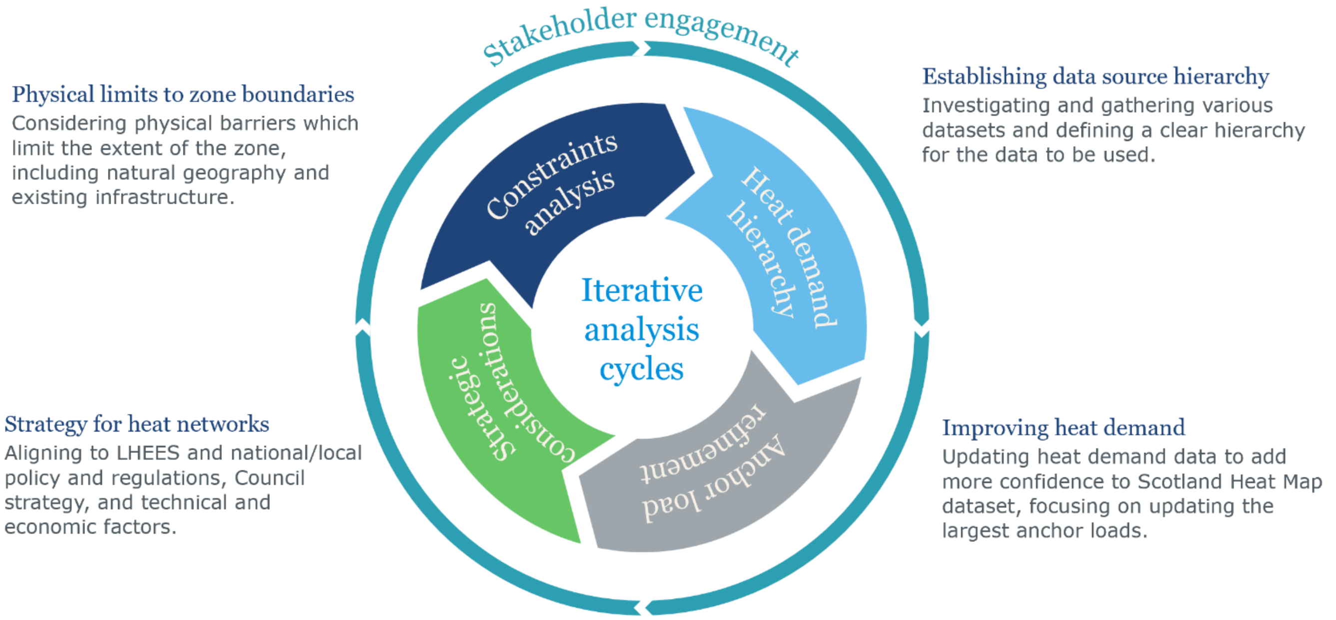



*Figure 28: The iterative analysis cycles to refine zonal boundaries.*

Each stage of this cycle is highlighted in the following subsections.

It is not yet clear the obligations that will be placed on owners and occupiers of buildings within a heat network zone in Scotland. Many of these decisions are anticipated in the forthcoming Heat in Buildings Bill among other developments, as discussed in section 4.1.2. The licencing, permitting and consenting regime is also awaited for released by the Scottish Government and Ofgem.

This has precluded any refinement of the boundaries based on regulatory requirements for building owners/occupiers as well as refinements considering the authorities' and operators' powers owing to licencing, permitting or consenting rules. We discuss these limitations at length in section 4.1, with the details of the limitations of these gaps on our analysis in section 4.1.3.

Further, the ongoing uncertainty on the Council's delivery model of choice persists. While there has been progress in shortlisting the key options, they remain too broad to be able inform zone refinement. The pending decision has precluded any refinement of boundaries based on delivery models and/or delivery vehicle(s). We discuss this limitation in 4.2.3.

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[64] See Figure 5 for the map and Table 3 for the zone-level data, section 4.2.1.

[65] For example, information about development sites, stances on policy, and other pieces of analysis running in parallel with or prior to our study.

### 8.2.1 Heat demand hierarchy

The data used for the Edinburgh LHEES heat demand analysis was from the Scotland Heat Map (SHM), which has its limitations. A large proportion is modelled, is outdated data, or may have reporting errors. We aimed to update as much of this as feasible within the timeframes of the study. To achieve this, we researched all key data sources available and developed a hierarchy of data accuracy which defines the data source to target and prefer when representing a building's heat demand. We continuously collected this data throughout the study.

Generally, the more accurate the data source the less of it is available, largely due to inaccessibility and resource intensity involved with data collection. For instance, half-hourly meter data or accurate annual heat demand figures reported directly by the building occupier are the most accurate. However, these are also the most resource intensive to collect.

Conversely, SHM data on heat demand, which is based on multiple sources of varying reliability, is the least accurate dataset within our use but its benefit is in its widespread coverage: it has a heat demand figure for practically every building in Scotland. Many of the demands in the SHM are based on buildings' estimated floor area and benchmarks where actual building energy use data is not available.

We established and gathered data under four hierarchy classes, illustrated in Figure 29. Stakeholder data in this instance includes the Council's own estate datasets which were used to represent heat demand across the largest Council-owned anchor loads.

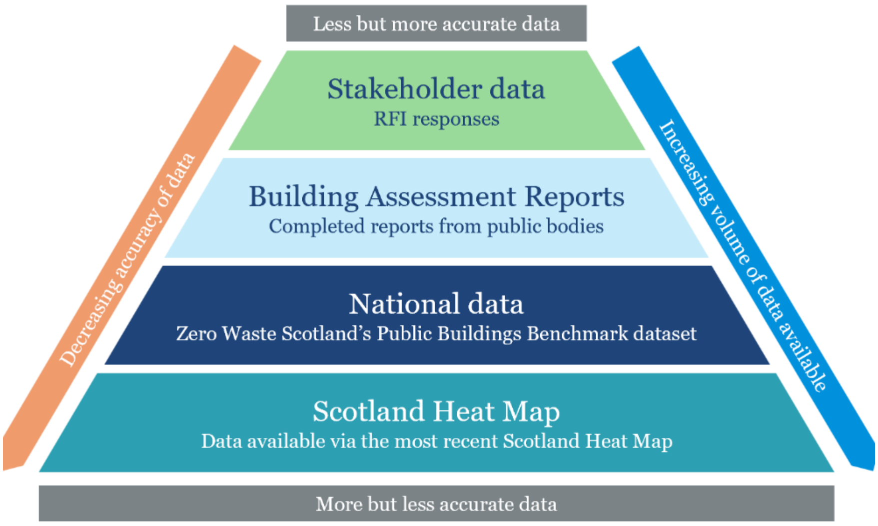



*Figure 29: Heat demand data hierarchy.*

### 8.2.2 Anchor load refinement

The viability of a large-scale heat network is contingent on anchor loads with substantial heat demand. We continued refinement of anchor load data. Once this data was updated, we regenerated LHD buffers and prioritised clusters as originally carried out as part of the Edinburgh LHEES zoning exercise (see section 4.2.1). For consistency, the threshold for an anchor load has been kept at >500 MWh/year. This allowed for a comparative analysis of the differences and provide the evidence for changing boundaries on the basis of heat demand (Figure 30).

Some of these changes are based on instances where the SHM has overestimated anchor load heat demand. This produces inaccuracies in the buffer generation as well as the prioritisation of buffers. It results in instances of apparent anchor loads which have a much larger estimated heat demand than the building would really require.

A prime example is warehouses which are very large but often mostly unheated[66]. Floor-area based calculations for buildings identified as warehouses are likely to result in inflated heat demand. This may have caused many to be classed as anchor loads in the Edinburgh LHEES work. In reality, these types of buildings are unlikely to have heat demands of the scale represented. Therefore, warehouses have been removed as anchor loads[67]. This is an example of a major swing in heat demands after corrections.

Several anchor loads were also found to be buildings or areas with no heat demand, such as car parks, demolished buildings and water tanks. The heat demands for these loads were reset at zero kWh.

[66] In some of these instances, the SHM uses floor area and building type to estimate a heat demand. However, there are multiple warehouse types which would be over-represented as they have very little to no practical heat demand for the purposes of heat network planning.

[67] While there may be warehouses with some heat demand and some even classifying as anchor loads, our decision is a less risky approach. We are not facing a lack of heat demand to help make zones viable, thus we can afford to be more conservative with our estimation. A more granular approach studying all anchor loads within a zone should be taken at the feasibility stage.

As part of the stakeholder engagement, we targeted several of the largest anchor loads in Edinburgh and across each Edinburgh LHEES zone with a request for information (RFI). Data gathered from RFI responses was continuously added to the anchor load attributes, replacing the heat demand estimate from the SHM. Other more accurate data in the hierarchy replaced the SHM data where data could not be obtained via the RFI.

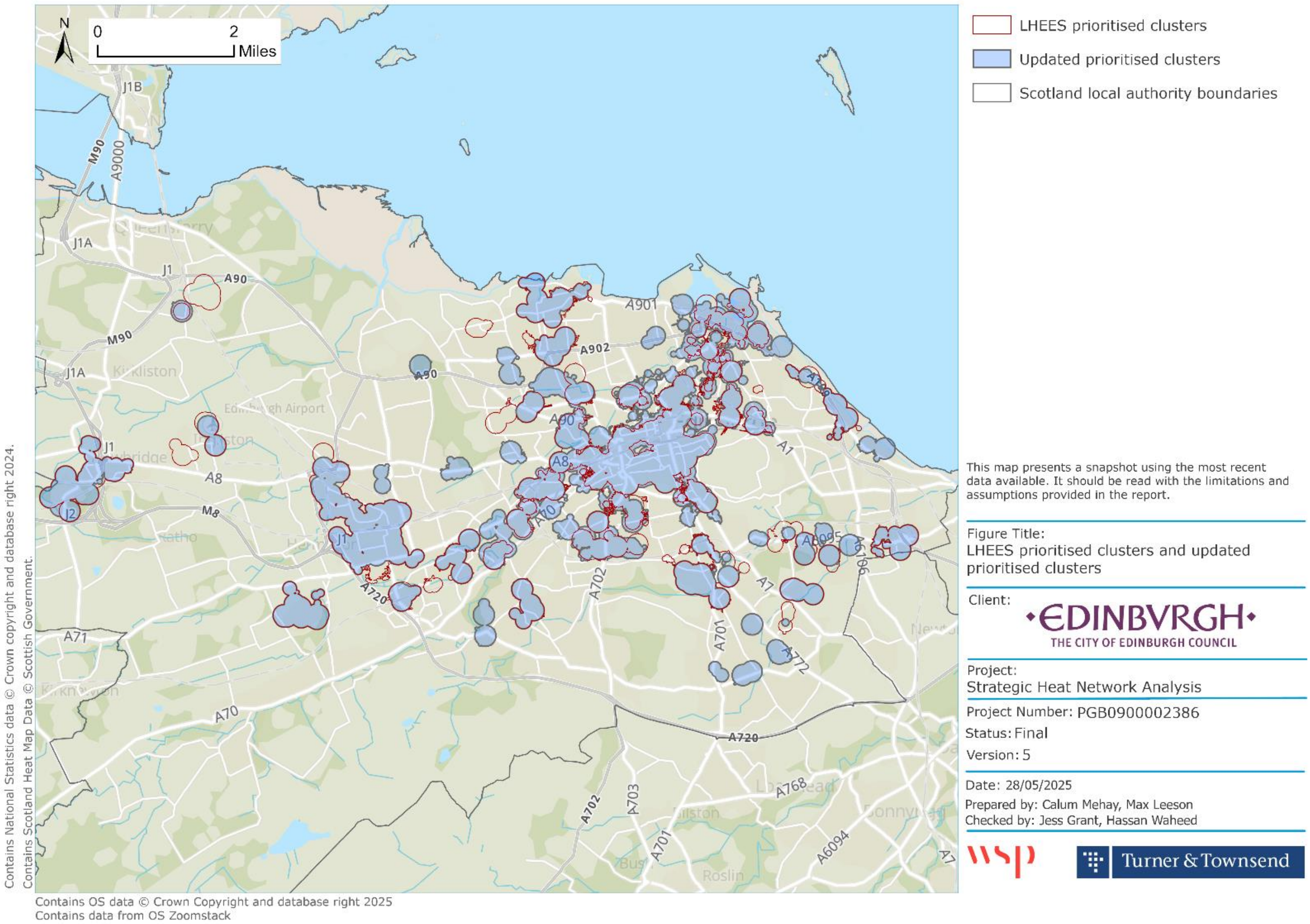



*Figure 30: Prioritised clusters generated as part of the Edinburgh LHEES and updated prioritised clusters.*

### 8.2.3 Strategic considerations

There were several aspects of policy and strategy to consider while zoning. Some of these were pursuant to the Council's obligations under the Heat Networks (Scotland) Act[68]. Others pertained to other legislation, national policies, local policies, and technical and economic factors whilst developing a heat network. We refined the zones iteratively as we received information regarding these considerations throughout the study. All of these considerations are summarised in Table 8.

| Strategic consideration | Description |
|---|---|
| **Fuel poverty** | This is a key consideration of the Council's LHEES as well as a consideration within the Heat Networks (Scotland) Act. The Council aims to leverage heat networks to protect vulnerable customers at risk of or in fuel poverty by driving down relative energy costs.<br><br>We were diligent about zoning areas of high potential fuel poverty as well as areas with a high concentration of social housing (including Council-owned housing). |

[68] The Edinburgh LHEES zones already attempted to cover these obligations. However, we aimed to further shore up this analysis as well as address any gaps.

| | |
|---|---|
| **Zone size and division** | Having many smaller zones has the potential to limit the speed of development in an area. It is also less attractive as an investment opportunity, especially as future expansion prospect for increasing revenue or adding value to the network over time. Feedback from stakeholders and the Council's own policy position also supported this viewpoint.<br>Therefore, we maximised the areas of zones and minimised the number of zones.<br>However, from stakeholder engagement we also understand that an imbalance could make some zones less attractive than others, skewing investor interest and hindering the development of a city-wide heat network. The heat demand of the city is concentrated in the centre with several clusters across the city (Figure 31).<br>With other strategic considerations, buildability of a network and constraints in mind, we aimed to distribute this demand across the relevant zones. |
| **Public buildings** | Public buildings (including the Council's own building stock) are an attractive potential off-taker for a heat network operator.<br>▪ Firstly, the public sector is more conducive to connection for multiple reasons, including control, public sector policy, net zero commitments, longer-term investment horizons and future regulatory levers.<br>▪ Second, the upcoming regulatory regime could vest the Scottish Government and potentially the Council with powers to mandate public buildings to connect to a heat network where one is available.<br>We attempted to zone for all opportunities presented by public buildings, including where demand may have been slightly lower but the potential for a network development high. This covers two zones (*Zone 7 – Colinton* and *Zone 11 – Queensferry*). |
| **Local development plan** | New development areas do not usually represent substantial heat demand in SHM, especially when they are proposed in areas with limited existing heat demand or buildings. However, they are attractive opportunities for a heat network as there is reliable future heat demand if the development is based on a heat network.<br>These areas are also typically less challenging to develop heat networks in, as they already have several other infrastructure upgrades planned or underway.<br>We included all relevant existing and new development areas within zones, including housing, industry, missed use and other types. |
| **Secondary heat sources** | Availability of heat sources is a key factor in the development of a network. Heat sources and other relevant resources include geological sources, greenspace, land space for an energy centre, water bodies, waste heat sources, and renewable energy. Heat can be transmitted via primary heat sources even from a distance, but the availability of secondary heat sources can enhance the economic case of a heat network.<br>We included all possible heat sources within or proximate to zonal boundaries. |
| **Existing heat networks** | There are already several heat networks in development within Edinburgh, or just beyond the local authority boundary. These include the Granton Waterfront network, the Shawfair heat network in Midlothian and the related BioQuarter network proposals, and the University of Edinburgh's heat networks.<br>These have been considered when the zone boundaries were assessed to include or support the expansion of these networks where viable. |
| **Land ownership or control** | Some areas of high heat demand are majority owned by one stakeholder, such as in the case of university campuses. In this case, these sites stand as 'islands' of high heat demand in otherwise low heat demand areas. |

| | |
|---|---|
| | For these stakeholders, it may be unpractical and/or uneconomical to extend their network into the surrounding areas. It is also likely that these stakeholders will be mainly or wholly responsible for developing heat networks in these areas.<br><br>We have decided to define zones at a 'campus level' size to allow the relevant stakeholders to take ownership of decarbonising their zone. This includes the Airport, University of Edinburgh, and Heriot-Watt University (see Figure 31). This gives the universities autonomy over the solution for their zones and the Edinburgh Airport a leading role for the zone including and surrounding their land, with the Council acting in a supporting capacity where necessary. |
| **The Council's role** | Due to the complex interplay of the factors above, as well the Council's limited resources, it is not viable for the Council to lead every opportunity. In fact, in certain locations other stakeholders are better placed to lead. And where the Council should have a leading role, some zones should be prioritised over others due to their scale and strategic importance.<br><br>While developing zones, we have considered how these could be developed and the Council's potential role in the development. We subsequently also assigned each zone with a lead and a suggested priority/approach from the Council's perspective. This is detailed in section 11.4.2. |

*Table 8: A summary of all strategic considerations undertaken whilst refining zones.*

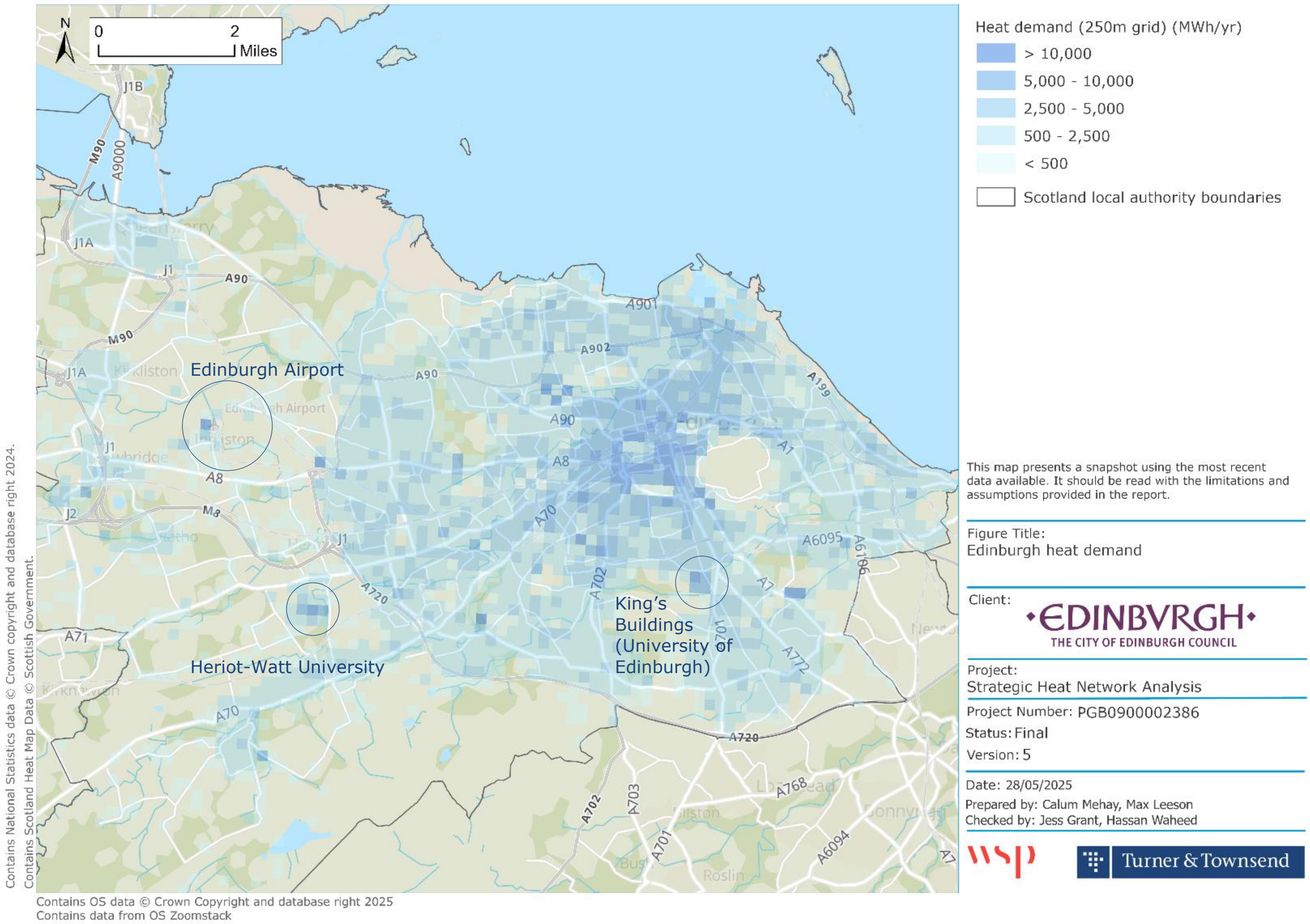



*Figure 31: Heat demand raster resolution showing the concentration of annual heat demand across the city. University campuses are annotated in relation to the heat demand 'island' 'phenomena' discussed in Table 8.*

### 8.2.4 Constraints analysis

We identified key technical and environmental constraints which could hinder the practicality or economics of a heat network zone as it would be difficult to cross areas with a heat network pipe or even serve as a physical barrier for pipes. The constraints considered are as follows:

- Transport infrastructure: major roads, rail lines and tram lines.
- Water bodies: rivers and lakes.
- Terrain and changes in elevation: valleys and hills.
- Buildings: avoiding intersection of zone boundaries with building and estate boundaries.

Where possible, the zone boundaries have been adjusted to avoid major and/or minor constraints. It is not possible to avoid all constraints. However, the refined zone boundaries enable the most efficient pipe routes and strategic crossings of rail, tram and rivers where necessary.

The zone boundaries have also been updated to follow streets, making it clear which buildings are included. Some Edinburgh LHEES zones did not clearly follow the roads in all cases and in some cases were left as unrefined linear heat density buffers. This meant that some zone boundaries were cutting through estates or buildings.

## 8.3 Updated zones

Due to the refinements of anchor load heat demands and the shape of zones, the estimated heat demand for Edinburgh's prospective heat demand has changed from the original Edinburgh LHEES zones. The zones have reduced in number from 17 to a more consolidated set of 11 prospective zones (Figure 32).

The overall annual heat demand across the zones has reduced from 3.7 TWh to 3.5 TWh, and the anchor load annual heat demand has reduced from 1.4 TWh to almost 1 TWh. The number of anchor loads in all zones has reduced from 545 to 515. The zones are summarised in Table 9 and have been used as the basis for further modelling in section 9.

| Zone number and name | Total loads | Total heat demand (MWh/year) | Anchor loads | Anchor load heat demand (MWh/year) |
|---|---|---|---|---|
| Zone 1 – Central Edinburgh North | 24,708 | 572,200 | 84 | 117,573 |
| Zone 2 – Central Edinburgh South | 50,305 | 909,486 | 134 | 237,153 |
| Zone 3 – Northwest Edinburgh | 18,543 | 287,565 | 34 | 119,078 |
| Zone 4 – Northeast Edinburgh | 44,522 | 798,839 | 90 | 76,588 |
| Zone 5 – Southeast Edinburgh | 12,327 | 308,968 | 45 | 178,050 |
| Zone 6 – King's Buildings | 47 | 74,662 | 20 | 71,552 |
| Zone 7 – Colinton | 196 | 9,050 | 5 | 5,389 |
| Zone 8 – Southwest Edinburgh | 22,193 | 368,385 | 77 | 127,323 |
| Zone 9 – West Edinburgh | 143 | 89,047 | 7 | 50,682 |

| Zone number and name | Total loads | Total heat demand (MWh/year) | Anchor loads | Anchor load heat demand (MWh/year) |
|---|---|---|---|---|
| Zone 10 – Heriot-Watt University | 78 | 21,343 | 15 | 9,691 |
| Zone 11 – Queensferry | 4,882 | 69,618 | 4 | 6,831 |
| **Subtotal (all zones)** | **177,944** | **3,503,163** | **515** | **999,023** |
| All areas outside zones | 105,240 | 1,682,841 | 95 | 129,829 |
| **Total (all Edinburgh)** | **283,184** | **5,192,004** | **610** | **1,128,852** |
| All zones as a percentage of total for Edinburgh | 63% | 67% | 84% | 88% |

*Table 9: Updated zone load and heat demand figures. The final row illustrates the coverage of zones across Edinburgh, demonstrating their centrality to realising Edinburgh's LHEES objectives.*

Despite containing slightly fewer heat loads and having an overall lower heat demand compared to the original Edinburgh LHEES zones, the refined zones still cover majority of Edinburgh's heat loads and heat demand as well as most of its anchor loads and anchor load heat demand.

## 8.4 Conclusions on zone refinement

Our zone refinement resulted in fewer, more consolidated zones which are more closely aligned to heat demand, constraints, fuel poverty, stakeholder input, LHEES indicators and factors associated with practical delivery of heat networks. Additionally, we have also developed zones which can be managed by the Council in more strategically effective way, both from a policy and practical perspective. The zones provide clarity on:

- Leadership and roles: the party primarily responsible for leading heat network development in each zone and the role the Council and other stakeholders would need to play.
- Priorities: the key zones to prioritise, linking to spinal routing, phasing and other factors (this is discussed further in section 11 in the context of a heat networks delivery strategy).

It is important to note that these zones remain as prospective zones and are not yet formally designated. Zone designation involves a formal process in line with the Heat Networks (Scotland) Act, led by a local authority, multiple local authorities collectively, or the Scottish Government. However, we consider these zones to provide the basis for designated zones when appropriate[69].

The following maps provide details of how we incorporated the various aspects of the refinement process described in the preceding sections 8.2.1, 8.2.2, 8.2.3, and 8.2.4.

[69] Although, the Council may find that further refinements need to be made to zones in line with new legislative or policy changes before formal designation.

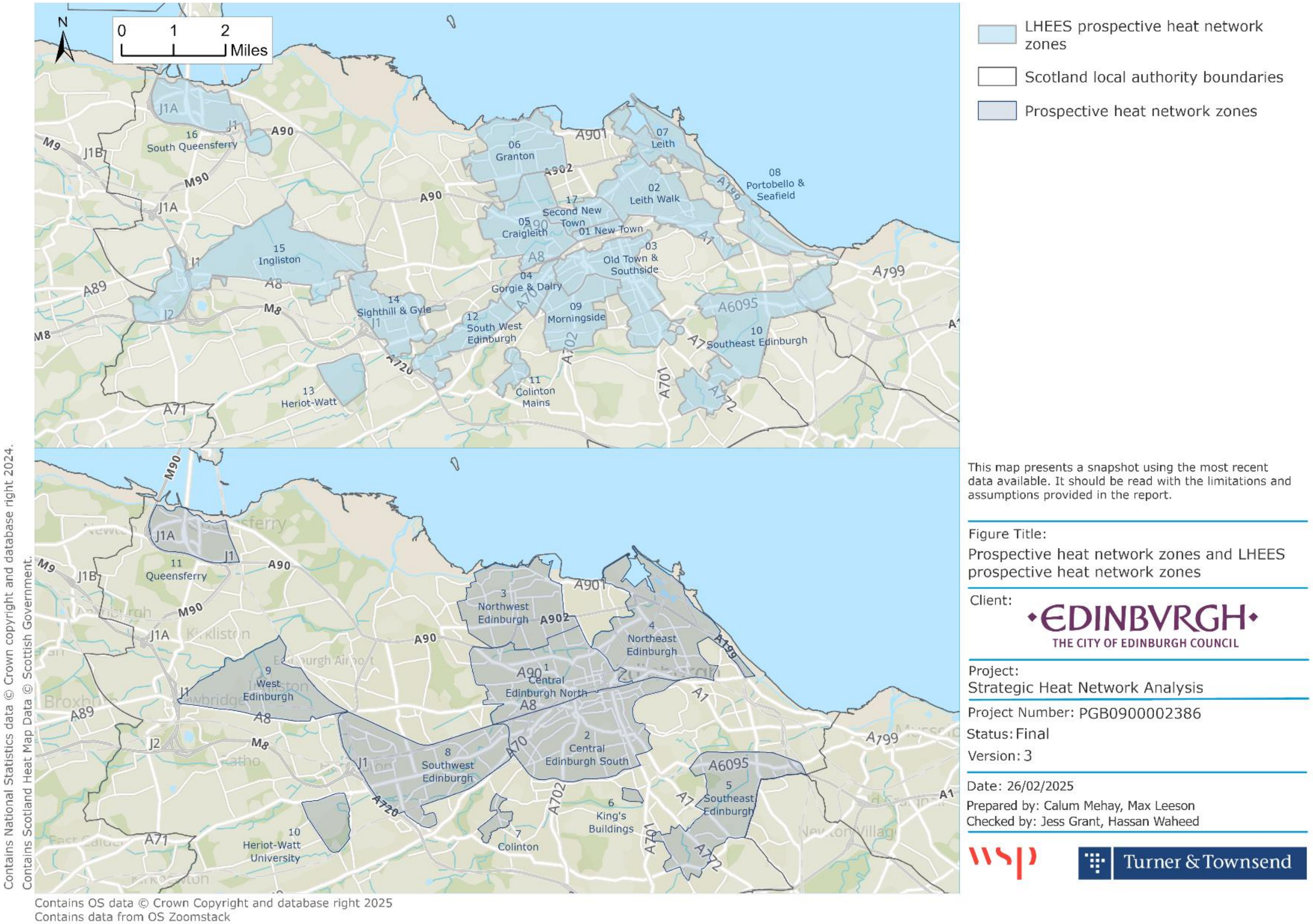



*Figure 32: A comparison of prospective heat network zones from Edinburgh LHEES (top) and the refined zones (bottom). Comparisons of individual zones are provided in section 12.1. Zones 1-5 and 8 are the largest in terms of heat demand as well as number of connections. These are likely to operate as large heat network schemes. Zones 6, 9 and 10 have been shaped to reflect the ownership characteristics of the landowners; these are likely to operate as campus-style or independently led zones. Zones 7 and 11 are relatively minor zones each with a handful of anchor loads (5 or less); these are likely to be public sector-led or exclusively public sector networks.*

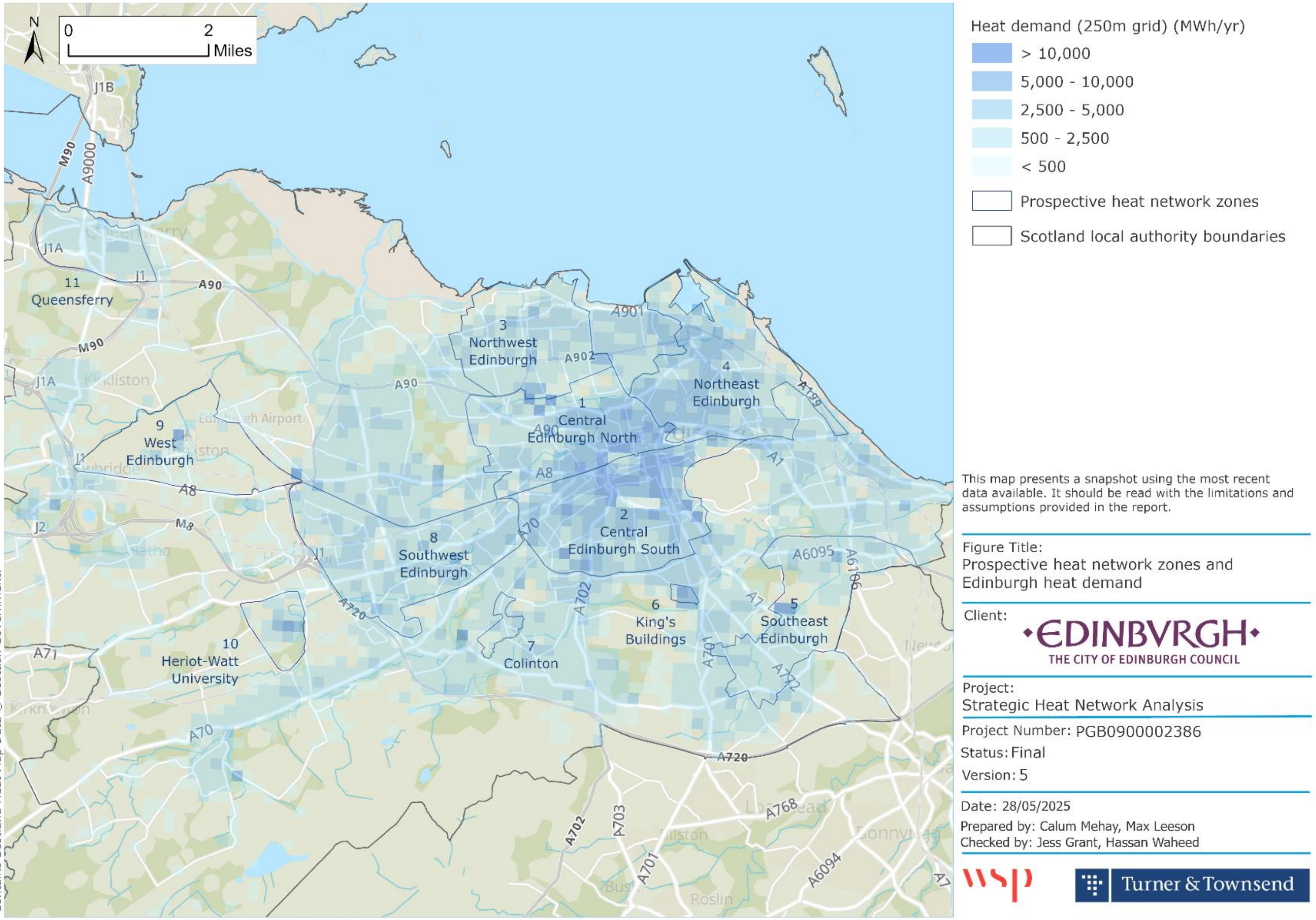





*Figure 33: Prospective heat network zones overlaid with annual heat demand raster resolution of 250m. We endeavoured to distribute heat demand across zones 1-4 and 8 in areas of central Edinburgh and those adjacent to the city centre. This aims to make multiple zones attractive for investment and avoids the risk of less attractive zones which are a challenge to develop.*

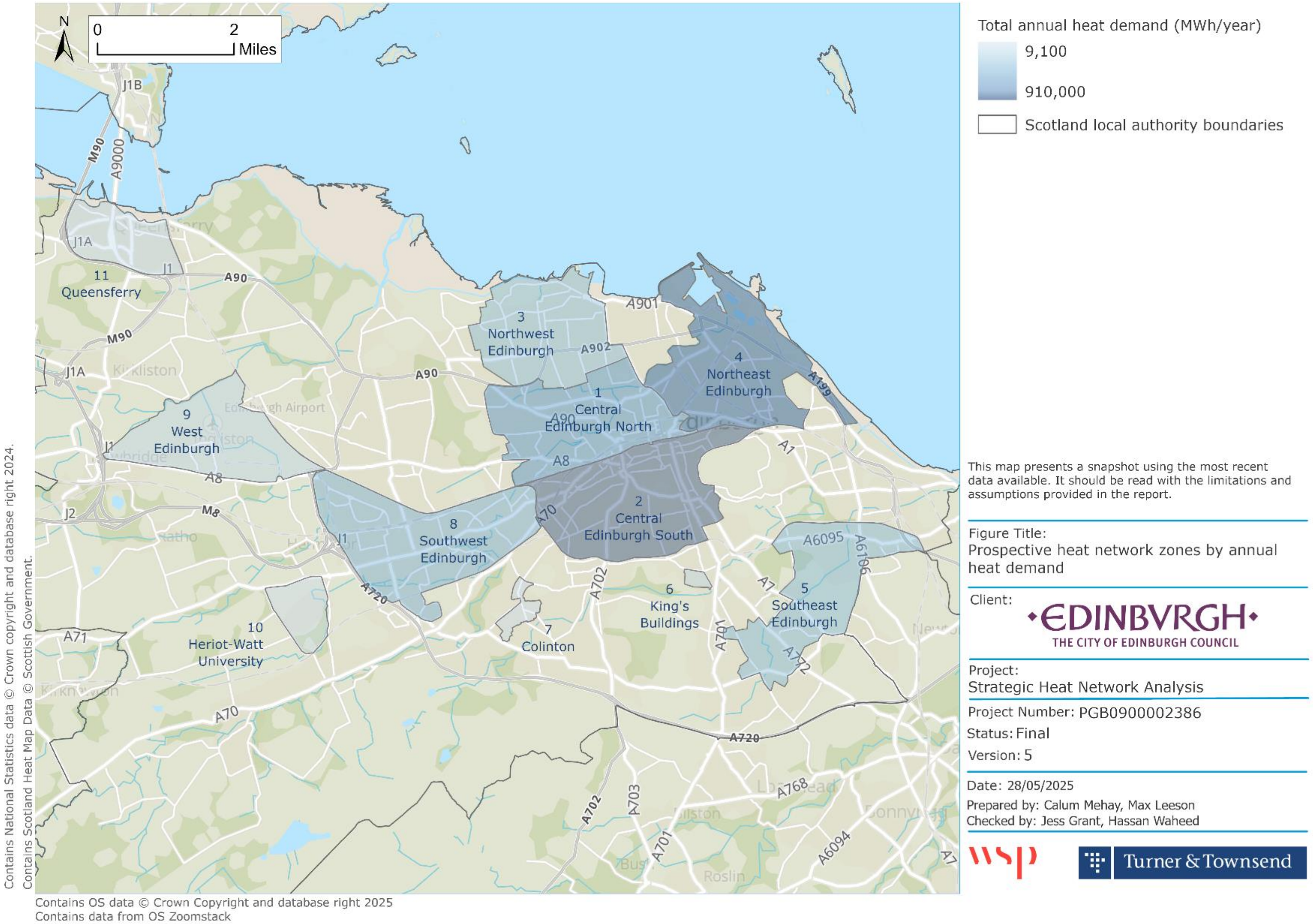



*Figure 34: Prospective heat network zones by heat demand. Each zone is colour coded by the volume of total annual heat demand. Zone 2 – Central Edinburgh South has the greatest heat demand due to unique combination of geography, constraints, heat demand, and other strategic considerations. However, zones 1, 3, 4, 5 and 8 all have strong heat demand and stand as major zonal scale heat network opportunities in their own right.*

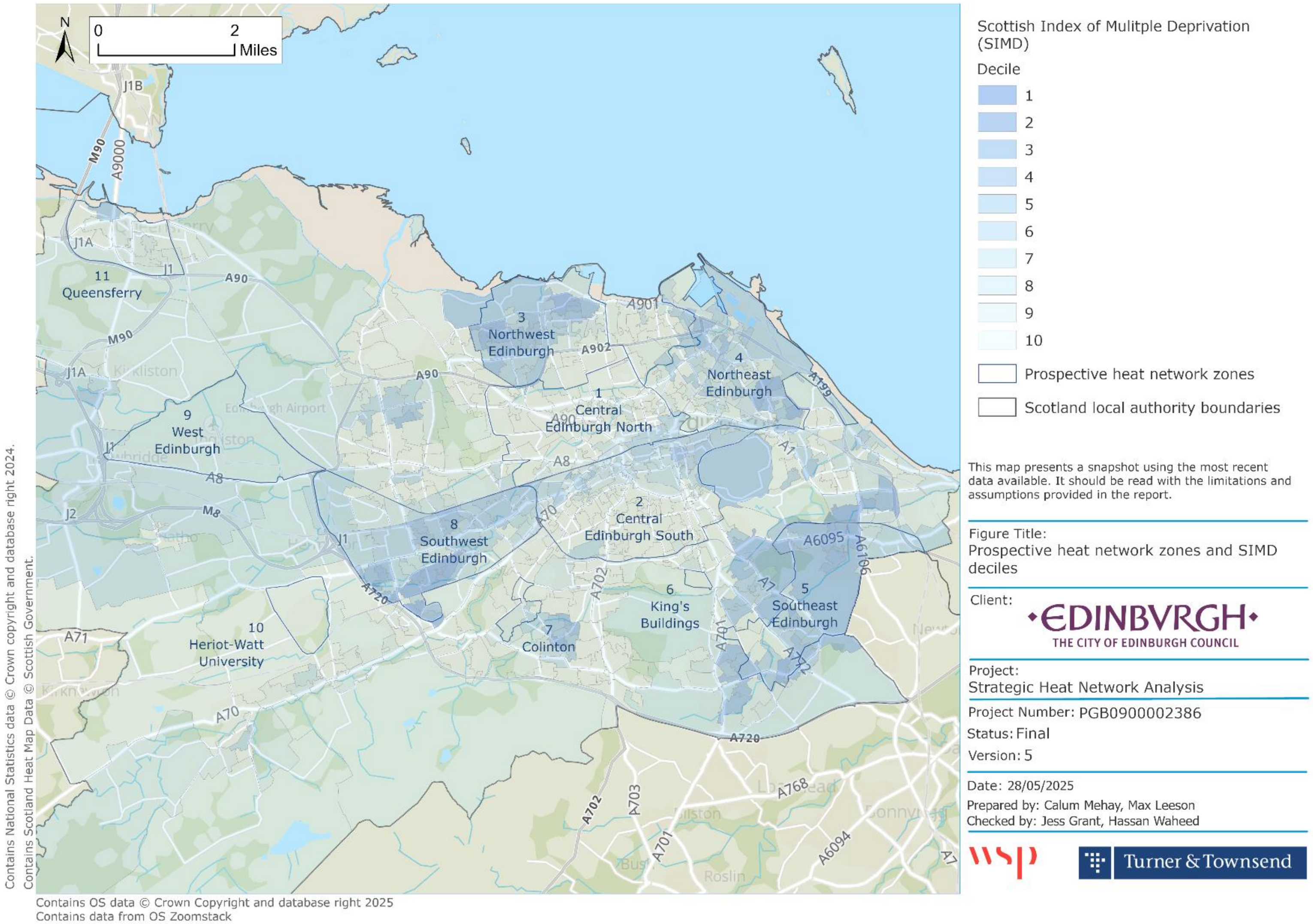



*Figure 35: Prospective heat network zones and SIMD deciles. Fuel poverty is a major strategic consideration and among the primary reasons for developing a heat network. The fuel poverty data for Edinburgh can be unreliable due to challenges with methodology and data quality. This was highlighted within the Edinburgh LHEES. As such, we opted to use SIMD as a proxy (this is not perfect, but helpful nonetheless). Our boundaries extended to try to capture as many areas of high deprivation as practical. For example, the southern border of zone 8 was extended to capture an area of social housing and relatively higher deprivation. Likewise, multiple other zones were extended to include areas of deprivation and/or known social housing estates.*

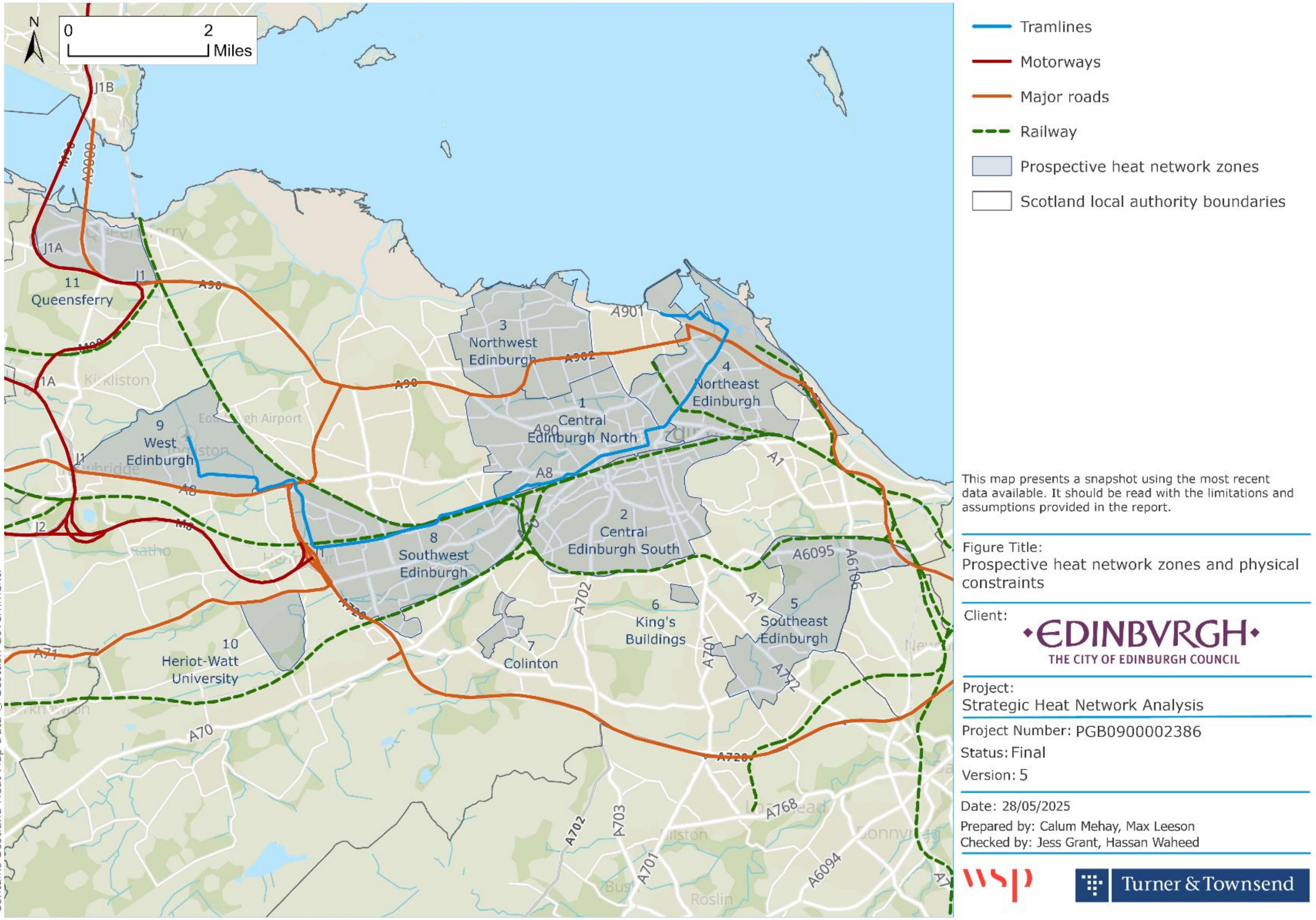





*Figure 36: Prospective zones and constraints which were used to inform their boundaries. Railway lines played a key role in determining many of the boundaries. Added to that, we also avoided major roads, the bypass, dual carriageways, and motorways. The tram line also played a role in shaping zones. Some major roads and tram lines were not as strict hurdles since decisions about crossing these are in effect within the gift of the Council. We crossed these constraints in cases where a strong case (e.g. heat demand, heat source, or strategic case) and a crossing point existed.*

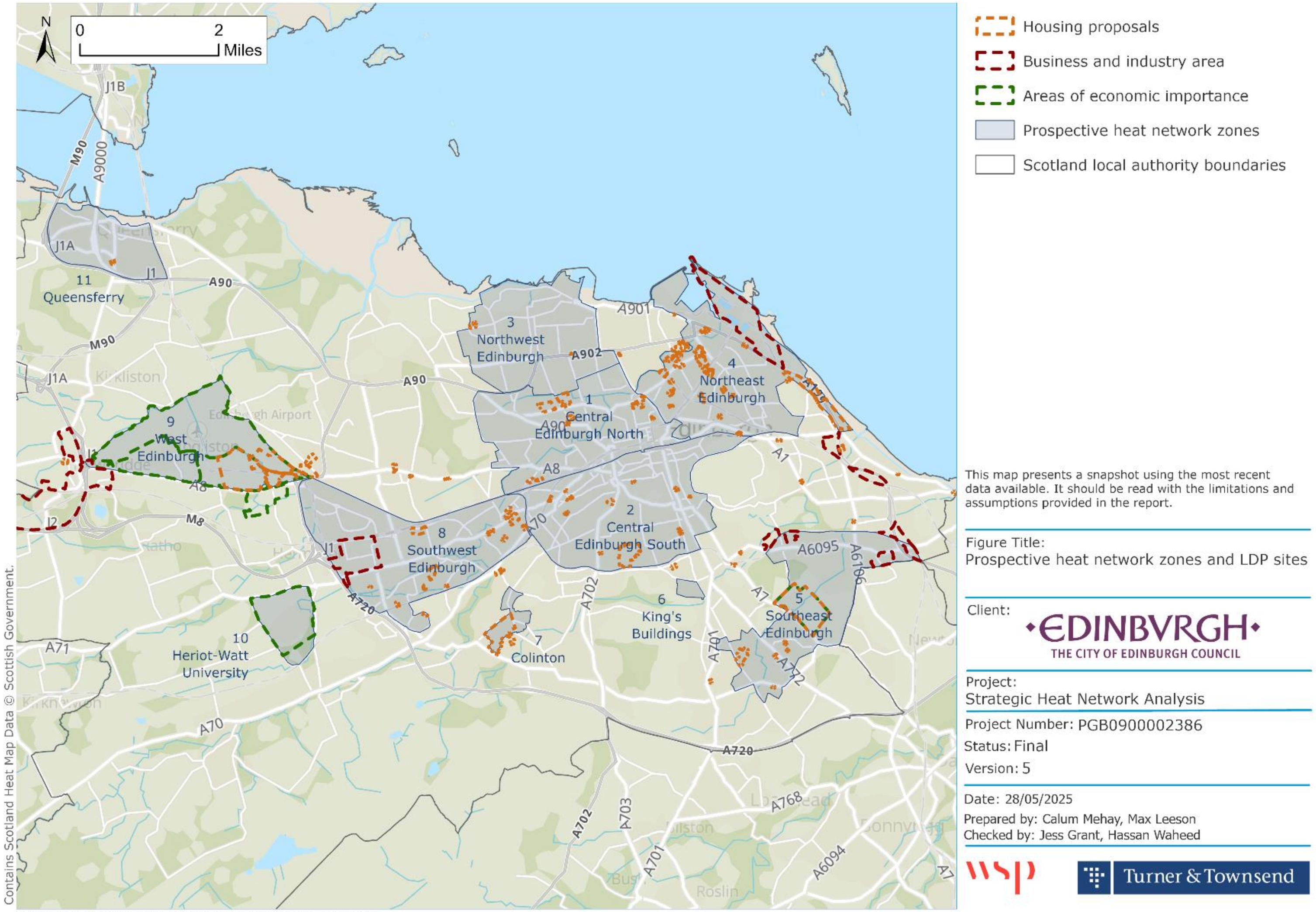





*Figure 37: Prospective heat network zone and city plan sites. We included all relevant development sites, specifically targeting housing proposals. We also mapped business/industry areas and areas of economic importance to highlight opportunities for high heat demand loads, potential energy centre locations, future waste heat sources and other relevant uses. However, these were not as critical to shaping the zones as we deferred to the heat demand data and other sources to help with the final decisions on refining the boundaries.*

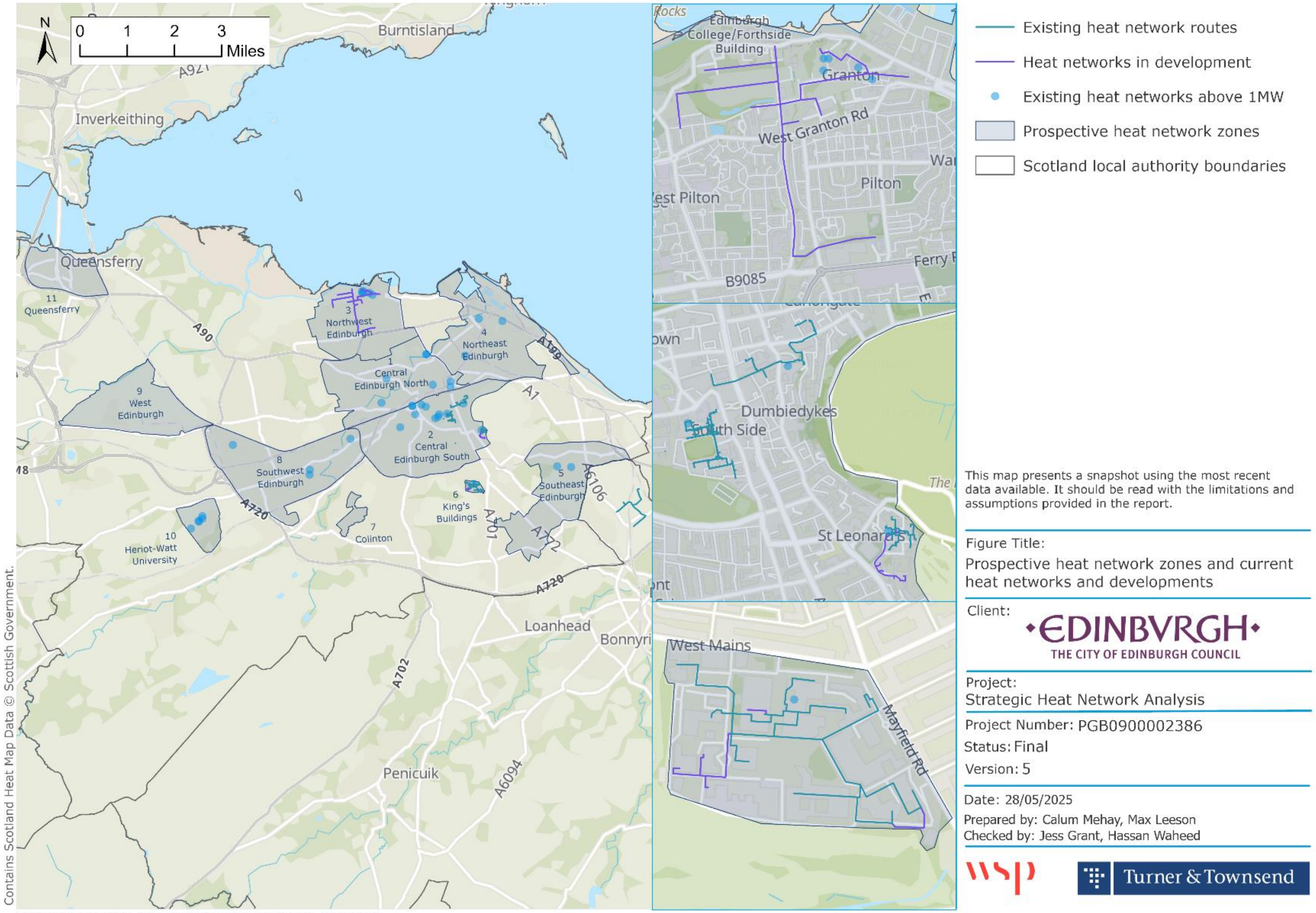





*Figure 38: Prospective heat network zones and existing and in-development heat networks. Inset from top to bottom: 1st box – Granton Waterfront heat network in development by Vattenfall under concession from the Council; 2nd box (top to bottom) – Holyrood heat network, Central (George Square) heat network, and Pollock Halls heat network, all operated by the University of Edinburgh; 3rd box – King's Buildings heat network operated by the University of Edinburgh. The blue points are based on Scotland Heat Map data on existing heat networks; however, many of these could be classed as communal networks connecting two or more buildings, or small heat networks connecting a several buildings within an estate.*

# 9. Feasibility review of zones

*The third objective of this study was to carry out an initial feasibility review on the refined individual heat network zones. This process involved developing a heat load profile for the anchor loads in each zone, energy modelling to estimate energy centre primary plant requirements, and zonal heat network route development. This enabled initial cost models to be developed, and basic economic viability tests applied. The analysis is high-level and indicative only at this stage. We made several assumptions where key aspects of the analysis could not consider real-world circumstances on many accounts, such as lack of data, limited scope and resource available for the study, and pending decisions and data from the Council, Scottish Government, regulators, and other local authorities. Detailed feasibilities should be carried out for each zone.*

## 9.1 Our approach to the analysis

### 9.1.1 Scope of the feasibility review

The feasibility analysis carried out for this study is broadly in accordance with the process for feasibility studies set out in the CIBSE Code of practice for Heat Networks (CP1). However, several steps have been simplified or consolidated to deliver this study within the time and scope constraints. This was agreed with the Council and the HNSU.

Hence it must be understood that this report does not represent a full feasibility study or studies (detailed feasibility studies are outwith the scope of this project), and that further work will be required to develop fully detailed CP1-compliant feasibility studies for each zone.

This initial feasibility review only considers economic indicators; carbon savings are not quantified. However, it can be assumed that the heat networks proposed in this study would deliver carbon reductions compared to current heating technologies.

The Granton Waterfront network has already had extensive development work carried out, such as feasibility studies, an outline business case, and the beginning of construction (within Granton). It was agreed with the Council that duplication of efforts should be avoided and instead the focus of this study should be on zones where there had not been substantial analysis carried out already.

Furthermore, three zones cover areas largely owned or controlled by their own respective entities. These are *Zone 6 – King's Buildings* (University of Edinburgh campus), *Zone 9 – West Edinburgh* (Edinburgh Airport and West Town Edinburgh), and *Zone 10 – Heriot-Watt University*. These zones have been shaped with due regard for the respective organisations' estates and land (see Table 8 in section 8.2.3).

It is the Council's view that these zones will largely be independently developed by these entities (if and as deemed appropriate by these organisations), with only a supporting role for the Council where required. Additionally, these zones are unique in that these organisations already have a significantly more detailed understanding of these areas than is available to us.

Therefore, the Council considers that further analysis should be progressed by these organisations with a more appropriate scope, depth and relevance of analysis achievable than is possible through this study. Finally, *Zone 6 – King's Buildings* already has a heat network which covers almost all buildings in the zone (Figure 38) and Edinburgh Airport is currently developing a heat network in *Zone 9 – West Edinburgh*. These developments also mean that our analysis would be moot with potentially limited additionality to these stakeholders.

For the reasons discussed these abovementioned four zones were excluded from this feasibility review. This leaves seven zones taken forward for the feasibility review; this is summarised in Table 10.

| Zone number and name | Included in feasibility review? |
|---|---|
| Zone 1 – Central Edinburgh North | ✓ |
| Zone 2 – Central Edinburgh South | ✓ |

| | |
|---|---|
| Zone 3 – Northwest Edinburgh | ✗ |
| Zone 4 – Northeast Edinburgh | ✓ |
| Zone 5 – Southeast Edinburgh | ✓ |
| Zone 6 – King's Buildings | ✗ |
| Zone 7 – Colinton | ✓ |
| Zone 8 – Southwest Edinburgh | ✓ |
| Zone 9 – West Edinburgh | ✗ |
| Zone 10 – Heriot-Watt University | ✗ |
| Zone 11 – Queensferry | ✓ |

*Table 10: Zones considered in the feasibility review.*

### 9.1.2 Heat demand profiling

We converted the heat demands for each of the zones into hourly demand profiles. The annual heat demand for each building was distributed across the 8,760 hours in a year[70] according to typical 24-hour heating and hot water profiles for the building types. We also made adjustments to metered data by using degree days so that profiles represent 'typical' weather patterns. These individual building energy profiles were then aggregated to produce total energy load profiles for the heat networks within each zone.

There were various uncertainties regarding each of the seven zones. This includes the delivery approaches to take zones forward, timelines for development, the extent of a potential network, availability of major heat sources via a spinal route (see section 10), lack of more granular heat demand data, and multiple other factors. Further, the limited scope and time available for this study placed several limitations on our analysis.

Due to these uncertainties as well as scope limitations, we decided to focus this feasibility review only on anchor loads within these zones. It is important to note that there is significantly more heat demand than just the anchor loads present within most of these zones. When we consider the demand from the infill (e.g. properties between anchor loads) the economic case potentially becomes stronger[71], although, these buildings will have a lower heat demand than those of the anchor loads. Therefore, our review presents a conservative estimate of the economic viability of these zones.

We would expect a detailed feasibility to consider the heat demand from all loads and in doing so arrive at a more attractive investment case (all other things being equal)[72].

Examples of heat profiles using the zones with the greatest and smallest anchor load heat demand are shown in Figure 39 and Figure 40, respectively. For the remaining profiles see section 12.1.

[70] Ignoring leap years.

[71] Since the pipe is already passing these buildings, the cost of acquiring these additional loads is reduced significantly.

[72] There are several other aspects which could also positively impact feasibility but could not be included due to scope limitations. These are discussed later in this chapter as well as in relation to discussions on spinal routes (section 10.1 and 10.2) and delivery strategy (section 11.2 and 11.3).

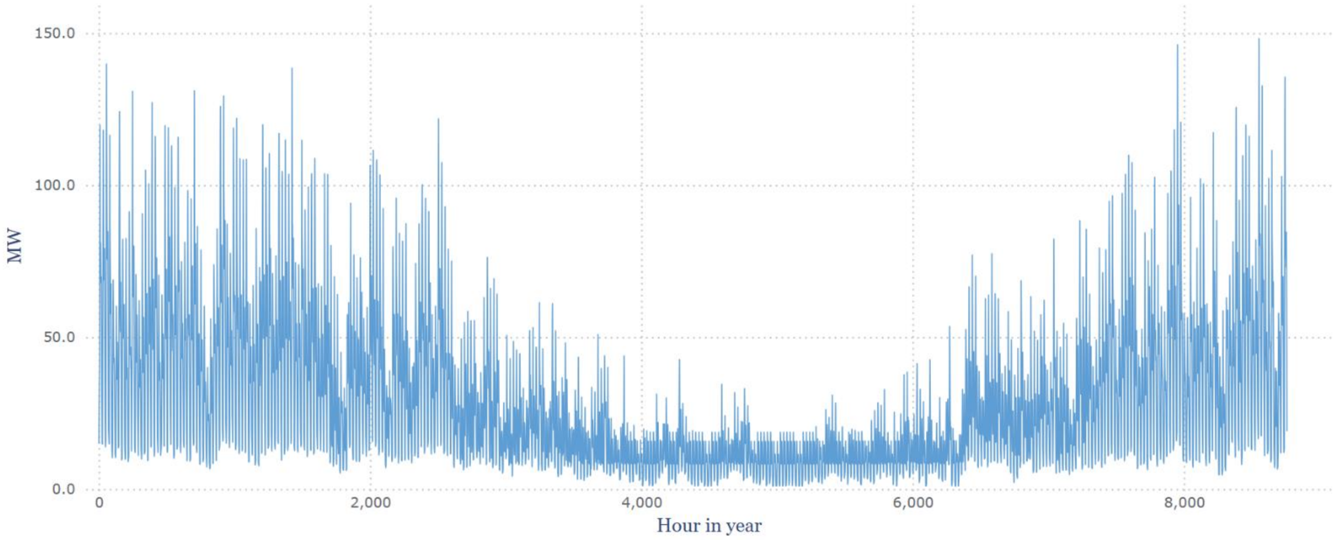



*Figure 39: Anchor load annual heat load profile for the largest zone, Zone 2 – Central Edinburgh South.*

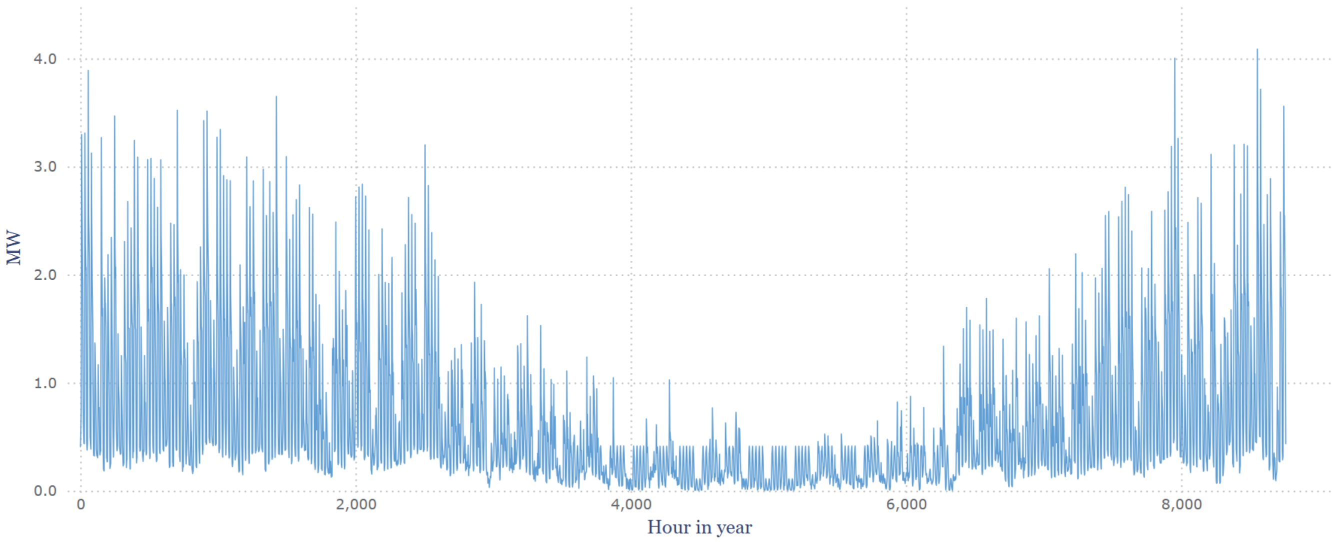



*Figure 40: Anchor load annual heat load profile for the smallest zone, Zone 7 – Colinton.*

The annual heat load for each zone is a key input to the economic analysis.

### 9.1.3 Energy centre configuration and modelling

Due to the strategic nature of this study, we have used a consistent approach to the energy centre configuration to allow for comparisons across zones. This theoretical approach is heat pump-based, as the majority of identified secondary heat sources are low grade (less than 100°C). Therefore, they will need to have their temperature boosted via heat pumps. This configuration also means that other heat source types can be included at a later stage, providing flexibility if/when new heat sources become available.

Where high grade secondary heat sources are available, such as from EfW, this will not need to run through a heat pump. Backup / peaking plant of natural gas boilers have been assumed; however, these could be switched out for lower carbon solutions (electric or biogas) in the future.

The basic configuration of energy centre primary plant we have assumed is shown below in Figure 41. Water source heat pumps (WSHP) convert low temperature heat from secondary heat sources to high temperature for the heat network. Additional low carbon heat capacity would be supplied by air source heat pumps (ASHP) taking heat from the surrounding air to supply the WSHP; the ASHP heat would be the lowest priority of the low carbon sources, allowing for the other heat sources to take precedence. Conventional mains gas fuelled boilers are assumed to provide back-up and top-up capacity for short periods when heat demands exceed the capacity of the low carbon heat sources (as an interim position until the use of mains gas is discontinued).

This configuration only uses secondary heat sources (where available within the zone) for energy centres and does not utilise any primary heat sources identified in section 7.2. While we consider primary heat sources to be more strategically important than secondary heat sources[73], a significant amount of information regarding primary sources is currently unavailable. The most important of this is the potential price of heat, but also potential heat supply available, timeframes, and configuration of the spinal route which would deliver this heat. We are also limited by the scope of this work which did not allow for analysis of these primary sources to determine price of heat or further information.

Due to these reasons, configurations and heat sources we have used are based on a theoretical set-up of locally-led heat supply. This utilises all secondary heat sources available and makes up the missing heat supply with ASHPs to provide a conservative estimate (worst-case scenario) of the economic indicators.

We recognise this as a gap which needs to be refined with further analysis. Heat sources should be confirmed, placing the primary heat sources available via a spinal route first to provide the bulk of the heat covering at least the baseload. This should then be supplemented with low-cost local heat sources where advantageous, using ASHP only where necessary and feasible.

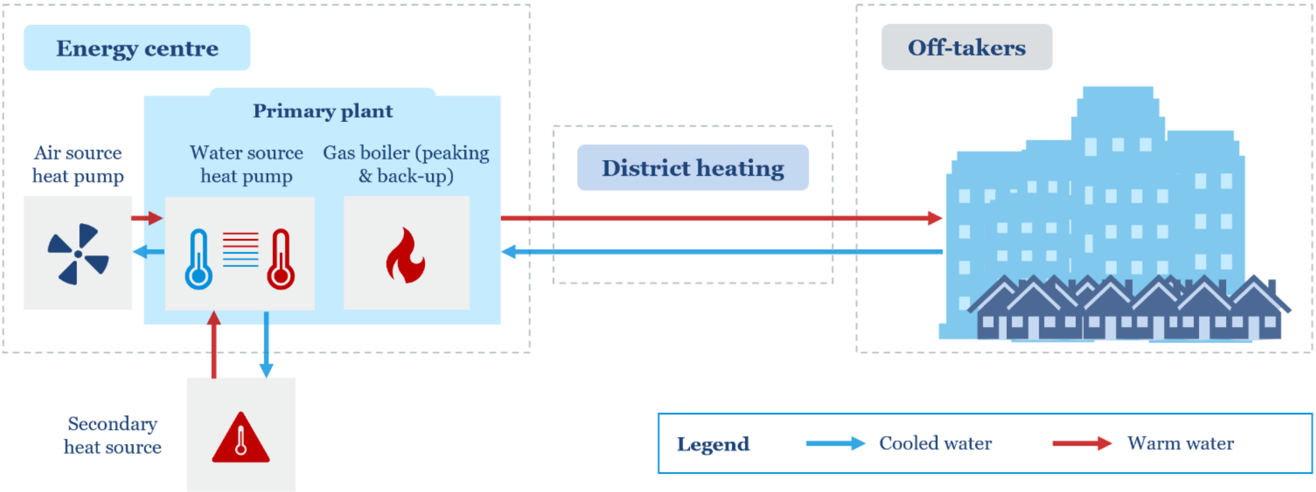



*Figure 41: Configuration of energy centre plant used for modelling purposes. This does not consider primary heat sources and spinal route connection due to study limitations; a spinal connection would result in displacing or potentially eliminating the need for any heat generating equipment at this point in the network. This means reduced or no ASHPs and no water source heat pump where secondary heat sources are not present. Instead of an energy centre, it would act as a 'heat substation' with pumps and controls to convert the spinal route's water pressure and temperature to provide most or all of the heat. This heat substation could also host a back-up or resilience plant in the event of an outage, or simply have a recovery point where a temporary heating plant could be connected when needed. The introduction of a spinal connection could also see other configurations, which should be investigated at a detailed feasibility stage.*

We have sized the total installed heat pump capacity based on 1,500 full capacity run hours of the heat profile for each network. This results in around 90% of the total heat generation by heat pumps (and secondary heat sources where available).

The primary plant sizing exercise allows the energy centre facility gross internal area (GIA) to be estimated. Energy centre costs have thus been estimated using a simplified cost per $m^2$ GIA for the building, and cost per kW capacity for the plant. These costs are used in the economic analysis.

We used energy modelling to predict how much of the annual heat load is met by each of the heat sources in each energy centre. The modelling assumes heat sources would be used in the following priority order:

- Secondary heat sources: waste or lowest cost source of low carbon heat[74]

[73] This is largely due to the fact that secondary heat sources identified cannot by themselves supply all of the anchor load heat demand within most of the zones, let alone heat demand of the entire zone. Even meeting anchor load demand would require a significant amount of additional heat from large banks of ASHPs which are unlikely to be viable or practical in most zones. On the other hand, the primary heat sources we have proposed could potentially provide the base load (majority or all) of the heat demand for all zones.

[74] As discussed in 7.1.3, primary heat sources should be used first in detailed feasibility analysis; however, we were unable to consider these at this stage due to study limitations.

- Air source heat pumps
- Any residual anchor load heat demand is assumed to be met by gas boilers as the 'peaking plant'.

We targeted the modelling to achieve 80-90% of heat supply by low carbon plant; increasing this to over 90% is often detrimental to the economic performance. This is demonstrated in Figure 42 and Figure 43.

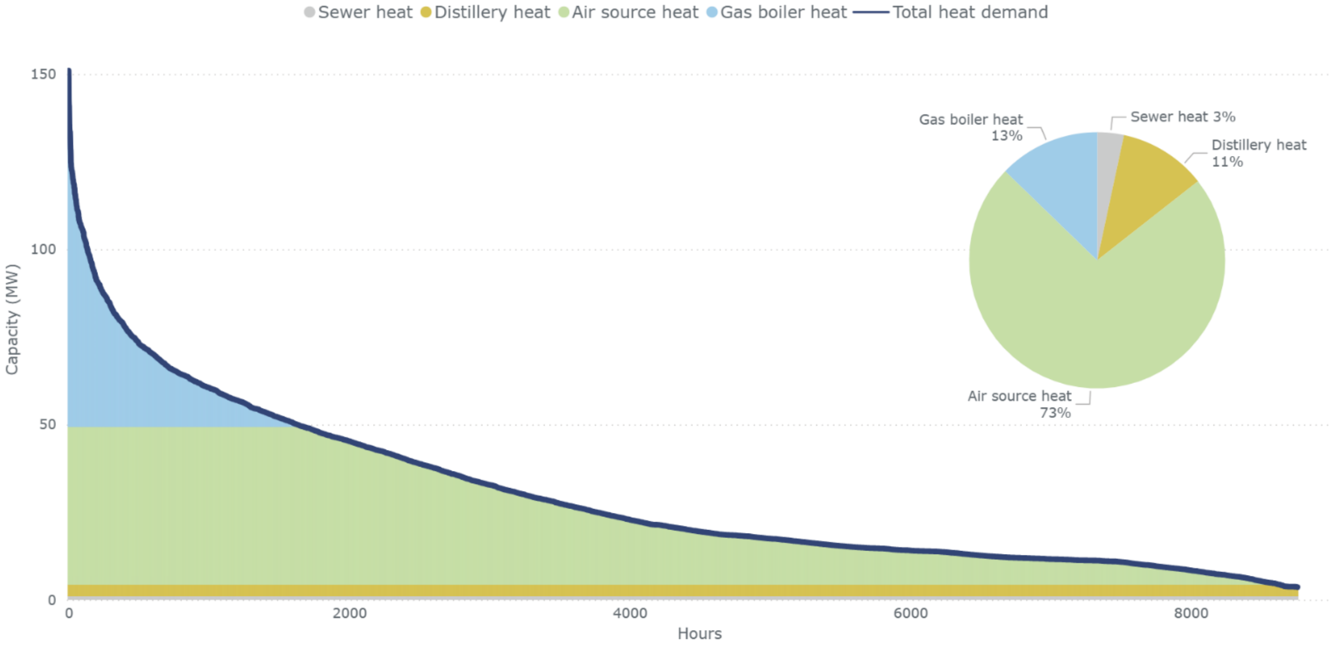



*Figure 42: Load duration curve for Zone 2 – Central Edinburgh South. This displays the capacity deployed across all hours of the year, ordered by demand magnitude (highest demand hour to the lowest demand hour). Gas boilers are modelled only for the most demand-intensive times to provide peaking capacity, whereas sewer source and distillery heat (secondary heat sources) are always preferred hence are at the bottom of the chart. In the absence of figures on primary heat sources and spinal route, for now we have modelled ASHPs to fill the delta to the ~90% renewable heat target. Inset: pie chart demonstrating the supply in MWh across the full year for each source, 87% for this zone.*

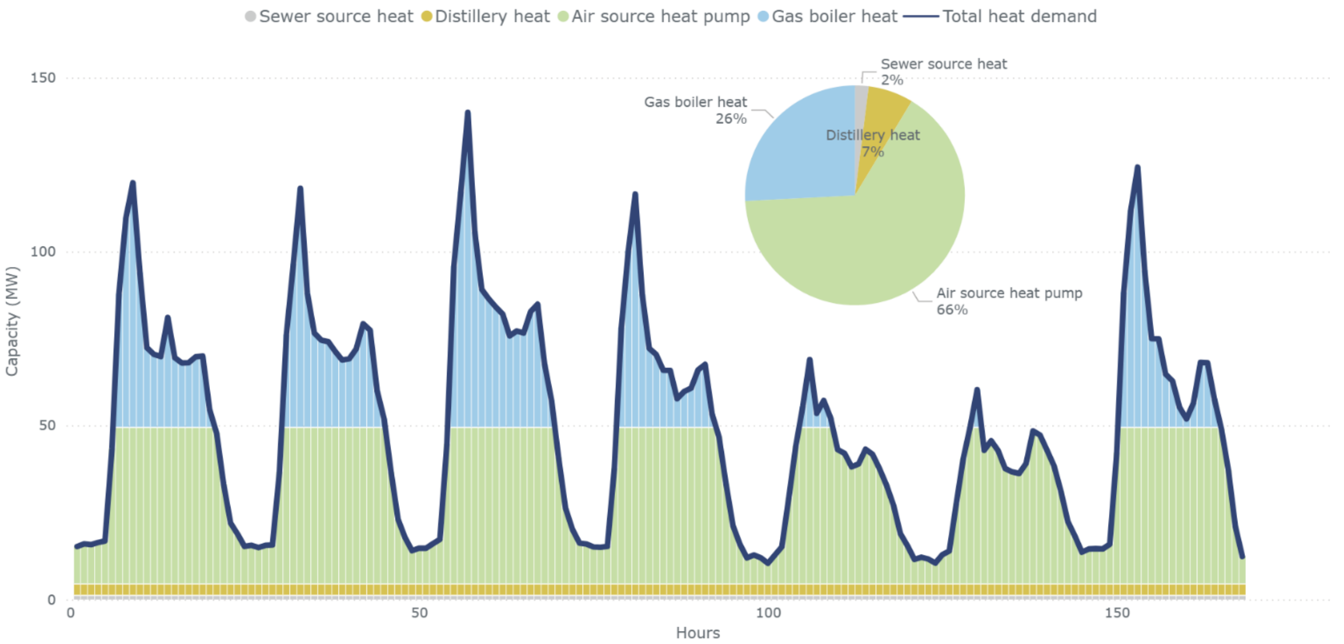



*Figure 43: This figure provides a typical winter week profile for Zone 2 – Central Edinburgh South. This illustrates the dynamic modulation of heat sources to meet the fluctuating heat demand using the most desirable sources and achieve the desired balance of cost effectiveness and carbon savings.*

Further modelling, including heat load phasing across the zone, thermal storage and plant optimisation must be undertaken at the detailed feasibility stage.

This configuration also enables the local networks to be initiated in the short-medium term utilising local secondary heat sources, whilst the spinal network is developed in parallel bringing the potentially lower cost bulk heat supply from primary heat sources (this is discussed further in section 11).

In reality, the local networks would develop more organically than modelled here, with the installation being phased. This means that it would likely not be realistic to install the full capacity of heat pump required from day one, but rather a gradual build out over time. This would also allow the developer and the Council to better plan the use of heat sources in a strategic manner. Depending on the timing, zone location and circumstances, this could even mean relying on heat from a spinal network without the need to develop most or any local generation we have modelled. The energy centre could be mostly dependent on spinal heat whilst using whatever comparably priced local secondary sources that are available (e.g. if waste heat sources are comparable in price and there is a business case to use them alongside the spinal heat).

On the other hand, there may be a case to maximise secondary heat sources for a zonal network, and also potentially install ASHPs in phases. There may be multiple reasons for this:

- Despite drawing most of their heat supply from the spine, a zonal developer may require back-up or support to safeguard against a scenario where heat from the spine becomes unavailable or falls short.
- If a local network is beginning development well in advance of the spine becoming available, it will need a local heat supply. This is the case for the Granton Waterfront heat network which is beginning development using sewer source heat. There is a need to progress without the spine as it could be many years until it reaches Granton. For zones in such a circumstance, some level of ASHPs could play a key role by allowing developers to slowly continue expansion whilst the spinal route is being developed, which can then allow full expansion through cheap heat delivered at scale. Since ASHPs are relatively cheaper and can be added as modules, these may be installed progressively as required/afforded by the growing network, and we assume that none of the major zones will install the level of ASHPs we have used for our modelling. And any ASHP equipment already installed at the local level could act as backup / support after a spinal connection.
- For some zones (e.g. *Zone 10 – Heriot-Watt University*) the investment case for a spinal connection is unclear.

In addition to challenges on the price of heat, there are also other concerns around the practicality of using ASHP arrays at scale from the standpoint of space availability, grid capacity, planning and other factors. These are discussed in section 10.1.

### 9.1.4 Network routing

#### 9.1.4.1 Route development

We carried out an engineer-led assessment of routes and obstacle identification to optimise practical routes. Initial anchor network routing was carried out using a Steiner tree algorithm, which identifies the shortest distance to route to all the desired building connections. Experienced heat network engineers then reviewed this in detail, making manual adjustments to avoid major constraints where possible. This includes avoiding multiple rail lines, tram crossings, areas of historical sensitivity, or areas of existing utility congestion.

We also carried out a desk-based survey of existing buried utilities, with areas of constraints highlighted to the Council.

An example of the anchor network routing is presented in Figure 44.

A detailed heat network route review must be carried out at detailed feasibility stage for each zone[75]. Analysis should be carried out to develop a 'day one' network along with phasing of the expansion along a timeline which considers practicality, heat supply availability, anchor off-takers ready to connect and multiple other factors.

#### 9.1.4.2 Heat network sizing

We carried out network hydraulic modelling using specialist software. The main purpose of this modelling is to provide a pipe size schedule for the delivery of heat to each of the identified buildings.

[75] Technical constraints such as flow/return temperatures, pressure ratings, elevation differences, and other factors may affect the feasibility of connecting to a heat network and thus the network route.

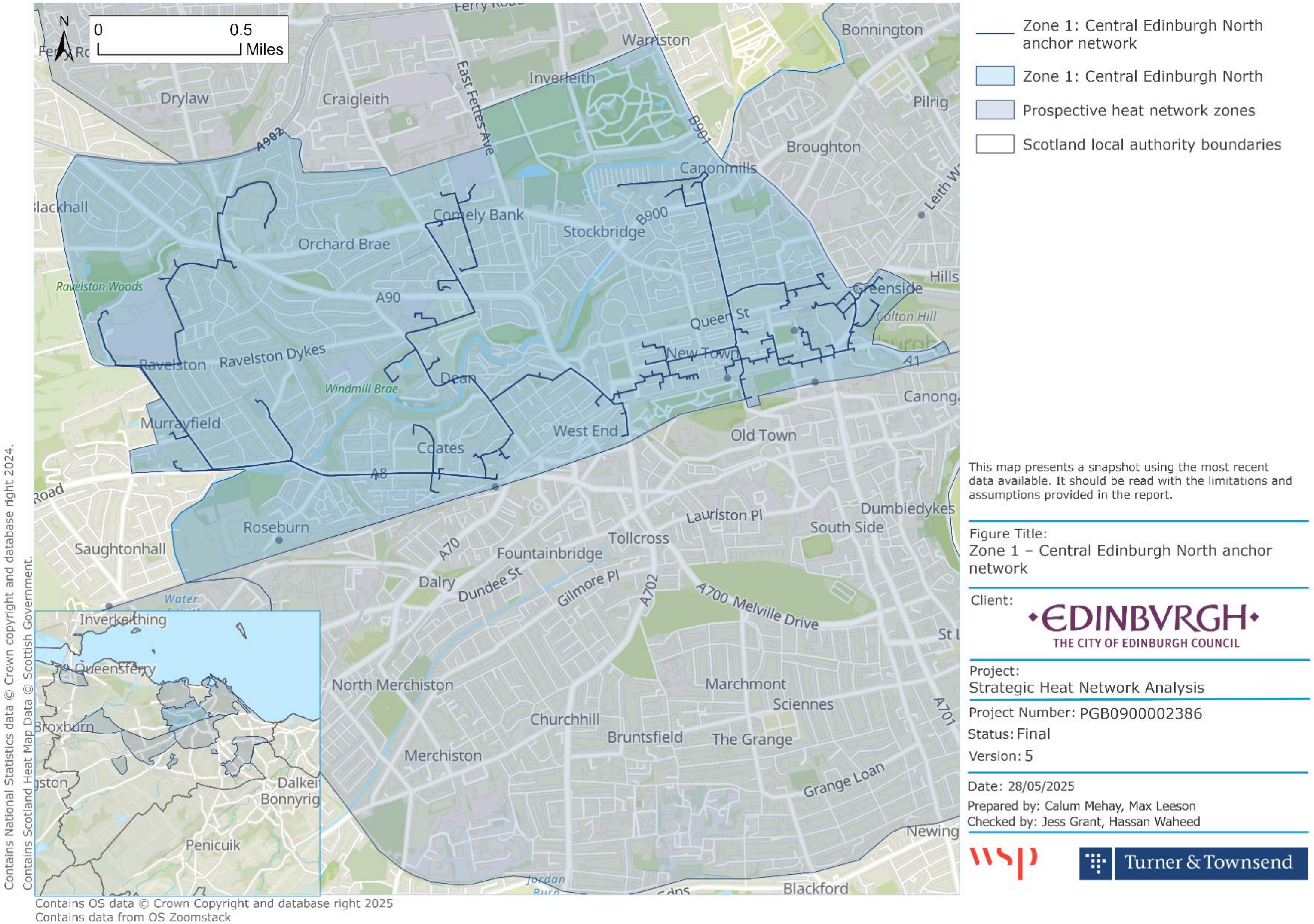
The main input to the hydraulic modelling is the buildings heat load schedule. The software calculates the pressure loss in Pascals per metre (Pa/m) for each pipe in the network based on the flow rate that is determined by the building heat load, selecting the smallest pipe size that does not exceed a maximum pressure loss of 250 Pa/m. We carried out the pipe sizing based on an assumed differential between network flow and return temperatures of 20ºC.

We defined diversity curves for heat loads in accordance with CIBSE CP1 Code of Practice and applied these at each branch in the network to determine optimum pipe sizes. The diversity of an individual pipe factors down the required flow in that pipe for the calculation, accounting for the fact that not all loads will require their peak heat demand at the same time. This application of diversity factors therefore ensures pipes are not oversized.

Full pipe schedules for each zone have been provided to the Council.

Pipe size schedules have been used to estimate the capital cost of installing the heat networks using schedules of £/m rates obtained from industry sources.

*Figure 44: Example of a zonal anchor heat network routing; Zone 1 – Central Edinburgh North.*



### 9.1.5 Economic analysis

#### 9.1.5.1 Approach

For the economic analysis carried out as part of this feasibility review, we considered the cost of generation only and did not analyse revenues. There is also no phasing included, with the networks being modelled as a full 'day one' network with all identified loads connected. Further assessment on revenues and phasing would be carried out during a detailed techno-economic feasibility study for each of the zones. All pricing is in nominal terms, i.e. does not include inflation. The basis for modelling is shown in Table 11.

| Parameter | Value used | Notes |
|---|---|---|
| Model Length | 40 years | |
| Model Start Year | 2025 | First year of CAPEX spend |
| Project Discount Rate | 3.5% | As per HM Treasury Green Book |

*Table 11: Basic economic modelling parameters.*

The model is based on two scenarios: one with no grant funding at this stage and the other with 50% grant funding for the CAPEX.

#### 9.1.5.2 Costs

##### 9.1.5.2.1 Capital & replacement costs

We evaluated the capital costs for each zone using a combination of previous contractor project costs and budget estimates. The capital costs include the following:

- Energy Centre & Plant
- Buried Pipework
- Building substations

##### 9.1.5.2.2 Maintenance costs

We modelled the maintenance costs as a percentage of the initial capital cost based on the anticipated equipment lifecycle for relevant terms.

##### 9.1.5.2.3 Fuel costs

The Council provided us with fuel costs, and these have been indexed to HM Treasury Green Book Supplementary Guidance utility price projections. For heat abstraction from the WWTW or sewers, Scottish Water Horizons has indicated that a fee of 0.5 p/kWh of heat abstracted would be charged (at current values).

We took the cost of heat from the Millerhill Recycling and Energy Recovery Centre (EfW plant) from a report produced in 2023 on the feasibility of connecting the expanding BioQuarter development to the Millerhill plant. The figure being used is 6 p/kWh heat, provided by Vattenfall.

#### 9.1.5.3 Levelised cost of heat

We carried out a levelised cost of heat (LCOH) assessment. LCOH is a metric used to assess and compare alternative methods of energy production. The LCOH provides the average total cost of building and operating the generation asset and associated infrastructure per kWh of heat generated over its lifetime. In the case of this study, the lifetime is assumed at 40 years.

$$LCOH\left(\frac{p}{kWh}\right) = \frac{Lifetime\ discounted\ cost\ of\ heat\ generation}{Lifetime\ discounted\ heat\ generation}$$

Whilst LCOH does not consider any revenues generated, it can be thought of as the average price at which the heat generated must be sold in order to offset the total cost of production over its lifetime.

Note that whilst these are shown in a p/kWh metric, it does not mean this is the variable rate at which heat should be charged. To offset this, all revenue charges should be considered as part of a detailed feasibility, such as connection charges, standing charges, and the variable charge.

## 9.2 Feasibility review outputs

Table 12 summarises the results from the analysis across all seven zones covered based on our theoretical ASHP-based zone assumptions, and not including potentially cheaper substitute heat from a spinal route. Recognising the availability and importance of grant funding via the HNSU, we have also included the LCOH of heat networks with 50% grant funding (the current maximum proportion of capital funding available via Scotland's Heat Network Fund).

| Zone number and name | Heat Demand (inc. losses) (MWh/year) | Linear Heat Density (kWh/m/year) | CAPEX (£m) | LCOH (p/kWh) | LCOH (p/kWh) *with 50% grant funding* |
|---|---|---|---|---|---|
| Zone 1 – Central Edinburgh North | 129,331 | 6,173 | £252m | 16.7 | 12.3 |
| Zone 2 – Central Edinburgh South | 260,868 | 8,841 | £394m | 14.6 | 11.1 |
| Zone 4 – Northeast Edinburgh | 84,246 | 3,333 | £238m | 19.6 | 13.2 |
| Zone 5 – Southeast Edinburgh | 195,855 | 10,884 | £267m | 13.3 | 10.2 |
| Zone 7 – Colinton | 5,928 | 2,757 | £17m | 21.3 | 14.6 |
| Zone 8 – Southwest Edinburgh | 140,056 | 4,892 | £299m | 17.6 | 12.8 |
| Zone 11 – Queensferry | 7,514 | 2,406 | £23m | 20.8 | 13.8 |
| **Total** | **823,798** | ***5,612 (average)*** | **£1,490m** | **N/A** | **N/A** |
| Individual ASHP counterfactual | 748,908 (no losses) | N/A | £1,334m | 15.6 | N/A |

*Table 12: Feasibility review summary results. This provides a summary of key economic indicators for the seven zones analysed. We also provide an individual building-level ASHP counterfactual.*

The capital cost breakdown for each zone is shown in Figure 45.


*Figure 45: CAPEX breakdowns of equipment for all zones (bar chart), and the CAPEX breakdowns for all seven zones in aggregate (inset donut chart). See appendix section 12.2 for figures on breakdowns of equipment per zone in a tabular format.*

For comparison, we have calculated the LCOH for building-level ASHPs to provide a counterfactual low carbon heat case. This gives a LCOH of 15.6 p/kWh[76]. Without grant funding, multiple zones are cost-competitive or within reasonable margin of the counterfactual while others are costlier. With grant funding applied, all zones become more cost effective than building-level ASHPs. Although, the grant funding may not be able to support all zones with the 50% funding we have modelled as an indication. In the current parliamentary term, the Heat Network Fund has a £300m budget for Scotland, thus the intervention rate might be lower. Furthermore, individual ASHPs for some public sector anchor loads might also attract central government subsidies, making comparison in these cases unclear.

There are other uncertainties which also prevent us from making a like-for-like comparison. For example, our costs do not account for grid upgrade requirements, which are likely to add substantially more costs to the building-level ASHPs counterfactual than heat network energy centres (based on discussions with SPEN).

Despite uncertainties, the comparison against the counterfactual is a positive early indicator given the modelled heat source for most zones is likely costlier than what could potentially be achieved with heat from primary sources supplied via a spinal route[77].

The total CAPEX figure across the city is approximately £1.5 billion. As a substantial zone, the CAPEX for a full anchor network in *Zone 3 – Northwest Edinburgh* (which we did not review) may fall in a similar range to zones 1, 4 and 5; they are similar in area, and have similar anchor load heat demands and total heat demands[78]. Additionally, *Zone 6 – King's Buildings*, *Zone 9 – West Edinburgh*, and *Zone 10 – Heriot-Watt University* (which we did not review) would potentially require investments in the same range as for the two smaller zones we reviewed (7 and 11). Including the zones we did not review, the zonal level investments to develop anchor networks based on secondary heat sources and ASHP exceed £1.5bn. We consider this to be in the appropriate region of what can be considered as a 'utility scale'.

Additionally, it is important to note that these figures are only accounting for anchor loads. Some zones have an overall heat demand which is several times greater than the anchor load heat demand, and further investments would be required to enable connection with other loads. We explore this in more detail in relation to the spinal route in Table 12. Therefore, the £1.5bn figure would further increase accordingly, as would the potential revenue stream.

The most significant proportions of the CAPEX are the distribution network and the energy generation plant. However, the CAPEX is based on theoretically self-sufficient zonal networks, some of which draw heavily on an unpractical level of ASHPs. In reality, an amount of this capital would be more efficiently focused on developing primary heat sources and a spinal route to supply heat to the zonal networks. This would reduce the potential CAPEX which we have modelled in positive covariance with increasing reliance on the spinal route.

In the extreme case, a zonal network which relies almost entirely or fully on the spinal route for its heat may have substantially lower energy centre and associated costs as it would function mainly as a pumping station[79]. Distribution network costs would become the primary expenditure, with other equipment costs significantly reduced.

Further, the CAPEX is based on a full anchor network build out on 'day one' which is unlikely for any of the zones. A phased approach to both the distribution network as well as energy centre capacity would be a more credible investment plan.

The zones present varying levels of indicative LCOH; we make the following observations on the outliers:

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[76] Note this is very high level and has been averaged across the zones. There are other challenges with standalone ASHPs for many of the buildings within Edinburgh, particularly in the city centre and the Old Town, where locating large ASHPs on historic buildings will be impractical. These limitations and the practical case for heat networks is discussed in section 11.

[77] Several gaps need to be addressed for a true comparison. Individual ASHP costs would have to factor significant additional grid upgrade costs, added costs/complexities of installations in conservation areas and on listed status buildings, ASHP efficiency losses for higher temperature systems or capital costs associated with building upgrades and distribution systems. Similarly, heat network development costs would have to factor the cost of developing primary heat sources and spinal route. This is further complicated by the fact that it is still not a straightforward comparison since the cost of individual ASHPs is a capital investment by a building operator and heat network CAPEX translates into the business model of the operator and indirectly translates into the price of heat. Detailed feasibilities for zonal networks would consider these factors to provide a like-for-like counterfactual on CAPEX and OPEX basis relevant to building operators.

[78] This is purely speculative and would need a feasibility review to clarify. There are differences such as the lower proportion of built heritage and unique heat demand density which could impact the outcome.

[79] There may still be back-up/resilience and peaking plant costs, but these would be substantially lower than the current modelled costs.

- *Zone 7 – Colinton* and *Zone 11 – Queensferry* have a smaller number of anchor loads each, which results in the highest LCOH. This does not mean that they should be ruled out. Identification of additional buildings (smaller than the anchor load threshold of 500 MWh/year used) might improve the economic case.
- Whilst *Zone 4 – Northeast Edinburgh* may not have performed well in terms of LCOH, we know this zone has substantial dense heat demand which does not meet the anchor load threshold[80]. Considering these buildings at full feasibility has the potential to shift the LCOH to a more attractive figure. Further, this zone also has the highest availability of secondary heat sources within Edinburgh and access to a primary heat source.
- The lowest LCOH is for *Zone 5 – Southeast Edinburgh*. This is due to the combination of the high heat density of the zone and major anchor loads such as The Royal Infirmary of Edinburgh. This is expected to improve once the BioQuarter development is fully built out. This zone is also proximate to the Millerhill EfW plant.
- This is followed closely by *Zone 2 – Central Edinburgh South*, which has the highest heat demand in Edinburgh. However, it may also be one of the most challenging to route a heat network through from a practical perspective, given the densely packed built environment, utilities' congestion, and heritage status of buildings.

There is a shortfall of over 50% of the secondary heat source supply for *Zone 1 – Central Edinburgh North*, *Zone 2 – Central Edinburgh South*, and *Zone 8 – Southwest Edinburgh*, with zone 8 having only 6% available from local secondary heat sources[81]. Additionally, Zone 5 – Southeast Edinburgh has an approximately 30% shortfall of secondary heat source supply. These zones are among the most reliant on ASHPs in our modelling, and we expect *Zone 3 – Northwest Edinburgh* (which we did not review) to also face a significant shortfall given the dearth of secondary heat sources.

These zones could benefit the most from a spinal route, however, the installation of some capacity of ASHPs may supplement an initial build out of the local network. Shortfalls across zones reviewed are provided in Table 13.

## 9.3 Conclusions on feasibility review of zones

Our feasibility review provides a strong indication for the viability and further investigation of heat networks in all zones. Despite study limitations preventing us from including the spinal route and primary heat sources, the zones demonstrate potential to warrant further study. With the addition of grant funding, zones become more competitive than an individual building-level ASHP counterfactual.

Furthermore, our analysis was limited to a high-level review of all anchor loads in each zone. We consider a more robust approach would entail a detailed investigation on the most promising starter networks with a substantially lower LCOH and higher rate of return. Thereafter, network expansion planning should phase the development according to the most economical way to scale to a zonal level, bringing in the lowest cost heat sources, building momentum and capturing economies of scale. It is also possible that it may not be economically viable to connect some pockets of loads within zones, but these would have been included in the analysis.

While a high-level analysis of a whole zone provides an indication of investment scale (Figure 46) and a possible long-term vision, it also dilutes the immediate investment potential of the most promising opportunities within the zones. We recommend the Council and stakeholders take these outputs as an indication of the scale and order of magnitude to inform strategies, but to refrain from utilising them where more robust data sources should inform decision-making.

[80] The anchor load heat demand is 76,588 MWh/year whereas the total heat demand of all loads is 10.4x at 798,839 MWh/year. This is considerably different from all other major zones (see Table 13).

[81] This is the lowest percentage of heat available locally from secondary heat sources among all zones covered under the feasibility review.

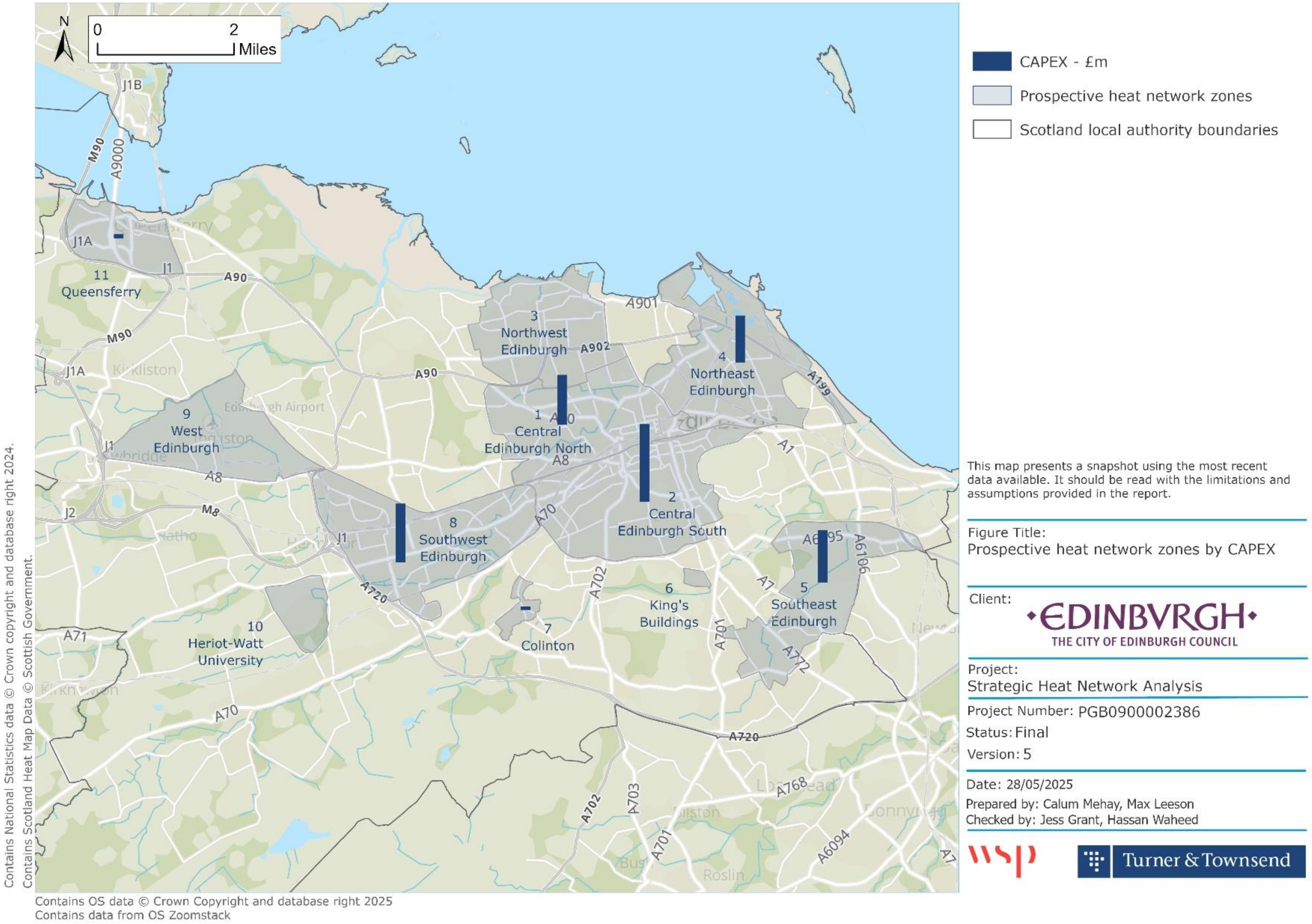



*Figure 46: Estimated investment scale across the seven zones studied.*

# 10. Spinal routing

*The fourth objective of this study was an investigation into the potential for a spinal route or transmission pipeline to bring bulk heat from low carbon sources to supply zonal networks. This could include heat from the peripheries of the city or other local authorities. It has become clear that Edinburgh's heat demand far exceeds what is available from local heat sources. Therefore, we have carried out high-level analysis to give an indication of whether it might be feasible to transport heat from further afield into the zones, and whether that heat could be economically attractive.*

## 10.1 The rationale for a spinal route

As there are limited heat sources compared to the required demand within the zones, much of the low carbon supply for multiple zonal heat networks is currently modelled to be met by ASHPs (discussed in 9.1.3). Whilst ASHPs are an attractive low carbon technology in many cases, the scale required comes with challenges in Edinburgh's context. This includes finding open space for large arrays of ASHPs within the city.

For example, secondary heat sources available in and around *Zone 2 – Central South Edinburgh*[82] can only meet 14% of the anchor load peak heat demand of 151 MW for the zone. Further, this 14% estimate would be dwarfed if we also factor in large numbers of smaller loads viable for connection. For comparison, the annual anchor load heat demand within this zone is 237 GWh and the total annual heat demand for all loads in the zone is 3.8x at approximately 909 GWh.

For now, our feasibility review is limited by only considering anchor loads and we have made a theoretical assumption of a 45 MW air source heat pump to help increase the renewable heating plant's anchor load peak coverage from 14% to 87%[83] (with remaining to be met by gas boiler peaking plant).

To achieve this, there would be a need for 7,716 m$^2$ for an energy centre and 4,208 m$^2$ for ASHPs, totalling almost 12,000 m$^2$ within the Old Town area of Edinburgh. This equates to approximately 46 tennis courts' worth of area with major heat generating equipment which would potentially also produce major cold plumes and substantial noise. Scaling this up to the demand for all viable loads would increase these requirements substantially. This is a major practical barrier owing to the cost and availability of land in the area and likely opposition to industrial operations within central Edinburgh.

This would also mean major electricity grid infrastructure upgrades to enable energy centre operations and significant regulatory and health and safety burden on a plant of this size and nature. The site would also have to contend with other risks which come with developments within central Edinburgh (access, archaeological heritage and subsurface structures, conservation areas, etc.).

Even if operations of this scale were approved, the land acquired, the necessary permissions granted and buy-in from the community secured, the factors mentioned could add substantial cost to the development beyond what we have modelled[84]. Ignoring all other factors, this approach would hamper the feasibility of the heat network from a core economic perspective. ASHPs can and should be utilised wherever viable, but sole reliance on them is unviable for the most heat demanding central zones.

This raises important questions about the ability to expand these networks to their maximum viable extent, beyond what secondary sources and a credible capacity of ASHPs alone can support. Table 13 provides a summary of this challenge across zones.

| Zone number and name | Total anchor load heat demand (MWh/year) | % anchor load demand covered by secondary heat sources (exc. ASHP) | Total demand for all loads as multiple of anchor load demand |
|---|---|---|---|
| Zone 1 – Central Edinburgh North | 117,573 | 34% | 4.9x |

[82] 1 MW of sewer heat which could be abstracted, and 3.3 MW optimistically assumed from the North British Distillery, although this needs to be qualified.

[83] As discussed in 9.1.3 we have targeted low carbon plan to meet 80%-90% of anchor load peak demand to avoid detriment to the economic performance. Any residual heat demand is assumed to be covered by the gas boiler 'peaking plant'.

[84] Our high-level modelled costs are indicative and based on benchmark and past contractor data. However, development costs could vary significantly across different zones based on the local environment.

| Zone number and name | Total anchor load heat demand (MWh/year) | % anchor load demand covered by secondary heat sources (exc. ASHP) | Total demand for all loads as multiple of anchor load demand |
|---|---|---|---|
| Zone 2 – Central Edinburgh South | 237,153 | 14% | 3.8x |
| Zone 4 – Northeast Edinburgh | 76,588 | 88% | 10.4x |
| Zone 5 – Southeast Edinburgh | 178,050 | 59% | 1.7x |
| Zone 7 – Colinton | 5,389 | 84% | 1.7x |
| Zone 8 – Southwest Edinburgh | 127,323 | 6% | 2.9x |
| Zone 11 – Queensferry | 6,831 | 90% | 10.2x |

*Table 13: This table shows the percentage of anchor load peak heat demand which could potentially be covered by secondary heat sources available in and around the zone (excluding ASHPs). To place the true scale of the challenge into context, the final column shows the total annual heat demand of all loads within the zone as a multiple of the anchor load heat demand. While not all buildings or anchor loads may connect to a network, this challenge remains even if a substantial amount do.*

As can be noted, *Zone 1 – Central Edinburgh North*, *Zone 2 – Central Edinburgh South*, and *Zone 8 – Southwest Edinburgh* have low or very low availability of secondary heat sources. Since these zones are also in or proximate to the city centre there would be limited scope for ASHPs. They would likely require a spinal connection to a primary heat source to make a zonal network viable. While *Zone 3 – Northwest Edinburgh* is not included in our feasibility review, we consider this to be in a similar position as zones 1, 2 and 8 since the only viable secondary heat source may be sewer source which alone is insufficient to cover a meaningful proportion of heat demand.

*Zone 4 – Northeast Edinburgh* seems to be a potential exception to the rule on the surface, given the availability of substantial volume of heat from the Seafield WWTW and the unique potential from the sewers converging toward it. In our analysis an adequate 88% of the anchor load peak heat demand can be met with secondary heat sources without the need for ASHPs (and while only using 8.5 MW of the potential 10+ MW available at Seafield WWTW).

However, this zone is unique in that it does not contain large numbers of single point anchor loads with major heat demand (above 500 MWh/year) but rather is constituted of a larger number of smaller loads densely packed together. As such, the total annual heat demand is more than ten times the heat demand of anchor loads, meaning the secondary heat sources are unlikely to be able to service the entire demand of the zone. Therefore, this zone is also in a similar position to zones 1, 2, 3 and 8 in that it needs a connection to a primary heat source to reach its full potential. However, this zone is distinguished by the presence of both a primary heat source (Port of Leith sea source heat pump) and substantial secondary heat sources to support a sizeable initial network as well as full build out. Our analysis is limited to anchor loads and a more accurate representation based on phasing and infill from all loads should be carried out as part of a detailed feasibility.

Despite the availability of potentially significant heat from the Millerhill Recycling and Energy Recovery Facility and ample sewer source heat modelled, *Zone 5 – Southeast Edinburgh* also falls short of the peak heat demand required for its anchor loads.

The nearby *Zone 6 – King's Buildings* is not covered under our feasibility review. However, from our engagement with the University of Edinburgh, we understand there are not practical options for secondary heat sources in the zone or in its vicinity. However, the intention to connect to a spine is currently unclear as it depends on multiple factors which the University would need to review as development plans become clear.

*Zone 7 – Colinton*, *Zone 9 – West Edinburgh*, *Zone 10 – Heriot-Watt University* all surround *Zone 8 – Southwest Edinburgh* and they also have an unclear case for connecting to a spine.

- Zone 7 was included within our feasibility review; it has the lowest heat demand of all zones (it is substantially low at about 9 GWh/year for all heat loads and 5.4 GWh/year for the five anchor loads which form the basis of the zone). We have modelled for this zone to be fully self-sufficient with 84% of its anchor load heat demand covered by secondary heating sources (largely sewer source and GSHP with no ASHPs), with remaining capacity in these sources to potentially cover all loads. The heat from the spine would have to be substantially cheaper, the connection costs viable, and the timelines appropriate for a spinal connection to be attractive.

- Zone 9 was not included within our analysis, but we believe the combination of secondary heat sources (a water source heat pump), renewables and battery storage available to the Edinburgh Airport makes the case for a spinal connection unclear. Its heat demand is comparable to *Zone 6 – King's Buildings* with the exception that there are potentially multiple options to meet its heat demand.
- Zone 10 was not included within our analysis. It has twice the anchor load heat demand and total heat demand compared with *Zone 7 – Colinton*. However, it is also one of the furthest in distance from the primary heat sources, requiring for a strong business case to connect to the spine with an adequately lower price of heat available than could be generated locally secondary heat sources and/or ASHP.

*Zone 11 – Queensferry* is the only one we have not considered for a connection to the spinal route. It is Considerably further from any zones and primary heat sources, with major constraints in the way to contend, as well as a very low heat demand (the anchor load heat demand is comparable to the smallest *Zone 7 – Colinton*.

Figure 47 visualises the relative amount of secondary heat sources compared with total zonal heat demands.

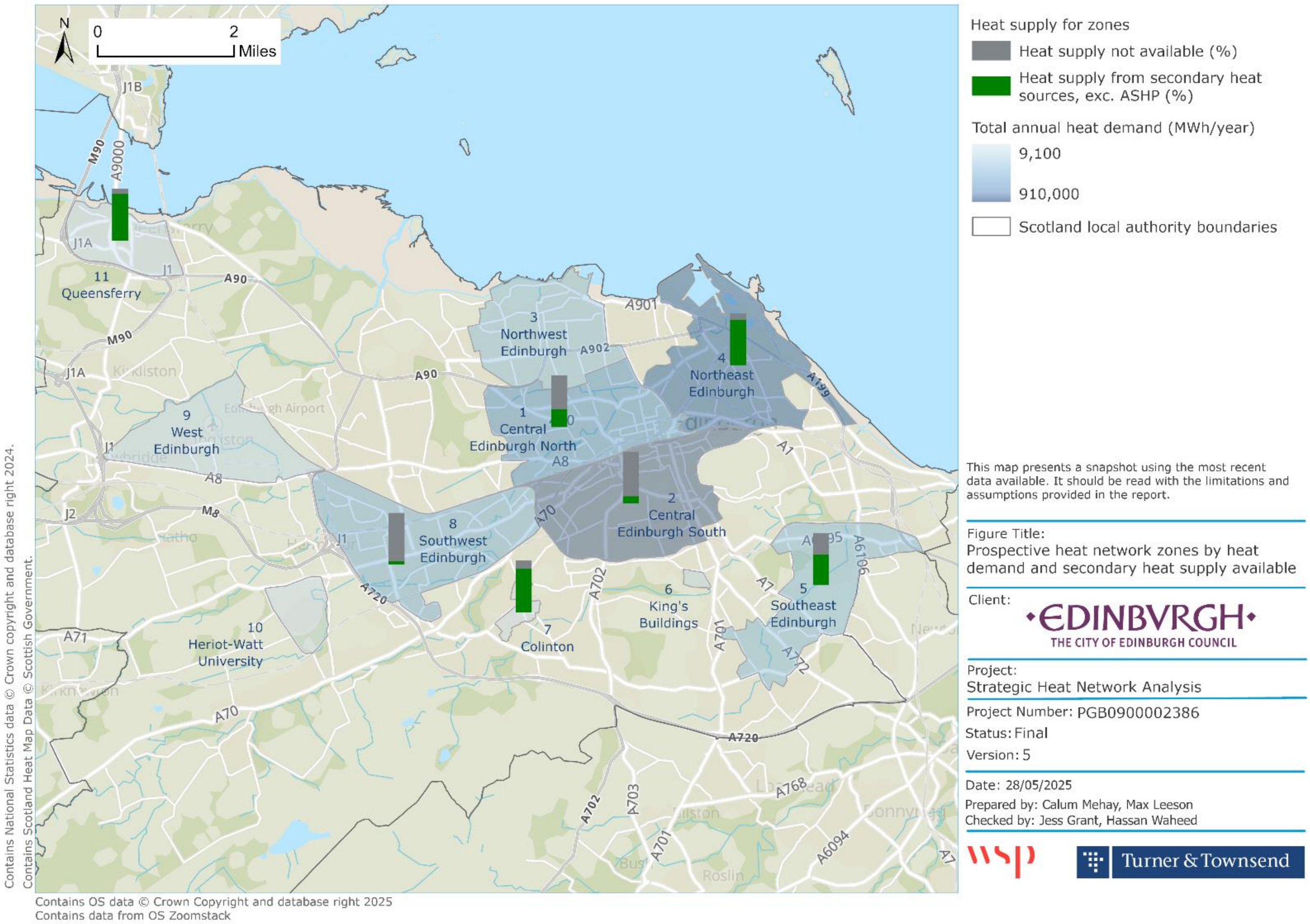



*Figure 47: A summary of the zones with their total annual heat demand and the percentage of anchor load heat demand that the secondary heat sources could cover.*

## 10.2 Primary heat sources

We consider large-scale import of low carbon heat as an immutable requirement for fully delivering a city-wide heat network. To achieve this, it is likely that the Council will need to collaborate with its neighbouring local authorities, such as East Lothian Council and Midlothian Council, to develop primary heat sources and a spinal route as a bulk heat transmission pipeline.

In section 7.2 we explored several potential benefits of generating heat on a larger scale using primary heat sources. For instance, it could be possible to negotiate low electricity prices, allowing heat to be generated at a much lower cost than if it were to be generated at a zonal level, thus creating a price margin which might support investment in the spinal route infrastructure. Economies of scale are likely to be very important, as the spinal route infrastructure will in itself be a significant capital investment. Further technologies and strategies such as the use of large-scale heat storage, connection to renewable energy sources, grid balancing services and innovations could further drive down the cost of heat delivered via the spinal route. These are discussed in relation to delivery strategy in section 11.2.

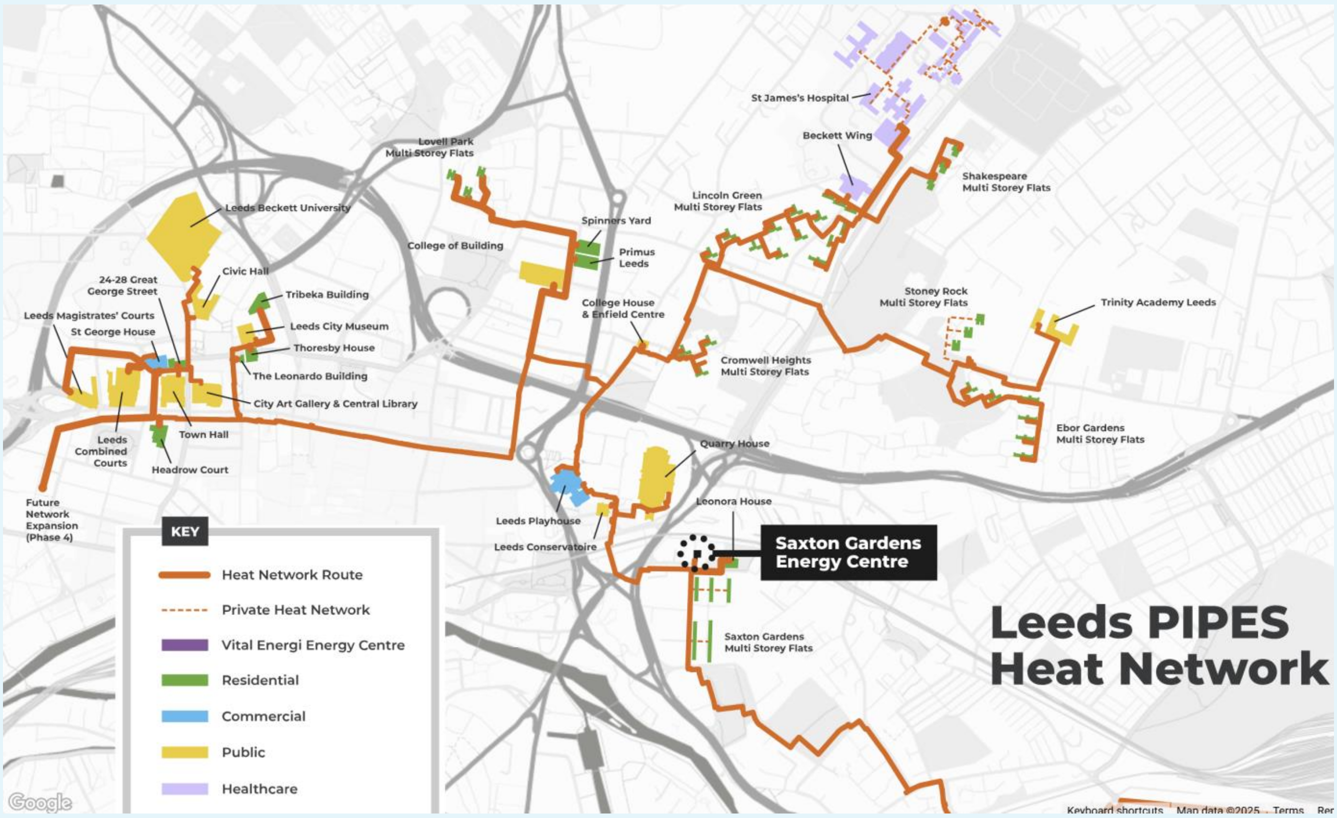
It is important to note that the scale at which we have proposed primary heat sources is achievable when compared with the available technology and existing/current developments in the UK.

### Case study: Energetik

Lee Valley Heat Network Operating Company Ltd (trading as Energetik), set up in 2015, is wholly-owned by Enfield Council. To date, it has connected 1,700 homes, a hotel, medical centres, and community spaces. Energetik has been developing major expansion projects which have seen an 8km spinal route built with a further 5km in construction and planning. This will be connected to a 60 MW energy centre (under construction and completion expected in 2026) to supply heat equivalent to demand from over 80,000 homes. Energetik is also planning to make cross-local authority connections with heat networks in Haringey and Hackney.

### Case study: Leeds PIPES[85]

Leeds PIPES is jointly owned by Leeds City Council and Vital Energi. It has connected 4,100 homes and 29 non-domestic buildings to its expansive 30km network, built within six years. Connections include university buildings, civic buildings (e.g. museum, library, courts, and playhouse), schools, several groups of multi-storey flats (including some with a small-scale heat network), and a hospital. The network has a capacity of 33 MW, of which 12 MW has currently been used.




### Case study: DIN Forsyning

While in a different context, multiple heat networks across the EU operate large-scale heat sources at magnitudes of hundreds of MW, demonstrating further scaling is technically viable. For example, DIN Forsyning is a publicly owned multi-utility company which operates heat networks in Esbjerg, Denmark, and nearby towns, supplied by diverse sources across sixteen heating plants: 282.5 MW of polluting heat sources and 338.5 MW of low-carbon heat sources. Similarly, Danish multi-utility company, Aalborg Forsyning, has commissioned four 44 MW heat pumps for a combined capacity of 177 MW for its heating plant on the northern bank of the Limfjord strait.

[85] Image source: Leeds PIPES.

We identified three primary sources as part of our heat sources audit (Figure 48).

| Source | Heat potential | Location | Key owners and stakeholders |
|---|---|---|---|
| **Port of Leith sea source heat pump** | 80+ MW | City of Edinburgh | Forth Ports and SEPA |
| **Cockenzie sea source heat pump** | 100+ MW | East Lothian | East Lothian Council and SEPA |
| **Open Loop GSHP – Monktonhall Colliery** | 20+ MW | Midlothian | Midlothian Council and Mining Redemption Authority |

*Figure 48: Primary heat sources heat profile.*

It should be noted that there are significant limitations on this analysis. We have not carried out a detailed options appraisal on these heat sources, and this section of analysis only illustrates possibilities.

Heat from the Firth of Forth in Edinburgh would be suitable for the northern zones (*Zone 1 – Central Edinburgh North*, *Zone 3 – Northwest Edinburgh*, and *Zone 4 – Northeast Edinburgh*). While the potential means more zones can be supplied, we have currently limited the supply to these three zones to avoid crossing the main railway line within the confines of the city. The potential low carbon primary heat sources identified in East Lothian and Midlothian could be sufficient to serve 90% of the anchor load demand for the zones south of the main railway (*Zone 2 – Central Edinburgh South*, *Zone 5 – Southeast Edinburgh*, and *Zone 8 – Southwest Edinburgh*). *Zone 11 – Queensferry* has been excluded from this assessment due to the smaller heat demand and the distance.

We suggest the concept of two spinal routes to be able to collect heat from all three primary heat sources, to serve all major zones, and to avoid crossing the railway line wherever possible. At this stage, this routing has not been developed through geospatial analysis, technoeconomic modelling or feasibility, but is rather based on strategic factors of the locations of heat supply and centres of demand and the major constraints between them. We consider this concept to evolve significantly over time, with possibilities of interconnection and route changes with more information becoming available from stakeholders within and outside of Edinburgh.

A block diagram of how zones could be served is shown in Figure 49.

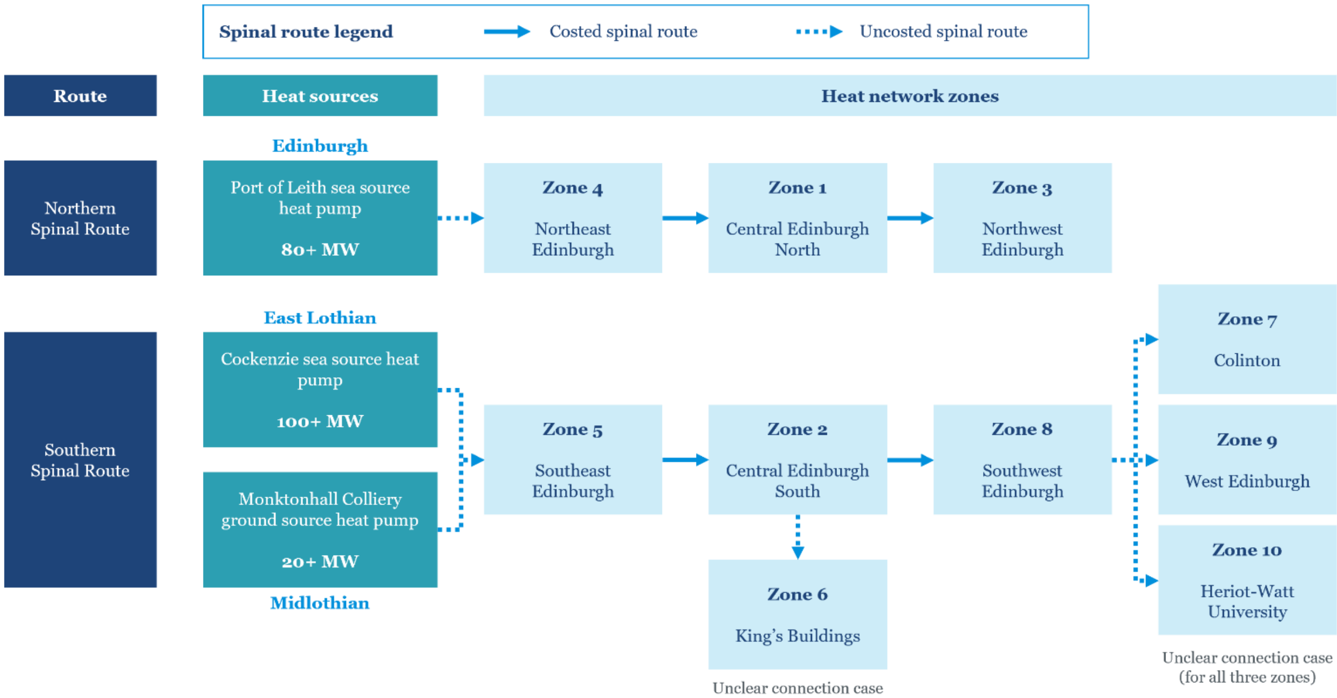



*Figure 49: Possible spinal route architecture. The initial dashed arrows (into zones 4 and 5) are uncosted because of uncertain information on primary heat sources. The dashed arrows into zones 6, 7, 9 and 10 represent the additional zones which could be served at a future date once the main spinal route is built, should the zone asset owners be receptive to a spinal connection.*

## 10.3 Hydraulic configuration

Due to the distances involved in transmission pipelines, we recommend that the spinal route is kept hydraulically separated from zonal networks (i.e. the heated water from the spine is physically separated from the zone network water by a plate heat exchanger). This is in part due to the likelihood that the spinal route would need to operate at a higher pressure than the zonal networks, up to 25 bar, due to the long transmission distances involved. There is also a potential for the spinal route to be a higher temperature (e.g. 90ºC) which could possibly aid in transfer of a greater amount of heat more efficiently. This would also potentially be required to allow for any losses and ability to maintain adequate flow temperature throughout the full length of the spine if multiple zonal networks along the route operate at up to 80-85ºC flow temperature.

Resilience is also a consideration; in the event the spinal route becomes the main source of heat serving Edinburgh, local energy centres would still be needed to act as a backup should the supply from the spinal route be disrupted. The hydraulic separation would allow for local resilience to continue providing the required heat, avoiding a large-scale heat supply concern.

Hydraulic separation could be achieved using heat exchanger substations at energy centres or strategic connection locations.

The implication of hydraulic separation is that zonal network pipes could not have a dual purpose as part of the spinal route; the zonal pipes and spinal pipes would have to be kept separate. Thus, in some instances zonal network and spinal route pipework might need to be installed in parallel if they need to cross or run in tandem at various parts of the route. Although, the outline design we have proposed in this study avoids this as much as possible.

This hydraulic separation is illustrated in Figure 50. This configuration also means that the spinal route and the local heat networks can be owned by different developers and operators. A zonal network would be a bulk supply customer for heat delivered by the spinal route.

This configuration also maintains the technology agnostic approach to heat sources. Theoretically, new primary sources, including new types of technologies, could be added to the spine if they are able to provide heat economically and reliably. This would also allow the expansion of the existing primary sources to scale up as the spinal route and zonal networks grow.

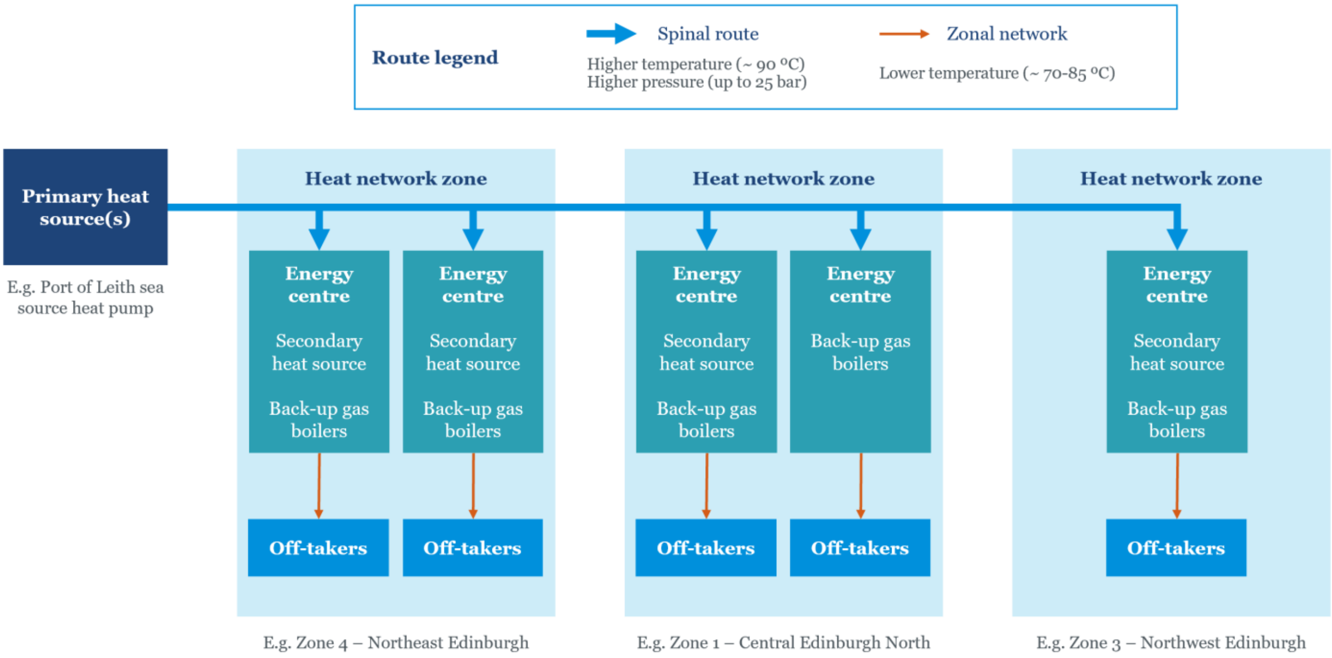



*Figure 50: This is an illustrative set-up of the spinal and zonal networks demonstrating various potential configurations. Conceptually, we position the primary heat sources and spinal routes as the supply for the 'baseload heat' for all zones they serve, covering the majority of the heat demand. There may be one or multiple energy centres serving a zone. Certain energy centres would potentially use heat from the spinal route for almost all of their heat supply, only hosting back-up and peaking plans, whereas in other circumstances energy centres would also utilise a secondary heat source alongside the heat from the spinal route. We consider the need for hydraulic separation of spinal route from zone networks in all scenarios.*

## 10.4 Indicative routing

We considered key constraints, heat demand across zones, primary heat source profiles and rationale for the spine to develop an indicative pipe routing. This initiates from the three primary heat sources and covers the relevant zones.

Our routing and costing only covers the spinal routes within zones where there is a likely future investment case, as discussed in section 10.1 alongside the rationale for the spinal route. While we have defined routes to zones where there the investment case is not currently clear, this only includes indicative routing which is not yet costed. The routing and costing carried out across zones is defined in Table 14.

| Zone number and name | Investment case | Routing |
|---|---|---|
| Zone 1 – Central Edinburgh North | Likely | Routing and costing |
| Zone 2 – Central Edinburgh South | Likely | Routing and costing |
| Zone 3 – Northwest Edinburgh | Likely | Routing and costing |
| Zone 4 – Northeast Edinburgh | Likely | Routing and costing |
| Zone 5 – Southeast Edinburgh | Likely | Routing and costing |
| Zone 6 – King's Buildings | Unclear | Routing only |
| Zone 7 – Colinton | Unclear | Routing only |
| Zone 8 – Southwest Edinburgh | Likely | Routing and costing |
| Zone 9 – West Edinburgh | Unclear | Routing only |
| Zone 10 – Heriot-Watt University | Unclear | Routing only |
| Zone 11 – Queensferry | Unlikely | No routing |

*Table 14: A schedule of zones and the routing and costing we developed for the spinal pipe reaching theoretical energy centre locations within each.*

Further to this, we have not costed for spinal routing to primary heat sources due to the uncertainty involved in the proposed sources. However, we have developed indicative routing to the assumed locations. It is important to note that routes in other local authorities are purely illustrative and any and all decisions here would rest with the respective local authority. The purpose of this high-level analysis is to understand the potential routing a pipe could take, whether it is viable to consider further and estimate the cost margin for the generated heat that would make the spinal pipe worthwhile.

The heat cost margin has been calculated by taking the estimated capital cost of the spinal route and splitting this across the amount of heat the spine could deliver over an assumed 50-year lifetime. This reveals how much cheaper the heat delivered by the spinal route would need to be compared with the heat generated via secondary heat sources. This margin provides an indication of whether a capital investment into the spinal route is economically worthwhile.

This analysis only assesses the heat cost margin required for the spinal pipe; costs associated with development of primary heat sources would need to be factored in when these figures are available. Further, this heat cost margin is a high-level output, and detailed economic modelling should be carried out to assess financial implications of various configurations for all parties, including the spinal operator, zonal network operator and the ultimate cost to off-takers. A more detailed feasibility would provide confidence on, both, routing and costs as well as primary heat source concept design.

Our analysis revealed that two spinal routes are currently the most viable options, given the locations of the primary heat sources, the locations of heat demand and key zones, and constraints such as the railway and tram lines.

Both spinal routes are presented in Figure 51 and discussed thereafter with their indicative economics.

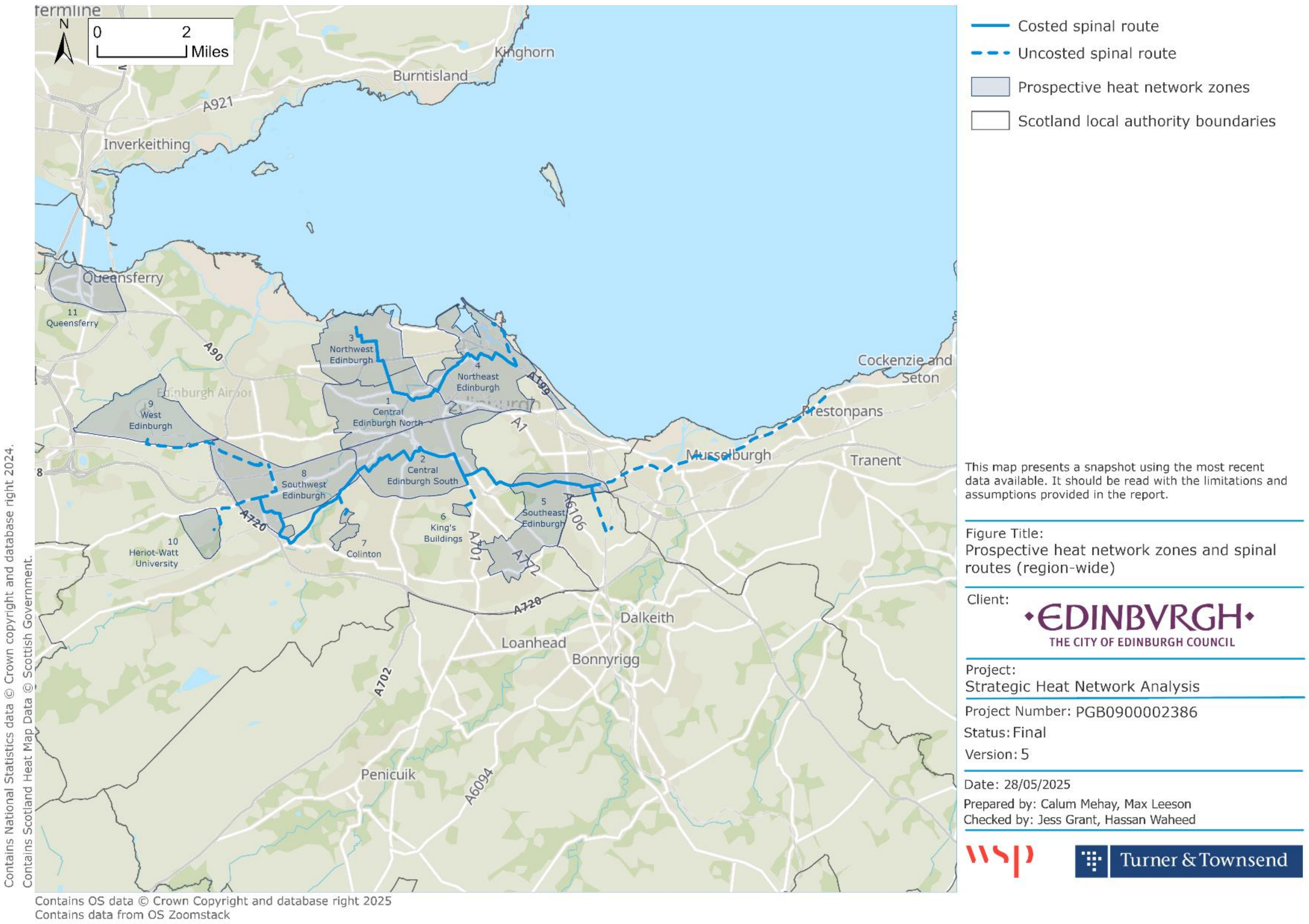



*Figure 51: Proposed Northern and Southern spinal routes. Routes in other local authorities are indicative only; any and all decisions about the spinal routes in these areas would be the perogarative of the respecive local authority.*

### 10.4.1 Northern Spinal Route

We propose a route serving the northern zones of the city, with the heat assumed to be generated by sea source heat pumps using the Firth of Forth. Installation of 80 MW of low carbon heat at Port of Leith could serve 90% of the anchor load demand within the three zones covered. This capacity could be increased to cover the infill where secondary heat sources are unable to meet the demand. This route is shown in Figure 52.

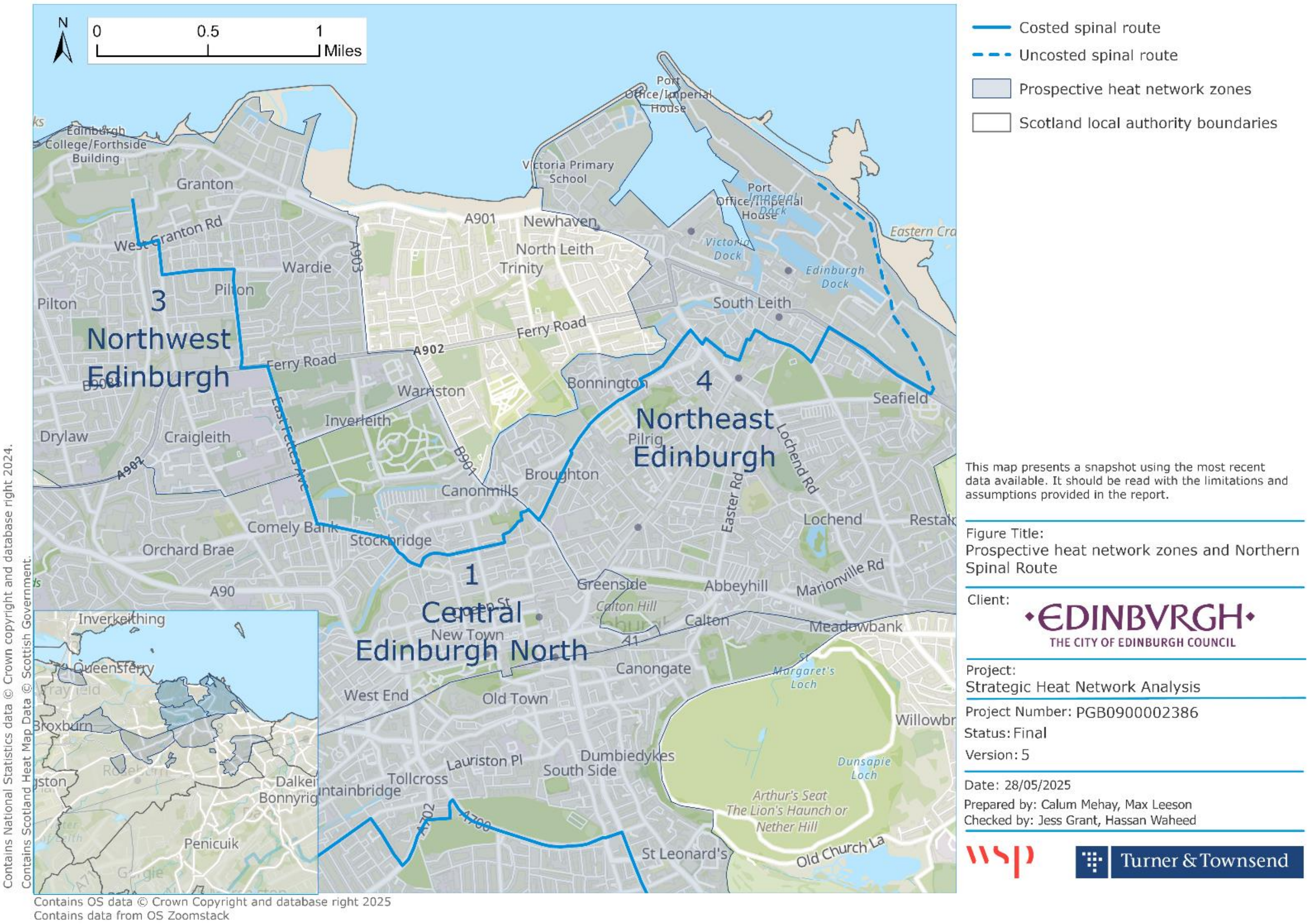



*Figure 52: The proposed Northern Spinal Route.*

We have carried out a high-level heat cost margin calculation to give an indication on whether the spinal route would be economically viable. This establishes how much cheaper the spinal heat would need to be (the margin) to offset the additional cost of the capital for the spine over its lifetime.

The costs listed are at present day values and no allowance is made for inflation. The lifetime for the spinal pipework is assumed to be 50 years. The key economic indicators are presented in Table 15.

| Indicators | Zone 4 | Zones 4 & 1 | Zones 4, 1, & 3 (total) |
|---|---|---|---|
| CAPEX - £m | £17.1m | £31.7m | £58.7m |
| Heat cost margin – p/kWh | -1.06 | -0.77 | -0.82 |

*Table 15: The CAPEX and heat cost margin of the Northern Spinal Route in phases from east to west, starting in Leith and ending in Granton.*

The total estimated CAPEX for the Northern Spinal Route is £58.7 million. The heat supplied from any large-scale heat pump via a spinal pipe would need to be at least 0.82 p/kWh cheaper than locally generated heat to be considered for investment.

### 10.4.2 Southern Spinal Route

We have proposed a route serving the southern zones of the city, with the heat being generated at either Cockenzie in East Lothian or Monktonhall Colliery in Midlothian, or potentially both primary sources. The main spine is intended to serve zones 5, 2, and 8, with optional connections to zones 6, 7, 9 & 10.

The capital costs have been applied to the main spine only, shown as the solid line in Figure 53 below, i.e. for zones 5, 2, and 8.

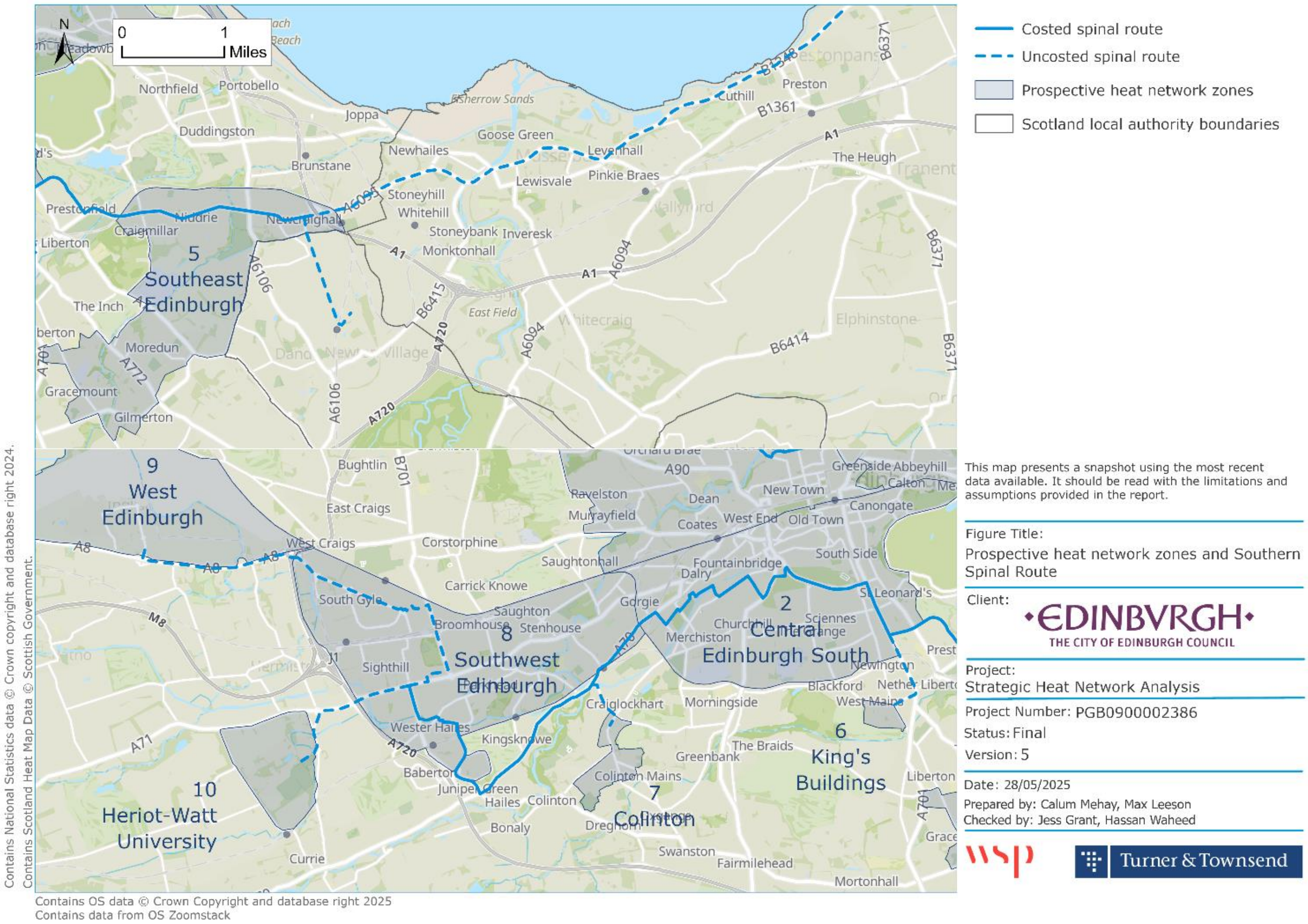



*Figure 53: The proposed Southern Spinal Route. Top: eastern half of the route from Cockenzie to Zone 5 – Southeast Edinburgh. Bottom: western half of the route continuing onto Zone 2 – Central Edinburgh South and throughout the rest of the zones.*

The lifetime for the spinal pipework is assumed to be 50 years. We have assumed a total of 120 MW available for the Southern Spinal Route, which would serve 90% of the anchor load demand. In the scenario additional heat demand is required for infill of smaller heat loads (of which there is significant demand) or connection to one or more optional zones is required, the primary heat sources could be scaled accordingly. Additional capacity at Monktonhall Colliery may be viable, but there may be barriers which prevent this (see section 7.2.3.3). However, infrastructure at Cockenzie could be developed further, including the addition of more heat pumps and/or thermal storage, to theoretically cover any uplift in heat supply required. The key economic indicators for the Southern Spinal Route are presented in Table 16.

| Indicators | Zone 5 | Zones 5 & 2 | Zones 5, 2, & 8 (total) |
|---|---|---|---|
| CAPEX - £m | £7.4m | £45.5m | £86.7m |
| Heat cost margin – p/kWh | -0.20 | -0.52 | -0.77 |

*Table 16: The CAPEX and heat cost margin of the Southern Spinal Route in phases from east to west, starting in Southeast Edinburgh and ending in Southwest Edinburgh.*

The total estimated CAPEX for the Southern Spinal Route is £86.7m. The capital cost is significant in the final stretch of the spine from zone 2 to zone 8 due to the trench length required. In general, the greater the length of pipe the lower the required cost of heat generation for it to be economically advantageous. The spinal heat would have to be around 0.77 p/kWh cheaper than locally generated heat. However, even the least favourable scenario with the pipeline extended to zone 8, the required heat cost margin is no worse than that for the most favourable scenario for the Northern Spine Route. The lack of heat sources of scale in western Edinburgh is presents a significant challenge for decarbonising that area of the city; therefore, the larger capital investment may be justified.

## 10.5 Conclusions on spinal routing

Our assessment finds that, due to the significant heat demand, spinal routes suppled via primary heat sources are the most practical option for developing heat networks in Edinburgh. Therefore, the spinal route will be central in bringing large volumes of heat supply from where it is available into areas of high heat demand within central Edinburgh (Figure 54).

The combination of a spinal route with primary heat sources could enable economies of scale as well as the development of these as strategic energy assets which take advantage of their flexibility and scale to drive down to cost of heat for Edinburgh's residents and organisations.

Given its proximity to the heat demand and fewer development constraints, we consider the Northern Spinal Route, alongside the Port of Leith sea source heat pump, a strong candidate for the Council's initial focus. This represents a lower-cost, lower-risk option that enables faster delivery of large-scale zones while also laying the groundwork for future investment in the Southern Spinal Route. Demonstrating a functioning spinal route at scale helps de-risk further development by proving the investment case and generating demand volumes that can support subsequent phases.

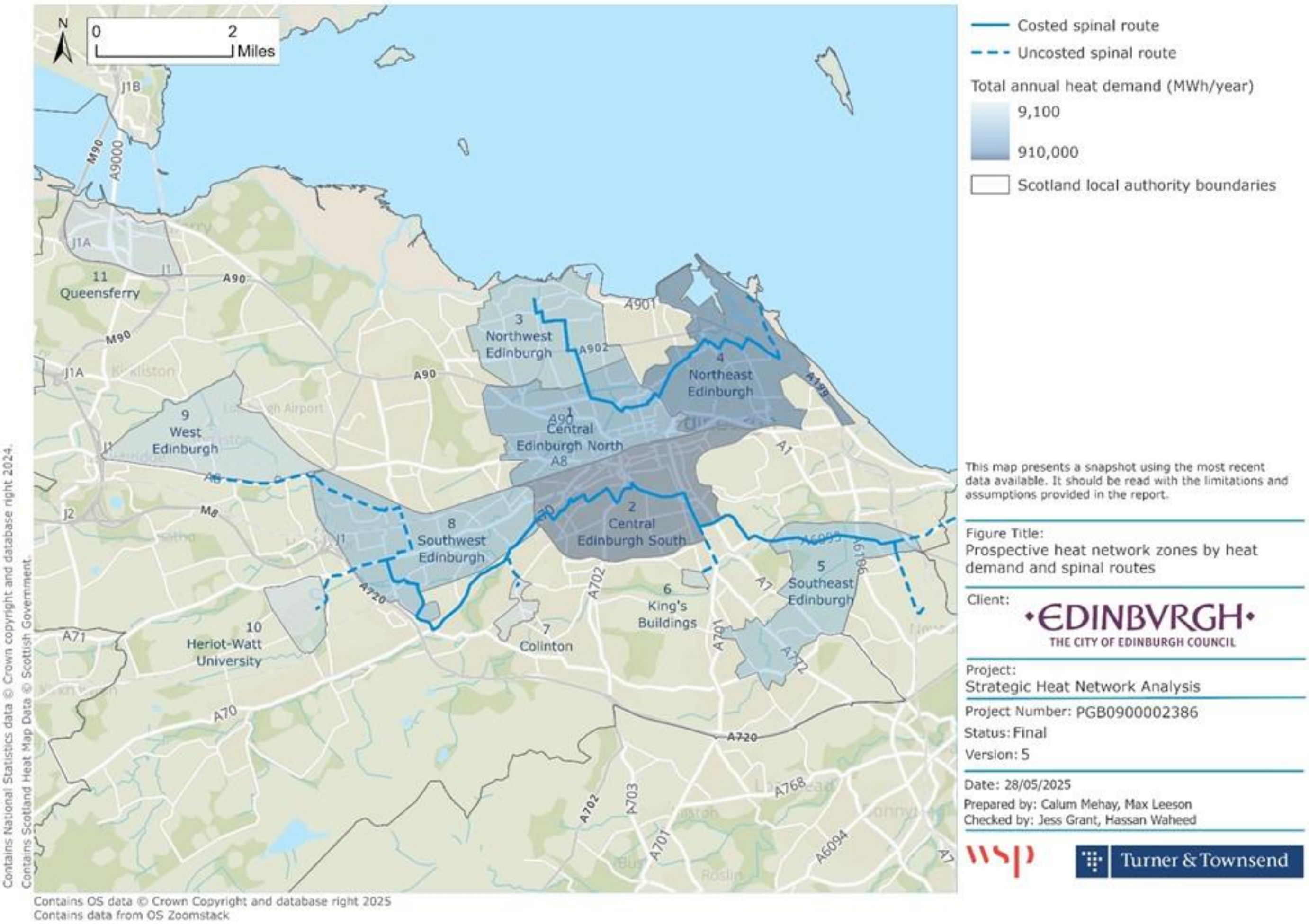



*Figure 54: Prospective heat network zones and their heat demand alongside the proposed spinal routes.*

# 11. Delivery Strategy

*Due to a combination of factors (discussed in section 11.1), heat networks are a preferable option over individual building-level decarbonisation solutions in Edinburgh's prospective heat network zones and, at times, the only practical option to decarbonise buildings. Further, the high level of Edinburgh's heat demand coupled with a lack of available space and sufficient secondary sources necessitate the development of large-scale primary heat sources and a spinal route to deliver this heat.*

## 11.1 Decarbonising Edinburgh's heat

The Edinburgh LHEES identifies two primary routes for decarbonising buildings: connection to heat networks or heat pump installation[86]. Individual building-level heat pumps are a highly effective and versatile technology which will play a key role in decarbonising heat in many areas of Edinburgh, as identified via LHEES Delivery Areas. However, within heat network zones, heat networks typically offer benefits over individual building-level heat pump installations:

- They have the potential to be the lowest-cost low carbon heat source given the right set of practical, regulatory and economic factors, both, in terms of CAPEX and OPEX for off-takers. This is not always the case, but it is likely for most properties within a zone.
- They are an opportunity to develop an infrastructure investment which could benefit many generations, driving down the cost of heat for the long-term and screening Edinburgh's customers from energy price volatility.
- As an infrastructure solution, they enable scalable area-wide rollout of a decarbonisation solution in a way that individual building-level installations are more challenging to deliver. Arrival of a network can catalyse place-based transformations by attracting large numbers of customers to connect.

The Edinburgh LHEES set the scope for a large and continually expanding city-wide heat network (or 'network of networks') covering as much of Edinburgh's heat demand as practical. In addition to the reasons presented in the Edinburgh LHEES, we find multiple other reasons for heat networks in Edinburgh's prospective heat network zones being preferable over individual heat pumps (discussed in Table 17).

| Circumstances where individual building-level systems are challenging | Reasons heat networks are preferable |
|---|---|
| Central Edinburgh and major parts of the city have substantial built heritage. There are 50 Conservation Areas, and around 5,000 listed buildings and structures, ranging from Georgian and Victorian tenements to medieval castles. Further, of the 266,144 homes in Edinburgh, 27,282 (10.3%) are located within listed buildings and 68,834 (25.9%) are located within conservation areas. Decarbonisation will likely require banks of ASHPs on these buildings or in areas nearby, or GSHP deep boreholes. Installing these is not always impossible but it is highly challenging, often requiring permissions and unique solutions. This adds substantial cost, making individual solutions less economically attractive for heritage buildings in dense urban areas. | A connection to a heat network often involves no additional space and is not as noticeable as a sizeable ASHP array would be or as challenging as boring multiple 100-200m holes per building in the city centre. A heat interface unit (HIU)[87] is less invasive and a simpler solution which replaces existing boilers. A heat network connection could save CAPEX and OPEX costs against an individual system. |
| Even where heat pump space is available, many buildings have unsuitable heating controls and | In contrast, a heat network operating at the appropriate flow temperature will allow an off-taker |

[86] There are other routes for decarbonisation and the Edinburgh LHEES does reference these (e.g. direct electric heating, solar water heating, biomass). However, it places these two at the forefront of heat decarbonisation plans. This is reflected in the LHEES process: delivery areas focus on individual properties (though for energy efficiency measures and/or heat decarbonisation projects) and heat network zones focus on heat network projects.

[87] A HIU is a device which is typically installed in an off-taker's boiler room, replacing the previous heating system (e.g. gas boiler). It typically contains a plate heat exchanger, valves and controls to regulate heat transfer, optimising the supply of heat to meet demand needs.

| | |
|---|---|
| distribution systems which result in lower heat pump efficiencies, resulting in higher operating costs over time. Building operators may replace controls or distribution systems to gain efficiencies and reduce operating costs, but this comes at the expense of higher upfront capital costs. Many buildings in Edinburgh face this predicament. | to replace the existing heating system with a HIU without the need for distribution system upgrades. |
| In cases where, both, heritage and distribution system barriers don't exist or are resolvable, individual heat pump installations at a meaningful scale would require significant grid reinforcements. Most of Edinburgh's grid would need to be upgraded to allow for any substantial proportion of buildings to install heat pumps. Once factored in, this would result in added costs and complexities. Further, without major UK-wide shifts in energy policy and behavioural change campaigns, many individual systems are unlikely to demand-responsive. This will add further challenges to renewable deployment, requiring installation of expensive grid-scale storage/balancing systems and continuing to cause curtailment of renewable energy. | Heat network energy centres require significant electrical power, often via high voltage supply, and the level of grid improvements required to support such a new connection also far exceeds those required for any typical individual building. However, these improvements are concentrated in one location, supporting a single energy centre which supplies hundreds or thousands of properties. In our engagement with SPEN we learned that this is considerably more cost effective and preferable from a practical perspective. This is further convenience when the locations of these energy centres are not in dense urban areas and can also be situated with grid connections in mind. Further, the grid has reduced stress from energy centres due to heat pump efficiency and waste heat usage. Finally, energy centres can be highly responsive and help balance the grid when utilising heat storage. This can be cheaper for the heat network operator (i.e. using electricity at the ideal times) as well as the grid operator (i.e. a responsive large-scale load which can modulate its demand). |
| While we have explored cases where heat pumps might be viable, in most cases within central Edinburgh, the space to install heat pumps (of any kind, but especially ASHPs) simply does not exist, even if the previously listed barriers were resolved. For example, tenement blocks, Grade A listed buildings, and most buildings in Edinburgh city centre are densely packed together and have a high heat demand. There is insufficient space for a heat pump of a suitable size to be able to meet the heating needs year-round. | In these instances, the only practical decarbonisation solution is a heat network connection. With a connection to the network and installation of an HIU, any property can draw the required level of hot water. |

*Table 17: Reasons heat networks are preferable over individual heat pump solutions in Edinburgh's prospective heat network zones (i.e. areas of high heat demand) from a cost and practicality perspective[88].*

This analysis establishes that a city-wide heat network would not only contribute to, but is also a necessity for, meeting the Edinburgh LHEES objectives as well as delivering on legally binding national targets. Hence, the refined prospective zones cover as many areas as practical for heat network roll-out, encompassing over two-thirds (67%) of all heat demand and the overwhelming majority (88%) of all anchor load heat demand. More importantly, the zones cover the urban areas of Edinburgh less suited to building-level decarbonisation solutions, aiming to provide all of Edinburgh's owners with a low-cost route to decarbonise.

Furthermore, in section 10.1 we discussed the challenges of locating energy centres within urban areas of Edinburgh. Practical options are limited to space-efficient energy centres utilising secondary heat sources. However, we also established that there is a major shortfall of available heat from these sources to support anchor loads in the major zones, and a further deficit when demand from all loads is considered.

Therefore, in the absence of sufficient secondary heat sources and the lack of available land for other forms of low carbon heat generation, it is necessary to develop large-scale primary heat sources (in suitable locations)

[88] Zones are large areas with multiple variances across factors, including building types and characteristics, physical constraints, preferences and unique needs, and existing investments. One obvious example is the buildings with dry heating systems are typically on some form of electrical heating system; they are already utilising low carbon heating and installing a wet system may be prohibitively example. A heat network connection may not be a favourable option in this scenario.

and deliver this heat where it is required via a spinal route. This is in line with the approach taken elsewhere in Scotland and the UK, including London (Figure 56).

**Case study: London**

The Department of Energy Security and Net Zero (DESNZ) has developed heat network zones for many urban areas of England in line with the approach set out in the Energy Act 2023. The Greater London Authority and London boroughs are progressing major plans for heat networks, recognising many of the challenges and opportunities we have identified.

One major example is the South Westminster Area Network (SWAN), a DESNZ-backed scheme to supply low carbon heating at 80ºC to buildings in and around the Strand, Whitehall, Victoria, Millbank and surrounding areas. This is planned to be one of UK’s largest heat networks upon completion. The private developers plan to invest £100m within 3 years, £500m within 10 years, and £1bn by 2050, with a £21m grant confirmed by DESNZ. Our high-level analysis provides investment estimates in the same order of magnitude.

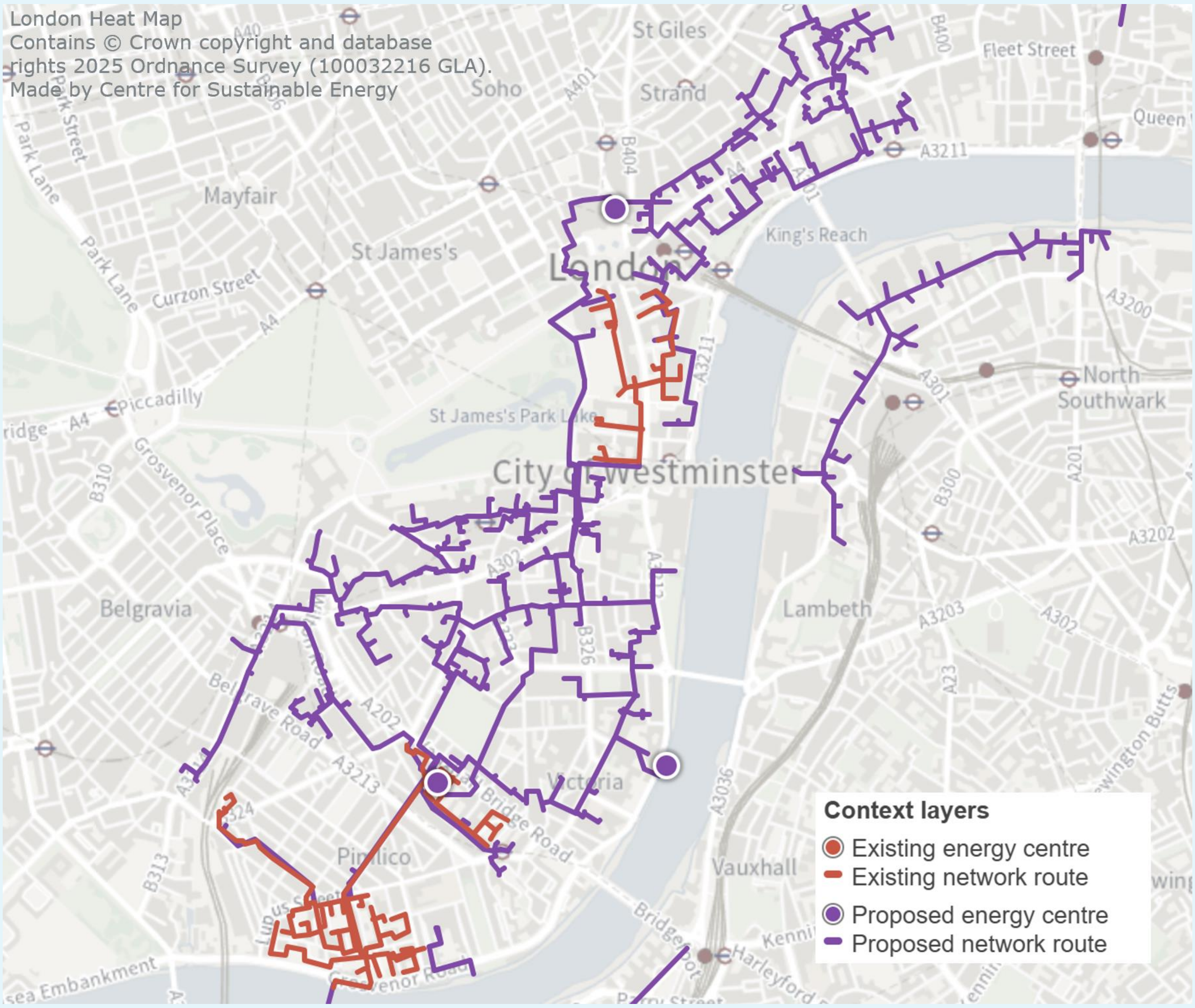



*Figure 55: Proposed SWAN anchor network (west and north of River Thames) and proposed energy centre locations, alongside existing network routes. Image credit: London Heat Map.*

*Figure 56: Case study of SWAN heat network, London.*

We anticipate the most cost-effective approach for Edinburgh would be to develop highly space-efficient heat substations which only house pumps and controls to transfer the heat from the spinal route into the zonal network[89]. Secondary heat sources should be used where these are available and cost-effective, though these will be limited, and much of the heat is likely to be delivered via heat substations connected to the spine. There may be a case for ASHP, but only in cases where there is sufficient space. We discussed this concept in section 10.3 and illustrated it at a high-level in Figure 50.

## 11.2 Strategic energy assets

While primary heat sources are necessitated by the constraints, they also open the door to several potential benefits which could drive down the cost of heat for Edinburgh's customers. This can be achieved by developing these as strategic energy assets which leverage the potential scale of heat demand:

- At the most basic level, a greater scale of electricity demand by primary energy sources will allow the negotiation of cheaper electricity via power purchase agreements.
- At the scale we are proposing, a primary heat source could also attract a private wire connection to renewable energy sources[90], in addition to grid connection, bypassing the transmission costs borne out of grid electricity when renewables are available. With the right mix of factors, this could result in significantly cheaper heat generation than is viable from any other method available for Edinburgh[91].
- A primary heat source should also include large-scale energy storage[92]. This will further allow the extraction of best value from access to lower cost off-peak electricity tariffs, maximise the use of private wire electricity, provide system resilience, reduce the reliance on the electricity grid, and also help to balance the grid:
    - Short-term heat storage can capture electricity from private wire wind farms and off-peak rates in the hours it is the cheapest and supply the heat when the demand is highest (and when electricity is often most expensive). This approach to heat storage will work across hours or a few days.
    - Medium-term heat storage can help to balance the supply and demand across weeks, storing energy during days it is abundant and low cost (e.g. excess wind energy during storms) and utilising it when grid electricity costs are high.
    - Long-term energy storage will allow the operator to take advantage of the energy boon in the summer months to store heat for the winter months.
- Large-scale demand will also provide economies of scale, allowing primary heat source developers to achieve efficiencies in heat generation equipment, operations and procurement, further driving down the cost of heat for off-takers.
- The primary heat source will also require a back-up heat supply as resilience and peaking[93]. This could be a combined heat and power plant (CHP)[94]. Under normal operational conditions, we would not expect these to contribute a substantial proportion of the heat supplied (e.g. less than 10% of total heat demand supplied). However, in the event this is required for peaking, it is also likely that grid electricity costs and heat demand are both high. The electricity generated via the CHP could help to displace the electricity demand from the grid, and the heat supplied could displace the need to generate heat via the electricity-intensive water source heat pump. This could help to mitigate against the costly demand peaks.

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[89] These would not house any heat generation equipment (e.g. heat pumps) and thus take significantly less space and lower energy. This increases the viability to situate these in city centre locations and also would not require grid upgrades in the same way as energy centres would.

[90] The most likely source of renewable electricity for Cockenzie is offshore wind and for Port of Leith would be potentially the same connection extending into Edinburgh. It is unclear what sources could be possible for Monktonhall Colliery.

[91] Wind energy is currently the cheapest form of energy in the UK.

[92] This should be primarily thermal storage, but there is a case to investigate the role of batteries and other forms of energy storage appropriate to the location of the primary heat source. A location such as this has the potential to operate as a strategic energy asset, taking advantage of its location, scale and connectiveness to the grid and renewable energy sources to generate revenue and reduce costs.

[93] For now, we have modelled backup/peaking plants entirely at the zonal level energy centres. However, a detailed analysis should be performed to understand the ideal location for these plants in configurations involving the spinal route. Here, we are assuming that these plants are concentrated with the primary heat source to explore possibilities.

[94] This could be powered by biomass or biogas (though we note the sustainability challenges which can be associated with these fuels). Alternatively, natural gas could be used for the medium-term until a more sustainable solution is available. In the long term, hydrogen (should it be cost-effective), battery storage systems or another sustainable fuel could be utilised.

These benefits are not theoretical but already being utilised extensively, including in the UK (see Figure 57).

**Case study: Gateshead Energy Company**

Wholly-owned by Gateshead Council, the Gateshead Energy Company deployed a 6 MW mine water source heat pump to supply its heat network, the first mine water scheme in the UK. This is supported 4 MW of CHP, 4 MW of solar PV, 3MW of electrical batteries and 250m$^3$ of thermal storage. The system is backed up by 7.5 MW of conventional gas boilers. The scheme supplies both heat and power to its customers via district heating pipes and private electrical power lines.

The scheme generates revenue by supplying grid services to National Grid; they stop or start their CHPs in response to grid balancing requirements. In the event there is limited or no need for heat but power is valuable, the company is able to store the excess heat produced by the CHP in its thermal storage for later use. When the CHP engines are not running or when electricity demand is greater than supply, the company imports electricity via its own grid connection. Further, the company installed 4 MW of solar PV mainly at brownfield sites to bolster its power generation capabilities; these feed directly into Council buildings. The company incorporated a 3 MW battery storage system to deliver frequency response services to National Grid, further increasing its revenue.

The scheme is an example of developing strategic energy assets which work together to generate revenue and drive down the cost of heat. Co-locating and flexibly operating various asset classes allows the company to deliver a guaranteed minimum cost discount of 10% on heat and 5% on power.

**Case study: Simpsons Malt**

While not a heat network, the UK's largest malting operation located in Berwick-upon-Tweed, provides an early example of utilising curtailed wind power to produce low cost low carbon heat at scale. AMP Clean Energy is financing, developing and operating a £45m low carbon energy centre for Simpson's Malt's facility. This is based on 18 MW of biomass boilers as the primary plant alongside a high-voltage 12 MW electric boiler dedicated to run on free curtailed wind power. While the biomass boilers provide the heat under normal operating conditions, the electric boiler is given priority when curtailed wind is available. The energy centre also includes a 1000m$^3$ of thermal storage to capture the excess heat generated from curtailed wind for later use, allowing the operator to maximise the benefit of this low cost clean energy.

**Case study: Assens Fjernvarme**

While different in context, other European nations can provide examples of how these accepts can be executed to supply low-cost heat to off takers. Assens Fjernvarme is a heat network located in Assens, Denmark. Established in 1960, the co-operative heat network supplies 3,400 owner-customers. It has a 2.3 MW heat pump with a COP of 3.4 alongside a 16 MW electric boiler, which collectively comprise its low carbon heating plant. It also has a 1.3 MW onsite turbine and 6 MW solar PV farm as its direct renewable energy source. It has a biomass CHP which produces 15 MW of heat and 5 MW electricity. Finally, it has a heat store with 200 MWh of capacity.

The heat network operator uses these assets to couple benefits of low carbon generation capacity with that of storage to drive down the cost of heat for its owner-customers. It has been selling heat at approximately €0.01-0.02/kWh for the past 25 years (data to 2023), including throughout the recent energy market shocks.

It does so by selling electricity (from biomass and renewable assets) when it is expensive on the market, purchase electricity (to power its heat pump and electric boiler and store the heat) when it is cheap on the market, and utilise its own energy-generating assets when the cost is moderate. In doing so, the operator also plays a role in balancing the grid. There are numerous such case studies in Denmark.

*Figure 57: Strategic energy assets case studies.*

The lifetime OPEX of a heat source is often several fold higher than its CAPEX, hence the cost of generating heat will have a greater impact on heat tariffs over the long term. At its core, this delivery strategy aims to minimise the OPEX for generating, storing and delivering heat to off-takers. However, the cost-effectiveness of developing a strategic energy asset using these technologies for Edinburgh needs to be assessed via detailed and independent technoeconomic analysis. This should identify the ideal combination of deliverable technologies which can achieve the lowest cost of heat for off-takers, along with the appropriate phasing and scaling of these in a way which best supports network expansion.

In any scenario, primary heat sources would be well-placed to meet the baseload of heat demand from zonal heat networks. This role could also extend to managing demand peaks, providing the majority of heat demand for the city.

## 11.3 Heat networks as a utility

The Edinburgh LHEES helped the Council transition from project-scale planning of discrete heat networks into zonal-level approach of developing heat networks at scale. Placing primary heat sources and the spinal route at the forefront now helps to position heat networks as a utility-scale undertaking. As discussed in 3.2, a public utility lens helps to establish heat networks as a core regulated service available to a majority of buildings in Edinburgh, transforming the way individuals and organisations use heat in the city. It also lends confidence to heat networks as a priority, attracting the capital that will be required to enable its development.

However, there are questions about the order in which the primary and secondary heat sources as well as spinal and zonal networks should be developed. There are multiple criteria to consider, including balancing supply and demand, providing the lowest cost of heat possible for the short and long term, avoiding the risk of stranded assets and investments, and creating circumstances which maximise the reach of heat networks to as many off-takers as possible. We carried out a multi-criteria assessment with the Council to highlight the main options and arrive at a preferred approach, detailed in Table 18.

| Approach | Advantages | Disadvantages |
|---|---|---|
| **Option 1**<br>**Distributed: zonal networks first**<br>This approach would entail developing zonal networks first using secondary heat sources and the capacity of ASHPs available, and thereafter develop the spinal route with primary heat sources. | Zonal networks will take less time to develop as they would not have to wait for spinal heat to be delivered before they are able to expand. This will enable the early development of heat networks across the city wherever the right combination of factors exist.<br>Networks can also maximise the use of cheap secondary heat sources as the basis of their heat supply. | Secondary heat sources across the major zones (1-5 and 8) are limited and unable to supply a substantial proportion of all loads in the zone. As a result, energy centres may require more space for ASHPs and local grid reinforcements to allow further network expansion, among other factors discussed in section 11.1.<br>These networks would likely need to wait for a spinal connection to expand to their full potential, or Edinburgh would risk small pockets of disparate developments. Another risk is that zonal networks are designed around local heat sources (as a spinal connection could seem uncertain to a developer) and thus unable to expand if a spinal connection becomes viable (e.g. due to pipe sizes or energy centre configuration). Developers will also face the risk of stranded or inappropriate assets (e.g. heat generation plan) in their zonal energy centre, potentially putting off a connection to a spinal route and thus the investment case for one. |
| **Option 2**<br>**Centralised: spinal network first**<br>This approach would involve the development of a spinal route first using primary heat sources. When the spinal route arrives, zonal networks can connect and expand. | This would allow for a planned approach which maximises the use of strategic energy assets (section 11.2). Operating at this scale would mean that zonal networks can be planned for maximum possible extent from day one, with the arrival of spinal heat unlocking this rapid expansion.<br>It would also allow developers to assess which secondary heat source is worthwhile utilising (i.e. via technoeconomic comparison against the spinal route as a counterfactual). | The uncertainty of demand from zonal networks would add significant risk to investment. Without a large-scale guaranteed demand, developing a primary heat source would likely be an unviable investment proposition for most developers. It could result in a development stalemate and be at odds with the perceived benefits of enabling network expansion.<br>Even if this approach is taken forward, it would likely take significant time and complexity, possibly delaying network development by many years due to a reliance on primary heat sources and zonal route taking shape. |
| **Option 3**<br>**Parallel development: phased** | This would provide greater certainty of investment for both zonal and spinal networks. The primary heat source would be developed with a guaranteed customer, the zonal heat network | While this has benefits for kickstarting development in the two Gateway Zones, it is likely to result in a decision to prioritise these over heat network developments in central Edinburgh until the spinal network arrives |

| | | |
|---|---|---|
| **spinal and zonal expansion**<br><br>This approach would involve sequential development of spinal and zonal networks at the same time in phases, beginning with zones closest to primary heat sources and thereafter expanding the spinal routes onward to support the next set of zones. | operator, who in turn would have a guaranteed heat supplier to meet the scale of demand required. The primary heat source could be phased accordingly, and the zonal network designed to reach the greatest extent viable.<br><br>This approach would catalyse early heat network projects in the 'Gateway Zones' of *Zone 4 – Northeast Edinburgh* (supported by the Port of Leith sea source heat pump which is within this zone), and thereafter *Zone 5 – Southeast Edinburgh* (supported by the Monktonhall Colliery GSHP and/or Cockenzie sea source heat pump). | (*Zone 1– Central Edinburgh North* and *Zone 2 – Central Edinburgh South*). This means building operators may need to continue relying on polluting heating systems well into the 2030s or possibly the 2040s (depending on project timescales). Although, to decarbonise their heat, majority of buildings operators in these zones would likely have to wait for spinal heat to arrive in any scenario (see section 11.1).<br><br>This would also add complexity in managing projects at two scales to balance the longer-term and larger-scale investment prospect (spine) with a shorter-term and smaller-scale prospect (zonal network). It will also require enhanced coordination between the spinal and zonal developments, potentially requiring complex agreements before developments can be finalised. |

*Table 18: Multi-criteria assessment to determine the most practical approach to developing heat entworks.*

We consider these options on a spectrum with zonal network-led development on one extreme (option 1), spinal route-led development on the other extreme (option 2), and various combinations of parallel development approaches in the middle (option 3).

We have presented key principles and advantages/disadvantages of a parallel approach (option 3) in Table 18 and a map of how this could be phased in Figure 58.

- Phase 1 – Gateway Zones: the first zones to be developed alongside the spinal route.
- Phase 2 – Central Zones: the most challenging zones with significant built heritage and space constraints, reliant on the spine for majority of their heat.
- Phase 3 – Expansion Zones: the final leg of the spinal route into western parts of Edinburgh

However, significant independent analysis is required to assess the possible development routes and arrive at an approach best suited to meeting the Edinburgh LHEES objectives. This analysis should include evidence-based technoeconomic feasibilities for *Zone 4 – Northeast Edinburgh* and *Zone 5 – Southeast Edinburgh*, considering:

- The spinal route and primary heat sources are indicative only, they should be assessed in more detail.
- All the viable technology options at the zonal and spinal levels should be considered.
- The delivery model which the Council selects will have a profound impact on the preferable approach.
- The implications of the spinal route for each zone should be reviewed. For example, the most advanced Council-led development in Edinburgh, the Granton Waterfront heat network, is in *Zone 3 – Northwest Edinburgh* which is in proposed phase three of the Northern Spinal Route. However, it is advantageous to continue developing this network as a priority and as far as possible using local heat sources as it is already a priority, an attractive heat network opportunity and a potential success.

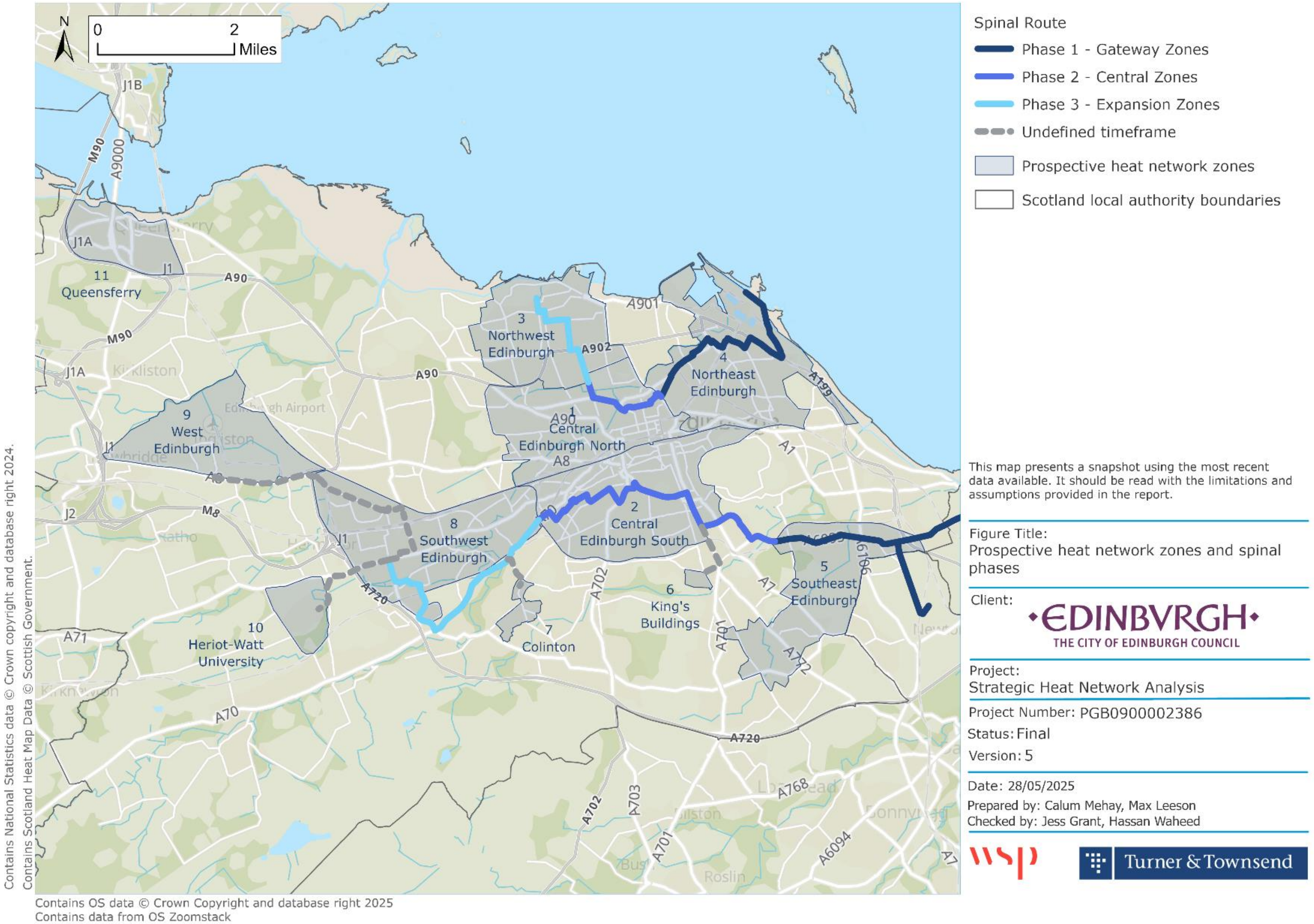


*Figure 58: Suggested phasing approach to parallel development of spinal and zonal networks. We recommend the prioritisation of the two Gateway Zones, Zone 4 – Northeast Edinburgh and Zone 5 – Southeast Edinburgh, to enable the development of anchor networks at scale, alongside the spinal route and required primary heat sources. Developing these collectively will provide confidence to build strategic energy assets and expansive zonal networks. The spinal route and primary heat sources can thereafter be developed to enable heat networks for Central Zones. There will be a possibility to supply Expansion Zones and other zones where the case and demand exists.*

## 11.4 Role of the Council

### 11.4.1 Delivering heat networks

Our policy analysis (section 4.1), stakeholder engagement analysis (section 6.2), technical analysis on heat sources (section 7.2), work on updating zones and reviewing their feasibility (sections 8.3 and 9.2), proposals on indicative spinal routes (section 10.4), and development of the delivery strategy (section 11), all point to the centrality of the Council in heat network developments.

The Council has multiple statutory functions which make it the *de facto* coordinator of heat networks. Its role in governing the city make it a critical partner from a practical perspective. Its actions influence investment intent in a major way, and its decisions define how, where and when developments can happen. It is important to understand that this is the case notwithstanding delivery model type. Even in a hypothetical private sector-led approach, the Council's substantial core role will remain in need and without the Council's leadership, it is unlikely that any substantial heat network plan can come to fruition.

Therefore, it is critical for the Council to increase its already significant and active participation in heat networks. As part of setting up the forthcoming heat network delivery programme, the Council should clearly define its role, considering the following recommendations:

- Launching the programme: on the whole, this analysis has made evident the centrality of a Council-led heat network delivery programme in supporting a city-wide heat network. In the coming months, the Council should gear up by investigating, defining and organising all the statutory and practical functions it needs to dispense in order to implement the programme. The programme should include the recommendations of this analysis and be structured to manage the delivery vehicle in terms of the Council's preferred role associated with it. It should have clear milestones and time-bound actions to achieve these. We recommend that the programme is led by an officer with an appropriate level of authority within the Council fully dedicated to this, and supported by an experienced team, along with a governance and operating model which enables rapid decision-making and delivery.
- HNSU support: a programme of this magnitude will require significant additional resources beyond the Council's current resources. Therefore, the Council should engage the HNSU to seek bespoke funding for personnel and other means of increasing capacity and skills. Further to that, the Scottish Government and HNSU have a key role to play in enabling a city-wide heat network beyond just helping to finance it. The Council should identify the gaps it faces in being able to deliver its programme functions and engage the government to help fill these, including:
    - Support in planning and managing heat networks as a major infrastructure development.
    - Policy and regulatory advice and support, especially in regard to initiating major energy infrastructure projects (e.g. primary heat sources or developing strategic energy assets).
    - Influence with relevant stakeholders to enable action and unblock barriers.
    - Bespoke and close delivery support in any other areas identified by the Council as part of programme development.
    - We also advise the Council to seek an appropriate and highly experienced HNSU official to help in the development and implementation of the programme on a longer-term basis. This will go significantly further than funding and review support for feasibility studies and business cases, by providing critical friend advice across multiple functions of the programme, helping to represent the Council in the market, supporting complex procurements, providing insights on strategy and risks, and aiding in dispensing programme functions. If this is not possible, then the Council could instead seek funding from the HNSU to procure similar support.
- Wider public sector support: the Council should continue its engagement with key partners across the public sector, including NHS Lothian, Universities, and other public bodies. Their role as potential off-takers, hosts of energy centres and heat substations, waste heat providers, and other potential roles will be critical in unlocking development potential.
- Delivery model refinement: the delivery model should be carefully considered as it will have profound impacts on the future delivery of zonal and spinal networks across Edinburgh. Beyond the high-level delivery model selection, the Council should also investigate how it could be implemented to realise the potential benefits identified in this analysis. Namely, how the delivery vehicle(s) for the spinal and zonal networks will be set up to allow these investments to be delivered in the most appropriate manner. Whether this is one vehicle or multiple vehicles (and in which case the level of Council involvement in each vehicle). Finalising the exact mechanics of delivery vehicles would then allow the Council to develop a clear procurement strategy, including the objectives, timelines, maximising

market confidence and appetite, maximising the benefit for off-takers, building safeguards to protect customers, unlocking rapid development and delivery of projects, cross-border collaboration, and supporting smooth operation of delivery vehicles in line with the policy and regulatory regime.

- Cross-boundary partnerships: given the potentially important role of primary and secondary heat sources in East Lothian and Midlothian exporting heat to Edinburgh, we advise the Council to begin a formal dialogue with East Lothian Council and Midlothian Council. This will help to agree and collectively deliver the approach to analysing, developing, financing, and operating primary heat sources as well as the spinal routes across the region. In time, this could also provide the foundations for negotiations, partnerships as well as potential designation of cross-boundary heat network zones.
- Heat pricing: the approaches we have highlighted previously in this section could potentially aid in generating substantially low cost heat. The benefits of this should be passed onto off-takers, especially the households most impacted by fuel poverty. Although, if a private entity is involved it will be important for the investors to realise profits from the risk they took. The Council should consider the development of a clear and fair heat pricing model based on the outputs of detailed feasibilities.

While the Council focuses on setting up its heat network delivery programme, it is important to continue supporting ongoing developments. This includes projects at Granton Waterfront and Edinburgh Airport. The success of these developments will bode well for confidence in the city's heat networks, and challenges with these are likely to reflect in the investor confidence on the Council's more ambitious plans.

### 11.4.2 Heat network development approach

As part of developing the zones, we worked with the Council on a potential delivery strategy which would be considered when shaping boundaries, in addition to the technical criteria detailed in section 8.2. After finalising the boundaries, we assigned each zone with one of three Council roles (subject to the preferred delivery model).

- Lead – priority: the Council will prioritise these zones and support the developer(s) in bringing a spinal connection to these as soon as possible.
- Lead – future prospect: the Council will consider supporting these zones.
- Support – independently led: heat networks in these zones are expected to be developed by another local organisation due to their presence, though the Council will support as appropriate.

These roles are assigned to each zone in Table 19 and visualised in Figure 59.

| Council role | Zones | Rationale |
|---|---|---|
| Lead – priority | Zone 1 – Central Edinburgh North | These five zones are priorities. They all have substantial heat demand; collectively, they comprise most of the heat demand of all prospective heat network zones. |
| | Zone 2 – Central Edinburgh South | |
| | Zone 3 – Northwest Edinburgh | |
| | Zone 4 – Northeast Edinburgh | |
| | Zone 5 – Southeast Edinburgh | |
| Lead – future prospect | Zone 7 – Colinton | This zone is based on public buildings, including Council buildings. However, it has the lowest anchor load and total heat demand of all zones, thus not a priority. |
| | Zone 8 – Southwest Edinburgh | While this zone has substantial heat demand (greater than two zones assigned as a priority), we have not assigned it as a priority because there are limited secondary heat sources available. Further, a spinal connection would only be possible in phase 3[95]. |
| | Zone 11 – Queensferry | This zone has a very low heat demand and is also unlikely to connect to a spine. It is also sizeable in area while |

[95] While Zone 3 – Northwest Edinburgh is also in phase 3 of the spinal route, it is a priority as it is an ongoing development.

| Council role | Zones | Rationale |
|---|---|---|
| | | depending on only 4 anchor loads (mostly by Council. It is a potential standalone project. |
| Support – independently led | Zone 6 – King's Buildings<br>Zone 9 – West Edinburgh<br>Zone 10 – Heriot-Watt University | These three zones have been shaped specifically with the relevant lead stakeholders in mind. *Zone 6 – King's Buildings* led by the University of Edinburgh, *Zone 9 – West Edinburgh* led by Edinburgh Airport, and *Zone 10 – Heriot-Watt University*.<br>The two university-led zones only contain campus buildings. Whereas the Edinburgh Airport-led zone contains limited areas around airport land; but these areas could potentially be supported by Edinburgh Airport's proposed heat network and are less likely to have another developer involved, although this is not impossible. |

*Table 19: The role of the Council across all prospective heat network zones and rationale for the assignment.*

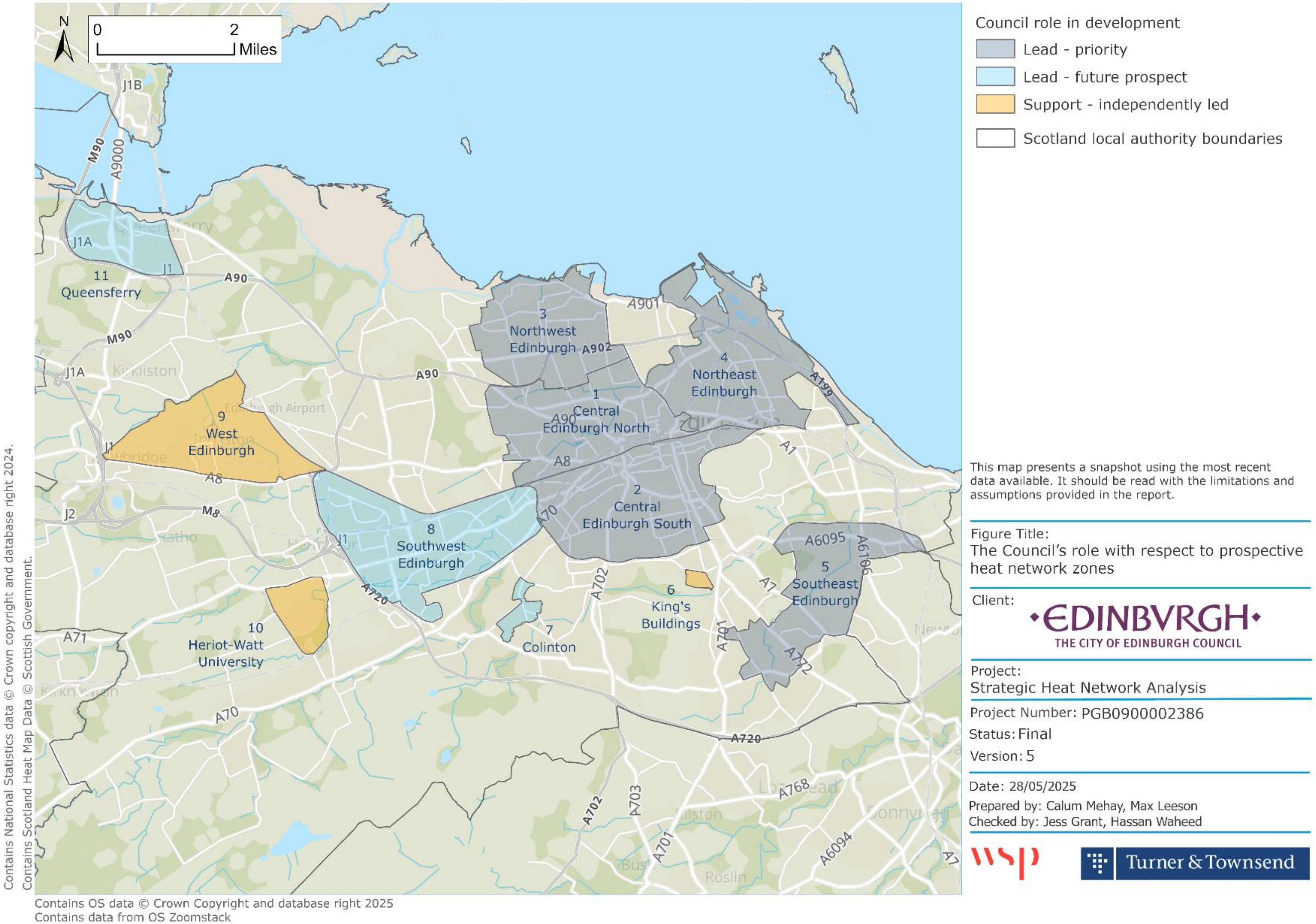


*Figure 59: The role of the Council with respect to each prospective heat network zone.*

## 11.5 Conclusions on delivery strategy and recommendations

Our analysis indicates that the most effective strategy for decarbonising majority of Edinburgh's built environment is via a city-wide heat network, affirming the Edinburgh LHEES vision. We find that a network of this scale requires a spinal route and primary heat sources, along with secondary heat where available.

We consider the Council's role to be central in developing the city-wide heat network, and the heat network delivery programme initially identified in the Edinburgh LHEES as the primary means for operationalising this role. We also consider the role of the Scottish Government, HNSU, public bodies and other partners to be instrumental in enabling this work.

We highlight the Gateway Zones as a priority, facilitating the parallel development of primary heat sources, spinal route and zonal networks to their greatest viable extent. Specifically, we consider *Zone 4 – Northeast Edinburgh* and the primary and secondary heat sources within this to be a key to a city-wide heat network. It will also be important to continue backing existing heat network developments at Granton Waterfront and Edinburgh Airport as important early successes, routes to gain experience, and instil market confidence.

Below we make twenty recommendations for the Council to consider for its programme in five sets: four sets mirroring the four objectives of this analysis and one set of recommendations on stakeholder engagement.

### 11.5.1 Heat sources

The Council should consider the following recommendations with respect to heat sources:

1. Develop a case for primary heat sources, focusing on evolving these into strategic energy assets, at the Port of Leith, followed by supporting this at Cockenzie and thereafter Monktonhall Colliery[96]. Primary heat sources are yet untested, and rigorous analysis is required before the Council can rely on them.
    a. The Council should place primary heat sources as core aspects of feasibility analysis, detailed project development work, business cases and commercialisation of the Gateway Zones. These should be fully integrated and developed as one, starting with the inclusion of Port of Leith in the feasibility for *Zone 4 – Northeast Edinburgh* and thereafter inclusion of the other two primary heat sources in the feasibility for *Zone 5 – Southeast Edinburgh* (further discussed in section 11.5.3).
    b. The Council would be well-placed to play a key role in facilitating the development of primary heat sources in neighbouring local authorities. This is partly because Edinburgh is the largest heat customer with a major stake in the approach and subsequent price of heat it can achieve and partly because the combined resources and coordination of local authorities will improve chances of success.
    c. Developing primary heat sources will need sustained backing from a coalition of stakeholders. The Council should consider one or multiple working groups/boards (depending on the heat source) enlisting East Lothian Council, Midlothian Council, HNSU, SPEN, relevant renewable energy suppliers, Scottish Water Horizons, Scottish Environmental Protection Agency, and the Mining Redemption Authority. The Council should also identify other core and non-core stakeholders to engage. This group should critically assess our analysis and thereafter support the Council in unblocking barriers as it progresses through the planning and development stages.
2. Conduct up-front data collection on sewer heat and mine water heat by funding monitoring and verification studies. Given these are most beneficial with one or multiple years of data, installation of appropriate equipment to begin collating the required data should be considered.
3. Reach out to the secondary heat source owners identified to gather data and potential support for supplying the network. Develop stakeholder profiles with preferences, risks and the likelihood and desirability of sourcing heat from the asset.
4. Continue scanning and appraising potential waste heat sources (e.g. distillery, data centres, etc.) and other new primary and secondary heat source opportunities.

[96] We have already established Port of Leith's precedence over Cockenzie as a development opportunity. Monktonhall Colliery is third in precedence as the heat potential is less certain (the mine water could be a closed system and/or require recharging or, equally, the potential could be far greater than anticipated). Therefore, it should first be further investigated.

### 11.5.2 Zone refinement

The Council should consider the following recommendations with respect to zone refinement:

5. In anticipation of the upcoming regulatory regime, prepare pilot zones to designate. These could be parts of a zone rather than a full zone, or a small zone with a key stakeholder[97]. The designation and regulation process will help the Council test and learn, preparing it to utilise these tools more effectively at scale. As part of this process, the Council can seek clarity on statutory and regulatory matters from the Scottish Government, including powers and responsibilities of all parties.
6. Assess further analysis required to refine boundaries ahead of formal designation of full zones. However, the Council should await further clarity on regulation, allowing the regime to be fully established before it decides to refine boundaries accordingly.
7. The Edinburgh LHEES focuses on area-wide decarbonisation and energy efficiency priorities as much as it does on heat networks. It is important to align this analysis with that of the current LHEES plans, including synergies with area-wide projects on energy efficiency, and clear distinctions between heat pump and heat network zones. This should also inform grid upgrade plans alongside SPEN as schemes are predicated on the availability of grid capacity. Further, the Council's delivery model should also consider the potential for a wider LHEES delivery vehicle. Whether this is the same delivery vehicle for both heat networks and a wider LHEES remit, or distinct delivery vehicles is a matter for the Council to consider.

### 11.5.3 Zone feasibility

The Council should consider the following recommendations with respect to zone feasibility:

8. Take forward detailed feasibility studies for *Zone 4 – Northeast Edinburgh*, followed by *Zone 5 – Southeast Edinburgh*, with support from the HNSU. These should consider, both, primary heat sources and spinal routes alongside secondary and other heat sources (e.g. ASHPs) as parallel developments.
9. A technoeconomic options appraisal should help develop the best network configuration and heat sources for each zone, as well as the ideal configuration for the primary heat sources as strategic energy assets. For example, for *Zone 4 – Northeast Edinburgh* this should:
    a. Analyse the Gateway approach: begin with appraising all scenario options for networks from small-scale networks based on the lowest friction path of development (e.g. small network(s) based on sewer source heat) to a fully-realised zonal network with the potential to expand into other zones via a spinal route. These should be compared with building-level ASHPs as a counterfactual. This will establish the basis for the required combination of heat sources for each scenario as well as the phasing and financial performance required for this to be investible on a standalone basis. This will provide the basis for an investment decision, providing the evidence to support safeguarding land, oversizing energy centres and pipes, and other actions which enable future expansion into the city (as well as the cost of not doing so).
    b. Demand profiles: for each scenario, establish types of anchor loads and their heat demand profile, along with a strategic assessment of load types (e.g. if it is reliant on private sector buildings less likely to commit to connecting, or if there are willing public sector or Council buildings which are eager to connect). The feasibility should also be informed by engagement and data collected from key anchor loads wherever possible to gain higher degrees of certainty on heat demand: building surveys of key anchor loads, half-hourly energy modelling based on metered data, and engagement with stakeholders (off-takers, anchor customers) to understand needs and potential to connect.
    c. Detailed options appraisal and technoeconomic analysis for each scenario: for example, for the fully-realised zonal network develop optimal technology options for the Port of Leith as a strategic energy asset (see section 11.2), understanding how the lowest cost electricity can be achieved from a potential private connection to offshore wind (e.g. via East Lothian), bulk electricity procurement, utilising flexible tariffs in combination with local electricity/heat storage to find the best combination of storage for the limited space, and import/export grid balancing options as a means to generate revenue. The analysis should also prioritise use of secondary heat sources and optimise the locations of energy centres/heat substations (alongside their plant/storage recommendations, if any).

[97] Pilot of a full zone might be preferable over a partial zone as it would avoid splitting an existing zone with further potential complexities.

d. As the inception of the spinal routes, *Zone 4 – Northeast Edinburgh* will define their route, specification and role in the short-term (for Zone 4) and the long-term (the viable expansion route(s) throughout the rest of the zones). It is critical for this feasibility to clearly establish this through rigorous technoeconomic analysis. This work is covered in 11.5.4.

e. Network route and energy centre analysis: site surveys, network route walks and utility surveys to develop zonal network routes to take forward, highlighting the specific route, and specifications, length and costs of pipe. This would also identify energy centre and heat substation requirements and preferred locations, helping the Council to initiate discussions with stakeholders. Major and minor constraints should also be identified.

f. Phasing: approach to phasing technologies identified via the scenarios. The analysis should investigate the greatest viable network expansion in balance with the lowest possible cost of heat achievable, and the relevant specifications of infrastructure could underpin procurement objectives and scope of requirements for the delivery vehicle. Wherever relevant, this should aim to avoid constraining network reach and future expansions at the expense of marginal short-term economic gains.

g. Enablement: highlight the power requirements, grid upgrades, risk appraisal, and ease of deliverability for phases (e.g. practicality of running pipe or developing an energy centre).

h. Stakeholder engagement: work closely with all relevant stakeholders, including utilities, off-takers and anchor loads, regulators, and others to inform analysis and decision-making.

i. Coolth: due to a changing climate, Edinburgh may face increasing need for cooling. While this was outside the scope of our analysis, the Council could investigate the potential feasibility for the city-wide heat network to supply, support or enable this, whether as part of the feasibility study or separately in the longer-term.

### 11.5.4 Spinal route

The Council should consider the following recommendations with respect to spinal routes, all included as part of the *Zone 4 – Northeast Edinburgh* feasibility study recommended previously in 11.5.3:

10. The spinal routes we have developed are indicative only and many parts of these are uncosted. The feasibility study should include a technoeconomic investigation of various scenarios for spinal route(s) based on the most viable route options, constraints and opportunities, and considering future recommendations in section 11.5.1. The spinal route scenarios should align with the scenarios being considered for the Zone 4 zonal networks (discussed in section 11.5.3). Where Cockenzie and Monktonhall Colliery are involved, this part of the study should jointly involve East Lothian Council and Midlothian Council, respectively.
11. The should also consider the options beyond Zone 4 to provide a future-proofed approach which can practically and cost-effectively reach Central Zones and Expansion Zones. In effect, this part of the feasibility study would extend beyond *Zone 4 – Northeast Edinburgh* to factor in the long-term implications of an investment decision at a high-level. This would factor in the opportunity loss of not having a spinal route across the other zones as a core aspect of the investment case, ensuring that an investment decision for Zone 4 is taken with the strategic objective of a city-wide heat network in mind.
12. The feasibility study should provide clear short-term and long-term economics metrics for the scenarios (CAPEX, OPEX, revenue, return etc.) to inform an investment decision.

### 11.5.5 Stakeholder engagement

The Council should consider the following recommendations with respect to stakeholder engagement:

13. A clear stakeholder engagement and communication strategy which identifies who, when and why the Council will engage on each of the preceding four areas of work. Engagement activities should be defined with a clear purpose. The strategy should be underpinned with the objective of moving forward the heat network delivery programme, including the previous four areas of action highlighted.

14. Engagements defined through the strategy should lead from those conducted as part of this and the delivery models studies. The Council should be sensitive to engagement fatigue but balance this with the need for deeper engagement in key areas[98].
15. There is substantial and growing community interest in Edinburgh's heat networks. There is an opportunity for the Council to leverage this to boost its programme. The strength of the local community behind heat networks will add major confidence to investments. Ways of involving the community range from basic aspects such as events and workshops to more involved ways such as representation on or involvement in delivery vehicle(s) at various levels considered appropriate. Meaningful community involvement should feature as a prominent pillar of the Council's stakeholder engagement and communication strategy.
16. Practical engagement with other local authorities in Scotland (including Aberdeen City Council and Midlothian Council) and western Europe (including the Danish Board of District Heating) to assess the delivery models that have been used to deliver zonal and city scale heat networks, the benefits and drawbacks of these approaches, and the applicability of these lessons to the Edinburgh context. This would inform strategic thinking on structure of the delivery model for heat networks in the city and would be insightful for setting up the next stages of the programme for delivery success.
17. Internal engagement with all Council teams will help align actions and interests across new build and retrofit for both domestic and non-domestic properties owned by the Council. Engagement with planning teams will solidify the role of heat networks in the Local Development Plan, master-plans, safeguarding for routes and energy centres, providing confidence to instruct heat network connections[99], and other areas for planning consideration.
18. Engagement with potential anchor loads have been limited due to the intensive nature of reaching out and communicating with off-takers. However, we recognise the need to increase engagement in this area as work toward delivery progresses. As part of the strategy, the Council should develop a multi-faceted communications approach targeting broad and narrow audience segments with relevant messaging to build support for, interest in, and desire for connection to heat networks. This should spread awareness in alignment with other broader Council messaging on net zero and LHEES, but also help to progress developments in a practical way, especially in zones with more advanced plans.
19. Issuing high-level guidance for designing connection potential as part of new build and major heating system works. This could initially be shared with public bodies, social landlords and key organisations within Gateway Zones, but later disseminated more broadly. This has the potential to save money for future off-takers through a marginal investment to become heat network-ready where the opportunity presents itself.
20. The Council should consider taking an active role in engaging with the emerging regulatory and policy regime through constructive engagements with:
    a. Ofgem and the Scottish Government to provide practical input into the mechanisms being developed and to clearly detail the needs for a utility-scale city-wide heat network in Edinburgh.
    b. National Energy System Operator (NESO) to feed into Scotland's Regional Energy Strategic Plan (RESP), to help guide the approach to grid decarbonisation and renewable energy investments in a way which can support the Council's approach to heat networks. If and where NESO is limited in terms of an outlook purely on heat, the Council should stress on reclassifying primary heat sources as strategic energy assets with a potential remit beyond heat (e.g. grid balancing services, potential electricity storage, private wire usage of offshore wind etc.), and seek inclusion into RESP plans on these grounds.

[98] As an example, close engagement with SPEN will be critical to identify the most impactful grid improvements. The Council can include SPEN's existing plans within further analysis to align infrastructure developments and reduce cost/complexities where possible. The Council can also inform SPEN of its intentions and ambitions for primary heat sources, energy centres and other assets where plans for grid upgrades by SPEN should be concentrated.

[99] Under the NPF4, new developments can be instructed to connect to a heat network where they are in or adjacent to a heat network zone. This includes heat networks which are planned but not yet in place. The Heat in Buildings Bill may bring proposals for connections from existing buildings (see section 4.1.2.1).

# 12. Appendices

## 12.1 Feasibility review of individual zones

We have summarised the outputs of the economic assessment for each zone in tabular format in the following section. The tables provide key data on heat demands, primary plant sizing, costs and a brief commentary on the outputs.

For the seven zones we have conducted energy modelling, we provide the capacity of each heat source modelled, alongside the capacity of the WSHP used to convert the low temperature heat to high temperatures required for the heat network, and the capacity of the back-up/peaking gas boilers. Table 20 provides a worked example based on *Zone 1 – Central Edinburgh North*.

| Approach to primary plant equipment sizing | Example: *Zone 1 – Central Edinburgh North* |
|---|---|
| Low carbon heat sources sized to provide up to approximately 90% of the total annual heat demand:<br>▪ Secondary heat sources.<br>▪ ASHP sized to fulfil the deficit toward the 90% target. | Low carbon heat sources (**total 27MW**) providing 87% of the total annual heat demand:<br>▪ Sewer heat – **5.5 MW**<br>▪ ASHP – **21.5 MW** (fulfilling the deficit toward the 90% target) |
| WSHP sized to the total of all low carbon heat sources to boost the temperature. | WSHP (**27 MW**) to boost the temperature of the low carbon heat sources. |
| Gas boilers as back-up/peaking sized to the peak heat demand. | Gas boilers (**88 MW**) sized for the peak heat demand. |

*Table 20: An example of the energy centre configuration.*

The sections for each zone include a load duration curve for each zone; this shows the magnitude of the heat demand and the number of hours in a year for which the heat demand reaches a certain level. The y (vertical axis) shows the predicted heat demand, the x (horizontal) axis shows the number of hours per year ordered by magnitude of heat demand in each. This chart shows the amount of heat demand that is predicted to be met by each of the principal heat sources.

Note that feasibility review outputs are only available for the seven zones selected for this analysis.

This review does not constitute a detailed feasibility and is based on the best data available to us. A detailed feasibility should investigate aspects discussed in section 11.5.3.

Alongside the economic analysis of each zone, we have provided two maps:

- Zone boundary refinement process: a map detailing the updates made to zones with reference to the Edinburgh LHEES zones.
- Heat sources and networks: a map showing the available secondary heat sources, spinal route, and existing and planned heat networks. This also presented the proposed anchor network we generated as part of zonal network routing.

### 12.1.1 Zone 1 – Central Edinburgh North

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **24,708**<br>Total number of buildings | **572,200 MWh/year**<br>Heat demand (all buildings) | **84**<br>Number of anchor loads | **117,573 MWh/year**<br>Heat demand (anchor loads) |
| Economics | **£252m**<br>CAPEX | | **16.7 p/kWh**<br>LCOH | **12.3 p/kWh**<br>LCOH (with 50% grant funding) |
| Energy modelling | **129,331 MWh/year**<br>Network demand inc. losses | **88 MW**<br>Network peak demand | **Sewer heat – 5.5 MW**<br>Secondary heat sources in zone | |
| Energy modelling | **Sewer heat – 5.5 MW**<br>**ASHP – 21.5 MW**<br>**WSHP – 27 MW**<br>**Gas boilers – 88 MW**<br>Generation equipment sizing | | **4,296 m² for energy centre**<br>**2,010 m² for ASHPs**<br>Total energy centre GIA required | |
| Energy modelling | **34%**<br>% heat load met by secondary heat sources (exc. ASHP) | | **87%**<br>% heat load met by low carbon sources (inc. ASHP) | |

#### Observations

*Zone 1 – Central Edinburgh North* is one of the largest zones with respect to heat demand and covers the north of the city centre, including New Town, West End, Roseburn, Murrayfield, Blackhall and Stockbridge. Whilst the base load of the heat demand can be covered by heat from the sewers, it is likely that a spinal connection is required to enable development, given space constraints.

For the purposes of economic modelling, we use 27 MW of heat pumps to serve 87% of the annual heat demand with low carbon heat. This includes 54% from air source heat and should heat from a spinal route be made available, this percentage would be reduced or eliminated.

The capital expenditure for construction of this zone network and energy centre is estimated to be around £252m in a theoretical set up with air source heat, with a LCOH figure of 16.7 p/kWh.

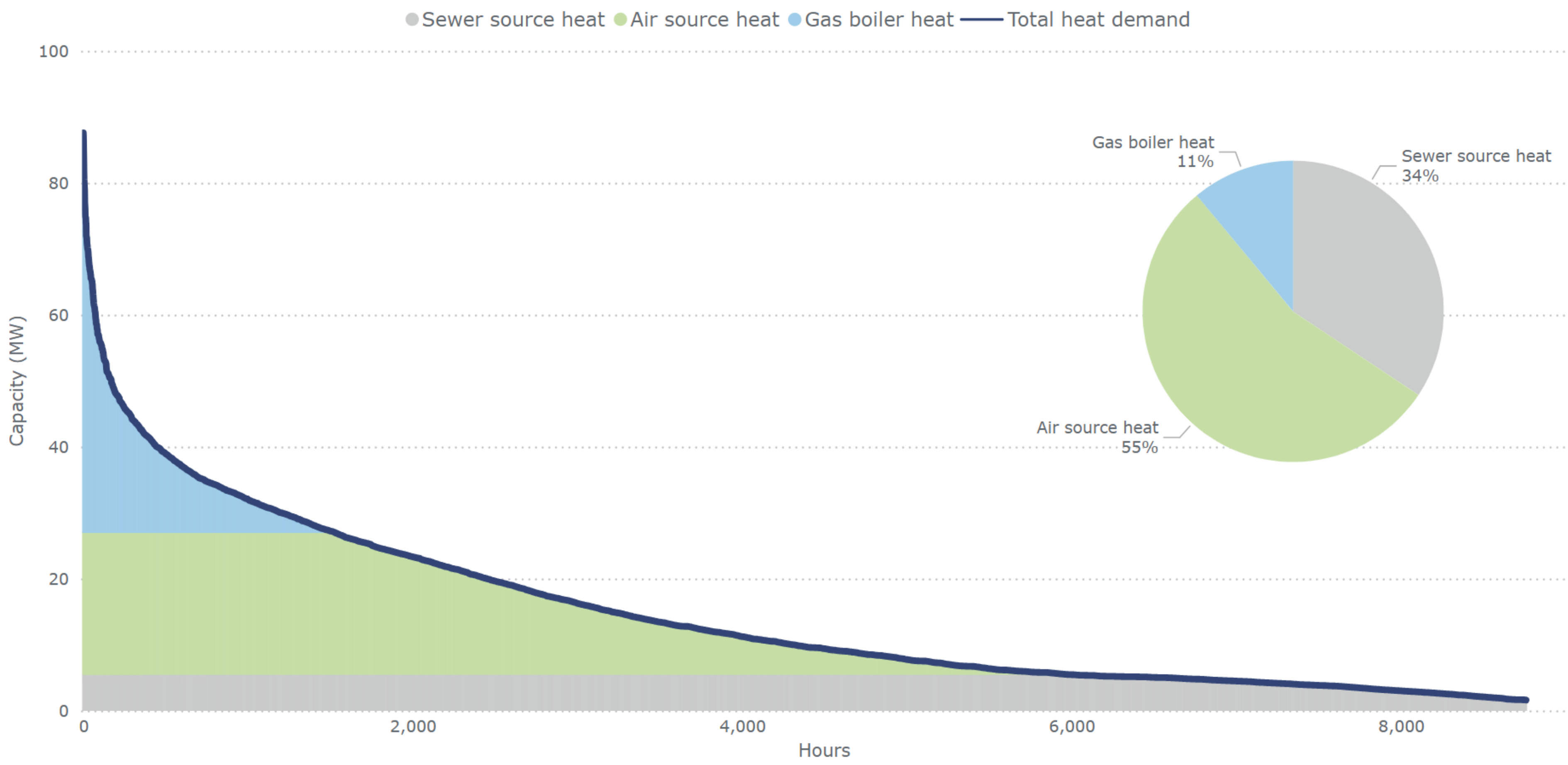


*Figure 60: Load duration curve for Zone 1 – Central Edinburgh North.*

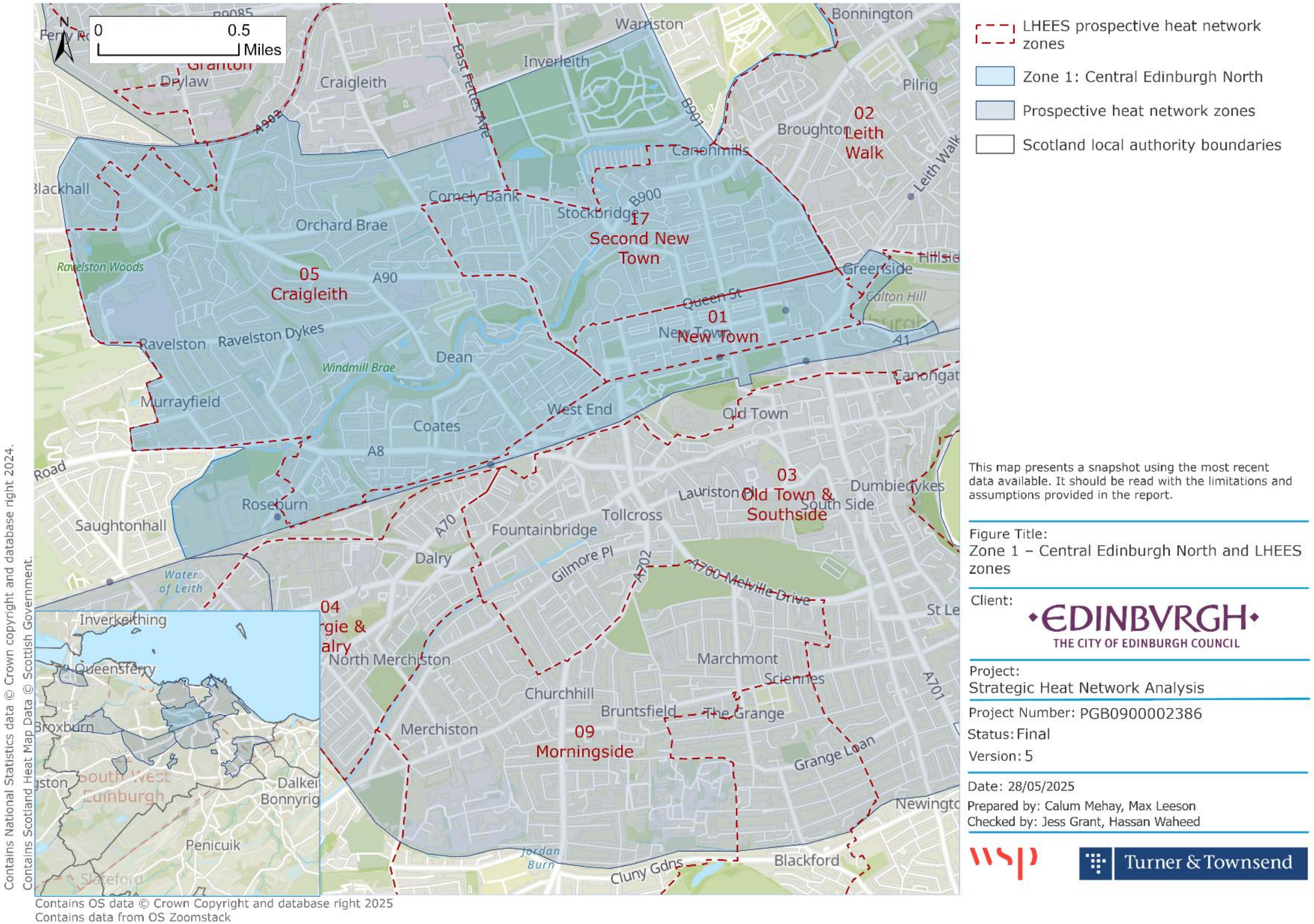


*Figure 61: Zone 1 – Central Edinburgh North now combines the previous zones of New Town, Second New Town, and Craigleith. The boundary is also extended further south, with the main constraint being the rail line. This ensures that there are no areas of buildings within the centre of the city which remain as 'islands', i.e. surrounded by zones but not within a zone themselves. The zone now also includes the previously excluded area of Inverleith and also expanded to include more previously excluded areas in its western corners.*

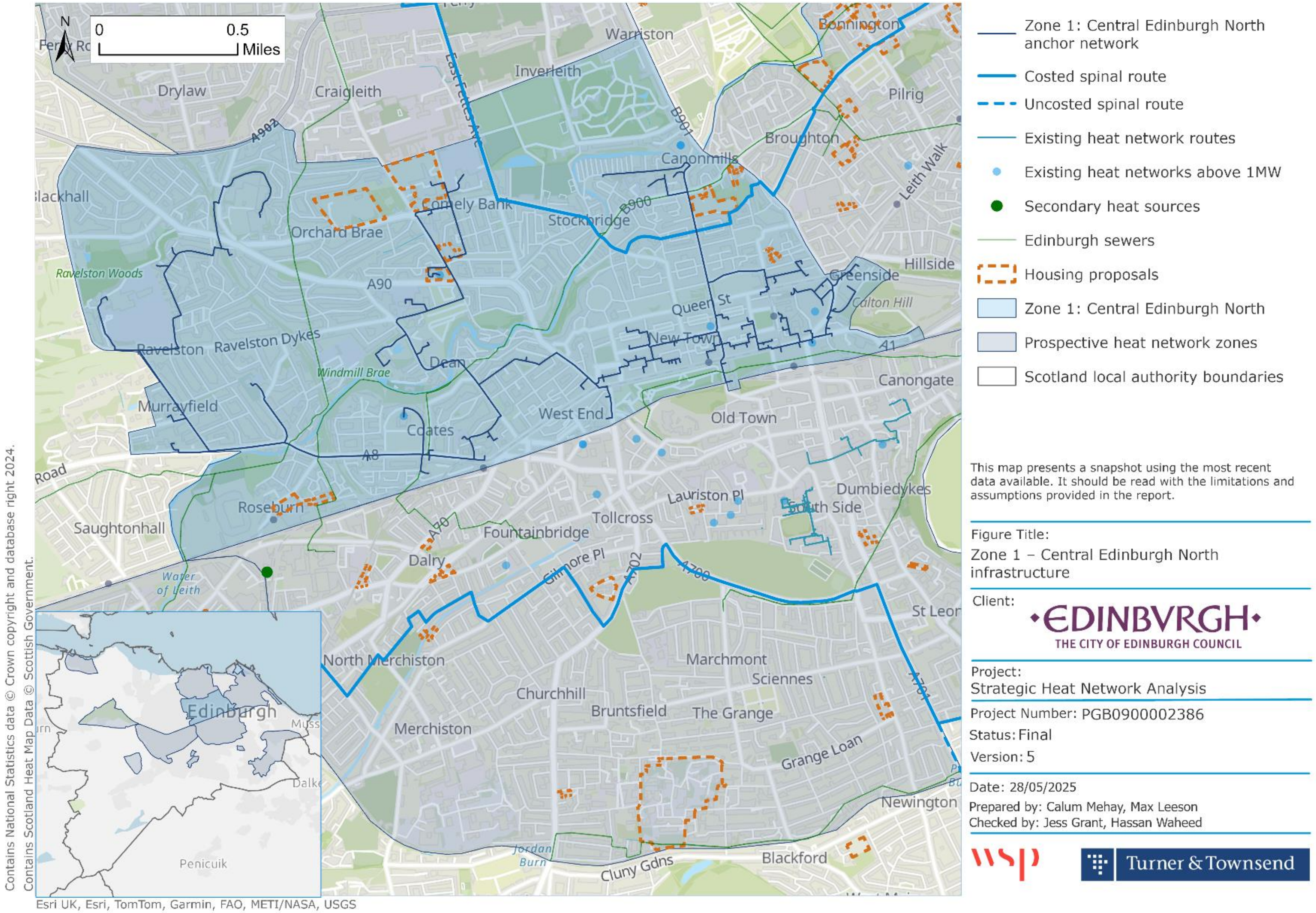


*Figure 62: Zone 1 – Central Edinburgh North boundaries, heat sources, anchor network and spinal routes.*

### 12.1.2 Zone 2 – Central Edinburgh South

| Headline figures | | | | | | |
|---|---|---|---|---|---|---|
| Heat demand | **50,305**<br>Total number of buildings | **909,487 MWh/year**<br>Heat demand (all buildings) | | **134**<br>Number of anchor loads | **237,153 MWh/year**<br>Heat demand (anchor loads) | |
| Economics | **£394m**<br>CAPEX | | | **14.6 p/kWh**<br>LCOH | **11.1 p/kWh**<br>LCOH (with 50% grant funding) | |
| Energy modelling | **260,868 MWh/year**<br>Network demand inc. losses | **151 MW**<br>Network peak demand | | **Sewer heat – 1 MW**<br>**Distillery – 3.3 MW**<br>Secondary heat sources in zone | | |
| Energy modelling | **Sewer heat – 1 MW**<br>**Distillery – 3.3 MW**<br>**ASHP – 45 MW**<br>**WSHP – 49.3 MW**<br>**Gas boilers – 151 MW**<br>Generation equipment sizing | | | **7,716 m² for energy centre**<br>**4,208 m² for ASHPs**<br>Total energy centre GIA required | | |
| Energy modelling | **14%**<br>% heat load met by secondary heat sources (exc. ASHP) | | | **87%**<br>% heat load met by low carbon sources (inc. ASHP) | | |

## Observations

*Zone 2 – Central Edinburgh South* has the greatest heat demand among all zones and covers the south of the city centre, including Old Town, Fountainbridge, Merchiston and Newington. A small proportion of the heat demand can be covered by heat from the sewers and potentially, waste heat from a distillery, it is likely that air source heat pumps will be required to supplement the low carbon heat generation to the extent viable (given space constraints) until a spinal connection arrives.

For the purposes of economic modelling, we use 49.3 MW of heat pumps to serve 87% of the annual heat demand with low carbon heat. This includes 73% from air source heat. Should other sources of low carbon heat be made from further afield, such as via a spinal network, and should heat from a spinal route be made available, this percentage could be reduced or eliminated.

The capital expenditure for construction of this zone network and energy centre is estimated to be around £394m in a theoretical set up with air source heat pumps, with a LCOH figure of 14.6 p/kWh.

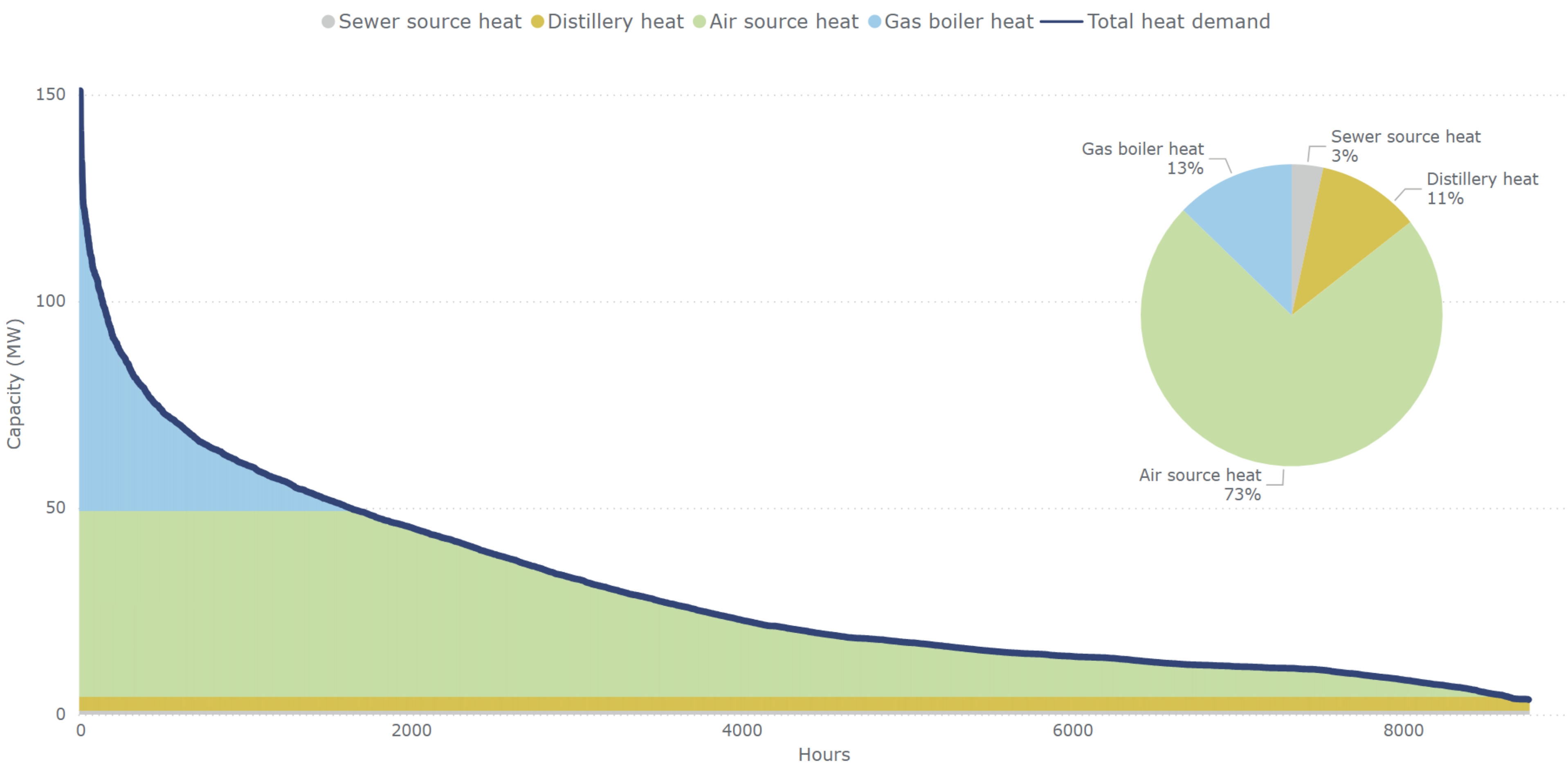


*Figure 63: Load duration curve for Zone 2 – Central Edinburgh South.*

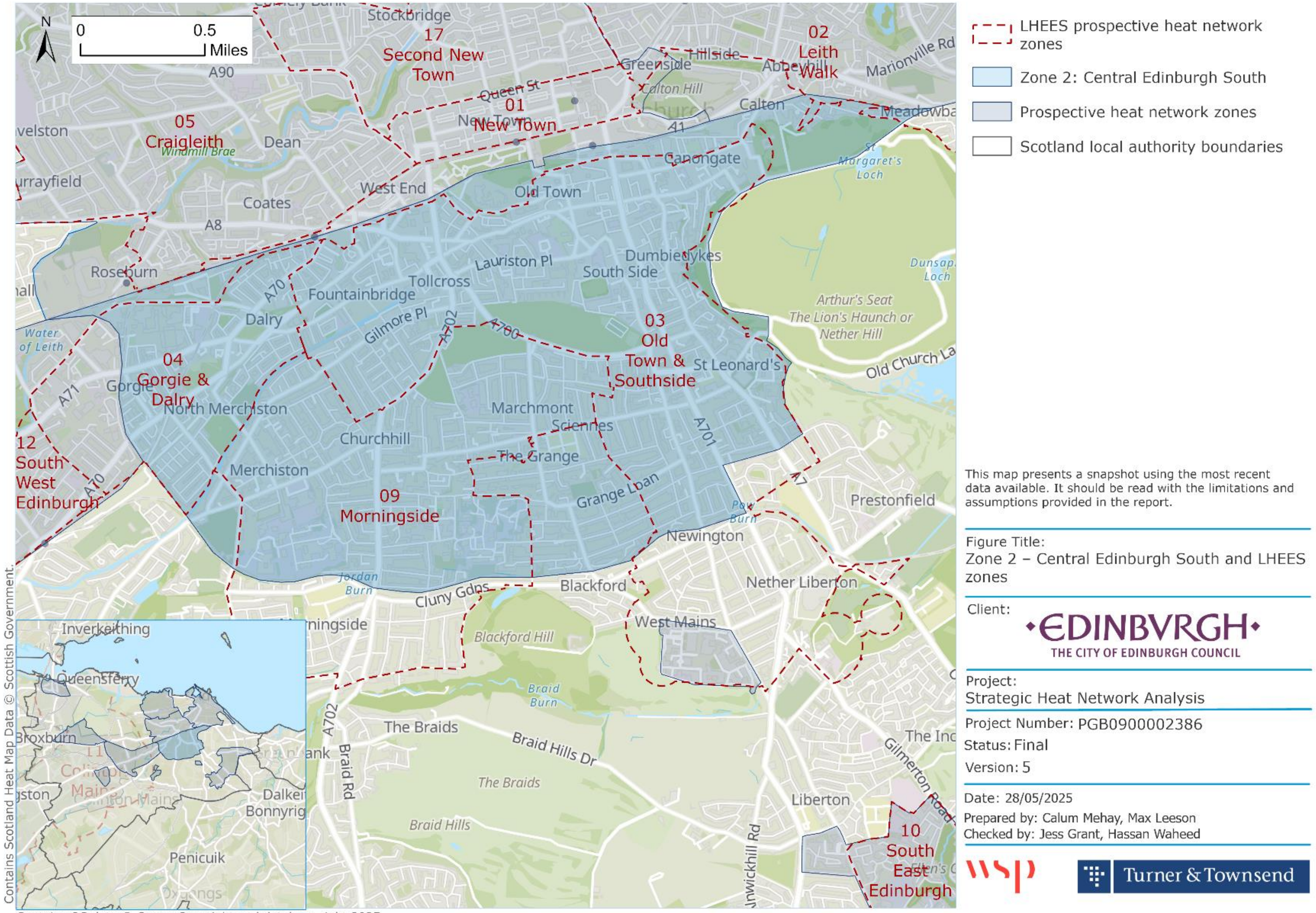




*Figure 64: Zone 2 – Central Edinburgh South covers much of the centre of the city south of the main railway line. It combines the previous zones Old Town & Southside, Gorgie & Dalry, and Morningside but excludes the King's Buildings (separated out as Zone 6 – King's Buildings). Similarly to zone 1, it has been stretched slightly to avoid any 'islands' which do not sit within a zone. The zone has also been extended in minor locations due to sufficient heat demand or other compelling factors.*

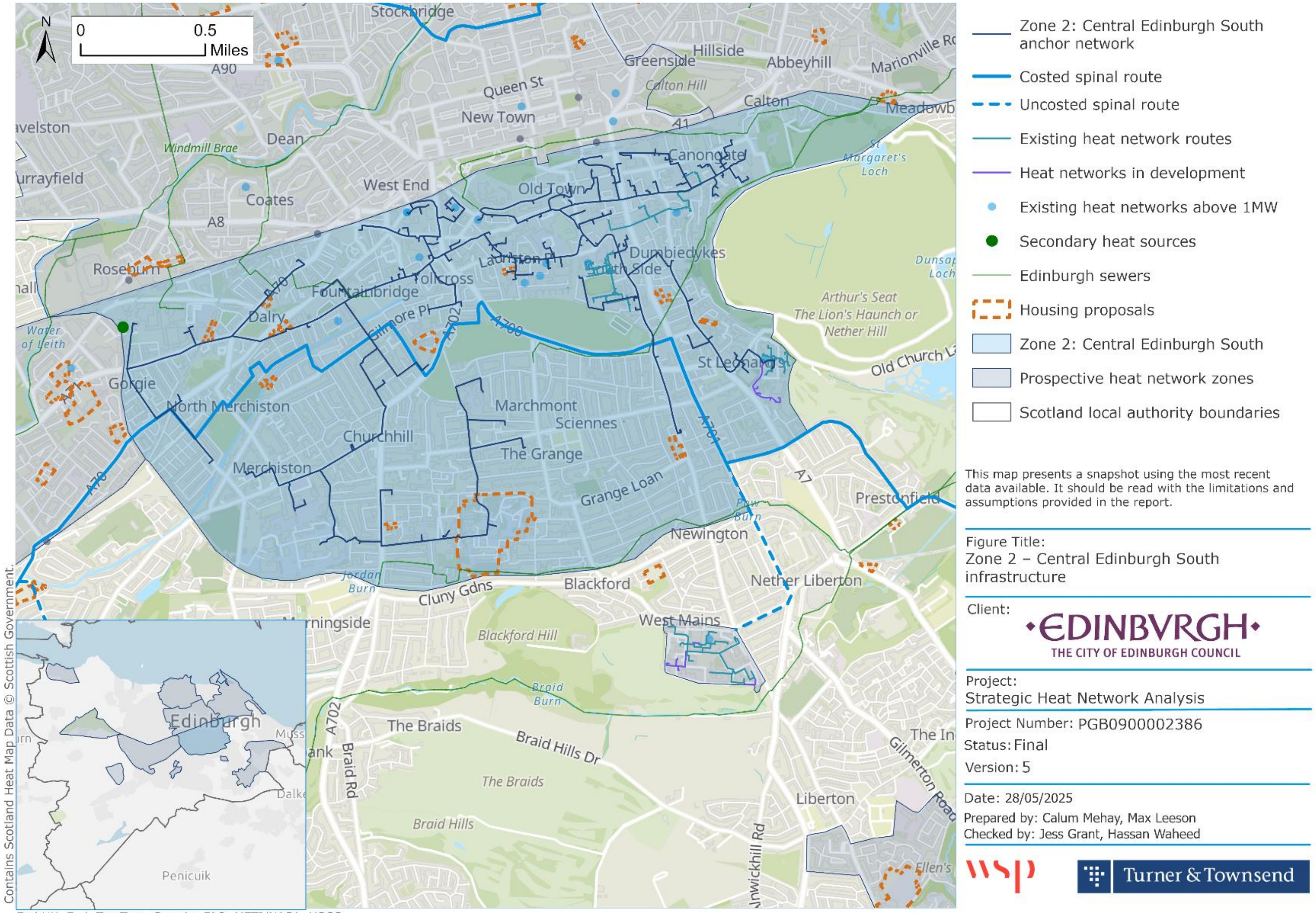




*Figure 65: Zone 2 – Central Edinburgh South boundaries, heat sources, anchor network and spinal routes.*

### 12.1.3 Zone 3 – Northwest Edinburgh

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **18,543**<br>Total number of buildings | **287,565 MWh/year**<br>Heat demand (all buildings) | **34**<br>Number of anchor loads | **119,078 MWh/year**<br>Heat demand (anchor loads) |

## Observations

*Zone 3 – Northwest Edinburgh* has the fourth largest anchor load heat demand and sixth largest total heat demand among all zones. It covers Pilton, Granton, Muirhouse, Craigleith and Inverleith. We have not carried out a feasibility review for this zone as there is an ongoing heat network development at Granton. The Council has already conducted a detailed feasibility and business case for this heat network, along with an appointment of a proposed concessionaire to develop and operate it.

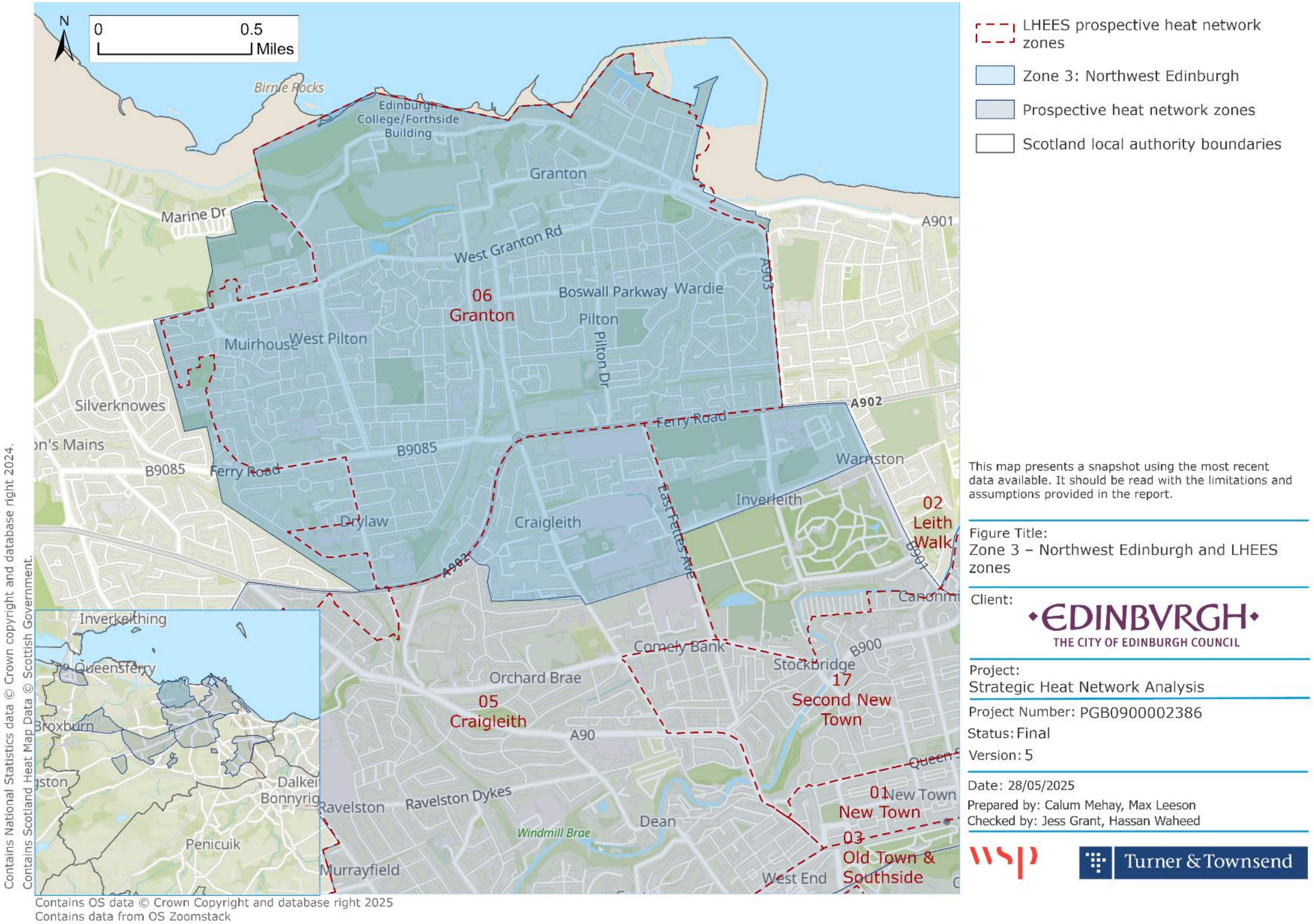


*Figure 66: Zone 3 – Northwest Edinburgh covers much of the city's northwestern urban and suburban areas. It has been kept mostly in line with its predecessor, LHEES Zone 6 – Granton, to maintain continuity for the Granton Waterfront heat network. However, we extended it slightly to the south to include Western General Hospital and areas of Inverleith. We also extended parts of the zone westward to account for viable heat demand and other compelling factors.*

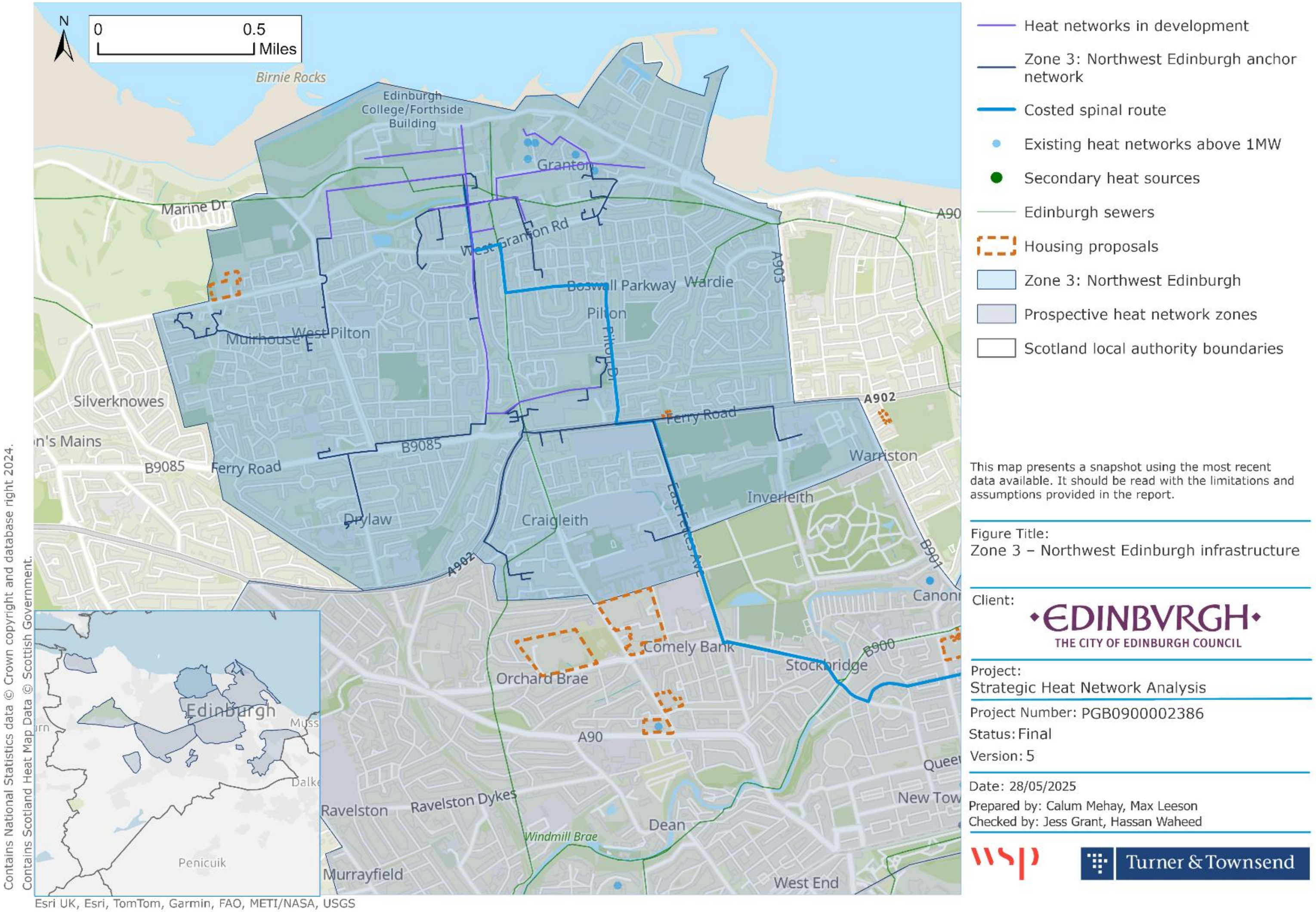


*Figure 67: Zone 3 – Northwest Edinburgh boundaries, heat sources, and spinal routes.*

### 12.1.4 Zone 4 – Northeast Edinburgh

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **44,522** Total number of buildings | **798,839 MWh/year** Heat demand (all buildings) | **90** Number of anchor loads | **76,588 MWh/year** Heat demand (anchor loads) |
| Economics | **£238m** CAPEX | | **19.6 p/kWh** LCOH | **13.2 p/kWh** LCOH (with 50% grant funding) |
| Energy modelling | **84,246 MWh/year** Network demand inc. losses | **53 MW** Network peak demand | **Seafield WWTW – 8.5 MW**<br>**Sewer heat – 10 MW** Secondary heat sources in zone | |
| Energy modelling | **Seafield WWTW – 8.5 MW**<br>**Sewer heat – 10 MW**<br>**WSHP – 18.5 MW**<br>**Gas boilers – 53 MW** Generation equipment sizing | **2,880 m² for energy centre** Total energy centre GIA required | | |
| Energy modelling | **88%** % heat load met by secondary heat sources (exc. ASHP) | **88%** % heat load met by low carbon sources (inc. ASHP) | | |

## Observations

*Zone 4 – Northeast Edinburgh* only has a moderate heat demand when considering only the anchor loads. However, its total heat demand (for all loads) is 10.4x greater than its anchor load heat demand and is the second largest among all zones. It covers the area to the northeast of the city, including Leith, Broughton, Bonnington, Lochend and the proposed Seafield development area.

A sizeable proportion of the anchor load heat demand can be covered by heat from the Seafield WWTW and the sewers, thus, air source heat pumps have not been modelled. With 18.5 MW of waste water source heat pump, it is possible to serve 88% of the annual heat demand with low carbon heat. The CAPEX figure for this zone is estimated to be around £238m, with a LCOH figure of 19.6 p/kWh.

When the total heat demand of all loads is considered, this will be inadequate. The Port of Leith sea source heat pump, a primary heat source, is proposed within this zone. While this could not be considered in this study, we recommend this to be a central part of any future feasibility analysis on this zone.

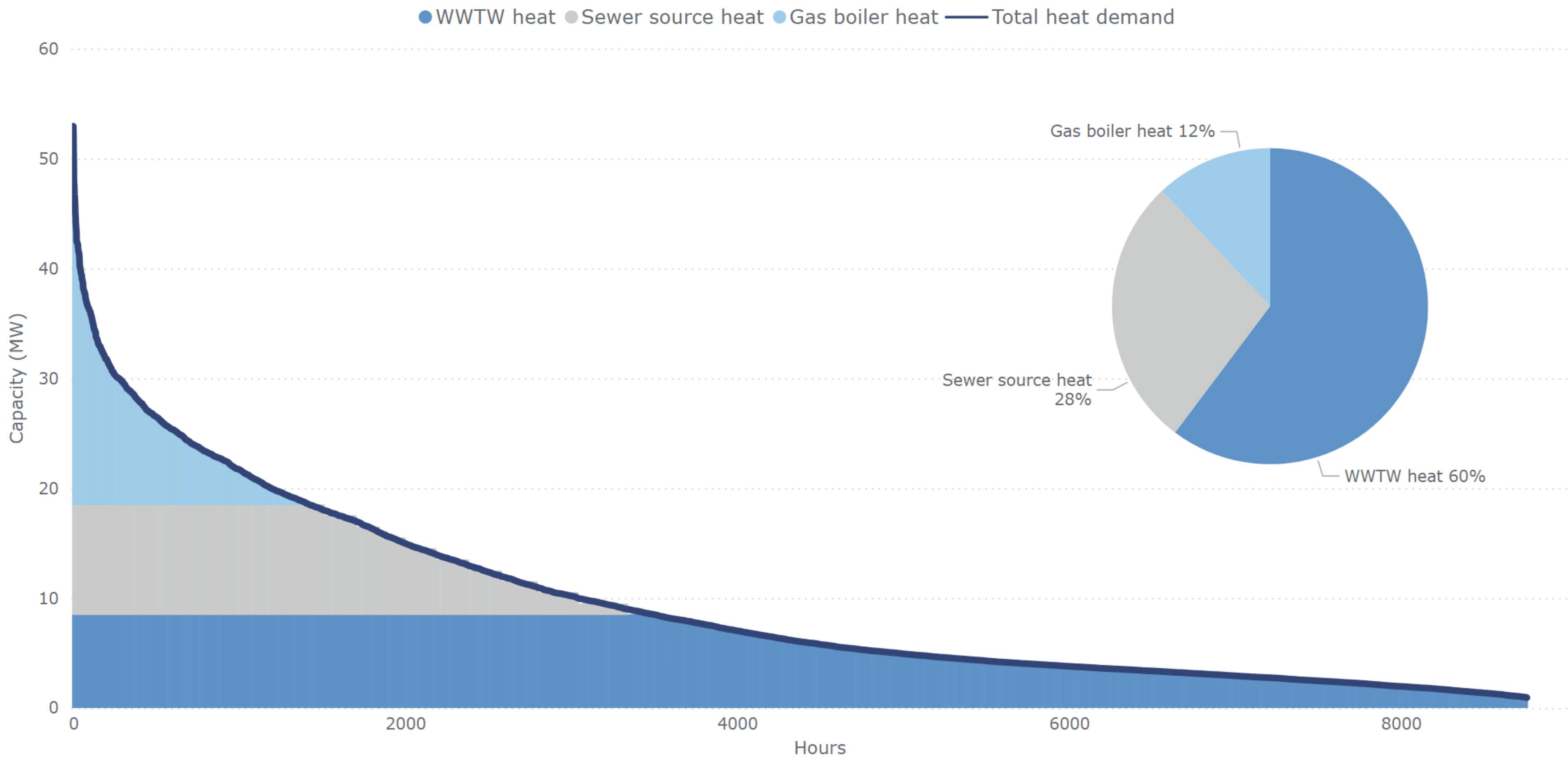


*Figure 68: Load duration curve for Zone 4 – Northeast Edinburgh.*

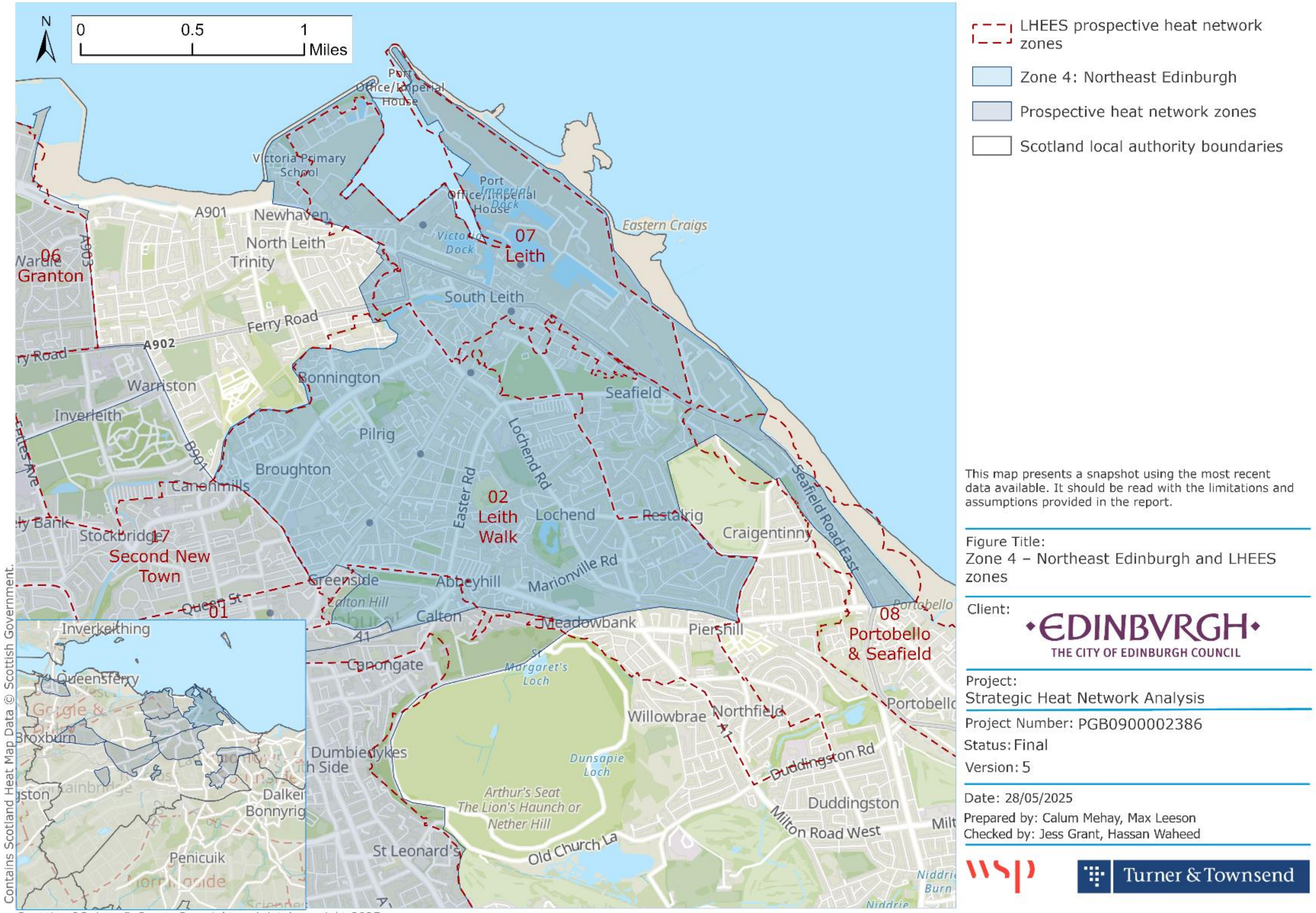




*Figure 69: Zone 4 – Northeast Edinburgh Covers the historic area of Leith and its surroundings. We combined three previous zones into one more consolidated opportunity and extended or removed parts of these to better reflect the heat density and other compelling factors. Much of Portobello has been excluded due to lower heat density in the available data, although there is potential to revisit this with more up-to-date data. This zone retains the area of the new development at Seafield.*

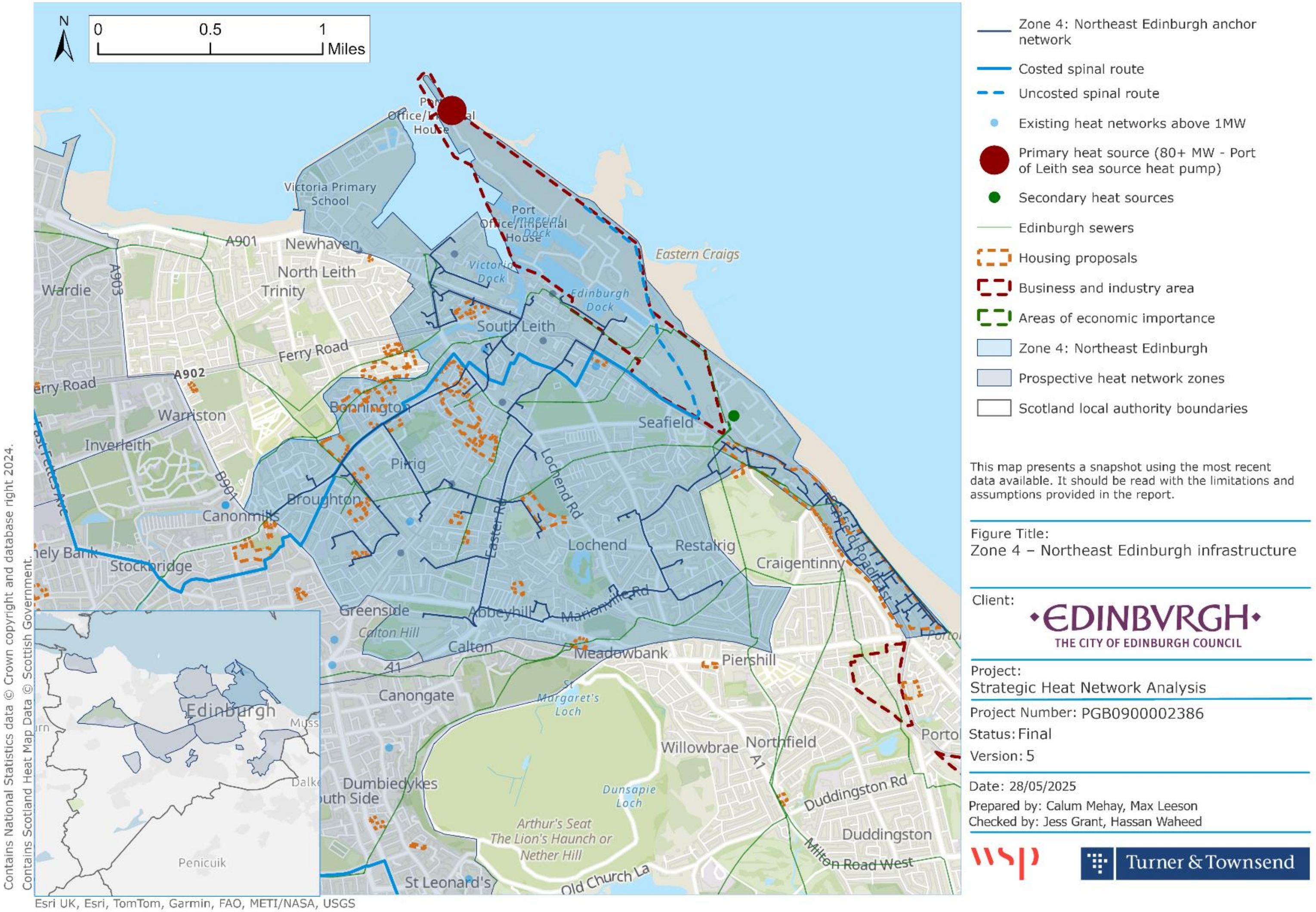


*Figure 70: Zone 4 – Northeast Edinburgh boundaries, heat sources, anchor network and spinal routes.*

### 12.1.5 Zone 5 – Southeast Edinburgh

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **12,327** Total number of buildings | **308,968 MWh/year** Heat demand (all buildings) | **45** Number of anchor loads | **178,050 MWh/year** Heat demand (anchor loads) |
| Economics | **£267m** CAPEX | | **13.3 p/kWh** LCOH | **10.2 p/kWh** LCOH (with 50% grant funding) |
| Energy modelling | **195,855 MWh/year** Network demand inc. losses | **89 MW** Network peak demand | **Millerhill EfW – 11.6 MW**<br>**Sewer heat – 4.4 MW** Secondary heat sources in zone | |
| Energy modelling | **Millerhill EfW – 11.6 MW**<br>**Sewer heat – 4.4 MW**<br>**ASHP – 19.6 MW**<br>**WSHP – 24 MW**<br>**Gas boilers – 89 MW** Generation equipment sizing | | **3,924 m² for energy centre**<br>**1,833 m² for ASHPs** Total energy centre GIA required | |
| Energy modelling | **59%** % heat load met by secondary heat sources (exc. ASHP) | | **88%** % heat load met by low carbon sources (inc. ASHP) | |

## Observations

*Zone 5 – Southeast Edinburgh* has the second largest anchor load heat demand and fifth largest total heat demand among all zones. It covers the area to the southeast of the city, including Fort Kinnaird, Niddrie, Moredun, Gracemount, and Edinburgh BioQuarter.

Whilst the base load of the heat demand can be covered by heat from the Millerhill EfW and the sewers, we have modelled ample ASHPs to increase the low carbon heat generation for portions of the demand peaks. With 24 MW of heat pump and 11.6 MW from the Millerhill EfW site, it is possible to serve 88% of the annual heat demand with low carbon heat. Of this, 28% is served by ASHPs. This assumes the full build out of the BioQuarter development. It may be that some or all ASHPs may not be required should heat from a spinal route become available.

The CAPEX figure for this zone is estimated to be around £267m, with a LCOH figure of 13.3 p/kWh.

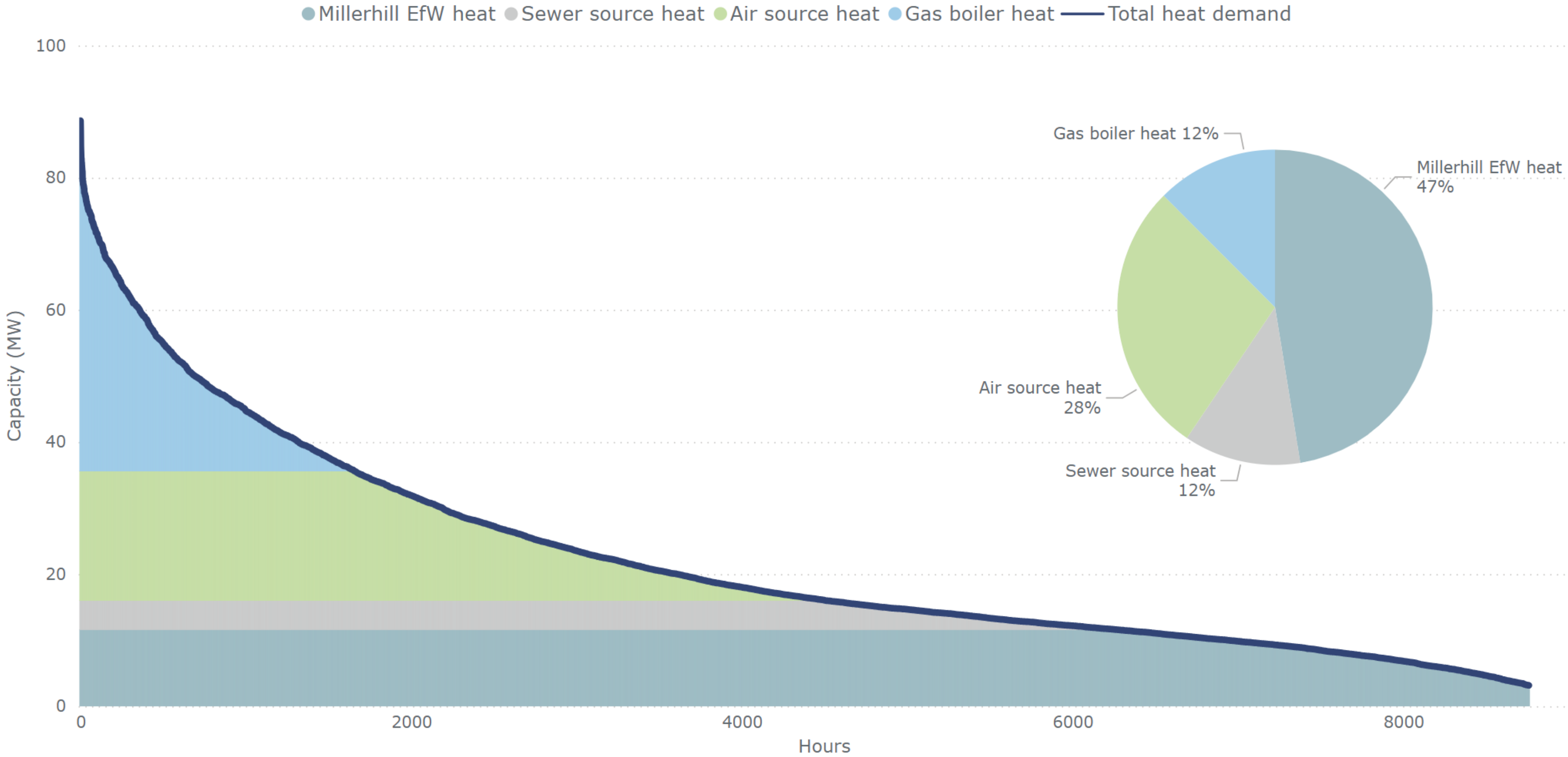


*Figure 71: Load duration curve for Zone 5 – Southeast Edinburgh.*

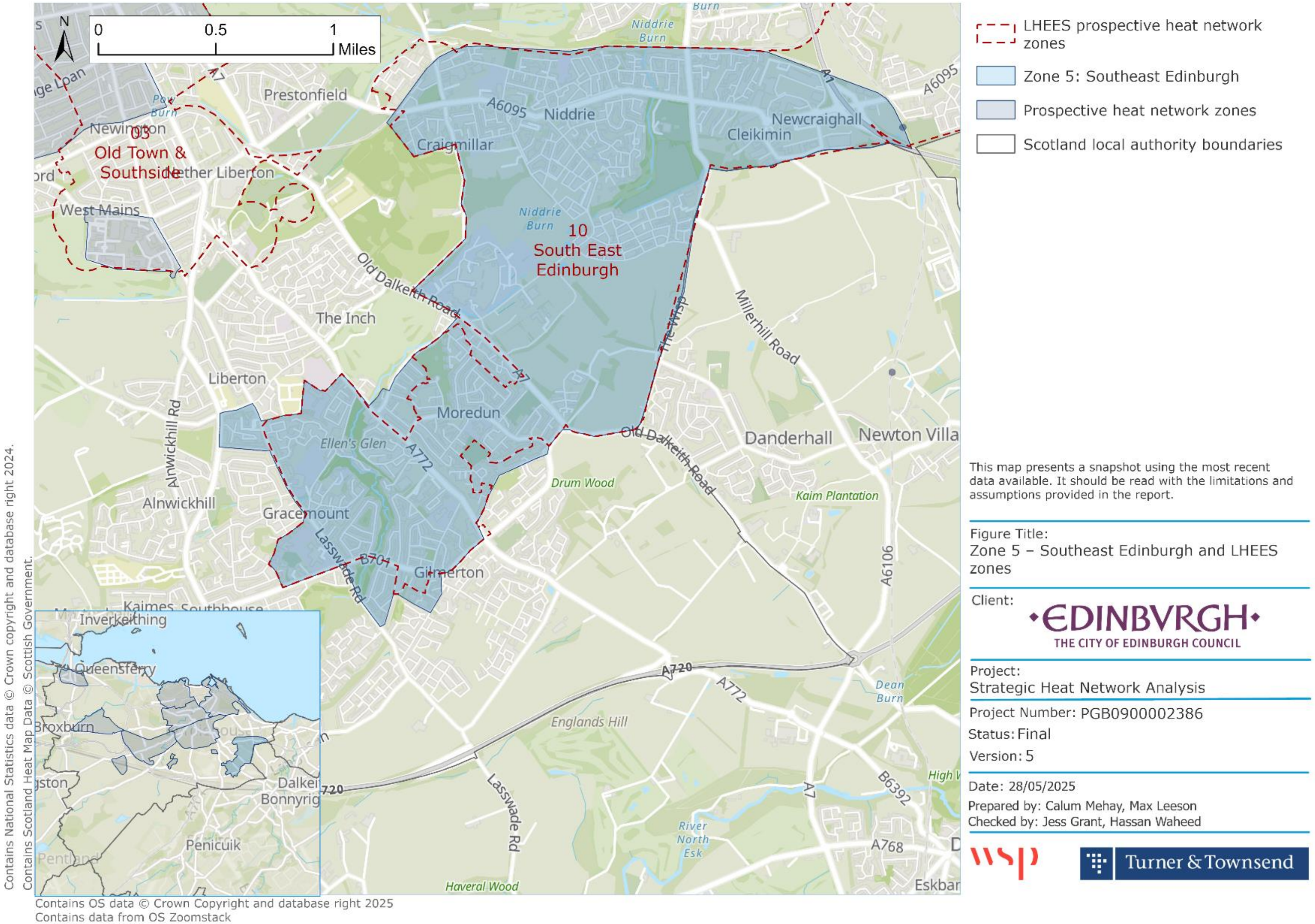


*Figure 72: Zone 5 – Southeast Edinburgh covers multiple neighbourhoods along the border with Midlothian. There are only minor changes to this zone from its LHEES predecessor zone, Zone 10 – South East Edinburgh. It incorporates areas in the middle of the zone but excludes some areas of low heat demand in the north of the zone.*

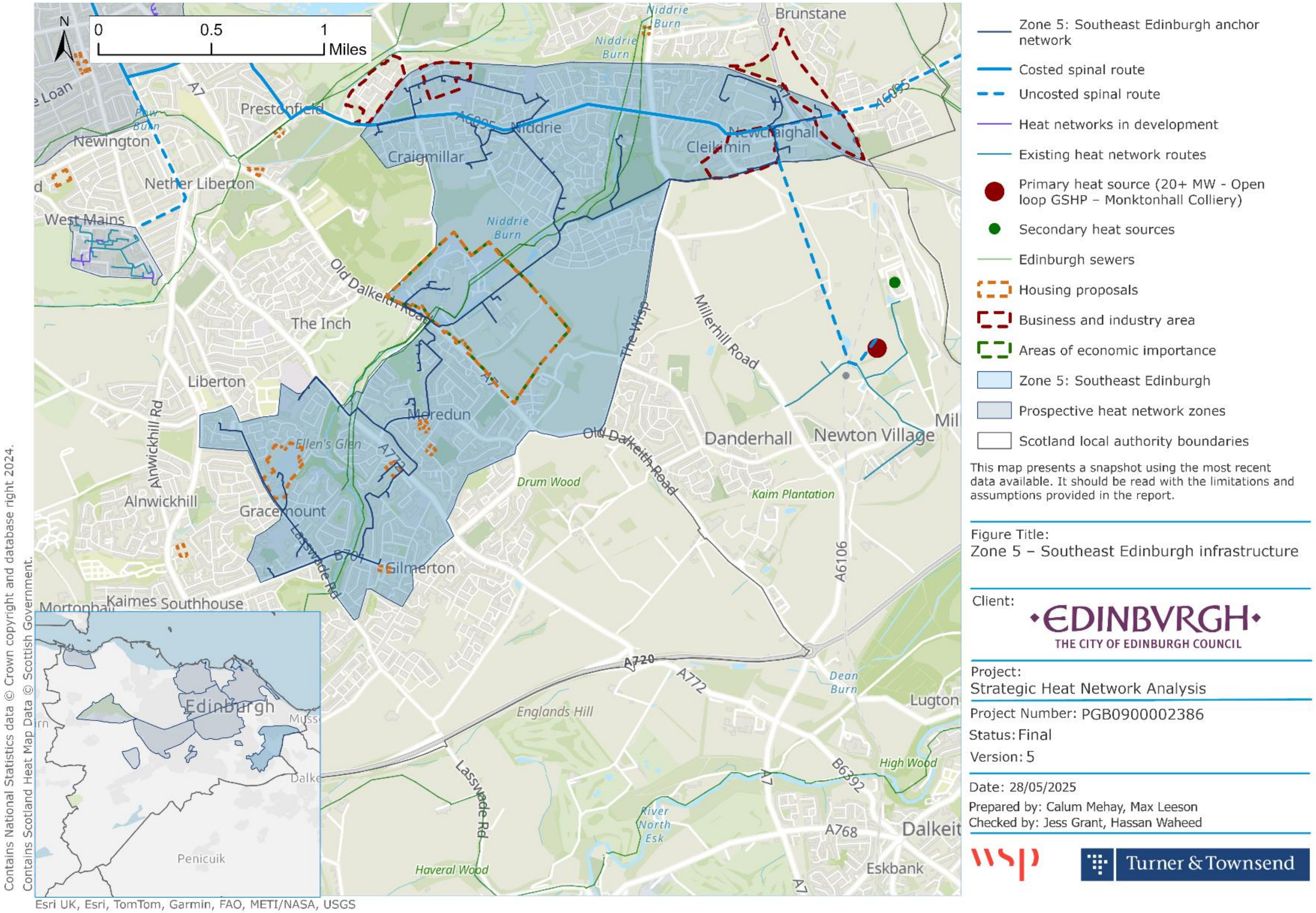


*Figure 73: Zone 5 – Southeast Edinburgh boundaries, heat sources, anchor network and spinal routes.*

### 12.1.6 Zone 6 – King's Buildings

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **47**<br>Total number of buildings | **74,662 MWh/year**<br>Heat demand (all buildings) | **20**<br>Number of anchor loads | **71,552 MWh/year**<br>Heat demand (anchor loads) |

## Observations

*Zone 6 – King's Buildings* has a small area and relatively low heat demand compared with the major zones. It is dedicated to the University of Edinburgh's Kings Building's campus. We have not carried out a feasibility review for this zone as all buildings are already connected to a University-operated heat network. However, this is not a low carbon heat network and the University intends to decarbonise it as part of its net zero targets.

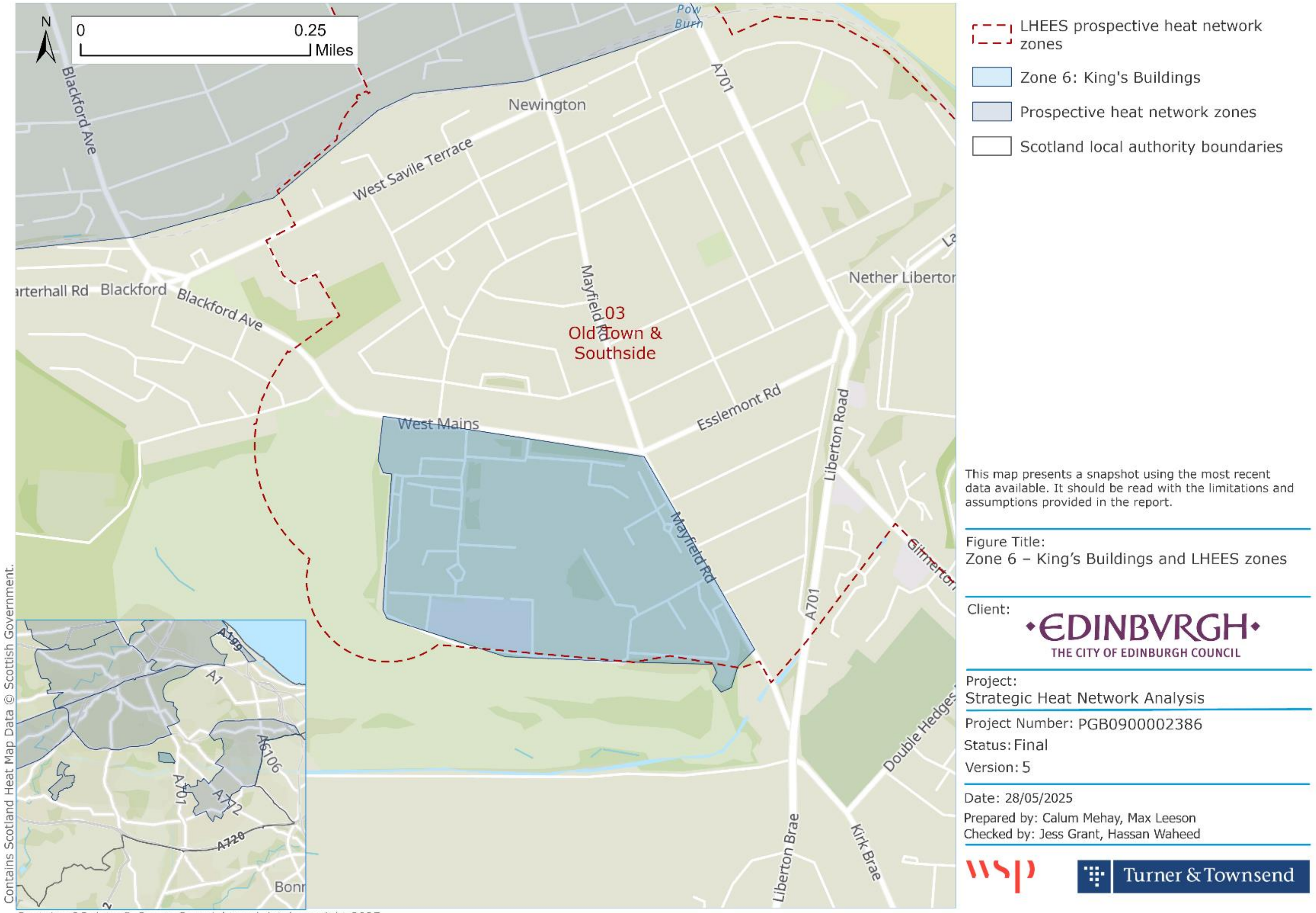




*Figure 74: Zone 6 – King's Buildings has been split out of the previous LHEES Zone 3 – Old Town & Southside. This is due to two reasons. Firstly, there is a low heat density area between the southern part of what is now Zone 2 – Central Edinburgh South and the King's Buildings. Due to the high heat demand from the King's Buildings this area was being zoned, but removing this influence reveals the lower potential across this gap. Second, dedicating this zone to the University campus simplifies the heat network development dynamics; they are unlikely to expand their campus-focused heat network toward the city centre and they are ideally placed to lead the decarbonisation plans for their 'island' of high heat demand.*

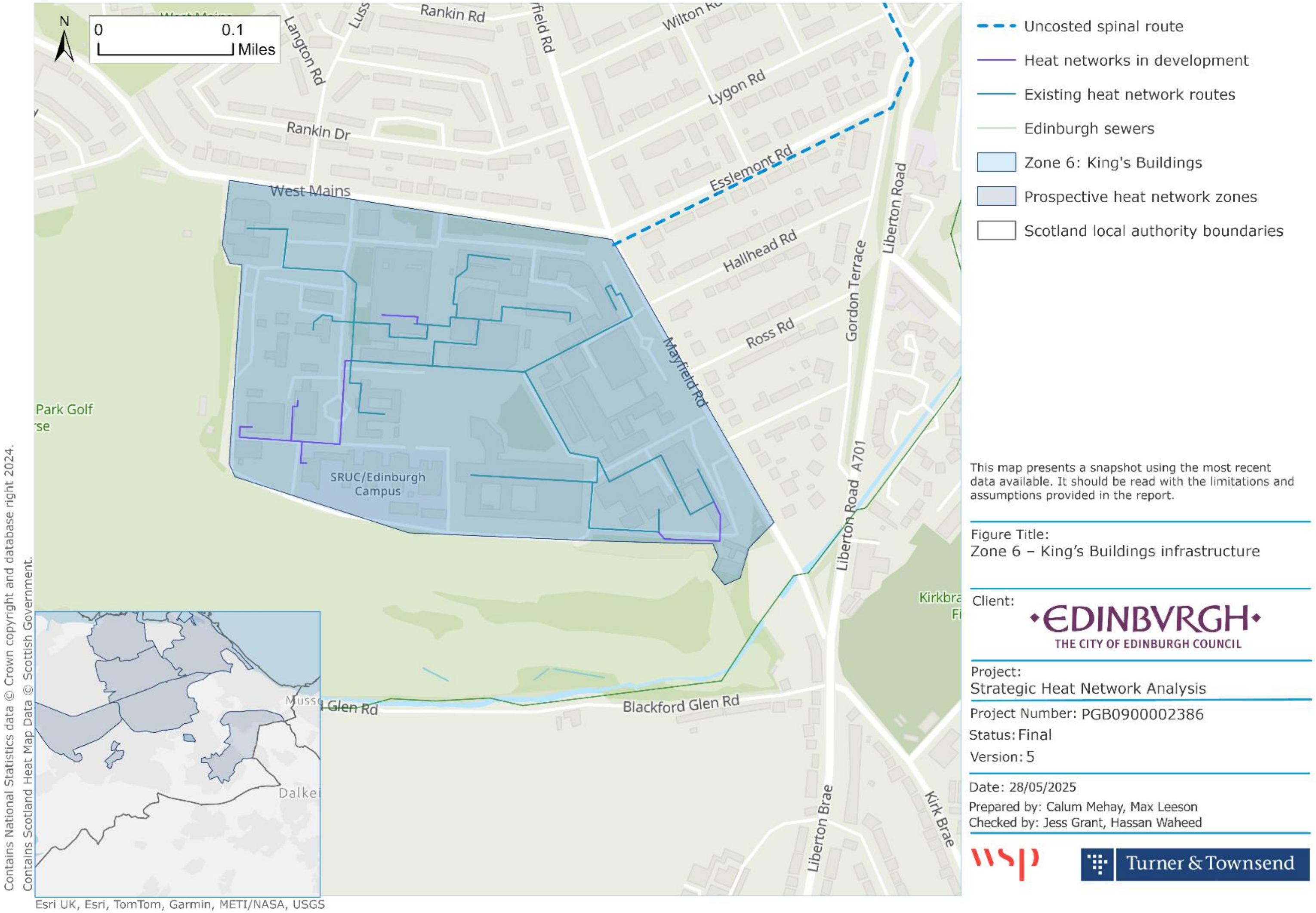


*Figure 75: Zone 6 – King's Buildings boundaries, heat sources, and spinal routes.*

### 12.1.7 Zone 7 – Colinton

| Headline figures | | | | |
|---|---|---|---|---|
| **Heat demand** | **196**<br>Total number of buildings | **9,050 MWh/year**<br>Heat demand (all buildings) | **5**<br>Number of anchor loads | **5,389 MWh/year**<br>Heat demand (anchor loads) |
| **Economics** | **£17.5m**<br>CAPEX | | **21.3 p/kWh**<br>LCOH | **14.6 p/kWh**<br>LCOH (with 50% grant funding) |
| **Energy modelling** | **5,928 MWh/year**<br>Network demand inc. losses | **4.1 MW**<br>Network peak demand | **Sewer heat – 0.73 MW**<br>**GSHP – 0.5 MW**<br>Secondary heat sources in zone | |
| | **Sewer heat – 0.73 MW**<br>**GSHP – 0.5 MW**<br>**WSHP – 1.23 MW**<br>**Gas boilers – 4.1 MW**<br>Generation equipment sizing | | **216 m² for energy centre**<br>Total energy centre GIA required | |
| | **84%**<br>% heat load met by secondary heat sources (exc. ASHP) | | **84%**<br>% heat load met by low carbon sources (inc. ASHP) | |

## Observations

*Zone 7 – Colinton* is the smallest zone by, both, total heat demand and anchor load heat demand. It covers a small area to the southwest of the city centre, including Edinburgh Napier University's campus, multiple schools, and Redford Barracks.

A considerable proportion of the heat demand can be covered by heat from the sewers and a GSHP, no air source heat pumps will be required to increase the low carbon heat generation. With 1.23 MW of heat pump, it is possible to serve 84% of the annual heat demand with low carbon heat. The case for a connection to a spinal route is currently unclear.

The CAPEX figure for this zone is estimated to be around £17.5m, with a LCOH figure of 21.3 p/kWh.

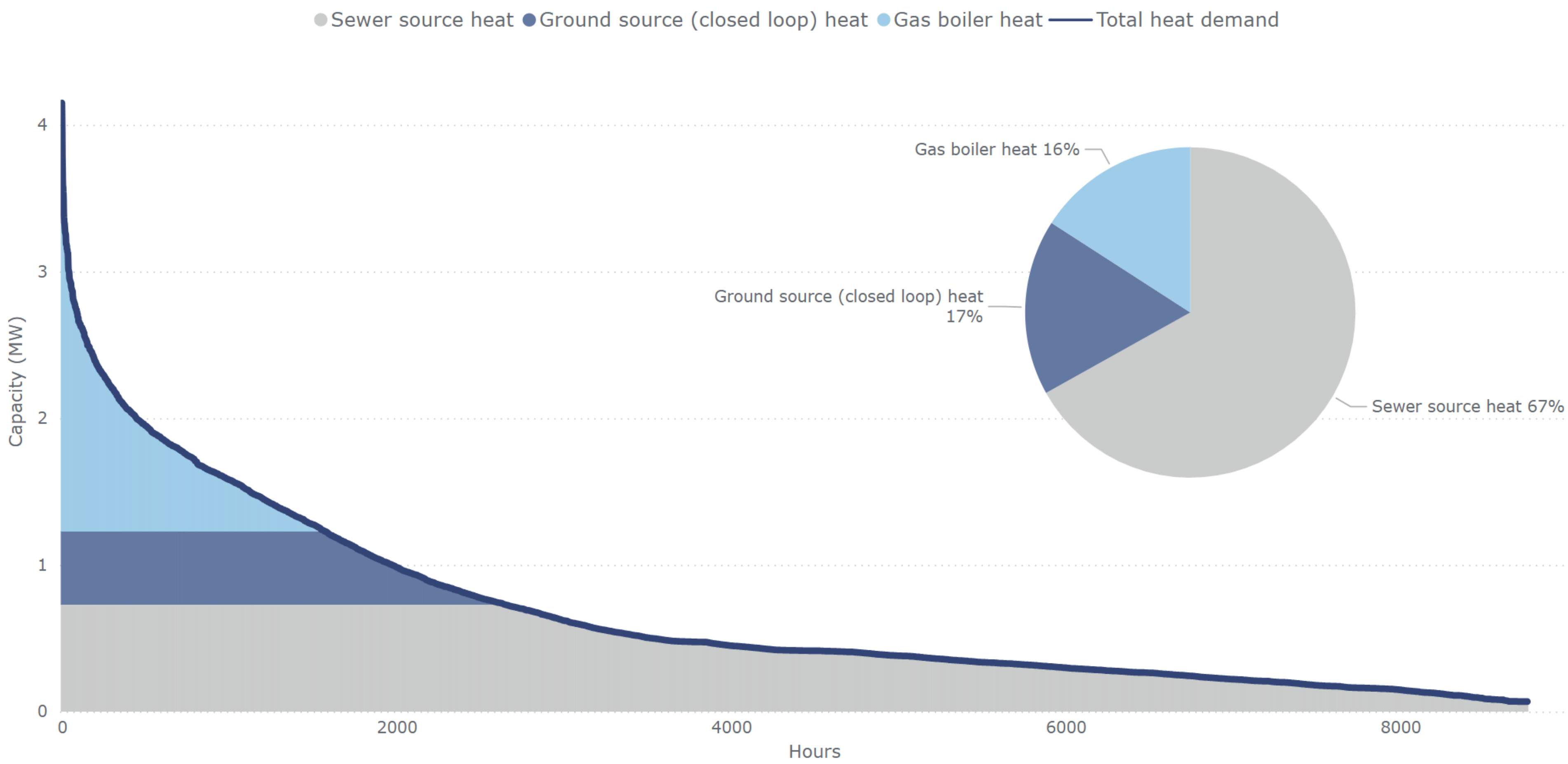


*Figure 76: Load duration curve for Zone 7 – Colinton.*

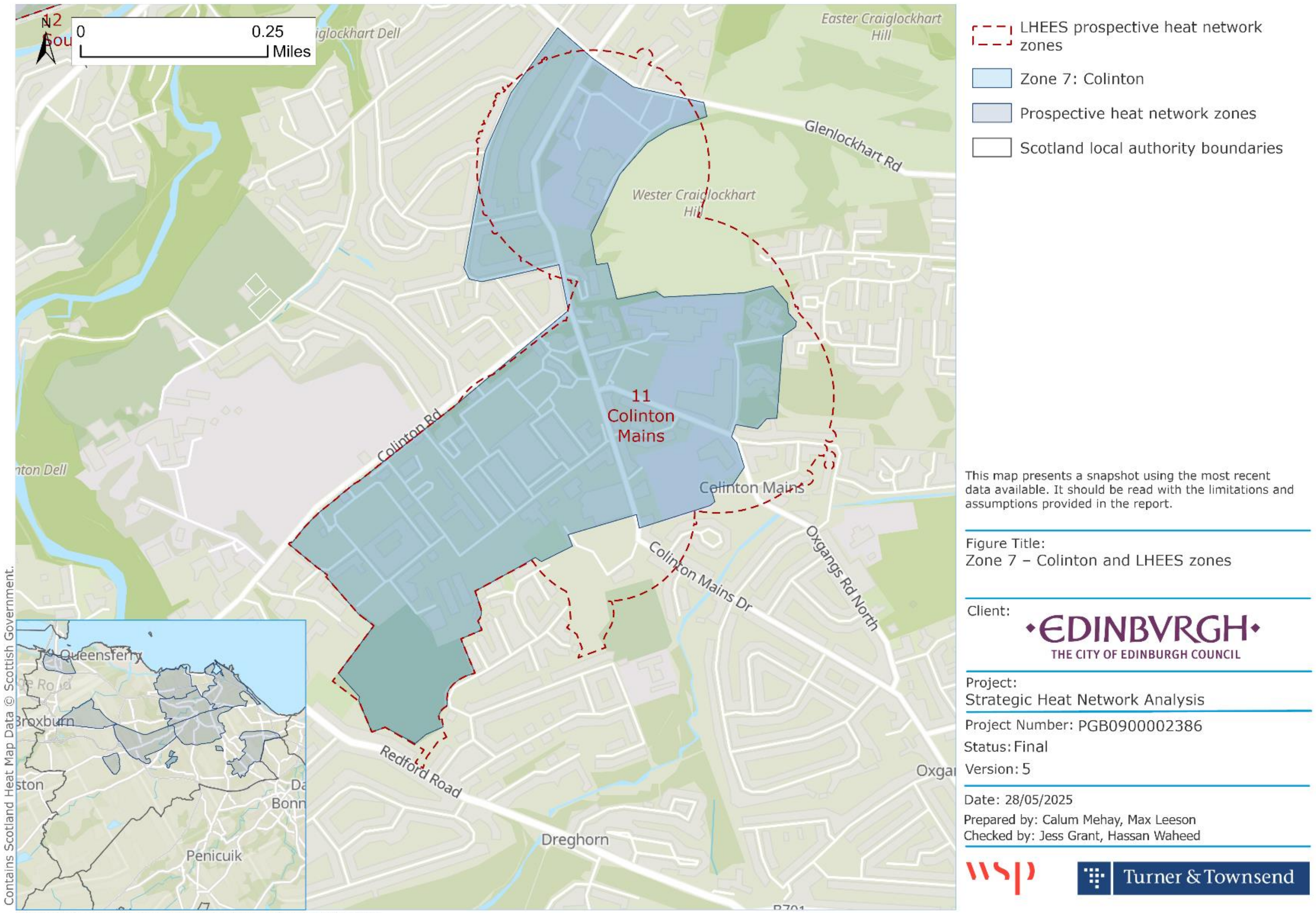




*Figure 77: Zone 7 – Colinton is dedicated to a small number of key anchor loads. It is unchanged from its predecessor LHEES zone, with the exception of refining the linear heat density cluster output into a boundary conforming to physical constraints.*

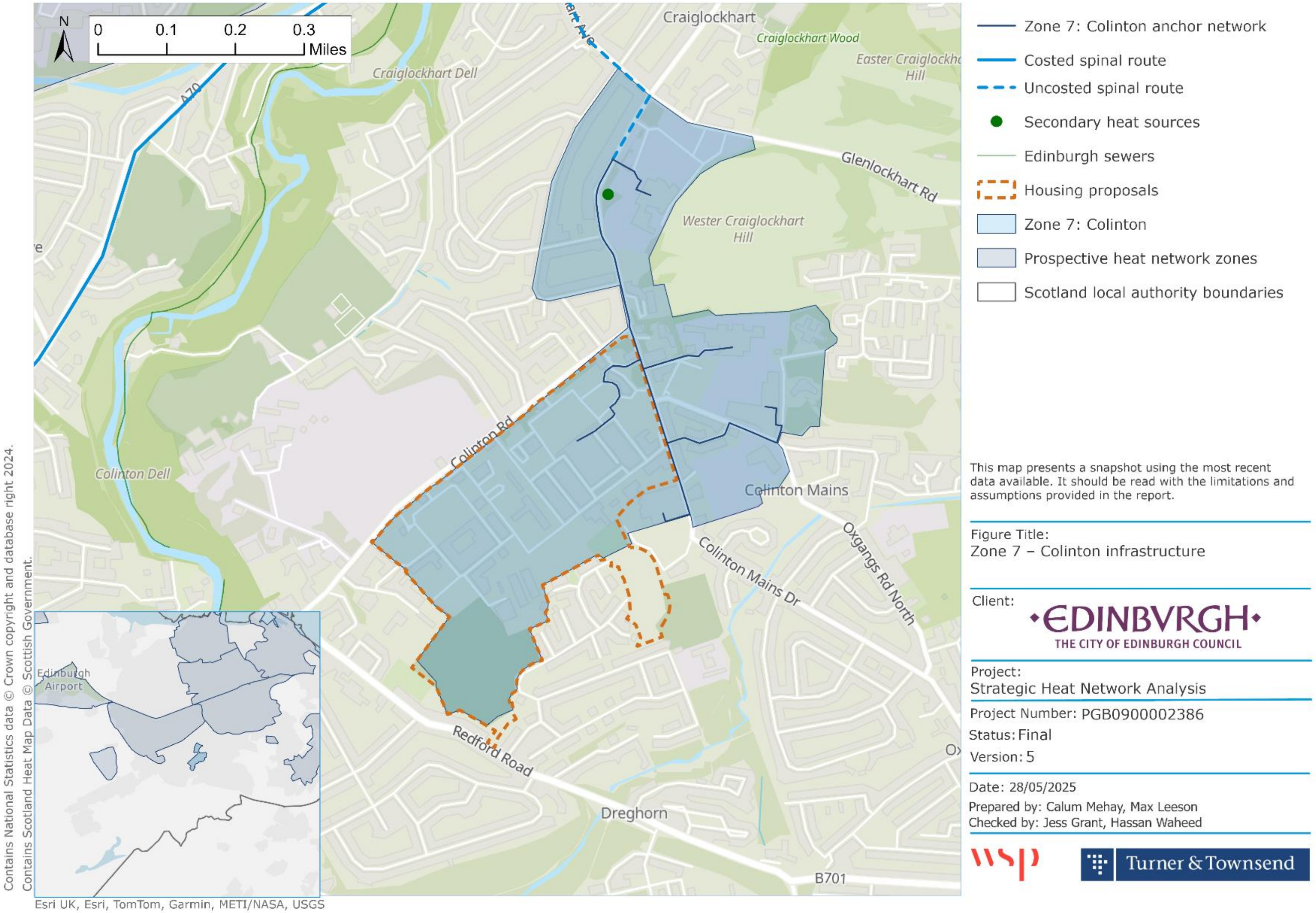


*Figure 78: Zone 7 – Colinton boundaries, heat sources, anchor network and spinal routes.*

### 12.1.8 Zone 8 – Southwest Edinburgh

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **22,193** Total number of buildings | **368,385 MWh/year** Heat demand (all buildings) | **77** Number of anchor loads | **127,323 MWh/year** Heat demand (anchor loads) |
| Economics | **£299m** CAPEX | | **17.6 p/kWh** LCOH | **12.8 p/kWh** LCOH (with 50% grant funding) |
| Energy modelling | **140,056 MWh/year** Network demand inc. losses | **93 MW** Network peak demand | **Sewer heat – 0.9 MW** Secondary heat sources in zone | |
| Energy modelling | **Sewer heat – 0.9 MW** **ASHP – 28 MW** **WSHP – 28.9 MW** **Gas boilers – 93 MW** Generation equipment sizing | | **4,572 m² for energy centre** **2,618 m² for ASHP** Total energy centre GIA required | |
| Energy modelling | **6%** % heat load met by secondary heat sources (exc. ASHP) | | **85%** % heat load met by low carbon sources (inc. ASHP) | |

## Observations

*Zone 8 – Southwest Edinburgh* has the fourth largest total heat demand and the third largest anchor load heat demand among all zones. It covers the southwest of the city centre, including Gyle, Sighthill, Wester Hailes, and Saughton.

Only a small proportion of the heat demand can be covered by heat from the sewers, the only available secondary heat source. We have modelled air source heat pumps to increase the low carbon heat generation. With 28.9 MW of heat pump, it is possible to serve 85% of the annual heat demand with low carbon heat, with only 6% of this coming from sewer heat. This zone would likely require heat from a spinal network.

The CAPEX figure for this zone is estimated to be around £299m, with a LCOH figure of 17.6 p/kWh.

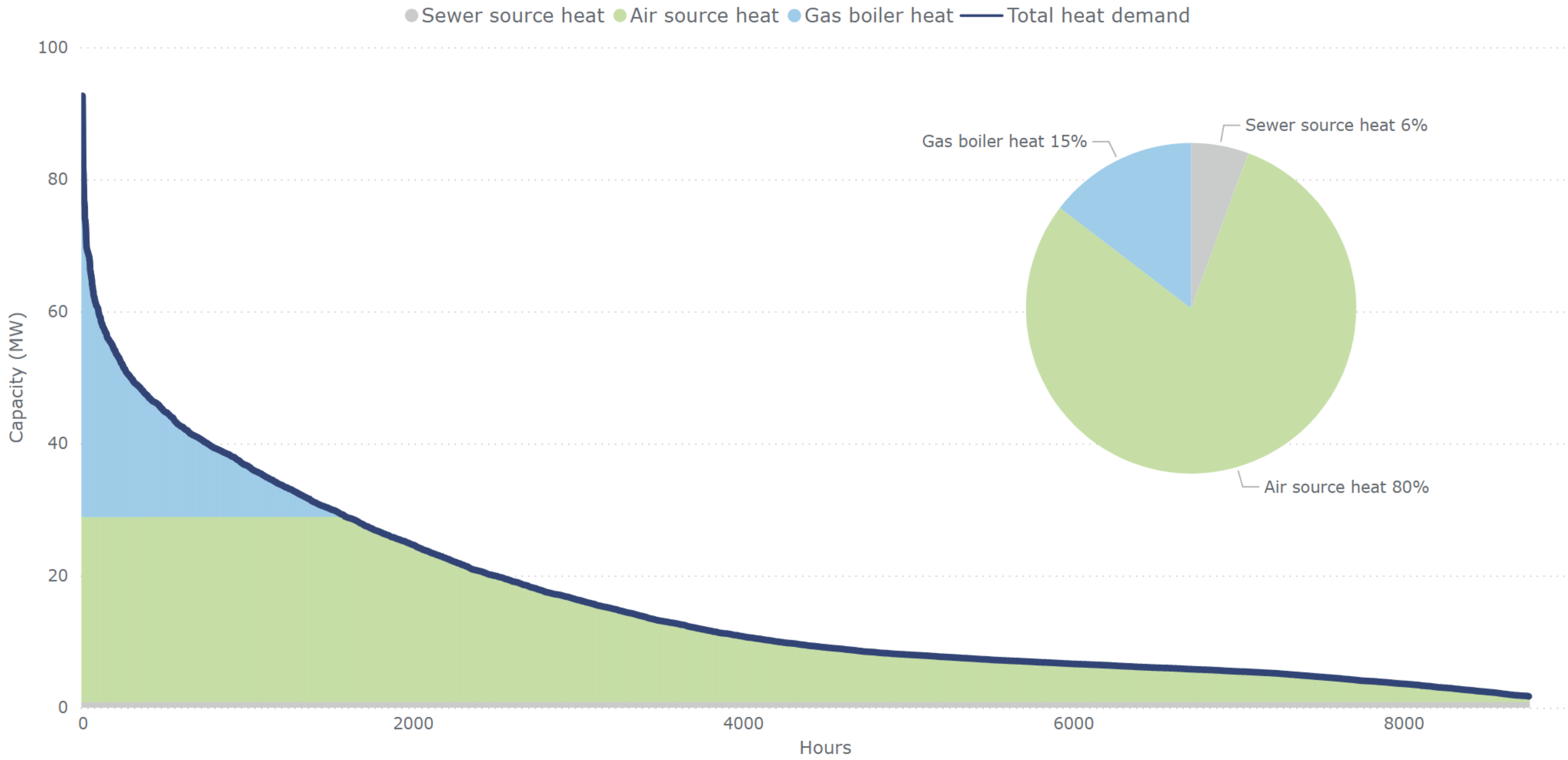


*Figure 79: Load duration curve for Zone 8 – Southwest Edinburgh.*

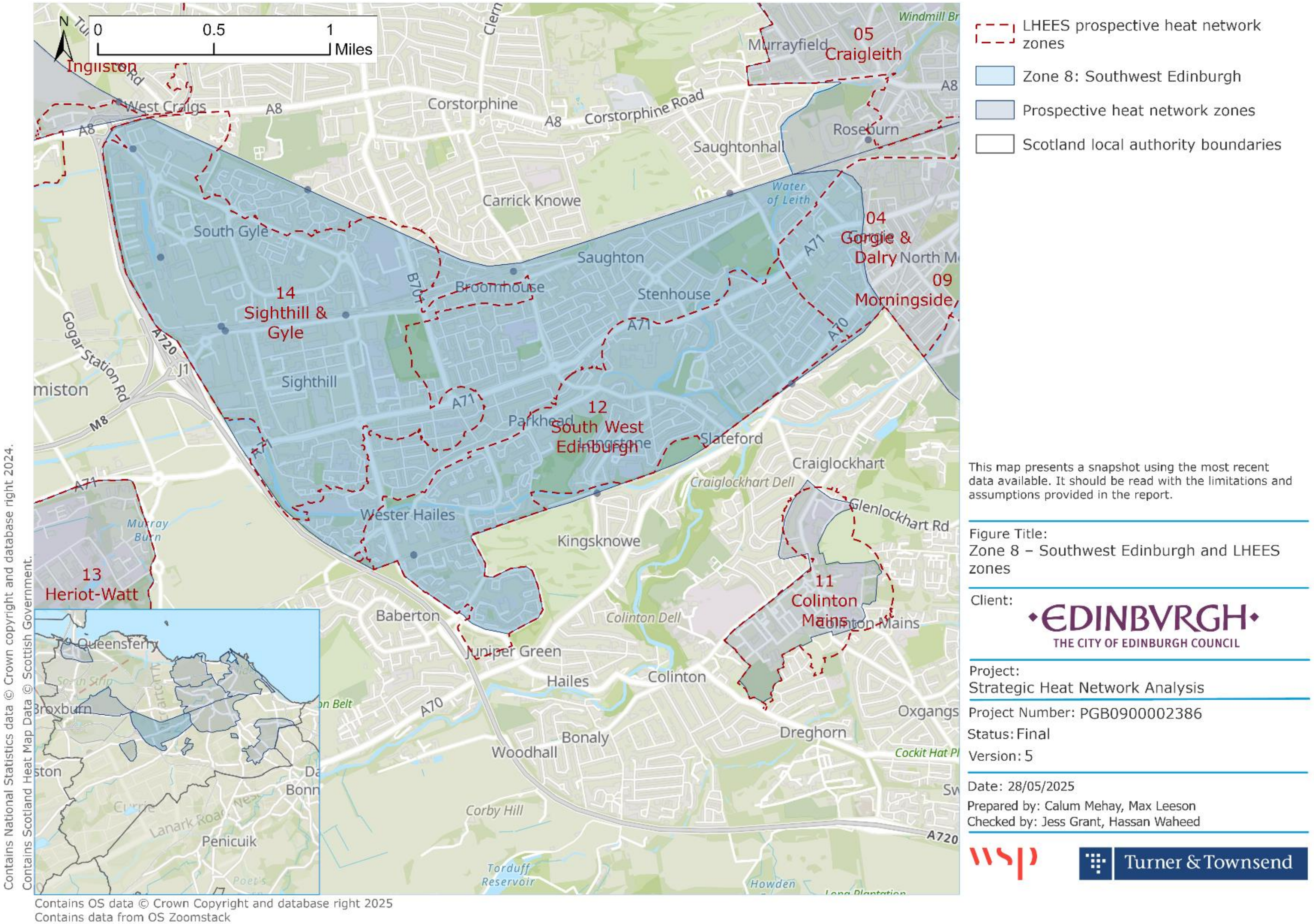


*Figure 80: Zone 8 – Southwest Edinburgh is a combination of three previous zones. Additionally, it extends to include multiple additional areas with higher heat demand density, such as the inclusion of Saughton and Stenhouse by extending the boundary up to the railway line.*

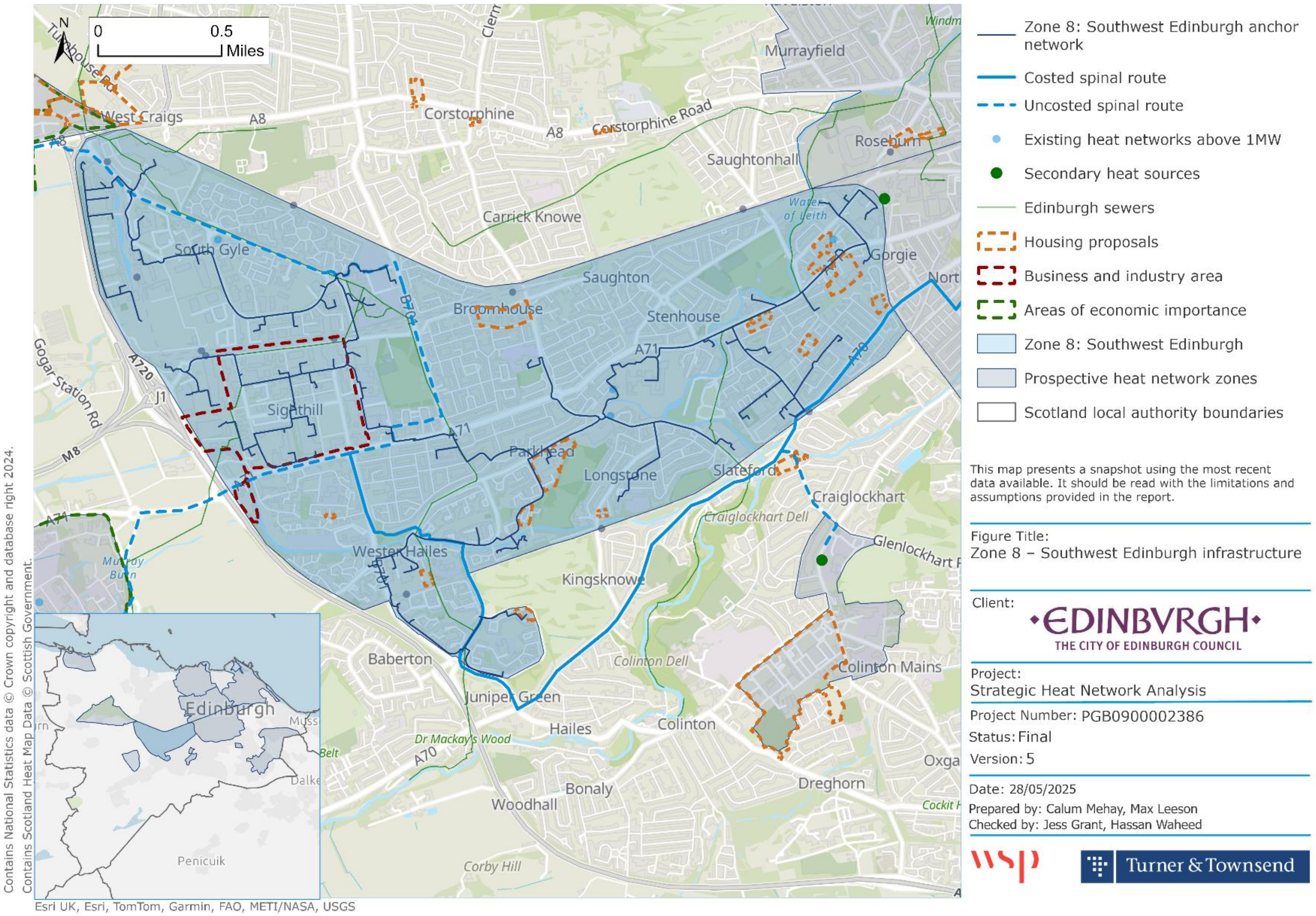


*Figure 81: Zone 8 – Southwest Edinburgh boundaries, heat sources, anchor network and spinal routes.*

### 12.1.9 Zone 9 – West Edinburgh

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **143**<br>Total number of buildings | **89,047 MWh/year**<br>Heat demand (all buildings) | **7**<br>Number of anchor loads | **50,682 MWh/year**<br>Heat demand (anchor loads) |

#### Observations

*Zone 9 – West Edinburgh* has a relatively low heat demand compared with the major zones. The majority of the zone is covered by the Edinburgh Airport, with some areas of land around it. These are new and ongoing developments. We have not carried out a feasibility review as the Edinburgh Airport is already progressing with a heat network development, currently at the financing stage. We anticipate this as a low carbon heat network serving the airport buildings, with the potential to expand outward into the surrounding areas.

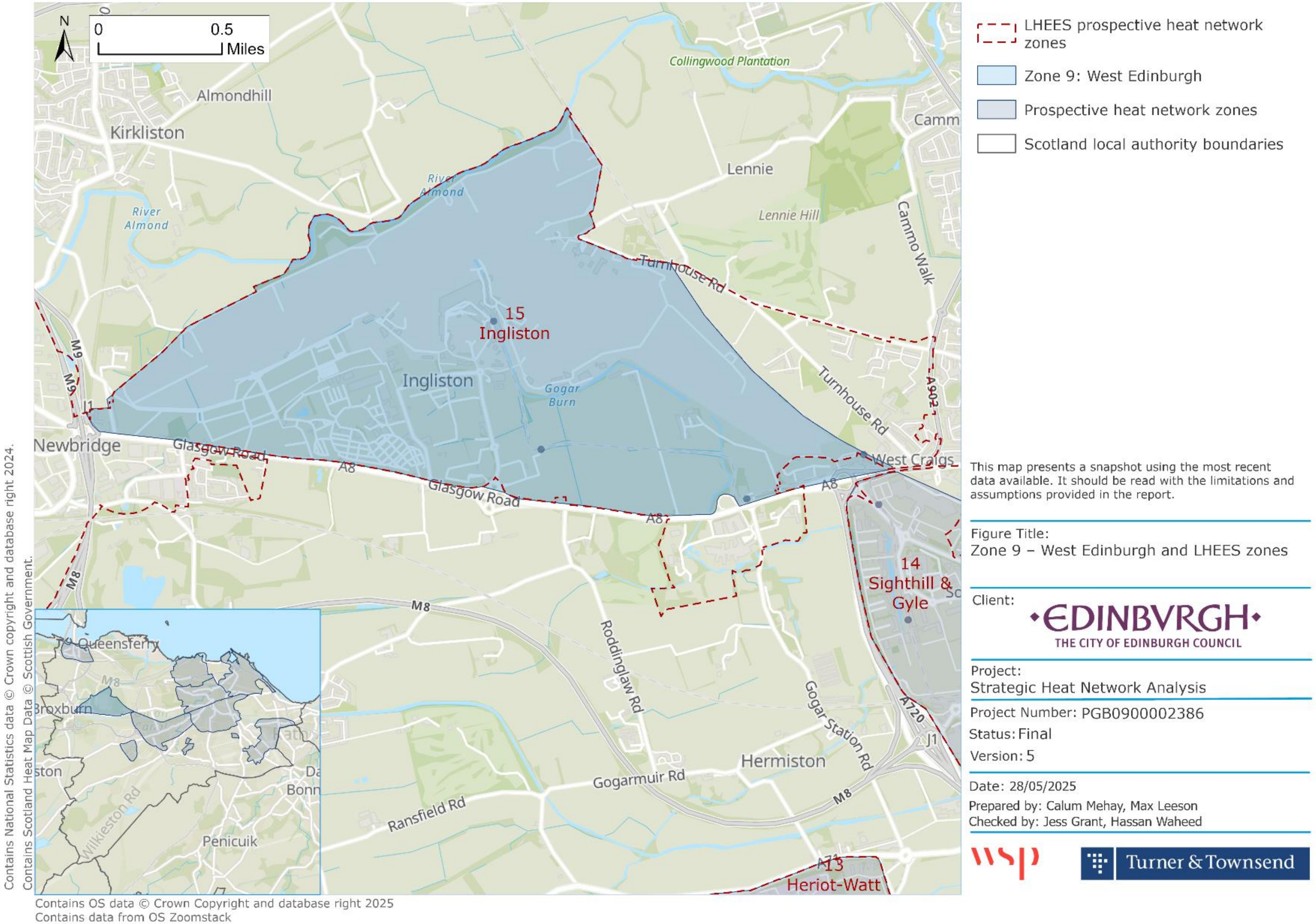


*Figure 82: Zone 9 – West Edinburgh has been reduced to cover only the airport boundary and some limited surrounding areas. The airport has indicated that they have their own plans for a heat network, which will also serve the new developments within their boundary. This also avoids needing to route any network across the M9 into Newbridge.*

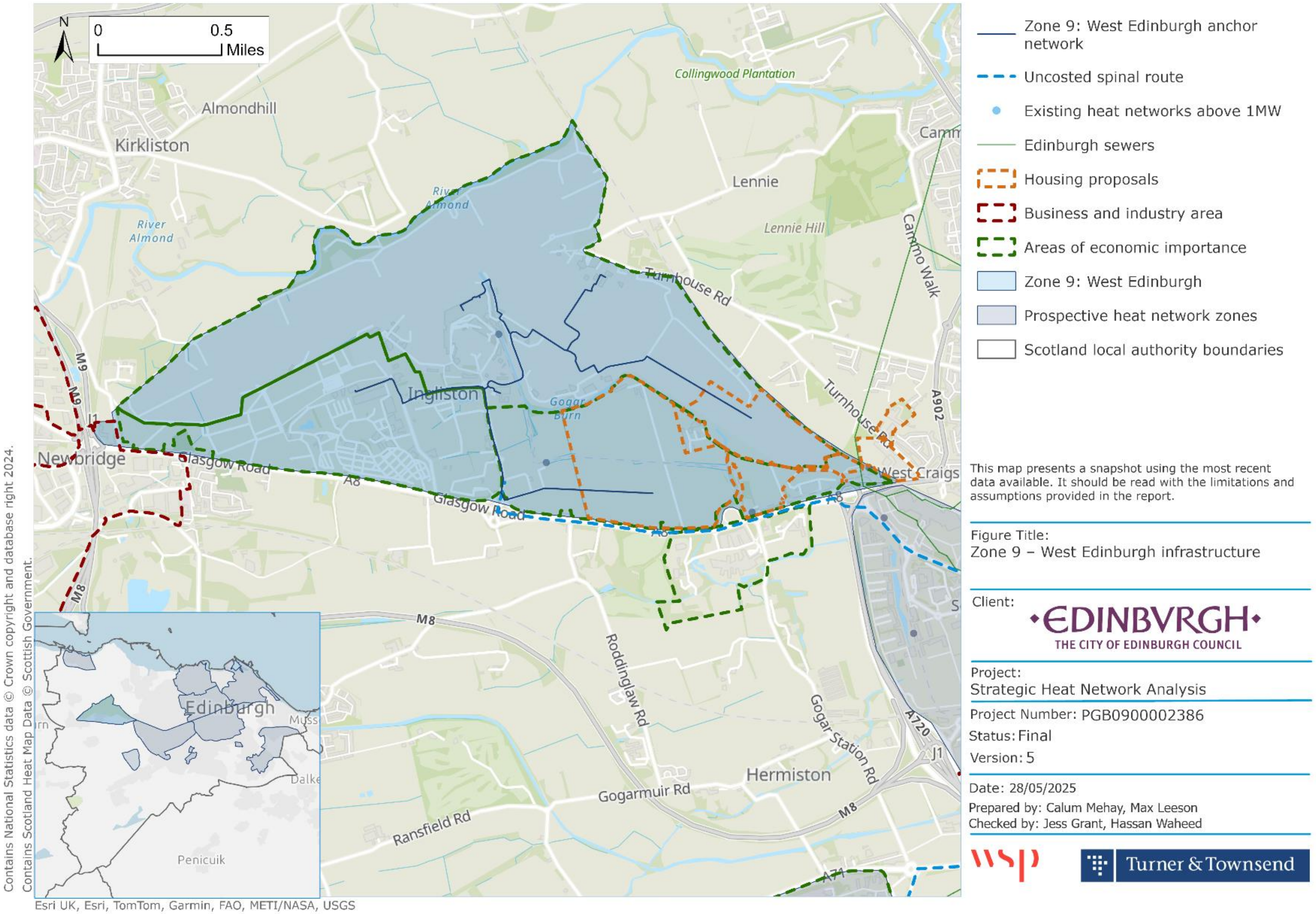


*Figure 83: Zone 9 – West Edinburgh boundaries, heat sources, and spinal routes.*

### 12.1.10 Zone 10 – Heriot-Watt University

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **78**<br>Total number of buildings | **21,343 MWh/year**<br>Heat demand (all buildings) | **15**<br>Number of anchor loads | **9,691 MWh/year**<br>Heat demand (anchor loads) |

## Observations

*Zone 10 – Heriot-Watt University* is dedicated to the University’s campus. It has a relatively low total heat demand (second smallest). We have not carried out a feasibility review as the remit of developing a heat network falls largely to the University. We assume the University will make a strategic decision on whether to pursue a heat network or prioritise individual building-level projects in due course. However, the area has been zoned to allow the Council to facilitate the University’s heat network plans should that course be chosen.

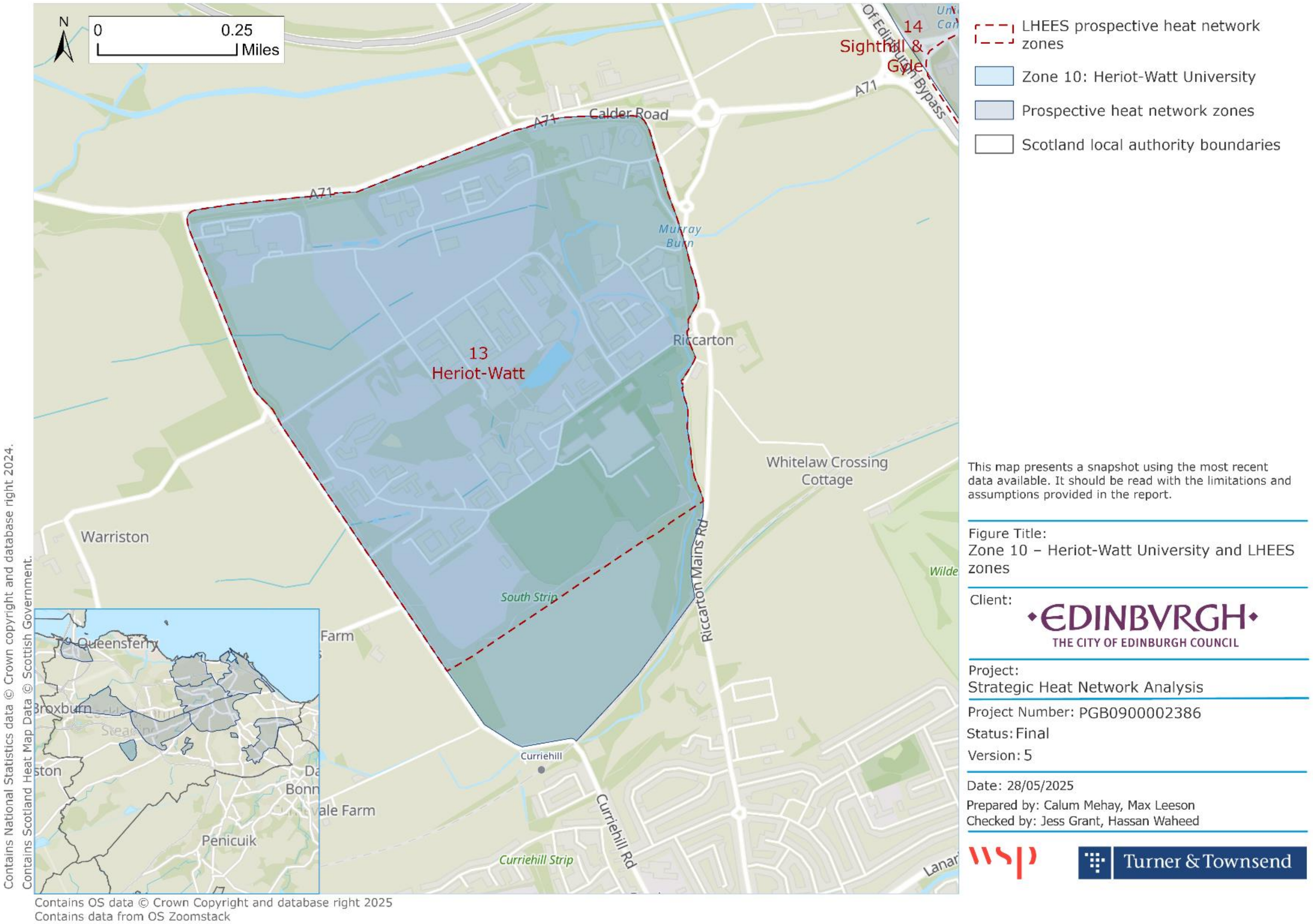


*Figure 84: Zone 10 – Heriot-Watt University is mostly unchanged, due to the campus not having any considerable heat density around it. It also means that the buildings in the zone have one owner in the university, who are already progressing with their own heat decarbonisation plans.*

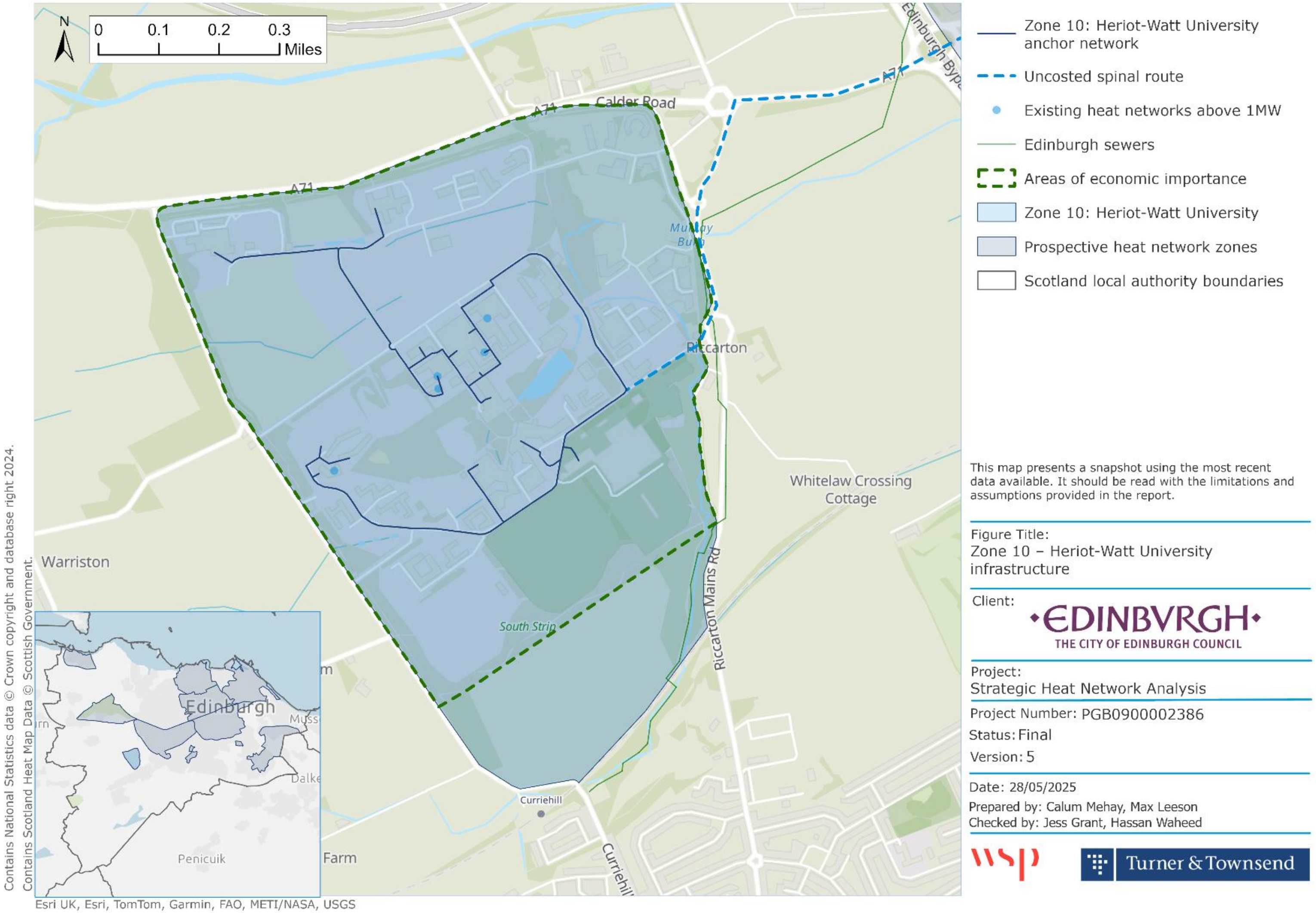


*Figure 85: Zone 10 – Heriot-Watt University boundaries, heat sources, and spinal routes.*

### 12.1.11 Zone 11 – Queensferry

| Headline figures | | | | |
|---|---|---|---|---|
| Heat demand | **4,882** Total number of buildings | **69,618 MWh/year** Heat demand (all buildings) | **4** Number of anchor loads | **6,831 MWh/year** Heat demand (anchor loads) |
| Economics | **£23.2m** CAPEX | | **20.8 p/kWh** LCOH | **13.8 p/kWh** LCOH (with 50% grant funding) |
| Energy modelling | **7,514 MWh/year** Network demand inc. losses | **6 MW** Network peak demand | **WSHP (sea/river) – 2 MW** Secondary heat sources in zone | |
| Energy modelling | **WSHP (sea/river) – 2 MW**<br>**Gas boilers – 6 MW** Generation equipment sizing | | **324 m² for energy centre** Total energy centre GIA required | |
| Energy modelling | **90%** % heat load met by secondary heat sources (exc. ASHP) | | **90%** % heat load met by low carbon sources (inc. ASHP) | |

## Observations

*Zone 11 – Queensferry* is one of the smallest with respect to total heat demand (third smallest) and anchor load heat demand (second smallest). It covers the town of Queensferry.

ASHPs have not been proposed for this zone as it is adjacent to the Firth of Forth and this WSHPs have instead been modelled to supply a significant proportion of the heat demand.

With 2 MW of heat pump, it is possible to serve 90% of the annual heat demand with low carbon heat.

The CAPEX figure for this zone is estimated to be around £23.2m, with a LCOH figure of 20.8 p/kWh.

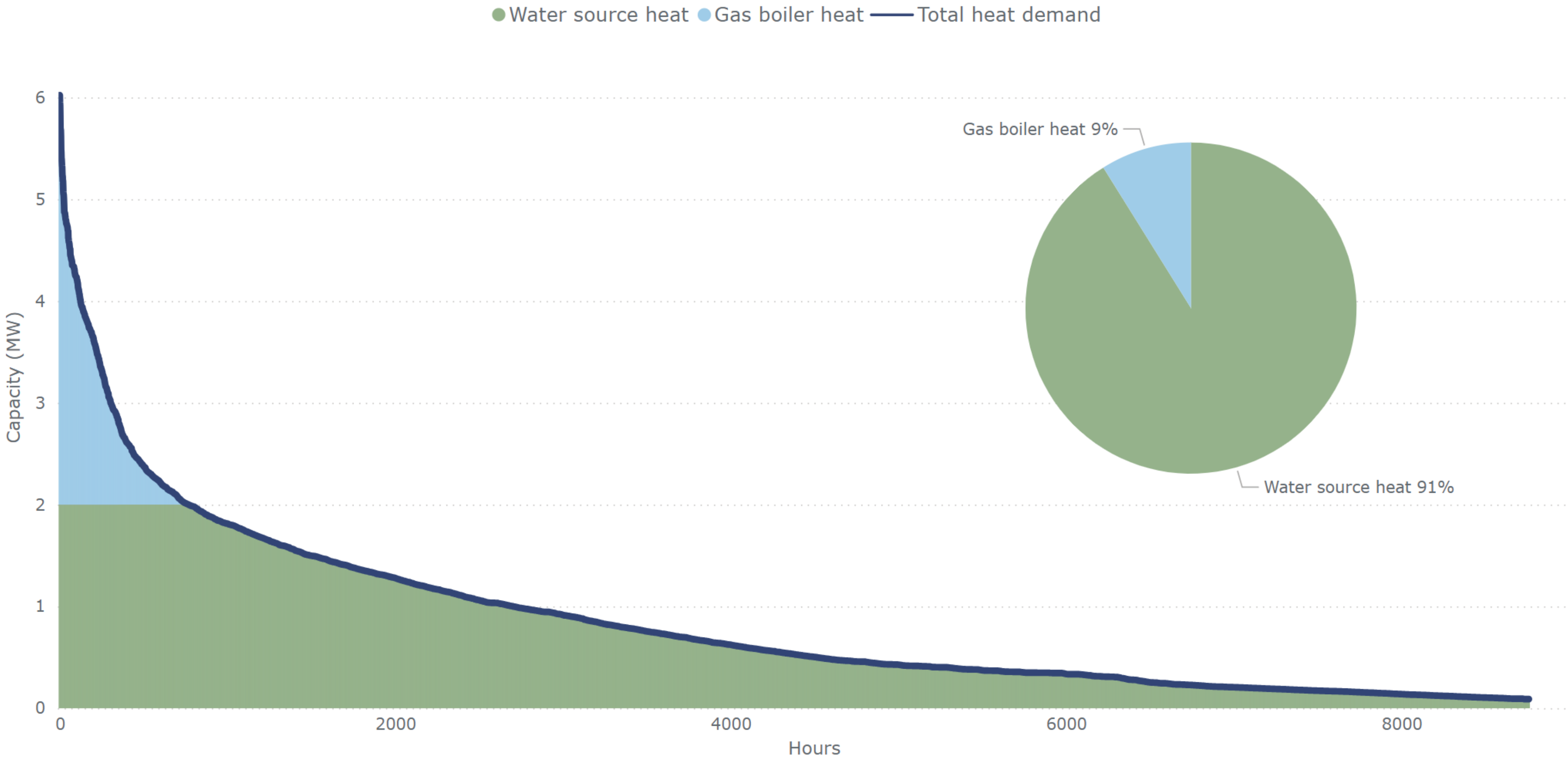


*Figure 86: Load duration curve for Zone 11 – Queensferry.*

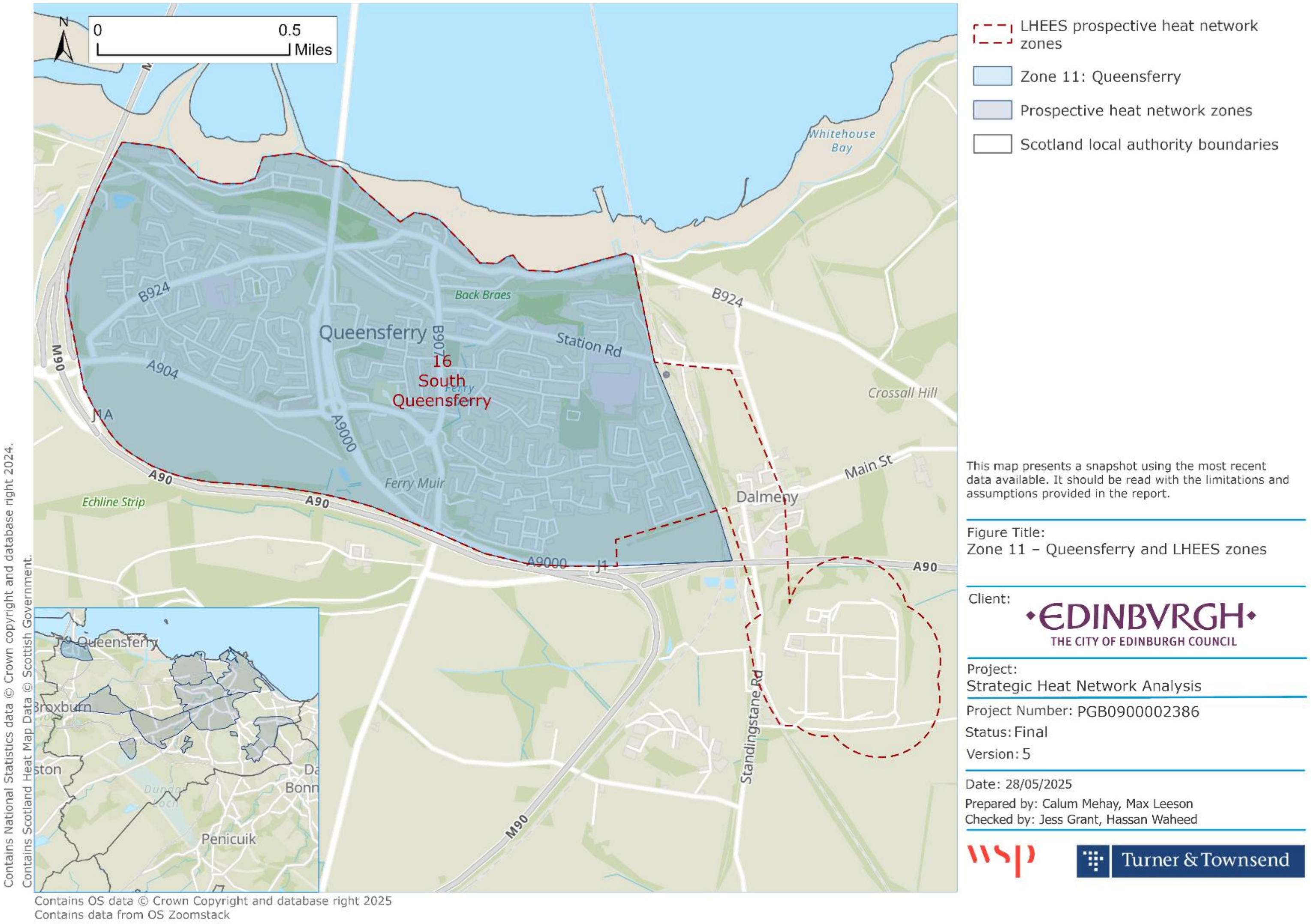


*Figure 87: Zone 11 – Queensferry has been reduced. It previously included the Dalmeny Tank Farm, but this has been removed due to unrealistic levels of heat demand from the site represented in the modelled SHM data. The boundary is now limited by the railway line to the east and flanked by the M90 to the west.*

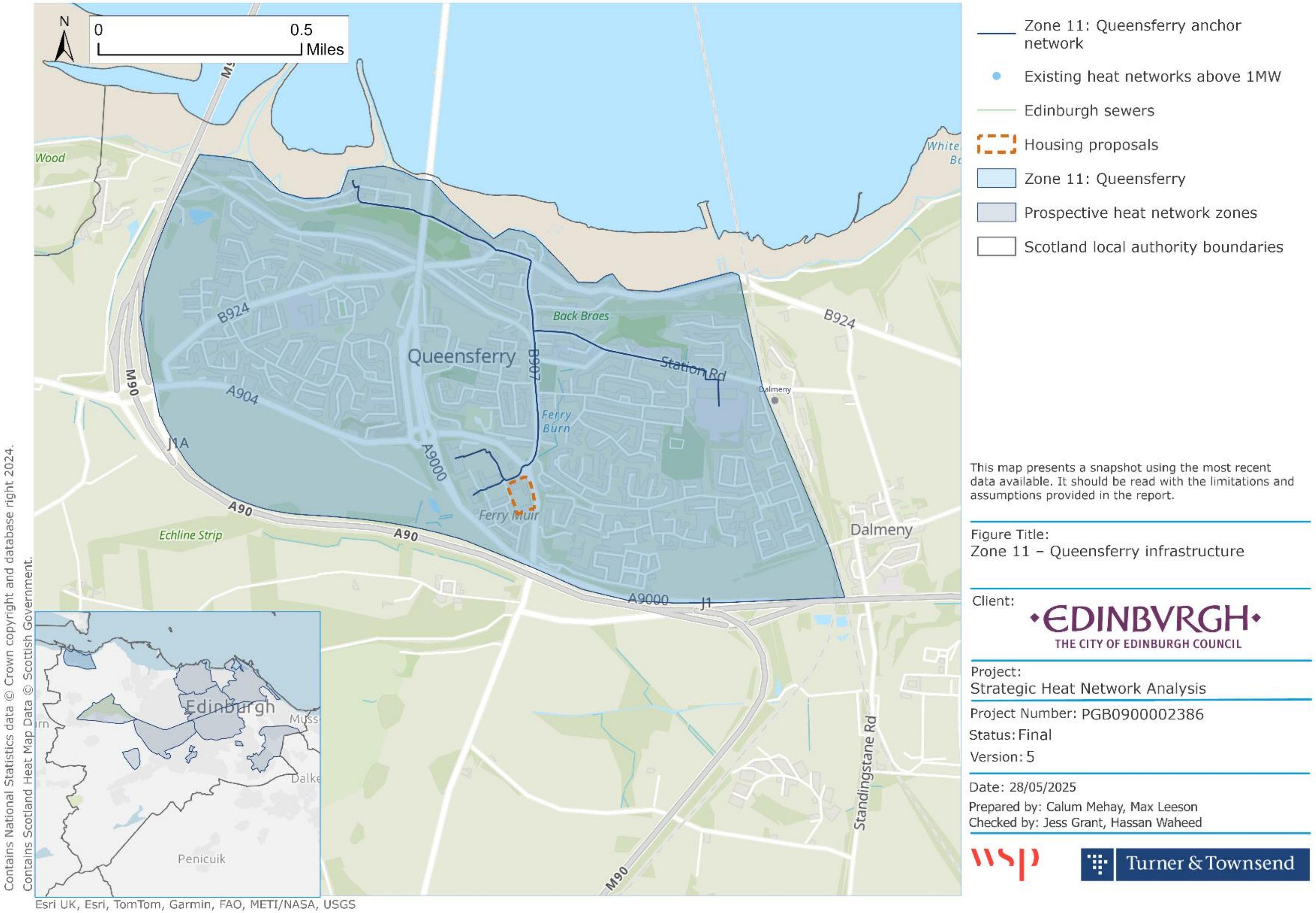


*Figure 88: Zone 11 – Queensferry boundaries, heat sources, and anchor network.*

## 12.2 Capital cost breakdowns

The following table provides a breakdown of estimated capital costs for developing an anchor network in each zone using the theoretical approach of secondary heat sources and an ASHP-based energy centre where the additional heat is unavailable.

| | Zone 1 | Zone 2 | Zone 4 | Zone 5 | Zone 7 | Zone 8 | Zone 11 | Total |
|---|---|---|---|---|---|---|---|---|
| | Central Edinburgh North | Central Edinburgh South | Northeast Edinburgh | Southeast Edinburgh | Colington | Southwest Edinburgh | Queensferry | **Total** |
| Energy Centre Building | £17m | £31m | £11m | £15m | £1m | £18m | £1m | £94m |
| Energy Generation Plant | £66m | £99m | £60m | £80m | £6m | £59m | £3m | £373m |
| Boiler Package | £11m | £18m | £6m | £11m | £1m | £11m | £1m | £59m |
| Mechanical & Ventilation | £20m | £34m | £12m | £20m | £1m | £21m | £1m | £110m |
| HV Electrical | £9m | £16m | £6m | £12m | £0.4m | £10m | £0.5m | £53m |
| LV Electrical | £12m | £22m | £8m | £16m | £0.5m | £13m | £0.6m | £71m |
| Distribution | £97m | £129m | £116m | £86m | £7m | £138m | £13m | £586m |
| HIUs / Substations | £22m | £44m | £19m | £28m | £1m | £29m | £2m | £145m |
| **Total** | **£252m** | **£394m** | **£238m** | **£267m** | **£17m** | **£299m** | **£23m** | **£1,490m** |

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