Heat Network Support Unit

Inverness Strategic Heat Network Support

Summary report

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ZERO WASTE SCOTLAND

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www.heatnetworksupport.scot

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Contents

Glossary

Term	Definition
ASHP	Air Source Heat Pump
BAR	Building Assessment Report
BAU	Business As Usual
BGS	British Geological Survey
CAPEX	Capital Expenditure
CHP	Combined Heat & Power
CNPA	Cairngorm National Park Authority
CoP	Coefficient of Performance
CO_2	Carbon Dioxide
DESNZ	Department for Energy Security and Net Zero
dT	Temperature Difference
EC	Energy Centre
EfW	Energy from Waste
EST	Energy Saving Trust Company
FME	Feature Manipulation Engine processing tool
GHiGs	Green heat in Greenspaces
GHG	Green House Gas Emissions
GSHP	Ground Source Heat Pump
GSP	Grid Supply Point
HIE	Highlands and Islands Enterprise

Term	Definition
HMP	His Majesty's Prison
HN	Heat Network
HNZPP	Heat Network Zoning Pilot Program
HP	Heat Pump
IMFLDP	Inner Moray Firth Local Development Plan
KPI	Key Performance Indicator
LCITP	Low Carbon Infrastructure Transition Programme
LDP	Local Development Plan
LHEES	Local Heat and Energy Efficiency Strategies
LHD	Linear Heat Density
MCA	Multi-Criteria Analysis
NHS	National Health Service
NPF4	National Planning Framework 4
OPEX	Operational Expenditure
OS	Ordnance Survey Maps
RAG	Red- Amber-Green also known as a traffic light report
RFI	Request for Information
SEPA	Scottish Environment Protection Agency
SHM	Scotland Heat Map
SSEN	Scottish and Southern Electrify Network

Term	Definition
SW	Scottish Water
SWH	Scottish Water Horizon
THC	The Highland Council
TOID	Topographic Identifier
WSHP	Water Source Heat Pump
UHI	University of Highlands and Islands
UPRN	Unique Property Reference Number
ZWS	Zero Waste Scotland

Executive Summary

Through the Heat Network Support Unit (HNSU) funding Zero Waste Scotland (ZWS) commissioned Buro Happold (BH) to undertake a strategic appraisal of heat network opportunities in Inverness for The Highland Council (THC). Alongside this strategic work a feasibility study was carried in parallel for the Raigmore area of Inverness, insights from this fed into this strategic analysis. Being a high level analysis this report should not be treated as an economic assessment but rather a strategic indicator of heat network suitability and viability for further investigation.

Heat network vision statement

The first element of the study was to capture Highland Council's heat network vision for Inverness, which was agreed as follows:

As a cornerstone of the Highland Council's decarbonisation strategy, we envision developing and expanding heat networks to deliver sustainable, affordable, and efficient energy solutions – providing the lowest cost low carbon heating option. Thereby, supporting Scotland's Net Zero goals by 2045 and providing social, economic, and environmental benefits to the region.

Through LHEES and aligned with national policies, the Council envisions a number of heat network zones across Inverness. These zones will reduce reliance on fossil fuels, decrease carbon emissions, and support energy resilience. The Council recognises that the heat network can deliver further benefits including:

- **Carbon emissions reduction:** By transitioning to low-carbon and renewable energy sources, heat networks significantly reduce greenhouse gas emissions which is essential for achieving the Highland Council's ambitious Net Zero emissions target by 2045.
- **Tacking fuel poverty:** Heat networks can provide consistent and reliable heating and hot water on demand. Providing affordable heat particularly in areas with a high proportion of older, less energy-efficient homes.
- **Creating job and economic growth:** The development and operation of heat networks stimulate local economies by creating jobs and supporting the growth of a skilled workforce. This economic boost can contribute the overall prosperity of the region.
- **Energy Security and Resilience:** By diversifying energy sources and localising heat production, heat networks enhance energy security and resilience. This approach reduces dependence on imported fuels and mitigates the impact of global energy price fluctuations.
- **Environmental Sustainability:** Heat networks facilitate the integration of various renewable energy sources, such as geothermal, solar, and biomass, promoting environmental sustainability and contributing to cleaner air quality in urban areas.

By embracing these benefits, the Highland Council can ensure that the development of heat networks in Inverness not only addresses environmental concerns but also delivers tangible social and economic advantages to the community.

Heat network areas

Inverness is the largest and most heat dense area of Highland and was the focus for this strategic work. Four areas were examined for heat network potential in Inverness, these are outlined in Figure 0—1, alongside some key strategic elements of the areas (please note the background THC areas indicate land rather than building ownership).

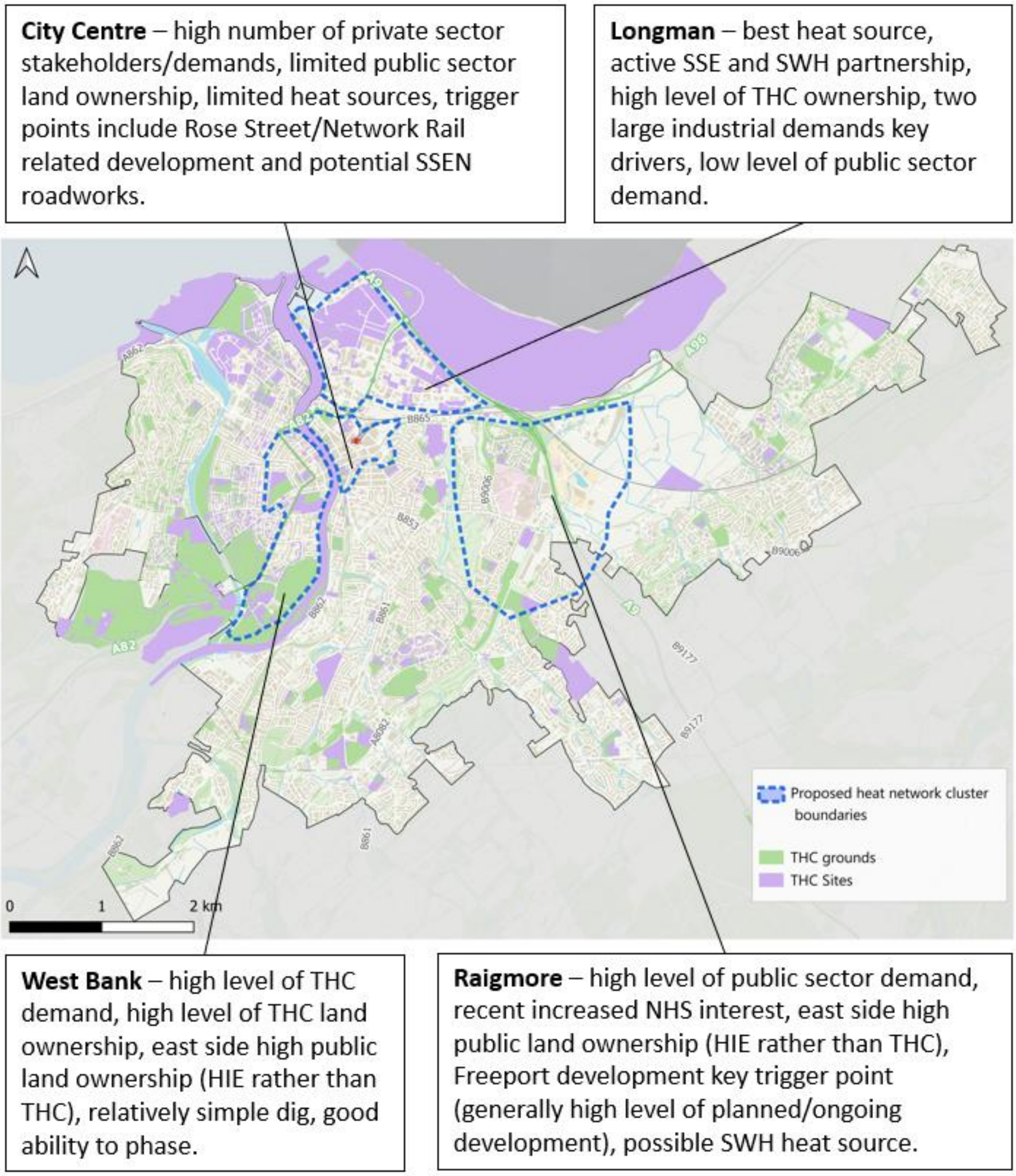

Figure 0—1 High level summary of some key strategic items the four heat network areas examined.

The **West Bank** area was found to present a promising heat network opportunity. It has a high level of Highland Council land ownership and large Highland Council heat demands. The proposed network routing runs through Bught Park, offsetting a relatively low Linear Heat Density (LHD) of 4.6 MWh/yr/m, this would be improved by a more optimised network design. The CAPEX £/MWh/yr thermal[1] measure of 0.85 for the core connections scenario is indicative of economic viability at this

[1] This is a measure of capital cost compared to heat delivered. As this project is strategic rather than feasibility more detailed economic measures were not modelled. However, this provides an indicator of economic performance. A heat network at this level of study would be expected to achieve a CAPEX £/MWh/yr thermal figure of 0.7 to 1 (less than 0.7 is very unusual but would represent a very economically attractive network, whilst greater than 1 indicates a need for optimisation).

level of analysis. The area has multiple low carbon heat supply options, including air, ground and water (from the River Ness) source heat pumps, as well as future potential waste heat from a data centre that is in the early stages of planning.

A recently announced strategic partnership between Scottish Water Horizons (SWH) and SSE is seen as a key driver for a heat network in **Longman**. The area has the best low carbon heat source identified in any of the heat network areas in Inverness (a SWH pumping station), which improves the attractiveness of the area. THC being a key land owner in Longman could be a key enabler for heat network deployment. Without two large private sector industrial loads (Baids Maltings and a Tarmac plant) connecting the LHD and CAPEX £k/MWh/yr thermal indicators perform poorly for the area (2.4 and 1.5 respectively), highlighting the importance of private sector stakeholder engagement at an early stage. When Bairds Maltings is included it raises to a LHD of 10.2 and CAPEX £k/MWh/yr thermal value of 0.33, indicating a high level of attractiveness (these values are very high level and purely indicative – industrial loads are particularly challenging to model for heat networks). These values are all for the western area of Longman, which is identified as presenting the best heat network opportunity.

The **City Centre** presents a promising opportunity for a heat network, with a high demand density (an LHD of 7.8). However, the dig complexity (with a high level of hard dig) indicates that the cost of network construction will be high – planned cabling work by SSEN could help mitigate these costs by reducing the civils costs associated with digging up the roads. This could reduce the relatively high CAPEX £k/MWh/yr thermal value of 1.08. The heat network has little public sector influence in terms of land or demand ownership, increasing the complexity of stakeholder engagement. The planned development in the Rose Street area and planned work by National Rail creates an opportunity for constructing an energy centre in what is a spatially constrained area of Inverness. There is also potential to link with the Longman area, and its large waste heat sources, but this requires more detailed analysis; including the economics of such a connection and the amount of waste heat that will be used within the Longman area. If the majority of the heat is used in Longman (which is likely the case if the Maltings and Tarmac plant are connected) the quantity of low cost heat that can be supplied to the City Centre will reduce, reducing the benefit of interconnection. Within the City Centre there are no waste heat sources identified, air source heat pumps are considered the most likely local heat source (the River Ness is adjacent but in a challenging location from a likely heat network build out perspective).

The **Raigmore** area presents multiple promising heat network opportunities. The area is split by the A9 and in a feasibility study alongside this report a heat network covering the full area, just the West and just the East of the A9 were examined. The latter was selected to progress to full feasibility in the report. Engagement with the NHS, due to the large and strategically placed heat demand of Raigmore Hospital, will be key for driving a network to the West of the A9 where the LHD and CAPEX £/MWh/yr measures appear to be promising (5.4 and 0.93 respectively). On the East of the A9, the planned Freeport development will be key to driving a heat network, the LHD and CAPEX £/MWh/yr (4.6 and 1.24 respectively) indicate a slightly less favourable network. However, this is offset by a likely reduction in cost due to high dig costs being assumed in the area and the economic effectiveness of connecting a new site (the Freeport development). The accompanying feasibility study found the East option viable and suggested continuing to outline business case. For both sides of the A9 there are large number of public sector anchor loads, meaning engagement is likely to be straight forward if the option is taken to progress the heat network opportunities. On the East of the A9 the high level of ownership by HIE will further ease the engagement process. Sewer waste heat, ground source and air source heat pumps all have some potential in Raigmore, with the feasibility study taking air source heat pumps forward as the selected technology.

Interactions between heat networks

When considering large scale strategic interaction between heat network opportunities it is important to understand the key drivers for interaction. These can be broken down to push or pull factors:

- **Push factors** relate to a drive to export heat from an area or a low-cost heat source acting to push interconnection in the area itself. This will generally be a large-scale heat source which either exceeds the heat demand nearby or is an area which is not well suited to heat network deployment.
- **Pull factors** are those which drive import of heat to an area. This will often be related to a highly attractive heat dense area. At the strategic level another pull factor could be the lack of heat supply potential within the area to meet the heat network opportunity. Other pull factors could be societal indicators such as fuel poverty – prioritising these areas for the lowest cost source of heat.

These are summarised for the different areas in Table 0—1. In Inverness there is generally a stronger set of pull than push factors within zones, which would generally lead to a lack of interconnection.

Table 0—1 High level summary of push and pull factors for different potential heat network areas in Inverness.

Area	Push factors	Pull factors
West Bank	Very few, potentially some benefit from the River Ness but would require detail assessment to demonstrate superior economics to ASHP or GSHP. High level of THC land ownership would aid broader push of heat if suitable.	High level of THC demands key driver for heat networks in the area.
Longman	SW pumping station is the most promising heat asset identified in Inverness. Potential route for electrolysis waste heat from adjacent hydrogen production site in planning. High level of THC land ownership allowing effective push of heat from the area. Justice Centre well located for a strategic connection for any push to wider heat interconnection. Large amount of available land near heat source provides space for a large energy centre and the potential for associated thermal storage.	Two large industrial demands but otherwise relatively few pulls for heat to the area.
City Centre	Very limited push factors, no major heat sources and spatially constrained.	High heat demand density.
Raigmore	Some waste heat potential from the sewer was shown to perform in a similar manner to ASHP, ongoing SWH activity in Inverness may help drive down costs for this technology.	Large number of public sector anchor loads.

The Longman area is the only one with significant positive push factors out of the area. The geographic proximity to the City Centre, which would have the greatest difficulty generating heat locally, means that interconnection could be considered.

Challenges for this include the danger of a relatively low-density connection route through the Longman site to the City Centre. It will be important to maximise connections on this route (such as the Justice Centre) to help improve viability of the connection. The redevelopment in the Rose Street area of Inverness is also well located for any route connecting Longman and the City Centre, which would be important to consider in any detailed layout options for the network. There is increased complexity in strategic alignment over large, interconnected areas.

Both the West Bank and Raigmore areas are, based on the findings of this work, initially better placed to consider in isolation. They have suitable land and heat sources to supply their own potential networks and there are good local pull factors in terms of heat demands and land ownership. For

Raigmore although the feasibility study considered the East and West sides of the A9 separately it is still important to consider the area as a whole:

- The increased interest of the hospital since the feasibility study was completed helps derisk the West network.
- The large sewer main on the East side may become more attractive, with increased SWH work in the area potentially driving down costs – this heat supply could be the push factor required to connect the East and West sides of the A9.
- The larger total heat demand is likely to be more attractive to investors.

The scale of the heat demand in the four areas examined are broadly similar. With demand varying between 24 GWh/yr and 49 GWh/yr, depending on the areas and the modelling scenarios selected.

Sequencing and heat network trigger points

All of the areas examined in Inverness show potential for heat network deployment. All the potential heat networks have specific benefits and challenges and how these are balanced and consider impacts their attractiveness. This section captures key trigger points for each area, many of which have been discussed previously, in Table 0—2 to Table 0—5 and then goes on to discuss how these influence sequencing of potential heat network zones and activity.

Table 0—2 Key trigger points for the West Bank heat network area.

Key trigger points
• Planned work at the leisure centre. • Understanding of heat supply technology in anchor loads and core connections. The replacement of heating systems will be a trigger point for connection for many loads, with a heat network connection not being available it could mean connection is not viable until end of life for the new heating technology. • The potential data centre could be an important waste heat source. Ensuring compatibility with any energy centre design should be considered. This could drive the price of heat down and could be a trigger for network expansion (it is considered likely that a first phase of West Bank could progress ahead of the data centre deployment).

Table 0—3 Key trigger points for the Longman potential heat network area.

Key trigger points
• The ongoing collaboration of SSE and SWH has already acted as key trigger point for this area. This has progressed interest faster than may be expected based on the other heat demand (rather than source) led opportunities in inverness. • Shared trenching captures a number of key trigger points in Longman. This includes a potential hydrogen pipeline and waste heat transmission from the electrolysis site on the old landfill site. Another being shared trenching with a private wire from the PV site in Longman (based around the pumping station). Finally, planned SSEN upgrades in the wider area may drive Longman interconnection (this is discussed further for the City Centre). • The interest of the Tarmac and Bairds Maltings sites will be a key trigger for deployment, without these the heat network potential in the area appears marginal.

Table 0—4 Key trigger points for the City Centre potential heat network area.

Key trigger points
• The Rose Street redevelopment is a key enabler for allowing for the centralised infrastructure of an energy centre in the spatial constrained City Centre. • SSEN have planned cabling upgrades in the City Centre. They have already expressed initial interest of using this as an opportunity for heat network installation, reducing the cost of pipework.

• Understanding of key anchor load requirements and interest for heat network connection. Eastgate is the single largest demand identified in the City Centre and would create a strong network spine, with the route passing other key loads like the Royal Highland Hotel.

Table 0—5 Key trigger points for the Raigmore potential heat network area.

Key trigger points
• The Freeport developments are key to driving the heat network to the East of the A9. • Recent increased interest from the hospital and understanding of required timescales and onsite plans will be key to determining timings on the West. This should also consider the potential redevelopment of the Raigmore, which could be the required trigger for connection. • Planned electricity network upgrades in the area (focused in the West) could provide opportunity for shared trenching, acting as a trigger point for pipework deployment. • There is also understood to planned ongoing in the south of the area which could be a trigger point for connection to the Police Scotland site. It may be hard to align this with the likely rate of network deployment on the West. Thus, it is important to review the ambitions on the West side of Raigmore consider whether laying a pipe to futureproof for connection to the Police Scotland building.

These trigger points help inform key considerations for heat network sequencing in Inverness, these are summarised below:

- **West Bank** – suggested to be the first network to pursue, focusing on the area to the south of Bught Park. Planned activity in the area adds an element of time criticality. Key will be engaging the Ice Centre to understand the appetite for cooling, as this will influence energy centre design. The energy centre design will also have to consider future proofing for potential expansion across Bught Park. In terms of sequencing this expansion across Bught Park is considered to be most suitable at a later stage, focusing on early delivery in the south of the area to reduce complexity and ensure the time critical opportunities are not missed.
- **Longman** – understanding the full ambition of heat networks in the wider Longman and City Centre areas is key to sequencing. The potential interconnection and transmission of heat is key to ensuring pipes are suitably sized. Many items to determine the sequencing will be based on stakeholder engagement to understand the desire of demands to connect. Shared trenching opportunities during electricity network upgrades, may drive activity earlier than would normally be expected in a heat network with the characteristics and complexities of Longman and the City Centre. In terms of overall sequencing some early activity in Longman is considered likely, due to the drive of SWH and SSE, but wider strategy and realisation of the opportunity is likely to take longer. This could potentially align well with the potential additional waste heat supply from the electrolysis site going through planning.
- **City Centre** – the city centre has some of the greatest complexities and in terms of sequencing is thus likely to be slower to progress than the other opportunities in Inverness. The main driver for any early-stage activity in the area will be cable upgrades by SSEN, potential reducing pipework trenching costs. As discussed for the Longman area the laying of pipework ahead of guaranteed connections and strategy does create substantial risks in terms of upfront investment. The trigger point of the Rose Street redevelopment is going to be key for sequencing development in the City Centre area, understanding the heat demands that are likely to connect and their scale before the redevelopment is key to effective sequencing and heat network planning for the City centre.
- **Raigmore** – is an area with relatively simple stakeholders to engage (this was demonstrated during the feasibility study. The sequencing of the East is laid out in detail in the accompanying feasibility study. The Freeport connections are key to the network and the sequencing. In the West loads are more well established and a network could potentially progress more rapidly, the engagement of the hospital at the end of the study and their ambitions will be a key actor and driver of timings in the West.

Next steps

There are large number of potential actions for progressing the heat network opportunities in Inverness, THC are exploring other opportunities outside Inverness but Inverness was the focus of this work. Some suggested actions, a few of which are already ongoing, include:

- **Consideration of delivery models** – an introduction to the options for these were provided in a workshop by Buro Happold at the end of the strategic study. Separately, Addleshaw Goddard are providing support to decide on delivery models for the different opportunities in Inverness. This will help determine the different actions for THC in the different heat network opportunities and how to progress through zone designation and delivery and bringing the opportunity to market.
- **Decision on indicative heat network zone boundaries** – this is linked to delivery models. It is suggested that both West Bank and Raigmore should be individual zones. For West Bank its relative isolation and the high level of THC demand in the area would suggest a different delivery model to the other opportunity areas. For Raigmore even though the feasibility focused on the East there could still be potential to connect both sides of the A9, particularly as the hospital is now more engaged. Additionally, the full Raigmore area is more likely to be of interest to private investment as it is of a larger scale and having the option of different distinct areas and phases of development is likely to be of interest to developers. For the City Centre and the Longman area the decision needs to be as to whether the areas should be considered as one or two potential heat network zones. The available heat from the pumping station and the availability of waste heat from the potential hydrogen site are key influences. If it becomes apparent Longman has large volumes of cheap heat it become suitable to group the two areas, to help reduce deployment complexity. This increase in heat demand scale is also likely to increase the desirability for investors.
- **Building Assessment Reports** – the identification of key heat demands in the opportunity areas should be a driver for BARs. For West Bank in particular this is seen as a focus for THC activity, understanding the heating systems and likely replacement timetables for equipment is key to building a cogent strategy for the area.
- **More detailed analysis of West Bank** – this should initially be focused in the southern area of the network. This area has the most pressing trigger point with the work at the leisure centre being an opportunity for initial deployment. There are multiple actions, three being: a utility survey, greater understanding of a potential energy centre location, future proofing for expansion and connection of any additional heat sources (e.g. the potential data centre in the area), and appraisal of heat supply technologies (this could include more detailed consideration of the Ness as heat source including insights from the Glen Mhor project, GSHP, and engagement with SWH to ensure there is not sewer potential).
- **Stakeholder engagement** – each potential zone has key stakeholders to engage, some like SSEN are key for all (to ensure network capacity is available for low carbon heat) whilst others are more localised, some key ones being:
    - In Raigmore it is important to engage with the hospital in the West and in the East the Freeport stakeholders are important to engage as well as HIE and the new prison. More details of these and other stakeholders are provided in the feasibility study.
    - In the City Centre there are multiple private sector loads key to the network viability. For the energy centre location National Rail are willing to set aside land as part of the Rose Street development, based on conversations with THC. Continued engagement with SSEN is required to ensure opportunities align with planned cable upgrades.
    - For Longman the Maltings and Tarmac plant are key for driving a network in Longman. The potential waste heat from hydrogen is also key to monitor through stakeholder engagement (and align any pipework). SSE and SWH are already pursuing a heat network in the area and are as such the key stakeholders driving the heat network. Continued understanding of their ambition and strategy is key to the overall strategy for both Longman and the City Centre.

  - West Bank is the most dependent on internal stakeholders at the Council and related bodies like High Life Highland.

These key next steps form initial actions to help take these heat network opportunities forward in Inverness. The opportunity to align with other activity in Inverness is seen as a key driver for Highland as a local authority to progress with large scale strategic heat networks. This building of a supply chain and expertise in the area will help realise a wider heat network vision for Highland, attracting interest and helping the exploration of opportunities across the local authority as a whole.

1 Introduction

Through the Heat Network Support Unit (HNSU) funding Zero Waste Scotland (ZWS) commissioned Buro Happold (BH) to undertake a strategic appraisal of heat network opportunities in Inverness for The Highland Council (THC). Alongside this strategic work a feasibility study was carried in parallel for the Raigmore area of Inverness, insights from this fed into this strategic analysis.

The aims of this study can be broadly summarised as:

- Creating a better understanding of the potential heat network opportunities in Inverness and their scale.
- Agreeing a strategic vision for heat network ambition in Inverness.
- Understanding of how heat network opportunities in Inverness could be realised and progressed.

The key sections of this report are:

- **Heat Network Vision Statement and KPIs** – this outlines the ambitions of THC and can act as a standalone document for engaging and gaining buy-in from stakeholders.
- **Methodology** – summarises the analysis undertaken to inform the strategic vision and captures some high-level assumptions.
- **Heat network areas** – provides details of the four heat network areas examined in Inverness, including indicative pipe route layouts and an analysis of the different demands in each area.
- **Multi Criteria Analysis** – this provides an overview of key assessment criteria considered for heat networks. It also provides an overview of an accompanying Excel tool that can be used to interrogate the various heat networks, depending on which criteria are most important for the specific appraisal.
- **Strategic overview and summary and next steps** – this section provides a summary of the key criteria, discussed in the Multi Criteria Analysis section, for each heat network. It also gives a summary of key trigger points for development. Finally, it gives some suggestions for next steps.

2 Heat Network Vision Statement and KPIs

This section establishes the aspirations for heat networks in a Vision Statement for Highland Council and the key performance indicators (KPIs) that sit alongside this to ensure that strategic heat networks explored are accurately assessed against this vision and other key Council metrics. Figure 2—1 shows where these two items sit in creating an overall strategic vision.

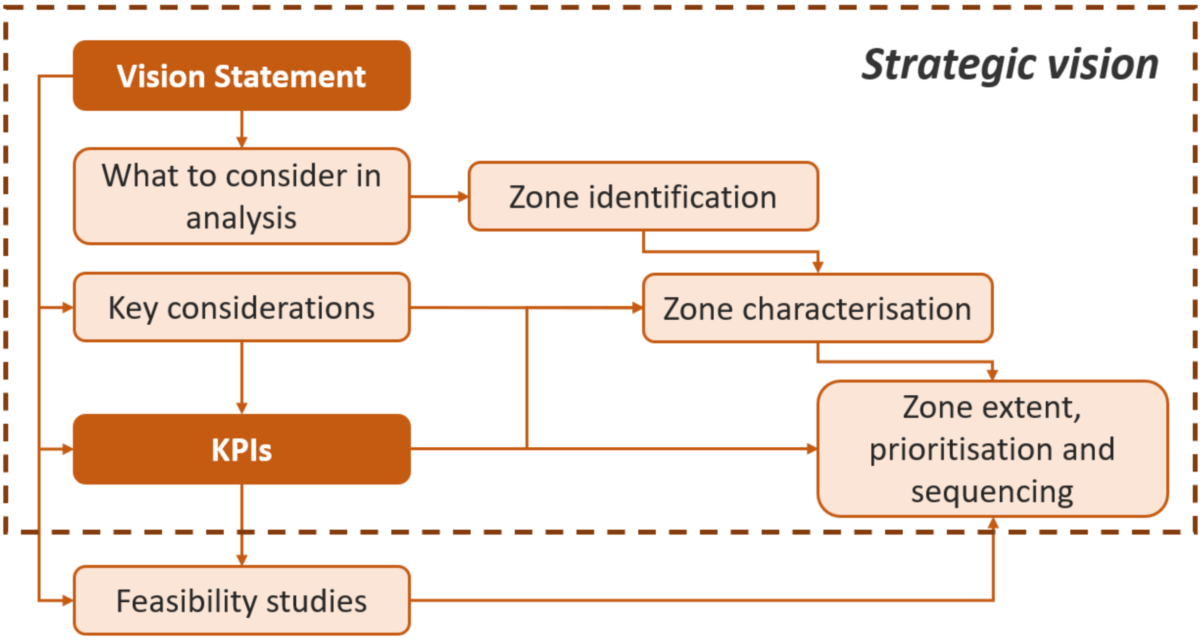

Figure 2—1 Summary of key elements of creating a strategic heat network vision.

2.1 Heat Network Vision Statement

The Heat Networks Vision Statement sets out the anticipated role that heat networks will play in the decarbonisation of heat across Inverness, and the position that the Highland Council expects heat networks to play in the delivery of broader policy outcomes and/or objectives. It draws on evidence compiled as part of Local Heat and Energy Efficiency Strategies (LHEES) and other heat network scoping activities carried out in Inverness. This statement can be used to introduce new internal and external stakeholders to heat networks opportunities in the area as well as helping to define the Key Performance Indicators (KPIs) and other consideration for the strategic assessment of heat network opportunities in Inverness.

2.1.1 Vision statement summary

As a cornerstone of the Highland Council's decarbonisation strategy, we envision developing and expanding heat networks to deliver sustainable, affordable, and efficient energy solutions – providing the lowest cost low carbon heating option. Thereby, supporting Scotland's Net Zero goals by 2045 and providing social, economic, and environmental benefits to the region.

Through LHEES and aligned with national policies, the Council envisions a number of heat network zones across Inverness. These zones will reduce reliance on fossil fuels, decrease carbon emissions, and support energy resilience. The Council recognises that the heat network can deliver further benefits including:

Carbon emissions reduction: By transitioning to low-carbon and renewable energy sources, heat networks significantly reduce greenhouse gas emissions which is essential for achieving the Highland Council's ambitious Net Zero emissions target by 2045.

Tacking fuel poverty: Heat networks can provide consistent and reliable heating and hot water on demand. Providing affordable heat particularly in areas with a high proportion of older, less energy-efficient homes.

Creating job and economic growth: The development and operation of heat networks stimulate local economies by creating jobs and supporting the growth of a skilled workforce. This economic boost can contribute the overall prosperity of the region.

Energy Security and Resilience: By diversifying energy sources and localising heat production, heat networks enhance energy security and resilience. This approach reduces dependence on imported fuels and mitigates the impact of global energy price fluctuations.

Environmental Sustainability: Heat networks facilitate the integration of various renewable energy sources, such as geothermal, solar, and biomass, promoting environmental sustainability and contributing to cleaner air quality in urban areas.

By embracing these benefits, the Highland Council can ensure that the development of heat networks in Inverness not only addresses environmental concerns but also delivers tangible social and economic advantages to the community.

2.1.2 Alignment with national legislation, Local Development Plans and strategy

There are multiple local and national policies which should be considered when developing a heat network strategy, key items include:

Heat Networks (Scotland) Act 2021: Mandates local authorities to designate Heat Network Zones, streamline permissions supporting the development of heat networks.

Heat in Buildings Strategy: Outlines Scotland's approach to reducing emissions from buildings, emphasizing the role of heat networks in achieving these goals. In April 2025 there has been an update on the future heat in buildings bill[2]. This includes creating particular requirements for large, nondomestic premises and including powers to require public sector buildings to connect to district heating when it is available.

The Inner Moray Firth Local Development Plan (IMFLDP2): sets out ambitions for low and zero carbon development, requiring new developments within identified Heat Network Zones to connect to existing networks or implement future-proofing measures.

The new Local Development Plan (LDP) - the Council is developing the new LDP for the whole of Highland excluding most of the Badenoch & Strathspey area for which the Cairngorm National Park is the Planning Authority (CNPA); (CNPA will likewise be developing a new LDP). The plan will set out how the land can be used by developers for the next twenty years and will be used alongside National Planning Framework 4 (NPF4) as a framework for planning of development and investment.

The Highland Council adopts a comprehensive approach to developing heat networks:

Identifying Potential Heat Network Zones: Through the LHEES, areas suitable for heat network development are identified, focusing on energy efficiency and heat decarbonisation.

Undertaking Feasibility Studies and Business Cases: Detailed feasibility studies and robust business cases ensure the viability of heat network projects, as evidenced by feasibility studies in Inverness Castle and Inverness West Bank.

Engaging with Stakeholders: Collaboration with communities, developers, energy suppliers, and investors is prioritised to ensure successful implementation.

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[2] https://www.parliament.scot/api/sitecore/CustomMedia/OfficialReport?meetingId=16359

Securing Funding and Investment: Active pursuit of funding opportunities, including grants, loans, and private sector investment, supports heat network development.

The LHEES process identified three potential Heat Network Zones in Inverness. Recognising that the zones identified during LHEES are smaller than the Highland Council's ambition for heat networks. A more long-term strategic view is required. This approach considers wider opportunities, demands and connections, building on LHEES, previous feasibility studies and an ongoing study in areas like Raigmore. The strategic work will characterise and assess potential Heat Network Zones in Inverness. This will help sequence heat network deployment to increase interest and promote deployment.

By embracing these strategies, the Highland Council aims to ensure that the development of heat networks in Inverness not only addresses environmental concerns but also delivers tangible social and economic advantages to the community.

2.2 Drivers and KPIs

For heat networks to be developed they often require certain key drivers, alongside the legislative and policy frameworks (briefly explored above). These can include localised items related to the character of an area, or specific temporal factors – such as new developments. Many of these drivers can have a quantifiable element making them suitable to be used to characterise different potential heat network zones. Through a workshop with Highland Council various different drivers and measures were considered to establish an agreed set of KPIs against which to review the relative performance of different heat network zones, the KPIs fall within four key themes:

- **Economic** – assessment of how well a scheme is likely to perform as an economic proposition. As this is a strategic review detailed techno-economic modelling is not carried out. Instead the economic indicators are include linear heat density and estimated capital costs compared to heat supply.
- **Deliverability** – covers several factors such as alignment with broader strategy and linking to the ease of network deployment. This also includes capturing indicators relating to Highland Council influence. Key items considered include the number and size of Highland Council heat demands as well as
- **Decarbonisation** – reducing carbon emissions is a cornerstone of heat network and related policy and thus a key item to consider heat network performance against. The KPIs for this are based around the amount of carbon saved by switching to a heat network solution as well as the presence of low carbon heat sources for a heat network.
- **Social** – factors such as fuel poverty are a key concern in many energy strategies, including being an assessment area within LHEES, and understanding the context of these social factors in potential heat network zones were considered important KPIs to capture. The measures used are the average fuel poverty score in the potential heat network zones and the amount of social housing.

These KPIs are considered in the methodology, using tools to enable the necessary information to be gathered to assess potential heat network zones against them. The precise KPIs items captured and quantified are detailed and explored in the multi-criteria analysis in section 5.

The KPIs are used to understand how the different potential zones meet different Highland Council objectives. This will form a useful basis for identifying which delivery models are best suited to deliver these opportunities. Highland Council have commissioned a separate piece of work, which will be completed after this strategic study, to explore the different delivery models available to them. Linked to this a key ask of the KPI process is to be able to understand which zones are most suitable to a high level of Council involvement and which may better be pursued by a third party, with less direct Council participation. This is also considered at the multi-criteria analysis (MCA) level.

3 Methodology

3.1 Review of existing work

Several feasibility studies have been conducted in recent years to evaluate the potential heat network opportunities in Inverness:

- Inverness West Bank heat network feasibility study (2023): The study identifies an opportunity for a heat network in the West Bank area of Inverness. This network could connect various buildings including the Highland Council Headquarters, Inverness Leisure Centre, and Inverness Botanic Gardens. The study evaluates the open-loop ground source heat pumps fed by an alluvial aquifer, supplemented by top-up electric boilers. The estimated annual heat demand for the network was found to be 13,070 MWh, with a peak of 5,830 kW peak and estimated 2700 m pipe network. The study suggests assessing the feasibility of adding the Inverness High School connection considering its load and proximity to the Highland Council HQ. The Linear Heat Density (LHD) for the network identified is 4.8 MWh/yr/m and the Internal Rate of Return (IRR) for the network was indicated as 3.6% after 40 years. However, as well as the additional load of the high school, other non-domestic loads not captured such as the Royal Northern Infirmary, the main building at Eden Court and Inverness Cathedral could improve the performance.

- Inverness Castle heat network feasibility study (2023): The study explores the potential for a heat network near Inverness Castle. The heat network was identified as connecting buildings like Inverness Castle, North Tower, Inverness Town Hall, the Inverness Art Gallery & Museum and a new development. The study suggests using air source heat pumps (ASHPs) as the primary heating technology with electric boilers for backup. The estimated annual demand is circa 1,070 MWh, with a peak of 910 kW and estimated 188 m pipe network. The IRR is 3.6% and the LHD is 5.7 MWh/yr/m. There has been significant work in this area of Inverness since the feasibility. There are 11 ASHPS installed at the new energy centre for the heat network. They provide heat to the castle. There is also a connection where the energy centre can export excess heat to the Town House plant room. The gas boilers in the Town House can also provide heat to the Castle via the new energy centre. The gas CHP in the Town House has been removed and a new gas boiler installed to act as lead boiler for the Town House. The energy centre is not fully commissioned yet.

- Heat network feasibility near the Longman (2019): The study assesses the utilisation of waste heat from Scottish Water (SW) existing sewage network to supply nearby loads. The Bairds Malting Company factory was identified as the main anchor load due to their high process heat demand. Other buildings considered for connection are the SW regional office and laboratory. The annual heat demand is estimated to be 60,000 MWh with a peak of 17 MW peak. It was estimated that approximately 4,000kW$_{th}$ of deliverable heat is available from the sewer heat.

- Raigmore heat network feasibility study (2025): A feasibility study for a heat network in Raigmore area is currently ongoing in parallel with this study. The report highlights that there are opportunities across the Raigmore area. The focus of the feasibility study was to the east of the A9. The full report should be read for completeness but the area examined had an LHD of 4.6 MWh/yr/m and a IRR of 12% with 50% capital funding. It was suggested that the opportunity is pursued to outline business case (OBC).

- Local and Energy Efficiency Strategies[3] (LHEES) (2023): The Highland Council (THC) has completed and published LHEES in 2023[4], outlining a strategy for long term decarbonisation with heat networks as a key element. The LHEES identifies three indicative heat network zones in Inverness:
    - Inverness 1: This zone encompasses Inverness High School and the Highland Council Headquarters with the combined annual demand of 1645 MWh.
    - Inverness 2: Located around the Justice Centre and Police Scotland buildings, this zone has a combined heat demand of 1431 MWh/yr.
    - Inverness 3: This zone is centred around Police Headquarters and Bannatyne Health Clubs, with a combined heat demand of 1956 MWh/yr. consistent heat demand that could be served by a heat network.

Figure 3—1 indicates the boundaries of the feasibility studies and highlights the LHEES heat network opportunities in Inverness.

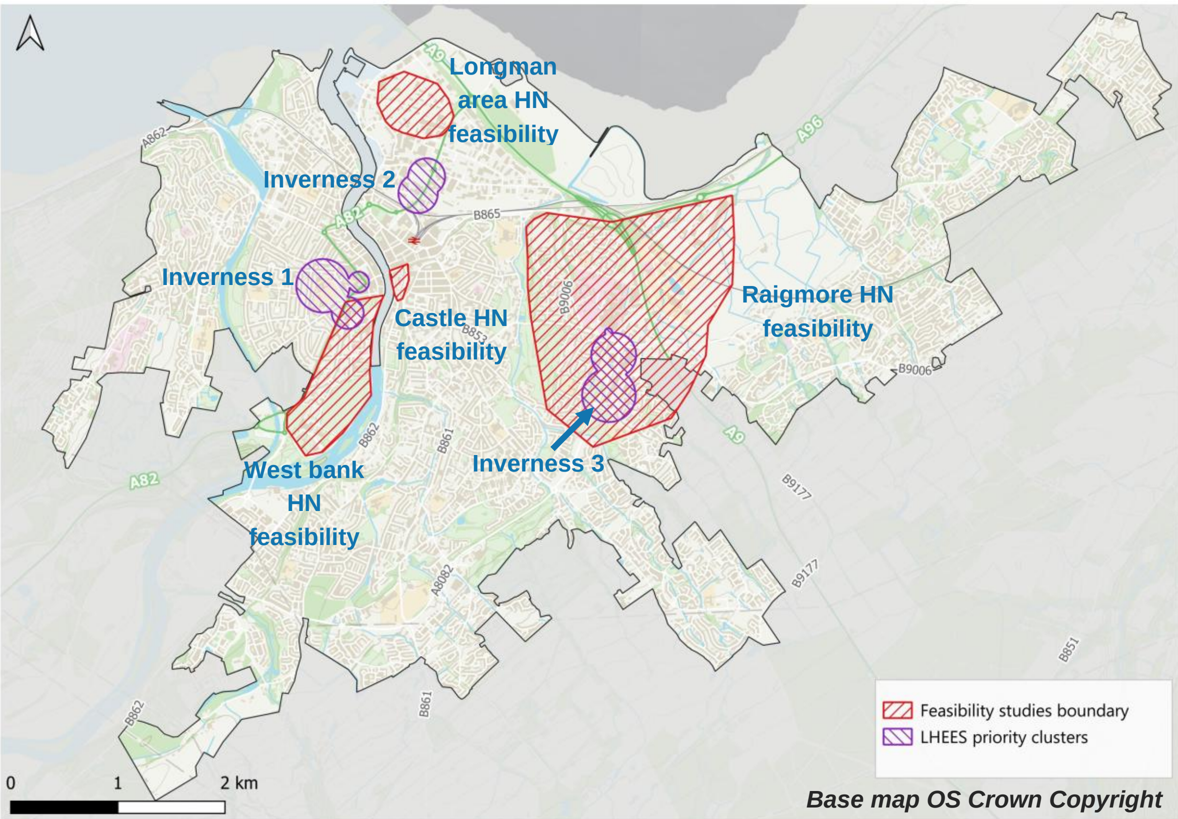

Figure 3—1 Feasibility studies boundaries and LHEES heat network opportunities

These studies demonstrates that Inverness has several viable opportunities for heat network development, utilising low carbon technologies such as ground source heat pump, air source heat

[3] Local Heat and Energy Efficiency Strategies (LHEES), mandated by the Heat in Buildings Strategy, are developed by local authorities to coordinate heat decarbonisation activities at the local level. The LHEES are designed to help meet Scotland's targets concerning energy efficiency and heat. A key element of the LHEES is the identification of potential heat network zones, informed by the First National Assessment and further refined by local authorities using their specific knowledge and datasets See: https://www.gov.scot/publications/local-heat-energy-efficiency-strategies-delivery-plans-guidance/

[4] https://www.highland.gov.uk/info/1210/environment/1097/the_local_heat_and_energy_efficiency_strategy

pump and water source heat pump, waste heat recovery. With the LHEES strategy in place, Inverness is positioned well to expand it heat networks.

Another heat network which is important to note alongside these wider studies is the Glen Mhor Heat Project[5]. The project was supported by a £1.6 million grant from the Low Carbon Infrastructure Transition Programme (LCITP) to commission and install a new energy centre housing a 1 MW water source heat pump, utilising water from the River Ness to supply heat to the Glen Mhor Hotel. There is potential for future connections, including a planned brewery, Visitor Centre Development, nearby social housing development and a nearby Church of Scotland. This project is on the east bank of the Ness, slightly to the south of the Castle HN feasibility marked in Figure 3—1.

3.2 Load assessment and new developments

For the heat demand analysis across Inverness, several datasets were used:

- **Scotland Heat Map (SHM)[6]**
  SHM consolidates various data sources available to the Scottish Government to provide estimates of the heat demand at both property and area level. It has been developed to identify opportunities to reduce carbon emissions in buildings. The datasets include: The Scottish Public Sector Energy Benchmarking Tool 2022, Local Authorities billing/procurement records, Energy Performance Certificates (EPCs), Energy Saving Trust's (EST) Home Analytics data, Scottish Assessors data and Ordnance Survey (OS) mapping data. When heat demand data is not available, estimates are derived using CIBSE TM46 benchmarks and Scottish House Condition.
- **Heat demands from feasibility studies**
  As detailed in section 3.1, Buro Happold has conducted several feasibility studies, some of which are ongoing. Where available, metered energy consumption has been used to determine the energy demand of the buildings in the study boundary. Where metered consumption data has not been available, industry standard benchmarks have been used in conjunction with relevant floor area data to assess forecasted energy demand.
- **The Highland Council energy benchmarking tool[7]**
  Developed by THC Climate Change and Energy Team, the tool provides a meaningful analysis of energy consumption, costs, and relative performance efficiencies for the non-domestic property estate.
- **Building Assessment Reports[8]**
  Under the Heat Networks (Scotland) Act 2021[9], owners of non-domestic buildings, initially in the public sector, are required to prepare Building Assessment Reports (BARs). These reports assess the suitability of these buildings for connection to a heat network, considering factors like heat demand and existing heat supply. This information will feed into review and designation of heat network zones and inform the development of heat networks within potential zones and supports a strategic approach to heat network planning.

To ensure the most reliable heat demand estimates, the following hierarchy was applied when prioritising data sources:

- Heat demand data from Buro Happold previous studies (covers key buildings near Inverness Castles, West Bank area and Raigmore area).
- Heat demand data collected from BAR (A BAR was available for two buildings in Inverness – with one of these being in the study areas).

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[5] https://www.gov.scot/publications/low-carbon-infrastructure-transition-programme-capital-projects-march-2024/pages/16/
[6] https://www.gov.scot/publications/scotland-heat-map-documents/
[7] https://www.highland.gov.uk/info/1210/environment/276/energy_use_in_our_buildings
[8] https://www.gov.scot/publications/building-assessment-report-bar-guidance/
[9] https://www.legislation.gov.uk/asp/2021/9

- Heat demand from the Highland Council energy benchmark tool.
- Heat demand data from SHM.

The datasets listed above provide the demand data at the individual property level for each individual property across Inverness; in flats, for example this would multiple properties in one building. For this study, these demands were aggregated from individual property level to the building level. This was performed using the buildings' Topographic Identifier (TOID), as properties within same building have the same TOID, whereas each individual property is identified by a Unique Property Reference Number (UPRN). The demands reported throughout the report reflect the building level demand rather than individual property demand. To define the building typology where a building contains multiple uses (e.g., a mix of offices and retails), the dominant typology was assigned based on the property type with the largest share of the total demand.

Figure 3—2 provides an overview of building level heat demand across Inverness, highlighting the data sources used. The figure highlights the dominance of the SHM as a data source, aligning to the LHEES heat network methodology. It is also useful for highlighting areas with a high number of Highland Council buildings and previous feasibility studies – these are good indicators of buildings that are likely to connect to a heat network and where the demand data will tend to have a higher confidence level. Figure 3—3 shows the distribution of the loads with over 100 MWh annual heat demand across Inverness.

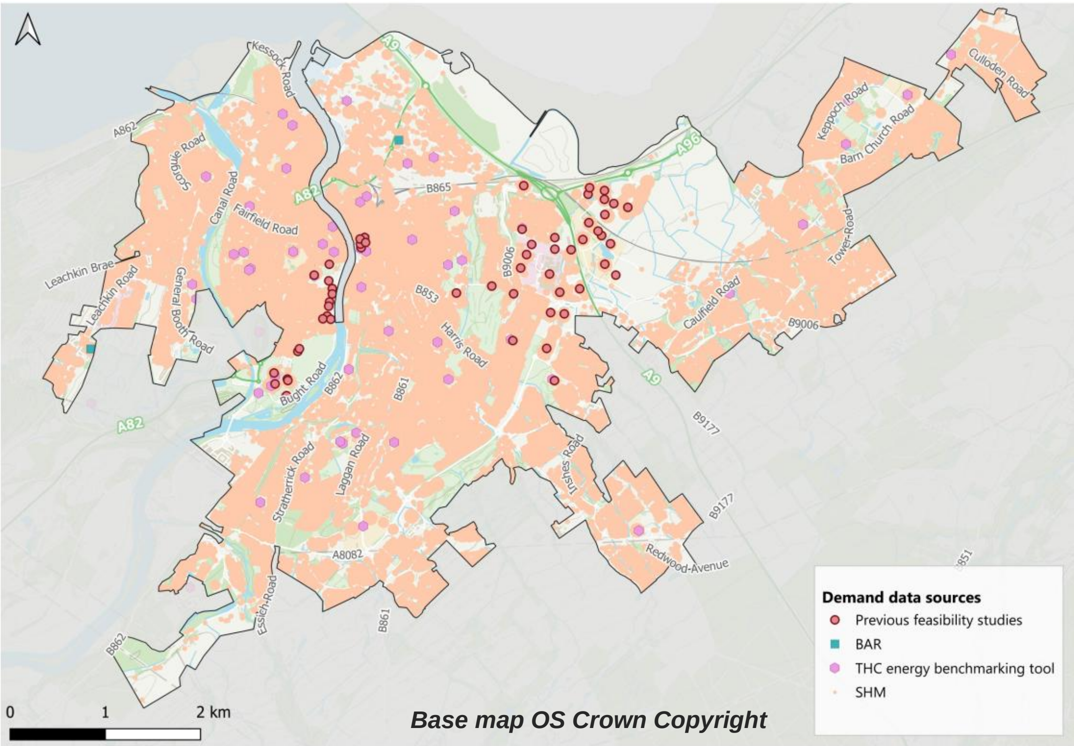


Figure 3—2 Building level heat demand across Inverness highlighting the data sources used.

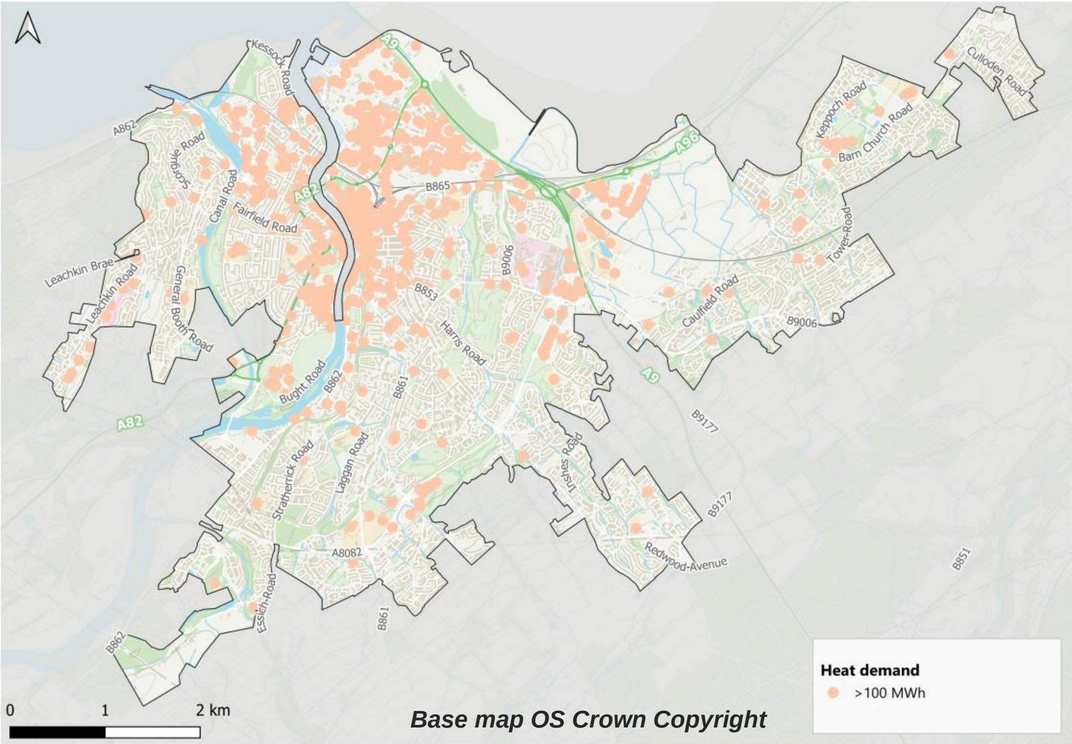


Figure 3—3 Inverness heat loads over 100 MWh/yr.

The allocations for adopted Local Development Plans (LDP) in Inverness according to the IMFLDP2[10] are presented in Figure 3—4. These are significant as they can act as drivers for heat networks in an area. Having a clear heat network strategy in an area can give confidence for the heat network system to be integrated into the building design. Understanding of LDP sites and their timings can be key to informing the temporal aspect of heat networks, as if the load is going to connect to the heat network it is important that there is a connection in place at the right time. Or if a network will not be available until after the LDP site is constructed, the heating system design is suitable for future heat network connection.

[10]https://www.highland.gov.uk/downloads/file/28837/inner_moray_firth_local_development_plan_2_strategy_and_general_policies

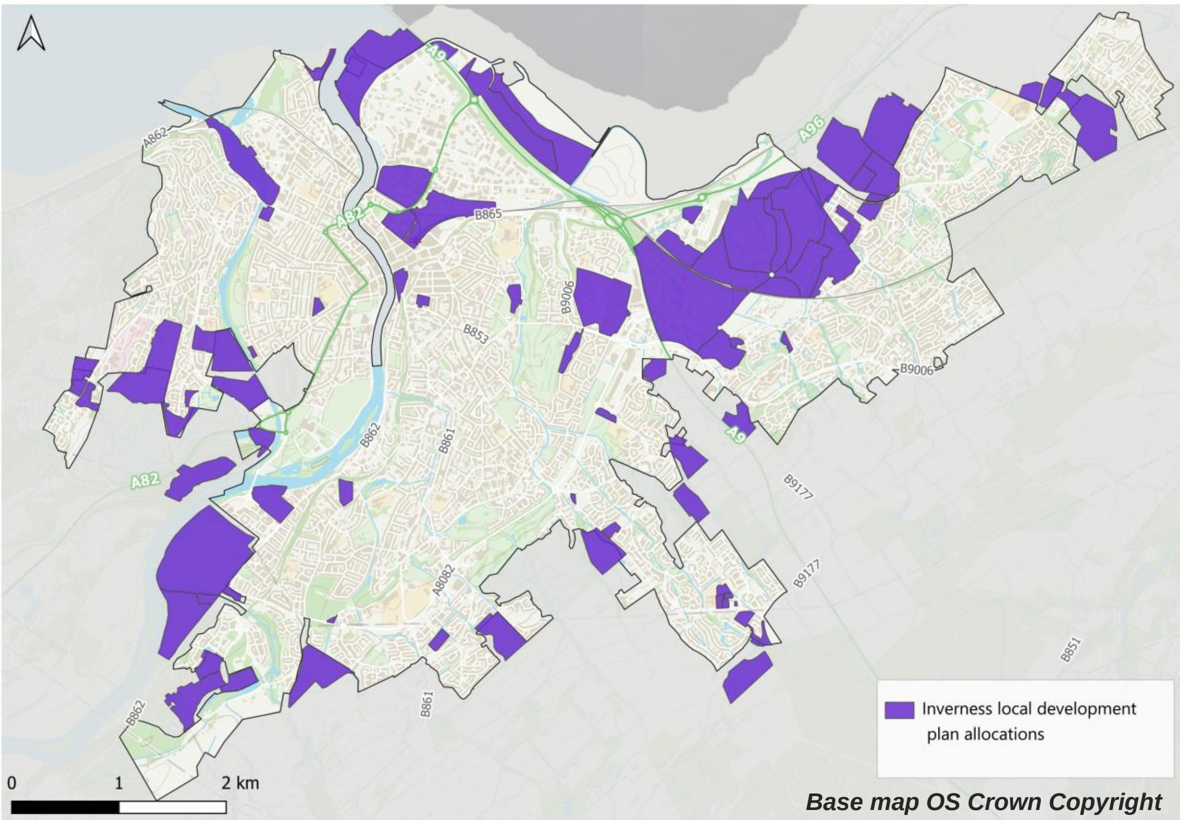


Figure 3—4 Inverness local development planned allocations

The planned development and redevelopment sites were noted but not modelled in the clustering analysis. While, they are not modelled, they remain important as potential trigger points for heat network development.

Some of key planned developments in Inverness are as follows:

- New prison – The new HMP Highland prison is being built in the Raigmore area to replace the previous HMP Inverness. It is scheduled for completion in 2026. The significance of this is discussed further in the Raigmore Feasibility Report.
- Freeport development - The Freeport development in Raigmore area represents the next phase for the University of Highlands and Islands (UHI) and Highlands and Islands Enterprise (HIE) campus, envisioned as a hub for education, research, healthcare, and innovation. Following discussion with THC, the scheduled completion for this masterplan is assumed as 2035, this second phase aims to attract innovative businesses, expand green spaces, and support the life sciences, tech, and renewables sectors, leveraging Green Freeport incentives. Again this is a significant element of the heat network feasibility study for Raigmore and one of the reasons for the focus on the East of the A9.
- Rose street development – as outlined in the IMFLDP2, a major redevelopment is planned in Rose Street, involving demolition of an existing car park and retail units to make way for a new hotel, retail and student accommodation. This is important for the City Centre potential heat network zone.
- Inverness railway station planned development as outlined in the IMFLDP2. Again this could present opportunities for the City Centre area.
- Longman landfill site phased redevelopment plan by THC. This includes the potential hosting of an electrolysis unit for hydrogen production just outside the site over the A9 on the old landfill site. This green hydrogen site could be a future source of waste heat for the Longman area.

- In additional to the green hydrogen site the Council are looking at several projects to produce energy, these can potentially link into the heat network strategy, providing local sources of electricity or shared utility routing. Some key examples are:
    - Solar PV Council Estate - optimise and expand solar PV across the Council's domestic and non-domestic, non-commercial, estate to supply green energy by direct wire; delivering a financial and carbon saving and protecting against future carbon tax liability.
    - Battery storage - collaborate with industry specialist to develop an investable model aligned to the Region's renewable energy potential.
    - Utility scale solar PV - develop a commercial solar farm at Longman. The project aims to sell generated electricity to the national grid, with future potential to provide direct energy sales to complementary developers on site.
    - Solar PV Commercial Estate - develop a Commercial PPA to generate income from the development of a solar portfolio.

New developments are noted for context rather than benchmarked. The exception for this is in the Raigmore area, where benchmarking of new developments was included as part of a feasibility study carried out in parallel to this work.

3.3 Linear heat density buffer analysis

To identify potential zones for heat network consideration, the LHEES stage 4[11] methodology is applied. This uses a radii-buffering approach is a deployed for identifying potential heat network zones. The buffers are defined using the linear heat density (LHD) metrics.

The LHD of a heat network is the total annual heat demand divided by the total length of the network. A higher LHD typically indicates better financial viability for a heat network. For instance, in areas where several high-heat demand buildings are clustered together, the required pipe length is relatively shorter, reducing capital expenses relative to the total connected loads.

LHD is used to determine a notional network length for each building based on its heat demand. Where buffer zones overlap, initial heat network clusters emerge, without considering the detail of a specific heat network layout. Figure 3—5 shows LHD buffering and connection distances for three heat demand points, assuming LHD of 4000 MWh/yr/m. The visualisation presents that the two properties on the left would be viable connections to each other due to their LHD 'buffers' overlapping, while the third property on the right is not viable for connection.

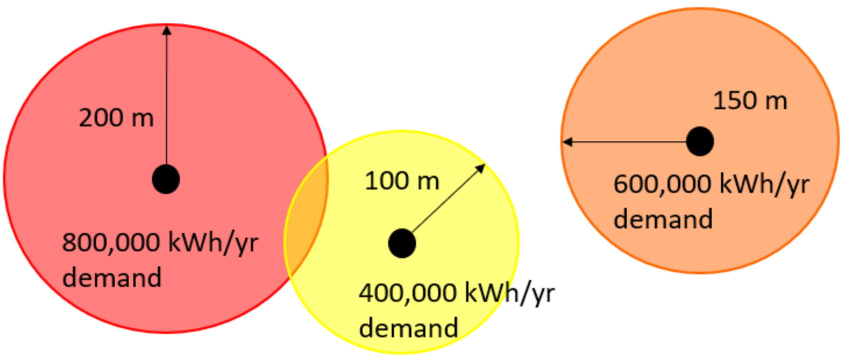


Figure 3—5 Example of LHD based buffering for 4000 kWh/yr/m, for three central points representing individual heat demands

To avoid very large buffers which could misleadingly suggest connection viability across whole towns or cities, the maximum buffer radius is capped at 250 m to restrict the maximum size of buffered

[11] https://www.zerowastescotland.org.uk/resources/lhees-methodology

circles. This also prevents heat demand points with low confidence level significantly influence the results.

The buffer radius is calculated for each building based on two LHD assumptions:

- 4000 kWh/yr/m (4 MWh/yr/m)
- 8000 kWh/yr/m (8 MWh/yr/m).

Although industry benchmarks for LHD tend to be higher, the 4000 kWh/yr/m LHD was selected to ensure potential heat networks are not excluded unnecessarily at the strategic stage. Figure 3—6 illustrates clusters formed at 4000 kWh/yr/m LHD and 8000 kWh/yr/m LHD clusters in Inverness, highlighting initial opportunities for heat network development.

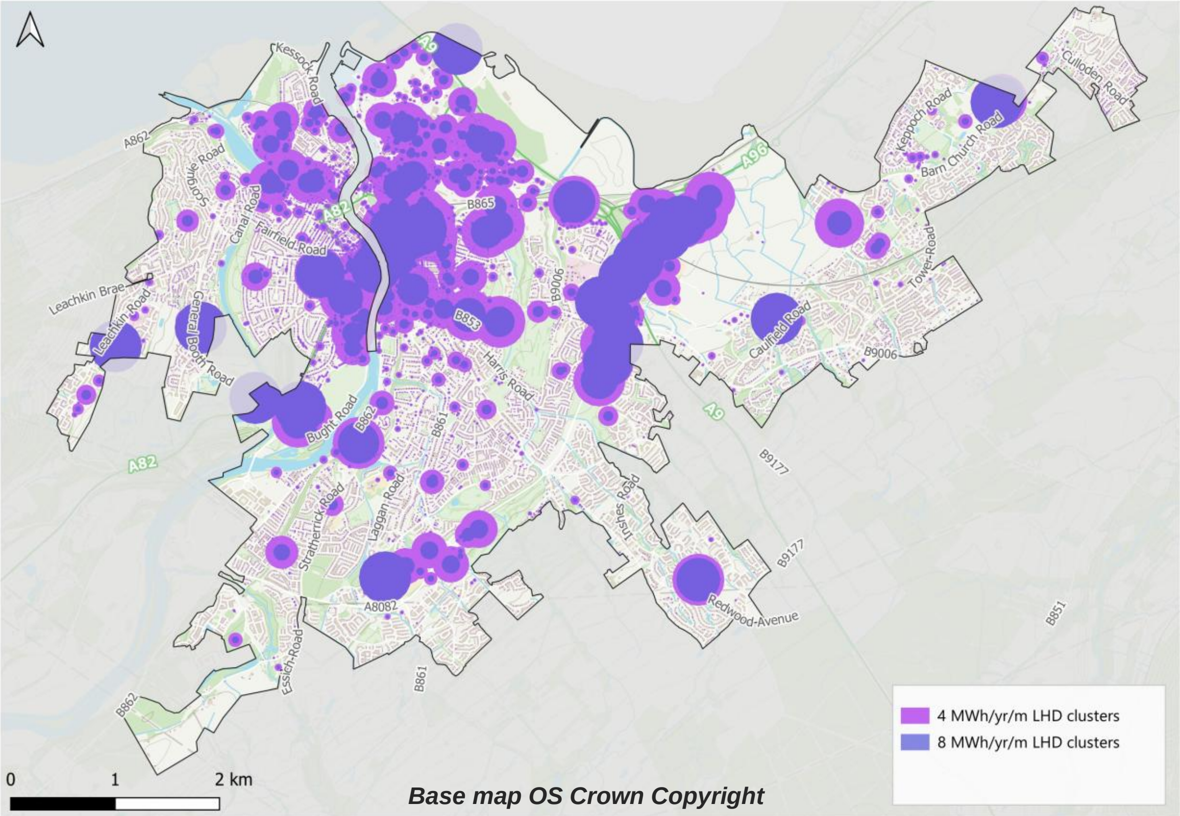


Figure 3—6 Clusters with LHD 4 and 8 MWh/yr/m

Anchor loads are high heat demand buildings and key connections on a heat network that usually drive project economics. These buildings often include public sector or local authority buildings, since these are typically easier to coordinate than private stakeholders in the early phases of heat network projects.

To prioritise clusters, a standard threshold of 500 MWh/yr is used to define anchor loads. Figure 3—7 presents clusters with at least 2 anchor loads, each with demand of over 500 MWh/yr. This highlights a number of potential heat network clusters in Inverness, including opportunities for heat network development in Raigmore (east of the Inverness), the City Centre, West bank and a few smaller areas around Longman. It is worth highlighting that the large Bairds Malting heat demand in Longman is not included in the map at this stage but is captured later in the analysis (see section 4.2.3.1). There are several reasons for this including distortion of the Longman heat network opportunity and the site not being properly captured in the SHM.

In addition to the anchor loads, other factors are considered when prioritising heat network clusters such as buildings tenure, planned developments, proximity to existing networks, deployment complexity.

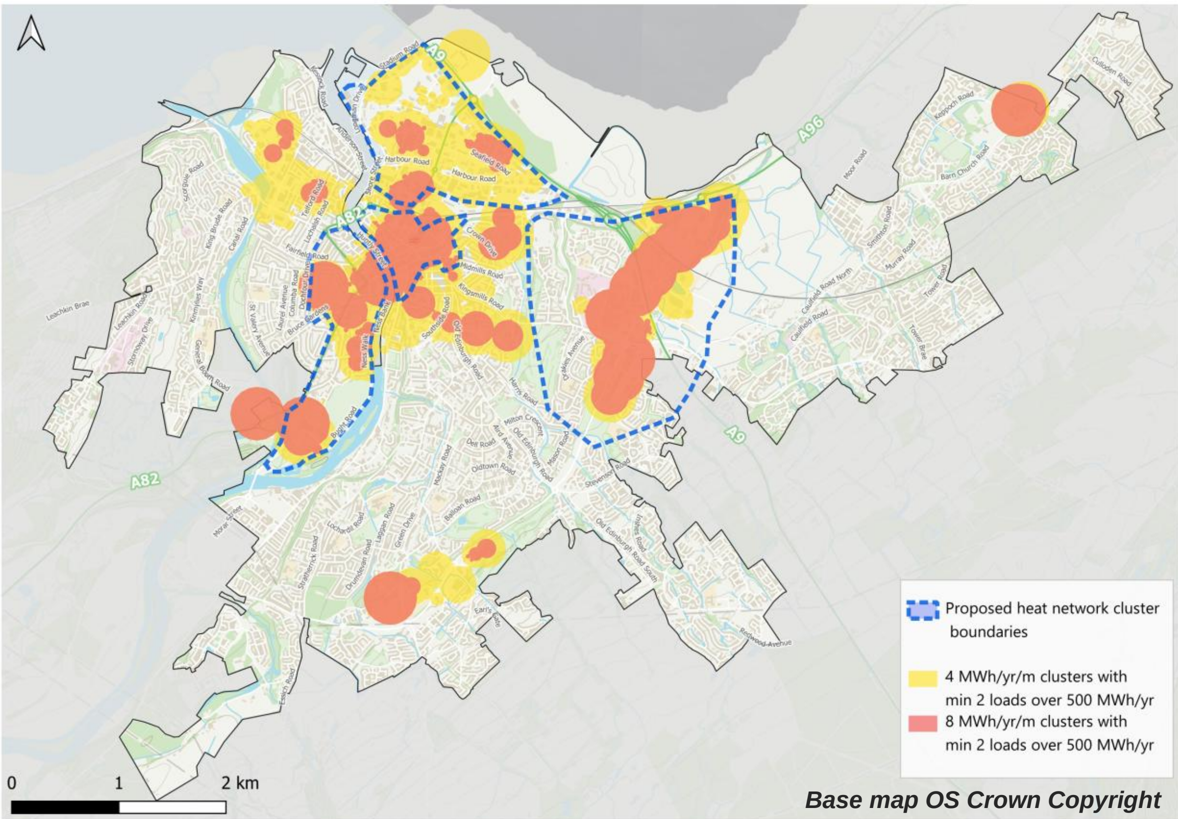


Figure 3—7 Clusters with LHD 4 and 8 MWh/yr/m with at least two anchor loads with over 500 MWh annual demand and the proposed boundary for the heat network clusters

This LHD buffering approach is used for cluster identification rather than assessment. The sections below describe the additional analysis to characterise and understand these potential heat network zones.

3.4 Heat source assessment

Alongside the LHD analysis, potential waste heat and low-carbon heat sources are identified. Waste heat refers to heat generated as a by-product of various industrial and commercial processes. Common sources include industries, Energy from Waste (EfW), electrical substations, wastewater treatment plants, data centres, hydrogen electrolysers and supermarkets refrigeration systems. Instead of being discarded, this heat can be captured through waste heat recovery and reused such as supplying it to a heat network. The feasibility of integrating waste heat into a heat network depends on several factors including the temperature grade of the waste heat sources, the scale of available heat, supply reliability and proximity to heat network. Additionally, some waste heat sources may require temperature upgrade to meet the heat network operational requirement.

Figure 3—8 highlights several potential waste heat and low-carbon heat opportunities in areas near the high LHD Clusters with estimated available heat exceeding 1 GWh.

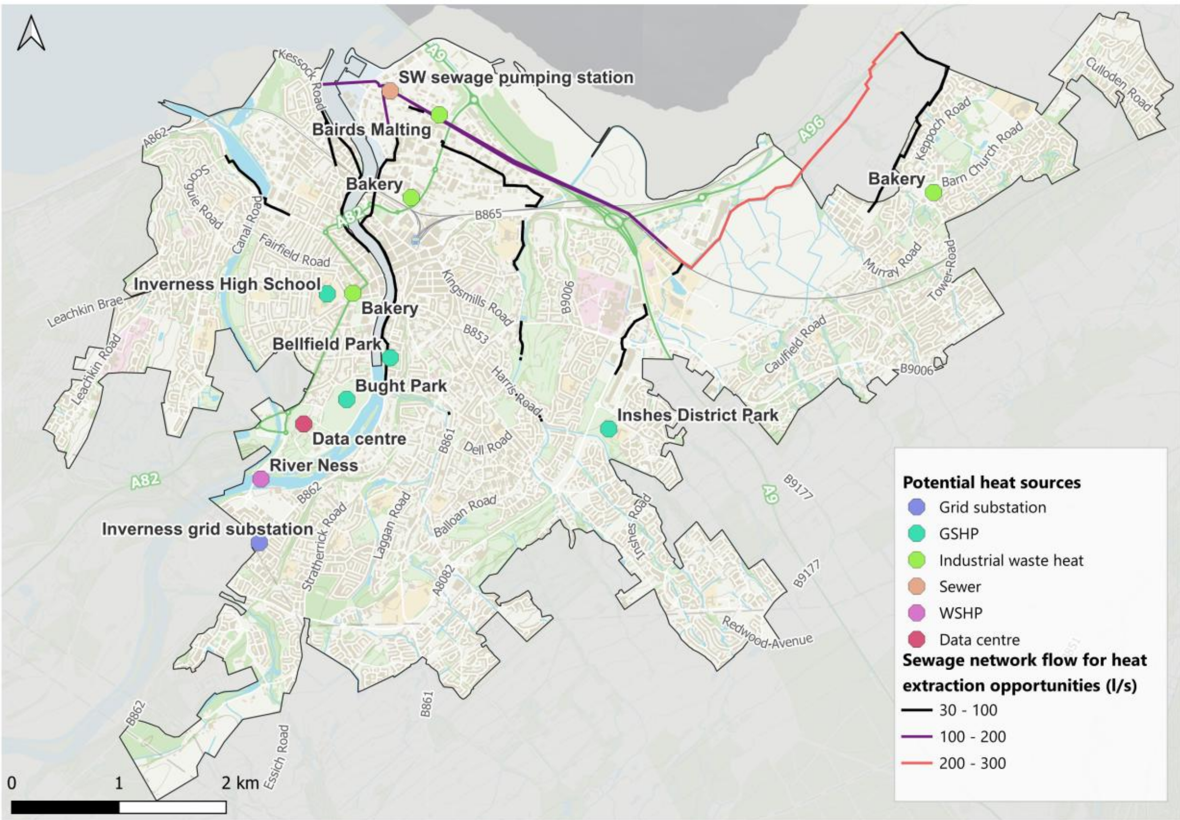


Figure 3—8 Waste heat opportunity map

In addition to the data provided by THC, the datasets outlined below were used to identify the potential heat sources in Inverness:

- **Scotland Heat Map (SHM)**
  It identifies potential sites including industries, electrical substations and supermarkets where excess heat could be repurposed for heating.

- **ReUseHeat database**[12]
  It maps the urban waste heat potential across Europe including heat from food retails, wastewater treatment plants, food production, tube stations, power plants, steam production, industrial site and data centres. The identified waste heat sources in Inverness are relatively small, primarily from food retails with available heat below 5 MWh.

- **Scottish Water Horizons (SWH) – Waste heat extraction opportunity map**
  It helps with the strategic identification of where wastewater could be a potential heat source. The key areas for heat extraction in Inverness include the sewage pumping station in North of Inverness in Longman with the sewage flow approximately 190 l/s and Raigmore area (East of A9) with the estimated sewage flow of circa 286 l/s.

- **ParkPower and Green heat in Greenspaces (GHiGs) Maps** (developed by Greenspace Scotland[13])
  It assesses the suitability of greenspace sites (e.g., public parks, gardens, playing fields and sport grounds) for low-carbon heating technology such as GSHP.

[12] https://cordis.europa.eu/project/id/767429
[13] https://www.greenspacescotland.org.uk/project-dashboard

- **Hydrogeological** map British Geological Survey (BGS) [14]
  It indicates aquifer potential across the entire Inverness boundary, classifying it as moderately productive aquifer for low carbon heat technologies such as open loop GSHP (see Figure 3—9). This requires further investigation to assess the potential abstraction rate.

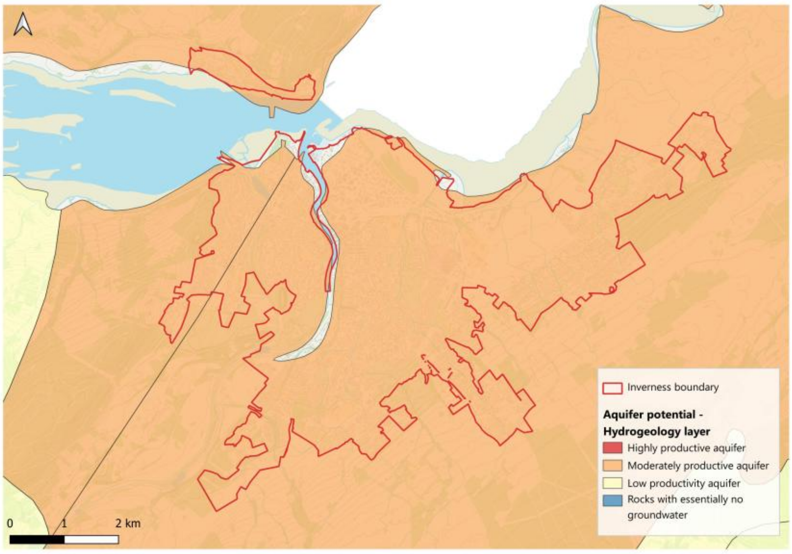


Figure 3—9 Aquifer potential in Inverness – Hydrogeology map

- **Additional datasets**
  Information gathered from THC and previous studies.

Table 3—1 provides an overview of the identified waste heat sources in Inverness including their type, temperature range and estimated waste heat potential.

Table 3—1 Potential heat sources summary

Name	Heat type	Estimated Temp °C	Potential heat MWh	Source	Note
Raigmore sewage network	Sewer	10 - 15	76000	Scottish Water Horizon Map	BH calculation (assumption: 286 l/s flow and 5 DT)
Sewage pumping station	Sewer	10 - 15	45000	Scottish Water Horizon Map	BH calculation (assumption: 190 l/s flow and 5 DT)
Bairds Malting	Industrial waste heat	50 - 100	Heat recovery from the kilning process		Malting also considered as a key heat off taker rather than source
Bught Park	GSHP potential	8 - 10	7300	GHiGs	
Bellfield Park	GSHP potential	8 - 10	1200	GHiGs	
River Ness	WSHP potential	5 - 20	Detailed value not available but heat availability is	National River Flow Archive and SPEA	Not enough data available to estimate the potential available heat

[14] https://www.bgs.ac.uk/datasets/hydrogeology-625k

			greater than the demand in the West Bank cluster	personal communication	but has been used successfully in Inverness in Glen Mhor (more information and site visit was sought but not available). SEPA were contacted and provided some indication of water depths.
Inverness grid substation	Grid substation	40 - 80	1400	SHM	New transformer with the uncertainty around the heat recovery potential and proven capacity
Bakery	Industrial waste heat	>120	5000	SHM	Relatively small and have technical challenges associated.
Bakery	Industrial waste heat	>120	1700	SHM	Relatively small and have technical challenges associated.
Data centre	Data centre	20 - 40		THC	Early discussion - 100MVA
Inverness High School	GSHP potential	8 – 10	3400	GHiGs	
Inshes district park	GSHP potential	8 - 10	10900	GHiGs	
Bakery	Industrial waste heat	>120	5000	SHM	Relatively small and have technical challenges associated.

It should be noted that, further investigation is required to confirm the practicality of using these waste heat sources including technical assessment, operational challenges and economic viability.

A summary of the long list of heat sources considered is provided in Appendix A.

3.5 Demand classification

The key heat demands to be considered for connection within a heat network cluster are categorised as core and Infill loads. This is defined based on the buildings' demand scale, and tenure. Generally, local authority and public sectors buildings are easier to engage early in heat network development, making them priority for core connections.

To align with the Scotland first national assessment[15], 73 MWh/yr is set as the minimum threshold for connections with all buildings of a demand lower than this being excluded from analysis. Building demands greater than 500 MWh/yr are typically defined as 'anchor loads' which usually drive project economics and the viability of a potential heat network.

Additional thresholds define core and infill connections:

- Demands above 500 MWh/yr: core connection regardless of tenure

[15] https://www.gov.scot/publications/first-national-assessment-potential-heat-network-zones/

- Demands between 250 MWh/yr and 500 MWh/yr: core connection if public buildings, council-owned buildings, buildings with existing communal heating and buildings with social housing/housing association tenures, otherwise infill connection
- Demands between 73 MWh/yr and 250 MWh/yr: infill connection regardless of tenure
- Planned development were not captured at a demand level (apart from Raigmore as this is a feasibility study) but were considered for context across the analysis,

Table 3—2 provides a summary of infill and core connection criteria. In some areas with a high concentration of private-sector properties (e.g., workshops, warehouses), the core connection threshold may be adjusted accordingly.

Table 3—2 Summary of connection approach

Connection group	Criteria
Core	Public and council buildings >=250 MWh/yr Buildings with existing communal/HN >=250 MWh/yr Housing Associations/social housing >= 250 MWh/yr Other tenure/non-domestic >=500 MWh/yr
Infill	Public and council buildings 73 MWh/yr to 250 MWh/yr Existing communal/HN 73 MWh/yr to 250 MWh/yr Housing Associations/social housing 73 MWh/yr to 250 MWh/yr Other tenure/non-domestic 73 MWh/yr to 500 MWh/yr (in areas dominated by private tenures such as warehouse, workshops, industrial buildings) this is adjusted to 250 MWh/yr to 500 MWh/yr

The core connections are the key driver of network viability and infill connections supplement the network and expanding coverage.

Buildings are assumed to be public if they fall into one of the categories below:

- Education
- Health
- Emergency services
- Place of worship
- Care homes
- Community and cultural centre

Buildings are assumed to be council-owned if they are run and controlled by the Council. These tenure data are provided through engagement with THC along with using land ownership data. If a building is on Council land but is listed as "Let to Third Party" or "Third Party," it is not considered as Council land.

3.6 Steiner analysis

Once heat network areas, key heat demands (core and infill), potential heat sources and energy centre locations are identified, a pipe network is modelled to establish the most efficient connections between heat demands and heat sources.

The pipe network is modelled:

- First for core connections only, to ensure the network economic viability. This routing forms the ‘spine’ of a network connecting typically the largest heat demands.
- Then for both infill and core connections, extending the network to other potential loads.

The routing methodology connects heat demand points to the chosen heat source/energy centre using the Steiner tree approach, which determine the shortest possible routes while following existing road networks. This method helps to minimise the network length and improve cost estimation. It is done using QGIS and an internal Feature Manipulation Engine (FME) processing tool. Figure 3—10 provides an example of the Steiner tree methodology for creating the pipe network. The process uses existing road networks (from OS) to give an indication of an optimised heat network routing.

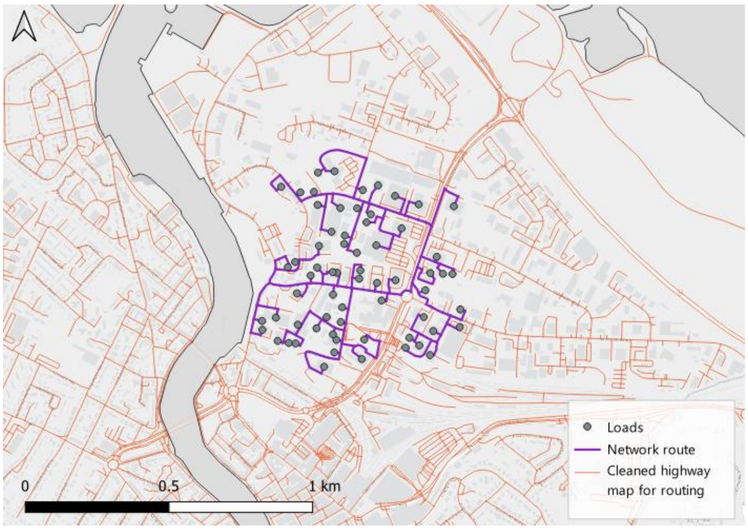


Figure 3—10 Example of heat network routing using Steiner tree analysis method

Following the generation of indicative heat network routes for heat network connection scenarios, the routes were manually inspected and validated to ensure accurate representation and to identify and rectify any routing anomalies.

Ground conditions and the surrounding environment could influence heat network trenching, dig type and cost of installation. Typical classification of dig types are as follows:

- **Soft dig:** Areas, such as footpath, greenspaces and parks, allow for low-disruption installation, resulting in the lower costs due to ease of excavation.
- **Suburban**: Suburban areas such as road, pavement or car parks in lower impact streets with moderate accessibility, involve coordination around private properties and existing utilities, resulting in mid-range costs depending on site complexity.
- **Hard dig**: Very urban environments, impacts busy routes, resulting in high disruption. They demand extensive planning and logistical requirements, leading to the highest costs.

These categories capture the variable dig types across Inverness. The Department of Energy Security and Net Zero (DESNZ) provides indicative costs for these dig types. Allowing a high-level differentiation to be used in creating an indicative capital cost for networks.

3.7 Contextual geographic analysis

In addition to demands and heat sources broader geographic and societal factors were captured and considered in the analysis. These were nominally fuel poverty, land ownership and the presence of existing heat networks/communal systems in the potential heat network areas. These are used in a multi-criteria analysis to further explore potential zones, this is detailed in section 5.

Fuel poverty

Figure 3—11 presents the properties where the probability that the property is in fuel poverty is over 50% (i.e. that the household's fuel bill represents more than 10% of its full income, after housing costs). This is obtained from EST Home Analytics database.

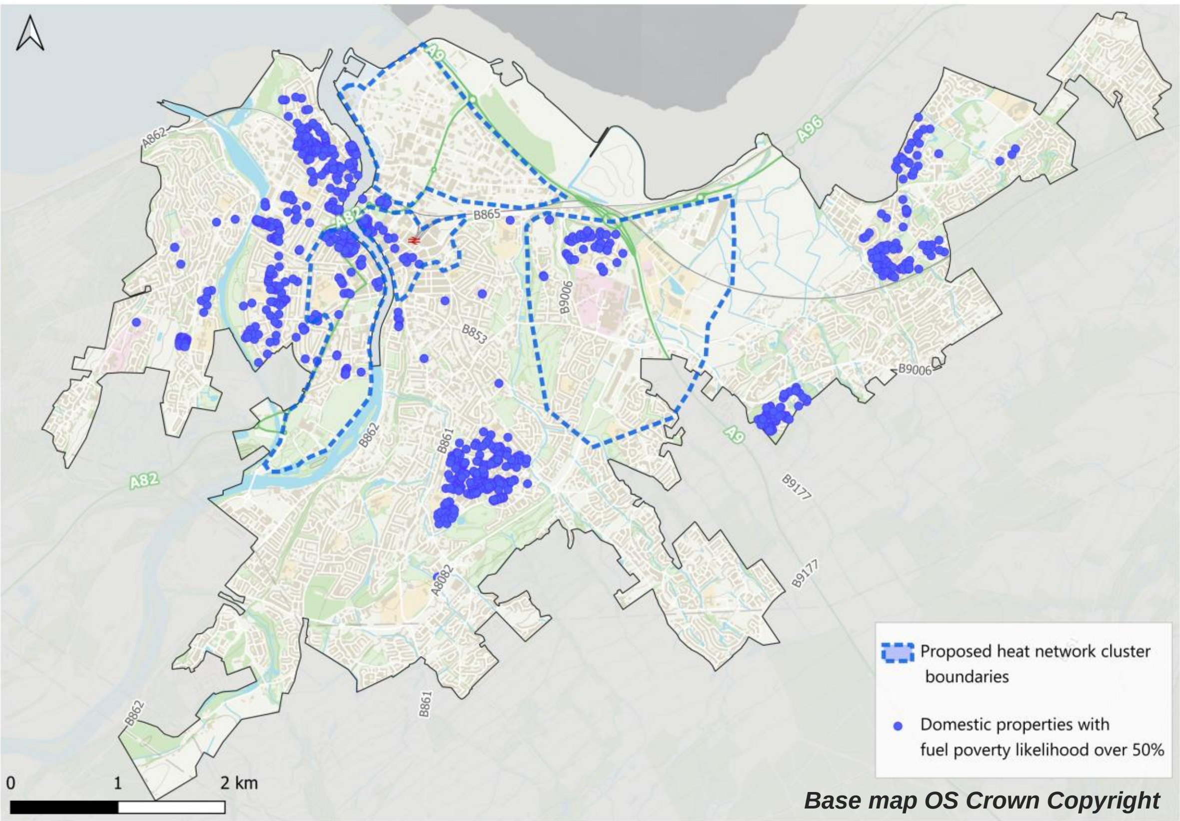


Figure 3—11 Domestic properties with fuel poverty likelihood over 50%

Land ownership

Figure 3—12 shows the council land ownership map. Some of these sites might be owned by the council and council pays the bills, but they might be managed by organisations such as High Life Highland. They can also be leased to industrial or commercial tenants. THC grounds show the sites where the grounds are maintained by the council.

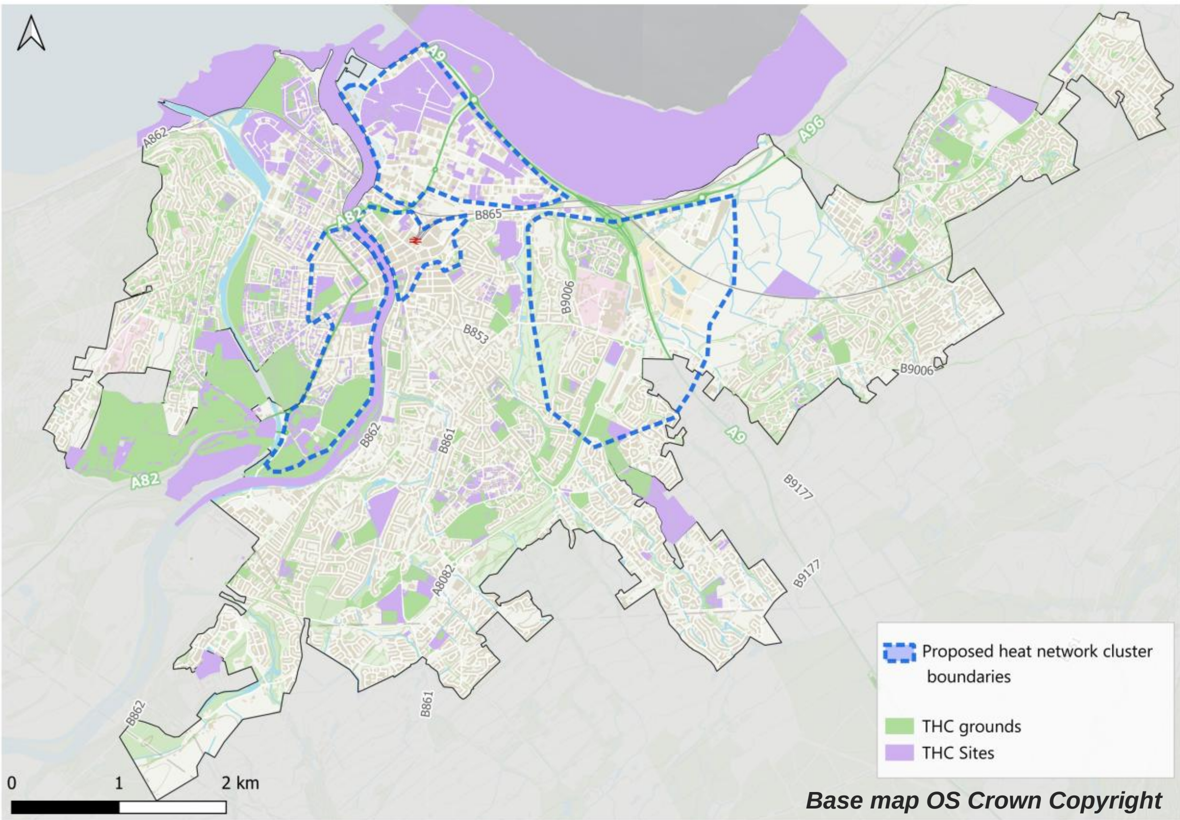


Figure 3—12 Council land ownership Map

Existing heat networks

The SHM data, along with the EST Home Analytics, were used to identify the existing heat networks in Inverness. It should be noted the existing heat network point data contained within the Scotland Heat Map captures network summary detail and not detail on connections at a property or building level. Additionally, EST Home Analytics was utilised to identify properties listed with communal heating, which could be part of communal or larger heat networks. Some discrepancies were identified between the two datasets; for example, a building shown with communal heating in EST Home Analytics is not recorded as a heat network in SHM and vice versa. Moreover, there are a few networks listed as district heat network in SHM, but further investigation proves them to be communal network where a number of properties are connected to central heating within one building.

Further data exploration shows no major heat network is recorded in Inverness except for the Wimberley way heat network, which is recorded as +1MW size, supplying heat to several Ministry of Defence domestic properties. The other networks recorded in SHM are rather small communal heat networks with a small number of connections. Figure 3—13 provides an overview of existing heat networks in Inverness. Existing networks are important to consider as they are generally likely to connect to larger heat networks (the Scottish Government are currently considering requirements for existing networks to connect with larger heat networks). Additionally, existing communal networks are one of the easiest ways to integrate domestic demands into heat networks. The lack of existing heat networks in Inverness means the opportunity for connecting smaller networks into a larger heat network is limited.

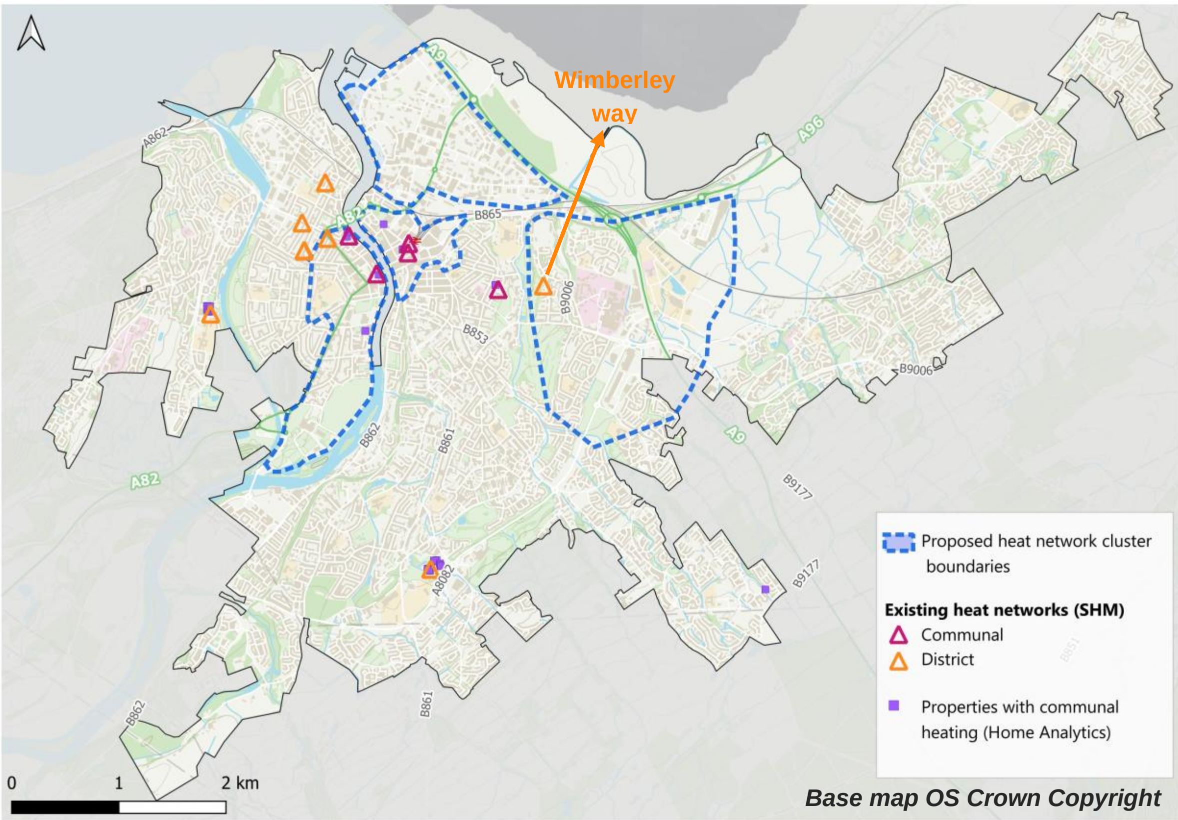


Figure 3—13 Existing heat networks (communal/district) in Inverness.

It should be noted that Inverness Castle and Glen Mhor are not captured by the SHM but are captured elsewhere in this report.

3.8 Stakeholder identification and screening approach

Stakeholders were considered throughout this strategic review. There is a particular focus in identifying areas where THC (or THC adjacent organisations like High Life Highland) are key stakeholders (such as in the West Bank) or where other public sector bodies have significant influence (such as Highlands and Islands Enterprise on the East side of Raigmore), as these can be key enablers for deployment; this can include owning land for the pipework to cross or being key demand that drive the economics of the heat network. Private sector stakeholders were also considered, with SSE and SWH being key to Inverness – particularly their recently announced ambitions to develop heat networks in the city with an initial focus on Longman.

In the feasibility study for heat networks in Raigmore carried out alongside this strategic study there was substantial stakeholder engagement undertaken. For the strategic work engagement was more limited but specific insights were gathered. For example, SEPA were engaged during the evaluation of the West Bank area, to better understand the potential of the River Ness as a heat source and any risks associated with its use. This engagement highlighted that SEPA do not hold detailed water depth information for the Ness in this area, temperature and the consistency of depth throughout the year were also not available. Further study is thus likely to be required. The successful WSHP project at Glen Mhor would provide useful insight to the tenability of a scheme on the Ness. Glen Mhor were engaged initial but due to various factors more detail could not be included during the time period of this study.

3.9 Cost analysis

A high level cost analysis was undertaken for this strategic work, adapting a simplified techno-economic model created by DESNZ for Heat Network Zoning Pilot Program (HNZPP). The model combines technical details of the network, such as CAPEX and OPEX, with revenue and cost inputs to generate annual cashflow. This allows for an assessment of viability and means of comparison between different heat network clusters.

Key input parameters include the heat network length, hard/soft dig proportions, obstacles on the heat network route, annual heat demand for connections (by building type), primary low carbon technology and the energy balance of the plants if there is more than one low-carbon technology. These inputs are also used to estimate the size and operation of the primary low carbon plant, as well as top-up/back up technology. Assumptions are then used to estimate the costs of the plant, network, and other associated costs to generate an estimate for the capital cost of the network. Table 3—3 provides a summary of the key cost assumptions.

An energy balance is generated from assumptions linked to the type of plant and the annual heat demand figures, which is used to generate a cash flow to derive the economic outputs. The model also generates an assessment of carbon emissions over a 40-year period, against a gas boiler counterfactual system.

It is worth highlighting that this is a high level analysis, enabling a comparative economic assessment of proposed heat network clusters within Inverness. However, a detailed feasibility study is required to further refine these estimates and provide a more comprehensive evaluation of the heat network economic viability. Additionally, the costs for grid reinforcement, if required, and for making the building compatible with heat networks, such as upgrading radiators, are not included in the CAPEX.

Table 3—3 Cost assumptions

Variable	Value	Unit	Lifetime (years)
Pipe work cost (suburban environment) Pipe work cost (dense urban environment) Pipe work cost (soft dig)	2 4 1	£m/km £m/km £m/km	60
Gas boiler	0.25	£m/MW	20
Heat pump - ASHP	0.75	£m/MW	15
Heat Pump – WSHP	1	£m/MW	20
Heat Pump – GSHP	1	£m/MW	20
Heat Pump – sewer source	1	£m/MW	20
Sever obstacles (e.g., single track railway crossing, canal crossing)	1	£m/obstacles	n/a
Major obstacles (e.g., river crossing, multi-track railway crossing)	5	£m/obstacles	n/a

4 Heat network areas

As outlined in section 3.3, the analysis of LHD 4 MWh/yr/m and 8 MWh/yr/m identifies a number of promising areas for further investigation as potential heat network clusters. Figure 4—1 is based on insights from these and shows the boundary of the proposed clusters.

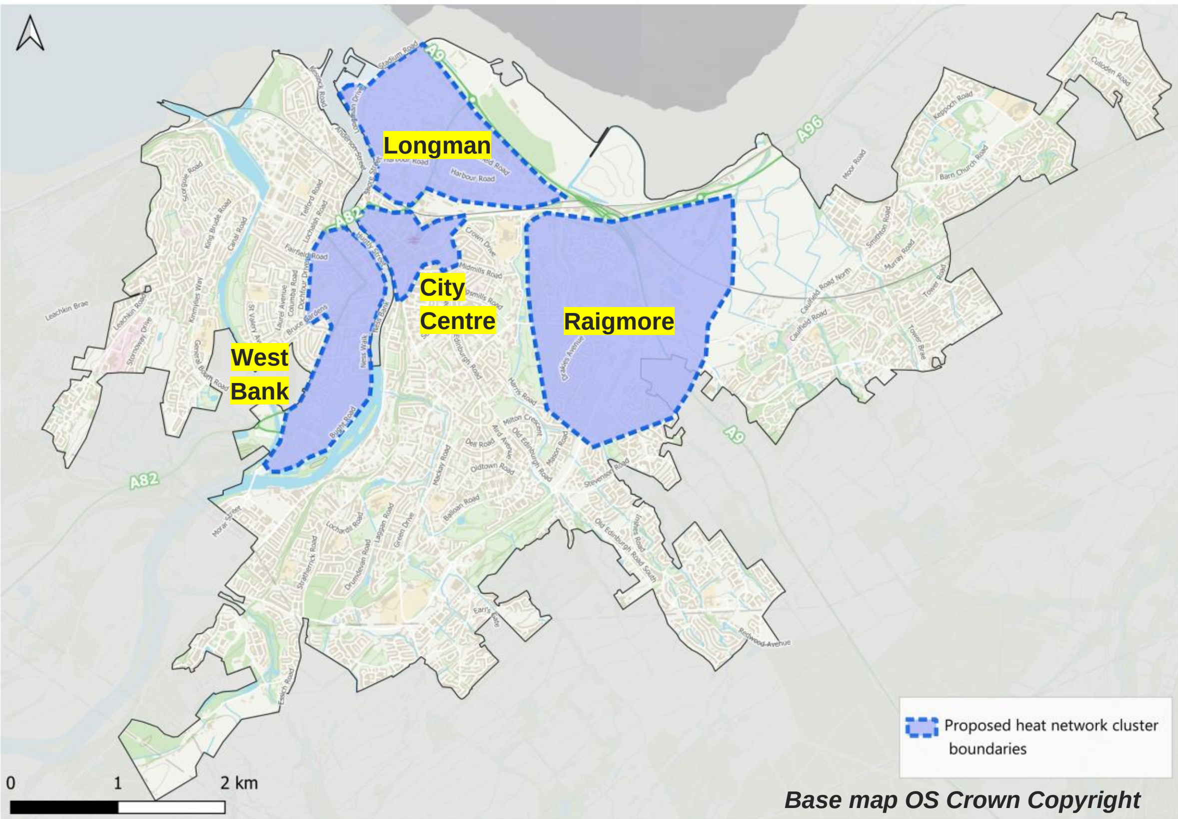


Figure 4—1 Inverness proposed strategic heat network clusters

Further details in each clusters including the area overview, the key demands, potential heat sources, proposed energy centre location, indicative capex, key risks and mitigations are provided in section 4.1 to 4.3 with higher level overview of Raigmore in 4.4, to avoid repetition of the parallel feasibility study.

4.1 West Bank

4.1.1 Area overview

The west bank area of the River Ness in Inverness has several buildings with high heating demands, and several council-owned and public buildings including the Highland Council Headquarters, Eden Court, Inverness Leisure Centre, Inverness Botanic Gardens and Inverness Ice Centre.

Buro Happold was commissioned to assess the opportunity for a heat network in West Bank area[16]. The study area is split geographically into north and south clusters with high heat demands, separated by stretches of land, mainly through Bught Park. Figure 4—2 provides the study boundary, key connections and the heat network route. The total annual heat demand for the combined north and south areas is estimated to be 13,070 MWh/yr. The southern area, near the leisure centre, has a LHD at 12.60 MWh/yr/m, compared to the northern area near the Council HQ, which has an LHD of 2.79 MWh/yr/m (as stated previously there are additional demands in the north which if connected would

[16] Inverness West Bank Feasibility Study 2023 Buro Happold

improve LHD). The proposed energy centre is adjacent to the Inverness Leisure Centre. The entire study area has an LHD of 4.80 MWh/yr/m, this means that for each meter of network length there is 4.8 MWh of heat demand per year. In areas with a low cost dig (which due to Bught Park West Bank is the case) a LHD of 4 MWh/yr/m is an indicative threshold, in more urban areas a LHD of 8 MWh/yr/m is a common threshold used in projects like LHEES.

Two scenarios were considered include a borehole closed loop GSHPs solution with initial CAPEX of £18.2M, and an alluvial aquifer open loop GSHPs solution with £14.9M initial CAPEX considered for heat sources with the energy centre adjacent to the Inverness Leisure Centre (these cost are for the whole area shown in Figure 4—2.

Figure 4—2 West bank feasibility study boundary, connections and heat network route [17]

4.1.2 West Bank Cluster

As outlined in section 3.3, the analysis of LHD 4 MWh/yr/m and 8 MWh/yr/m identifies the West Bank area as a prime opportunity for heat network development. This aligns with the findings of the previous BH feasibility study conducted in the West Bank, which also indicated potential for heat network development. However, the proposed area extends beyond the feasibility study boundary to include several additional large heat loads including Inverness High School, Central Primary School, St Joseph's Primary School, a number of hotels and buildings with existing communal heating system. The additional loads strengthen the network viability by increasing the heat demand density. Figure 4—3 presents the LHD clusters and the proposed West Bank cluster boundary. The River ness is considered as a natural boundary preventing to extend the network to river east. Additionally, crossing the river poses a major obstacle, which is why the West Bank and City Centre clusters are kept separate.

[17] Inverness West Bank Feasibility Study 2023 Buro Happold

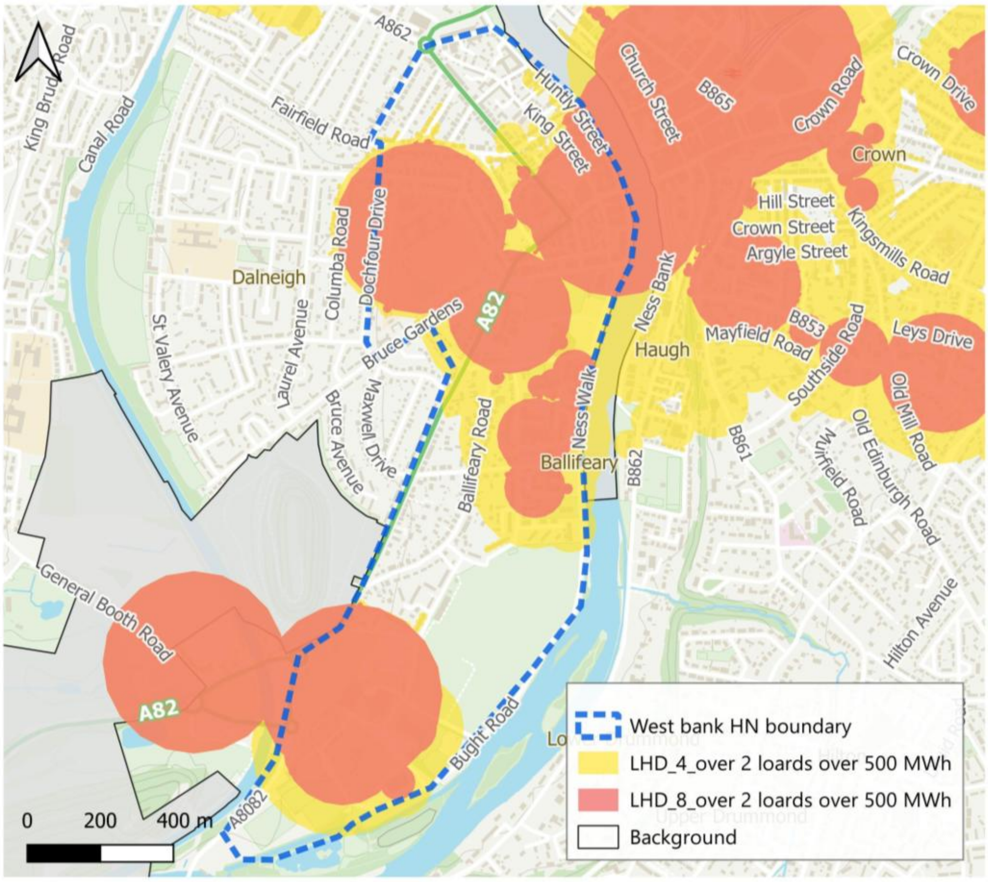


Figure 4—3 LHD 4 MWh/yr/m and 8 MWh/yr/m bubbles and West Bank proposed heat network boundary (***Base map OS Crown Copyright)***

The total heat demand in the proposed cluster is approximately 60 GWh/yr. This includes all buildings regardless of their typology or suitability for heat network connection, so the demand connected to a heat network would be lower than this 60 GWh/yr figure.

A significant proportion (over 46%) of the proposed cluster area consists of the council-owned land. Moreover, there are over 160 properties with the fuel poverty likelihood of exceeding 50%, which could benefit from heat network connection to alleviate fuel poverty. Additionally, the area contains 419 social housing properties. Having similar ownership would make connecting to the heat network less complex compared to privately owned housing.

The West Bank cluster includes 15 council owned buildings and 12 public buildings in the proposed cluster, each with demand over 73 MWh/yr. This makes the area strong candidate for a public-led heat network development benefiting from the streamlined decision making with fewer stakeholders. This is likely to be a key consideration in the heat network delivery model work Highland Council is undertaking with a legal consultant alongside this strategic study.

As explained in section 3.5, buildings are considered for heat network connection based on factors such as scale of heat demand, typology and tenure as core or infill connections. Two assessments were performed:

1) A heat network consisting of only core connections – focusing on the high demand buildings to establish financial viability of the network
2) A heat network consisting of the core and infill connections – where additional buildings are integrated to improve network utilisation and efficiency

Key features of the West Bank cluster are shown in Figure 4—4, where the left presents a heat network with only core connections. right presenting a heat network with both infill and core connections.

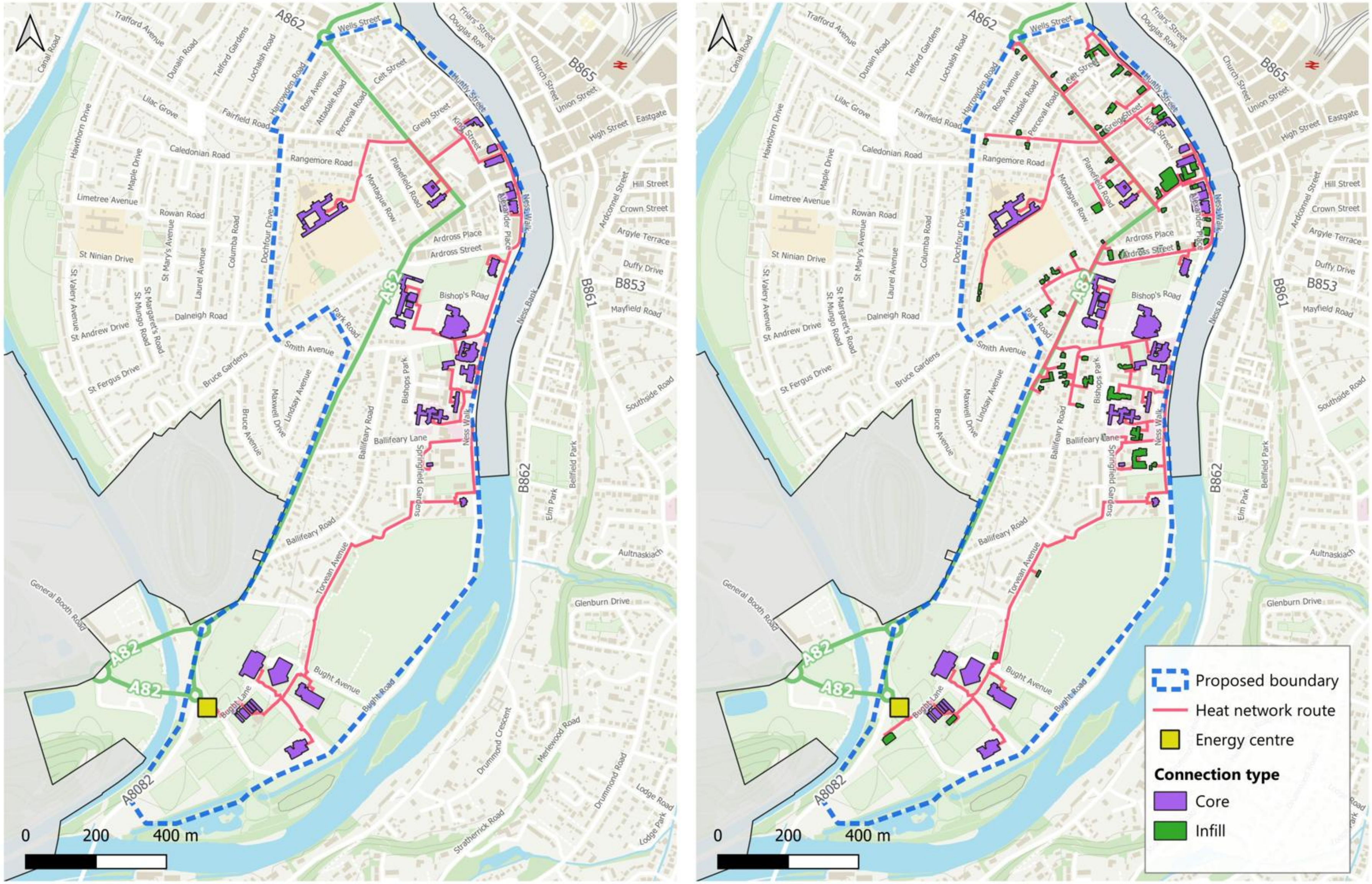


Figure 4—4 West Bank indicative heat network left only core connections and right: both core and infill connections (*Base map OS Crown Copyright*)

Further detail on the heat network key heat demands, heat sources and distribution network along with high level capex are provided in the subsequent sections. Moreover, the key risks and potential mitigations identified for successful development of the heat network are addressed in section 4.1.6.

4.1.3 Heat demand and key loads

Figure 4—4 shows the total annual heat demand and the distribution of this demand between different building categories. The total demand in the West bank cluster boundary is around 60 GWh/yr and the heat network with core connections would connect circa 24 GWh/yr of the demand and the heat network with the core and infill connections connect around 33 GWh/yr of heat demands.

In both network council-owned and public buildings form large share of the total heat demand with 75% in core connection heat network and 58% in core and infill connection network.

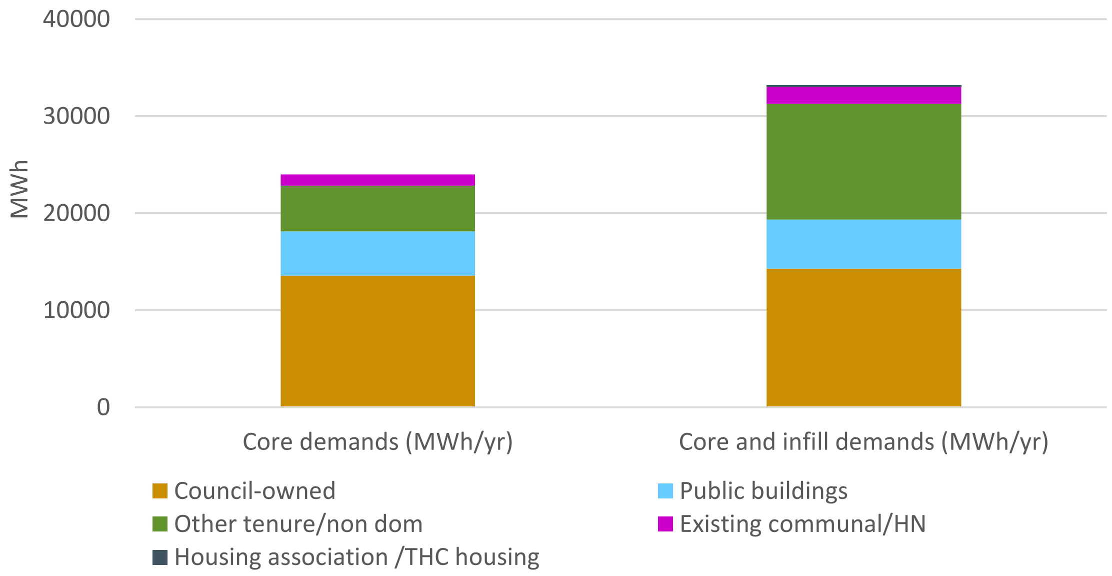


Figure 4—5 Heat demand based on the connection typologies defined in section 3.5

Inverness Leisure centre, Inverness High School, Council HQ office and Eden Court are among the largest demands in West Bank. Table 4—1 provides further details of the key heat demands.

Table 4—1 Key anchor loads in West Bank cluster

Building name	Building connection category	Building typology[18]	Annual heat demand (MWh)	Data source
Inverness Leisure Centre	Council-owned	Sports and recreation	6890	Previous feasibility study
Columba Hotel	Other tenure/non-domestic	Hotels	1924	SHM

[18] Some buildings might contain more than one typology, such as both domestic and non-domestic typologies. The building typology is defined based on the typology that has the largest share of the total heat demand in the building.

Inverness High School	Council-owned	Education	1882	THC benchmarking tool
Eden Court	Council-owned	Entertainment /Catering	1754	Previous feasibility study
Palace Hotel	Other tenure/non-domestic	Hotels	1546	SHM
Highland Council HQ	Council-owned	Offices	1360	Previous feasibility study
Botanic Gardens	Public buildings	Entertainment/ Catering	1230	Previous feasibility study
The Royal Northern Infirmary Hospital	Public buildings	Health/Hospital	835	SHM
The Edens Hotel	Other tenure/non-domestic	Hotels	670	Previous feasibility study
Inverness Ice Centre	Public buildings	Sports and recreation	590	Previous feasibility study
Premier Inn Inverness Centre	Other tenure/non-domestic	Hotels	585	SHM
Central Primary school	Council-owned	Education	574	THC benchmarking tool
University of Highlands and Islands	Public buildings	Education	500	Previous feasibility study

There is not any major new planned development planned in the cluster, the two items noted during the study being:

- A park kiosk is planned to be demolished, and a new pavilion is planned to be constructed in its place built following Passivhaus principles. The newbuild pavilion was originally planned to be heated using GSHP with a vertical borehole array. However, following a ground condition survey, the ground conditions were unsuitable for ground source heat pumps, so the decision was made to revert to air source.
- There are also plans to construct a new pavilion and clubhouse at the Bught Park stadium seating, both will be built in accordance with Passivhaus principles. Heating with GSHP in a plant room was originally planned. However, this is reverted to ASHP after ground condition survey conducted by THC.

Both of these new demands are relatively small and thus not considered to make a large difference to the overall routing and total demand connected. However, ongoing activity (particularly the stadium) could be a trigger point for encouraging deployment in this southerly part of the West Bank.

4.1.4 Heat sources and energy centre

Several potential waste heat sources are identified in the West Bank cluster as outlined in Table 3—1.

A key option for consideration is deployment of a GSHP in Bught Park. Both closed loop and open loop GSHP were assed in the previous feasibility study. With the finding indicating that the aquifer open-loop GSHP shows lower capital cost and better overall economic performance when 50% grant funding was factored in the economic model. However, a subsequent ground condition study conducted by THC found the ground condition unsuitable for GSHP deployment in Bught Park. Therefore, although GSHP was examined in the previous feasibility study, GHSP was not considered as a viable heat source option anymore.

Another potential heat source is a WSHP, which could extract heat from the River Ness, particularly near the Hydro Ness[19], taking advantage of the river depth. However, there are not sufficient data regarding the river temperature variations through the year, flowrate and depth variations, to assess the viability of WSHP deployment. Some engagement with SEPA has been made which indicates there could be some opportunity. More detailed studies are required to understand the feasibility for a WSHP and assess the practical limitations of installing equipment for processes such as water abstraction. The existing Glen Mhor WSHP the other side of the river does lend confidence to the viability of such a scheme but the increased distance of the energy centre from the heat demands as well as the lack of spatial constraint in the area meant this technology was not considered to be vital to make the scheme viable.

Therefore, a large centralised ASHP was identified as the primary low carbon heating technology for the West Bank cluster which offers lower capital cost and proven reliability and scalability for heat networks. Additionally the flexibility of location reduces the civils costs compared to the WSHP solution.

A potential location for the energy centre was proposed on council-owned land parking area adjacent to the Highland Rugby Club. This site was chosen due to proximity to key heat loads in the area, including Inverness Leisure Centre and Inverness Ice Centre. Additionally, the site’s closeness to Hydro Ness would be advantageous if water source heat pump deployment is determined in future. The Ice Centre produces waste heat from its cooling processes, which could be captured and integrated into the heat pump system. This would enhance the overall efficiency by improving the heat pump COP, lowering the energy demand and operating cost as well.

Other potential waste heat sources were also presented in Figure 3—8, but are not considered as main heat sources due to uncertainty around their proven capacity and heat recovery practicality.

Gas boiler is included for back-up and peaking plants due to their low cost, compact size, and rapid ramp up. However, to meet the long-term goal of full decarbonisation by 2045, gas boiler must be replaced by low-carbon alternatives, such as electric boilers. Electric boilers will have an elevated running cost compared to gas due to the relative difference in price and also require substantial headroom on the electricity network.

4.1.5 Heat network characteristics

Figure 4—4 presents the proposed network route for both options: the core connections (left) and the combined infill and core network (right). The proposed network has been developed using the Steiner tree methodology (as detailed in section 3.6), which determine the shortest possible routes while following existing road networks to minimise the construction complexity.

A key consideration in the network routing is the opportunity for soft dig within Bught Park, from Warrand Rd (North of the Bught Park) to the major heat loads in the southern part of the cluster, including Inverness Leisure Centre and Inverness Ice Centre. Soft dig costs will potentially be lower.

[19] https://www.highland.gov.uk/info/1210/environment/971/hydro_ness/

The soft dig through the Bught Park was factored in the pipe routing cost estimates for the West Bank cluster, helping to reduce the overall capital cost and improve the viability of the heat network.

A summary of the key network parameters including the total heat demand, network length and LHD for both networks is provided in Table 4—2. Extending the network to the north of the West Bank cluster by incorporating both infill and core connections, would reduce the network LHD. However, this area has a large number of social housing (primarily council-owned stock), which could be integrated into the heat network. This could further improve the overall LHD, making it more economically viable. Additionally, given the current LHD of 4.6 MWh/yr/m for the core network, extending connections to additional buildings along this route could also be considered which increase the network efficiency and economic.

Table 4—2 West Bank cluster summary

	Core network	Core and infill network
Total demand (MWh/yr)	24015	33213
Network length (m)	5200	9500
LHD (MWh/yr/m)	4.6	3.5

As detailed in section 3.9, a simplified techno-economic model was utilised. The model incorporates the pipe length data (including soft dig/suburban/dense urban environment), major obstacles, the annual heat demand by building typologies. It creates a heating profile and annual load duration curve to size the low-carbon plant and back-up plant. The ASHP size is estimated to be around 5.9 MW for the core network and 7.8 MW for the core and infill network. In both heat network options, over 85% of heat demand is expected to be met by heat pump. Table 4—3 provides an indicative capital cost and estimated carbon savings compared to a gas boiler counterfactual for both networks.

Table 4—3 Indicative capital cost and carbon savings for West Bank

	Core network	Core and infill network
Capex £m	20.3	37.1
Carbon saving TCO2e over 40 years	158170	224750

It is worth noting that the indicative capex does not account for the electricity grid reinforcement if required.

The routes presented for both scenarios are not optimised, instead considering the potential full extent of the network. The best opportunity is likely to be based around the old feasibility study area (shown in Figure 4—2) but extended to include Inverness High School. Additional smaller demands could be connected along the route to help increase the LHD further and improve viability.

4.1.6 Key risks and mitigations

The table below outlines key risks, constraints and potential mitigations for the West Bank cluster heat network:

Table 4—4 Key risks and mitigations for West Bank

Risk / constraints	Mitigation
Road crossing	The West Bank network requires crossing the A82 main road. A study is needed to evaluate the feasibility of these crossing and reviewing the potential constraints presented by existing buried utilities. The final network may be able to minimize this with Inverness High School being the only key load the other side of the A82 from the other key loads in the area.
Proposed network route cost	The proposed network is following the existing road infrastructure. However, opportunities for cost reduction have been factored in including the soft dig opportunity through Bught Park, from Warrand Rd (North of the Bught Park) have been factored into cost estimates to reduce the CAPEX. Ground assessment should be carried out to confirm this.
Electricity network capacity	The nearest SSEN electrical substation (Inverness Substation, south of the cluster, across the river) is currently unconstrained. However, the Dalneigh substation is overloaded. Early engagement with SSEN is required as part of a full formal application in determining network capacity in the area.
Low Linear heat density in the heat network option with both infill and core connections	The North of the West Bank cluster includes a high portion of social housing (primarily council owned stock), which could be integrated into the heat network to improve the overall LHD, making it more economically viable. Additionally, given the current LHD of 4.6 MWh/yr/m for the core network, extending connections to additional buildings along this route could also be considered which further enhance the network efficiency and economic. The soft dig does offset some concerns of the relatively low LHD but enhancing the LHD will still help the economics of the network.
Non-optimised routings	Explore options for focusing on the most economic areas of the network, this is likely to limit the extent of the network (probably excluding the area to the north). The value of crossing Bught Park should also be assessed or whether two networks are more viable (due to the low dig costs this is indicated as viable although maybe not optimal in this analysis). Adding additional small loads along the northwest edge of the park will help building the case for connecting both sides of the network.
Buildings compatibility for heat network connection	For the new development, engagement with planned developments is required to ensure secondary systems are connection ready to DHN. For existing buildings, enabling works on the buildings that currently operate at high temperatures to ensure heating system compatibility. Enabling works may include design and contractor works to replace existing heat emitters (radiators and fan coil units) to operate at lower temperatures.
Land ownership and implications for energy centre locations	There is a risk that energy centre locations identified in this report may not be available and suitable for use for construction of an energy centre. Having a high level of THC land and influence helps de-risk this major aspect of development. A full energy centre location assessment should be conducted.
Heat demand and heating system data accuracy	There is a risk that the heat demand estimates may be inaccurate as some of them are benchmarked. Moreover, the key connections are assumed to be all gas boiler and technically suitable to join the heat network. A feasibility study with stakeholder engagement is required to validate and confirm the assumptions and address potential complexities. The previous feasibility study helps de-risk this element as does the high level of THC loads, this is more of an issue in the north of the area.
Missing alignment with broader activity	Aligning to ongoing activity is key, for example, if a heating system is being replaced soon it can create technology lock in for a period until the new system reaches the

	end of its life. The redevelopment of the leisure centre is a case in point, ensuring development links with this opportunity is key. Similarly, the likely replacement date of heating technology in other key THC assets and connections should be established to help understand the key timings for the network.

4.2 Longman

4.2.1 Area overview

The Longman area has a previous feasibility for a heat network focusing on linking the SW pumping station with the Bairds Maltings site. The area is important strategically for Inverness, representing the best area in terms of heat source, with the SW pumping station and also being a potential key route for waste heat from a hydrogen electrolysis which is going through planning (the site is in the old landfill area the other side of the A9).

The area has a very high level of THC land ownership. Making the Council a key enabler for any activity in the area.

Most significantly for providing impetuous for a heat network in the area is the recent announcement of collaboration between SWH and SSE in the area to develop a heat network.

4.2.2 Longman Cluster

The Longman area generally has a low heat demand density, based on the SHM, than the other areas examined. This is shown by a relatively small amount of the area being covered by the 8 MWh/yr/m LHD in Figure 4—6.

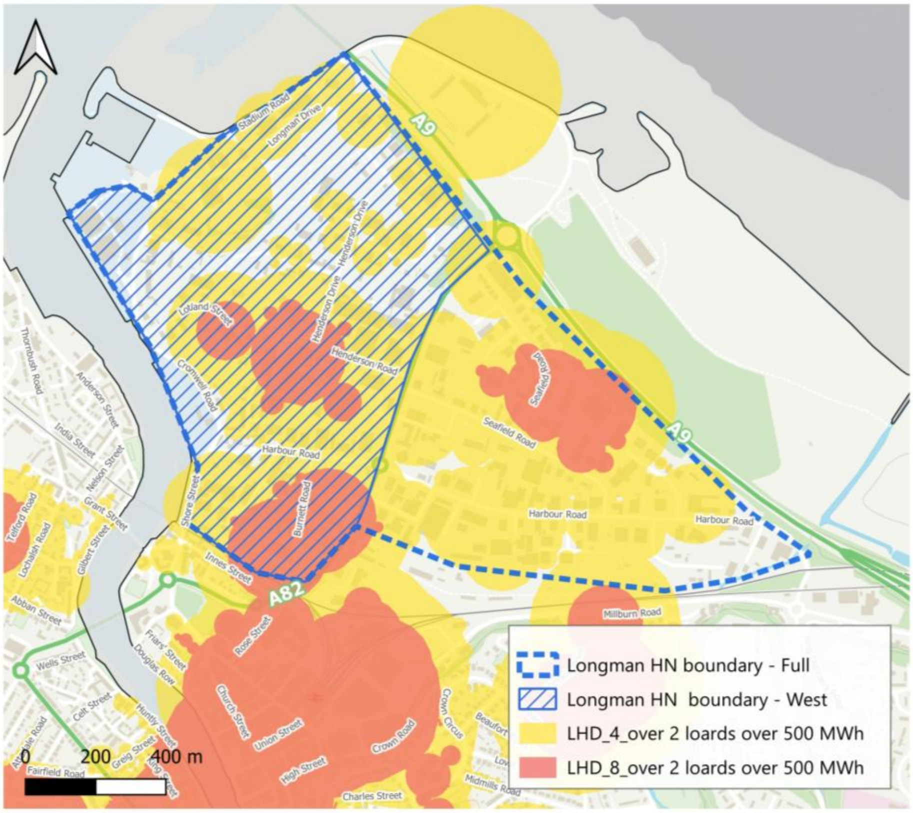


Figure 4—6 LHD 4 MWh/yr/m and 8 MWh/yr/m bubbles and Longman proposed heat network boundary (*Base map OS Crown Copyright*)

As shown in Figure 4—6 for Longman two different scales of heat network area are examined. The largest blue boundary is for the whole Longman area, indicative connection and pipe routings for this area are provided in Figure 4—7. A smaller area just covering the west of Longman is also examined, this area has the highest heat density areas (as shown in Figure 4—6), indicative pipe routings are provided in Figure 4—8. This is in part due to the two largest heat demands in the area being poorly captured in the SHM, due to being industrial in character. This is discussed in 4.2.3.

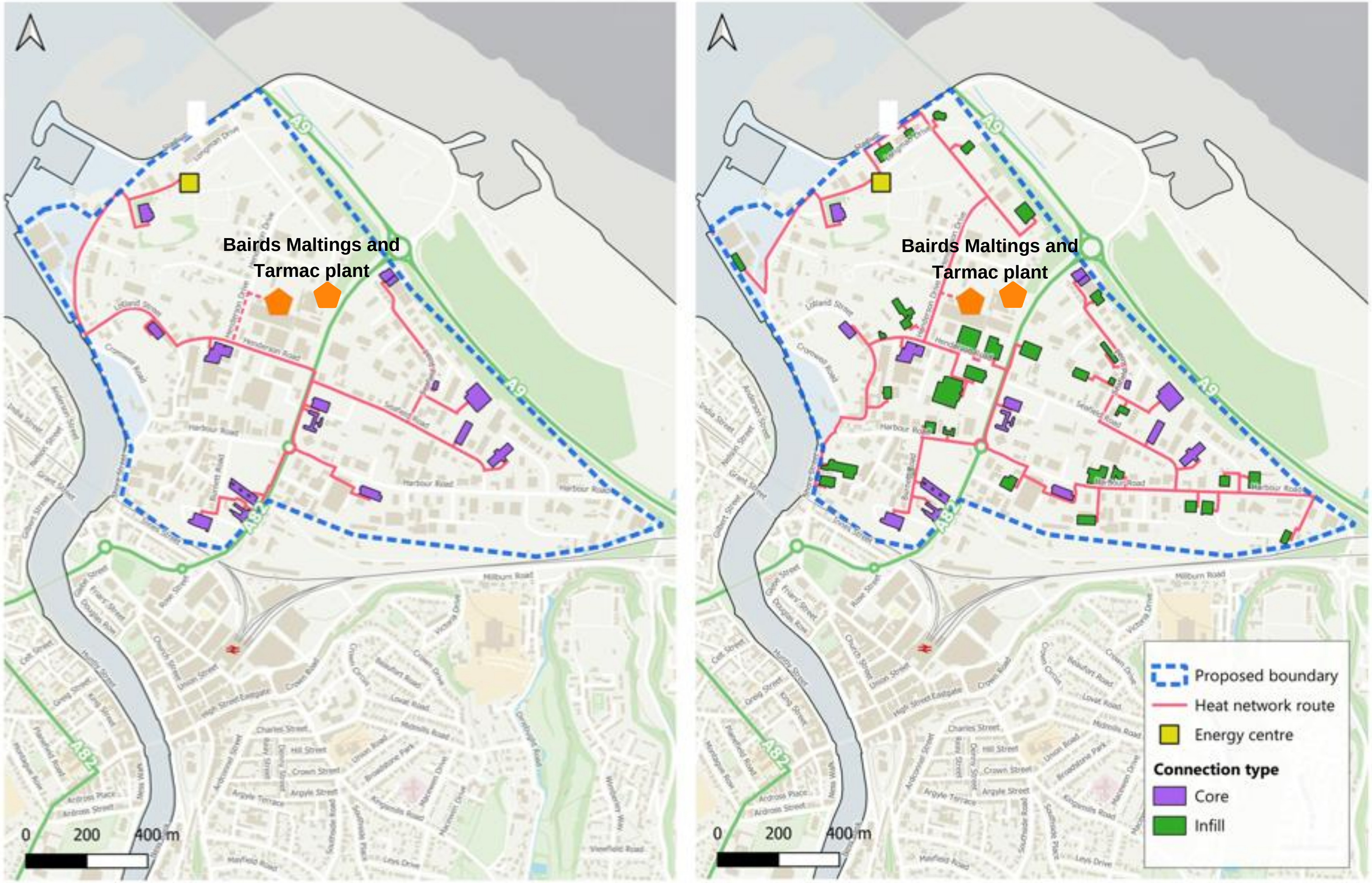


Figure 4—7 Full Longman area indicative heat network left only core connections and right: both core and infill connections (*Base map OS Crown Copyright*)

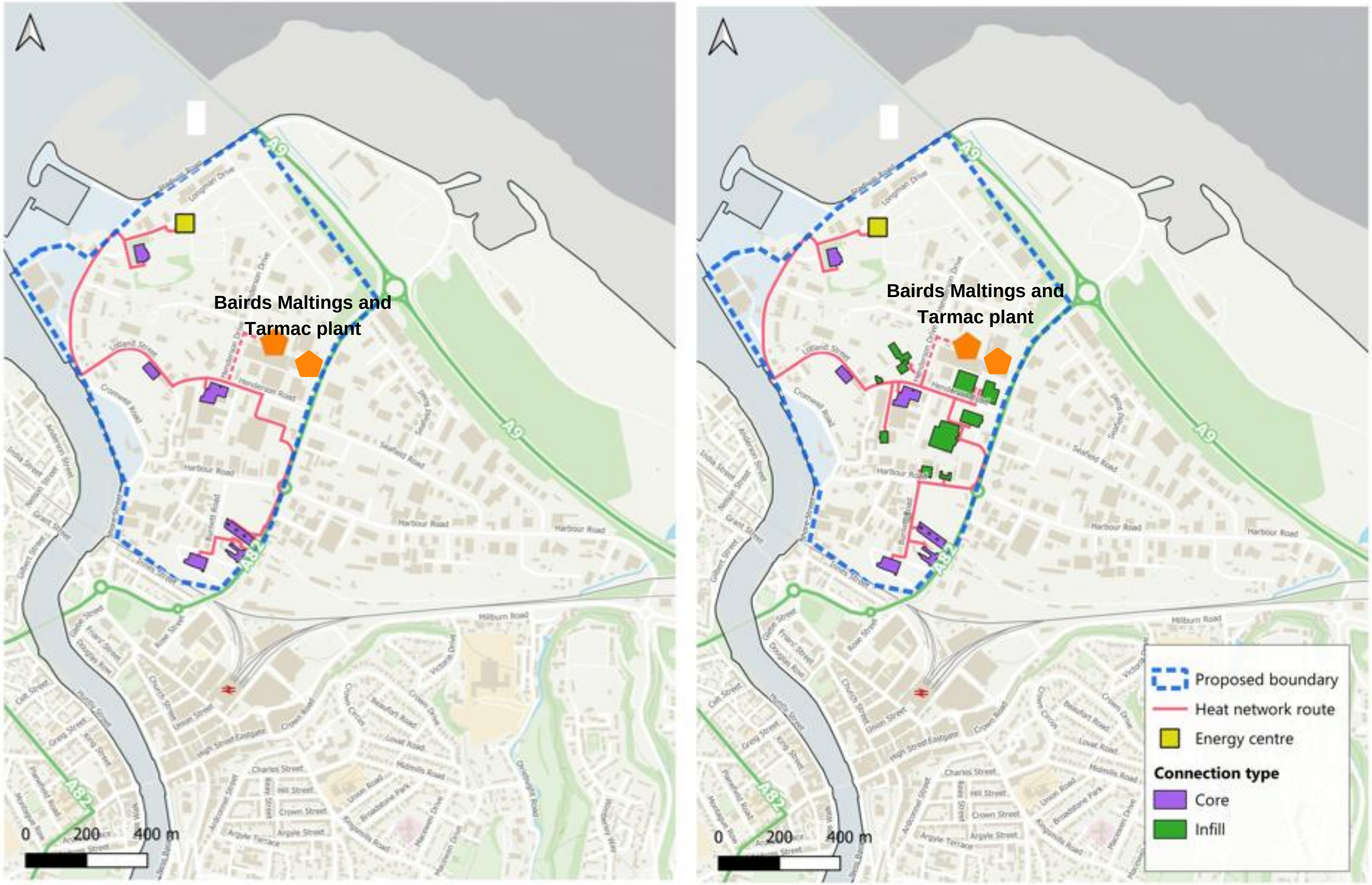


Figure 4—8 West Longman area indicative heat network left only core connections and right: both core and infill connections (*Base map OS Crown Copyright*)

4.2.3 Heat demand and key loads

The majority of demands in the Longman area are industrial units. These generally require a high level of validation compared to benchmarking of SHM, which can sometimes lead to large overestimations in heat demand. This is important to note in the context of Figure 4—9 which summarises the demands in the Longman area.

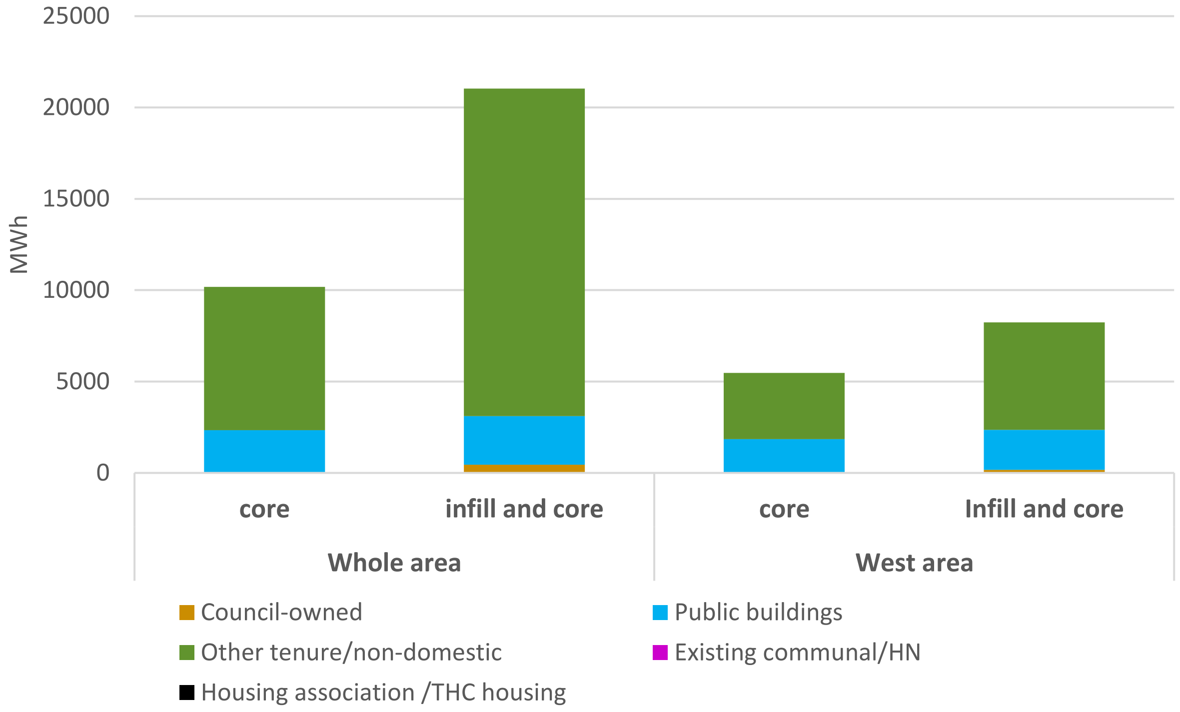


Figure 4—9 Heat demand based on the connection typologies defined in section 3.5 for full and west boundary.

The two largest industrial demands are excluded from the graph. These are the previously mentioned Bairds Maltings site and the Tarmac plant which is adjacent to the Maltings (in the north). Both of these demands are not fully captured in the SHM. The Maltings was captured based on the previous feasibility study work; however, the Tarmac plant was only captured in the project close out meeting. As such the Tarmac plant demand is not captured in any technical analysis but noted as a key demand to examine in the future.

There is relatively limited direct public/council sector control of heat demands, however, THC do own a large portion of the land in the area which is seen as a key enabler of a heat network in the area. A summary of the key anchor loads (those with over 500 MWh/yr) are captured in Table 4—5.

Table 4—5 Key anchor loads in Longman cluster

Building name	Cluster	Building connection category	Building typology	Annual heat demand (MWh)	Data source
Scotbake	West/ Whole	Other tenure/non-domestic	Industrial buildings	1175	SHM
MacGregor Industrial Supplies Ltd	West/ Whole	Other tenure/non-domestic	Industrial buildings	1097	SHM

Inverness Sheriff Court and Justice of the Peace Court	West/ Whole	Public buildings	Offices	1120	SHM
Insight Systems Ltd (and other offices in 50 Seafield Rd)	Whole	Other tenure/non-domestic	Industrial buildings	1021	SHM
Royal Mail – delivery office	Whole	Other tenure/non-domestic	Offices	904	SHM
Police Scotland Inverness Burnett Street	West/ Whole	Public buildings	Offices	737	SHM
Transport Inverness	West/ Whole	Other tenure/non-domestic	Retail	683	SHM
Scottish Water offices	West/ Whole	Other tenure/non-domestic	Offices	667	SHM
Thrifty Car Rental (and other retails in 33Harbour Road)	Whole	Other tenure/non-domestic	Retail	596	SHM
Stagecoach Inverness	Whole	Other tenure/non-domestic	Offices	571	SHM
Highland Industrial Supplies	Whole	Other tenure/non-domestic	Retail	563	SHM
Thornbridge Timber Inverness	Whole	Other tenure/non-domestic	Retail	557	SHM

It is worth noting that the Longman House building, with an annual demand of 215 MWh/yr, has been added as a core connection to the whole Longman network. The building is owned by the Scottish Government and is considered core because it is close to the 250 MWh/yr core threshold in public buildings and has a BAR report, which provides greater certainty and indicates engagement.

Another important load not captured in the table above is the SSEN office in Longman – as it falls below the 500 MWh/yr threshold. Alongside the Scottish Water offices this would be two of the main connections for the heat network being planned by SSE and SWH in Longman (due to the presence of a strategic partnership between the companies). The other two demands would be the Tarmac plant and the Bairds Maltings site – which is discussed in section 4.2.3.1.

4.2.3.1 Bairds Maltings site

Bairds Maltings represent a significant potential heat load in Longman cluster, with an estimated heat demand of 60000 MWh/yr, accounting for approximately 60% of the total estimated demand in the cluster. According to the previous Buro Happold study (2019), the existing Bairds Malting plant (before it was expanded) had an estimated demand of 29000 MWh/yr with a peak demand of 8.2 MWh/yr. Following Bairds planned expansion (now complete) the demand was projected to result in an additional 31000 MWh/yr of heat demand with the estimated peak of peak of 8.7 MW – bring it up to the 60000 MWh/yr.

While the existing plant operates at high temperature requirement (~160^{o}C), making it unfeasible to integrate directly to the heat network, the expansion is expected to have lower temperature requirement (60-80^{o}C). This presents an opportunity to utilise heat from the heat network.

Therefore, for the purposes of this study 50% of the heat demand is considered as potential demand to be met the heat network. This could act as a pre heat for the older portion of the site or as direct supply for the newer (lower temperature area). Stakeholder engagement would be required to establish the scale of demand which could be served by the network and the willingness to connect – it is understood this would be one of the first actions of the SSE/SWH collaboration looking to develop a network in Longman.

4.2.4 Heat sources and energy centre

The key heat source in the areas SW pumping station, which is already being explored by SSE/SWH. This was the best heat source identified in Inverness for any of the potential heat networks. The land availability next to the heat source makes this an ideal site for the energy centre. The high level of THC land ownership in the area means pipe routing from an energy centre in this location would also be relatively straightforward.

The previous feasibility examined utilising sewage heat recovery as a potential heat supply. The analysis is assed based a sewage flow rate of 190 l/s (based on the SWH dataset records) and a temperature differential of 5ºC. Assuming a COP of 3.2 for the heat pump and utilising 100% of flow, the estimated deliverable heat would be up to 5.7 MW_{th}, with a potential maximum annual heat supply of 50000 MWh. The SWH and SSE partnership is expected to provide more accurate estimations of this heat resource. However, this initial indication suggests the amount of heat would be sufficient to supply Longman in any of the scenarios examined.

With the exception of the Maltings and Tarmac loads the heat demands in the area are relatively small and the heat density is thus lower than other areas. This low heat density means cheap heat is very important to a heat network in the area.

In addition to the SWH site there is potential waste heat form hydrogen electrolysis at site of historic landfill. This project was submitted under the UK's Hydrogen Allocation Round 2 (HAR 2) for funding support, with a final award decision expected in June/July 2025. The proposed development at Longman Landfill includes a 50 MW hydrogen production facility that uses renewable energy for electrolysis, producing green hydrogen with an expected output of approximately 20,000 tonnes annually. This hydrogen opportunity is thus relatively early stage and not confirmed. Complex routing with A9 but could be viable if a hydrogen pipeline is deployed at the same time. Very early stage so not considered as fully as SWH. If this was to connect into a large energy centre which also captures the SWH heat it will be important to future proof the site in terms of space. However, Longman could only act as a heat transmission corridor for any waste heat from hydrogen into the more heat dense City Centre area, in which case this heat source would not need to be considered in the energy centre location.

There were also some heat demands that were considered as potential waste heat sources but discounted for a variety of reasons. One is the Maltings which is instead considered primarily as heat demand, the other is Scotbake. BuroHappold's experience of the potential of waste heat from bakeries for heat networks led to it not being explored further. The key reasons for this are: less complex and larger heat sources in the area, the need to fit around what are often short periods of time the site is not being used for production for the relevant equipment to be fitted, and the flammable condensate that often accumulates in the oven flues (which is where heat offtakes would generally be fitted).

4.2.5 Heat network characteristics

A summary of the key network characteristics is provided in Table 4—6.

Table 4—6 Longman cluster summary

	West Area		Full Area	
	Core network	Core and infill network	Core network	Core and infill network

Total demand (MWh/yr)	5480	8240	10180	21029
Network length (m)	2780	3480	5180	9715
LHD (MWh/yr/m)	2	2.4	2	2.2
LHD (MWh/yr/m) with 30000 MWh/yr Bairds Malting demand	11.6	10.2	7.4	5.2

The associated costs with a network at Longman are provided in Table 4—7.

Table 4—7 Indicative capital cost and carbon savings

		West Area		Full Area	
		Core network	**Core and infill network**	**Core network**	**Core and infill network**
Without Bairds Malting	**Capex £m**	9.4	12.5	17.5	33.7
	Carbon saving TCO2e over 40 years	34039	50333	62789	129029
With Bairds Malting	**Capex £m**	19.2	22.2	27.7	41.9
	Carbon saving TCO2e over 40 years	230719	247538	258888	325753

These tables highlight that without considering Bairds Maltings the LHD and carbon savings are much lower in Longman, showing the importance of this large connection for driving the viability of a network in the area.

4.2.6 Key risks and mitigations

The key risks associated with the Longman area and potential mitigations are summarised in Table 4—8.

Table 4—8 Key risks and mitigations for heat networks at Longman.

Risk / constraints	Mitigation
Electricity network capacity	The nearest SSEN electrical substation is currently unconstrained according to the high level SSEN heat map, however, there is known to be general upgrade work being undertaken in the area. Early engagement with SSEN is required as part of a full formal application in determining network capacity in the area. As SSE are set to be a key partner for delivery of a heat network in the area this is not seen to be a major risk.
Low Linear heat density	Low-cost heat can make lower LHD more viable. The two large industrial demands (the Maltings and Tarmac plant) substantially improve the linear heat density – reducing this risk. Finally, the potential interconnection to the City Centre opportunity would improve the heat density and many of the connections in Longman would be considered as additional connections. These mitigations would generally align to a focus on the West of Longman.

	This is due to the much high LHD in the City Centre and lack of heat supply options – this is explored in section 4.3.
Heat demand and heating system data accuracy	There is a risk that the heat demand estimates may be inaccurate as some of them are benchmarked. Moreover, the key connections are assumed to be all gas boiler and technically suitable to join the heat network. A feasibility study with stakeholder engagement is required to validate and confirm the assumptions, confirm suitability and addresses potential complexities. This is particularly key for Longman given the nature of the load.
Dependency on two private sector large consumers large consumer	Bairds Maltings and the Tarmac plant would account for a large portion of total network demand, meaning any operational changes, shutdowns, or process modifications at the plant could impact the financial viability of the heat network. A long-term heat supply agreement would be essential to mitigate this risk and ensure demand stability. Engagement with Bairds Maltings and the Tarmac plant to establish willingness to connect and how much demand would be suitable to be served by a heat network. If these demands are not interested in connection, it will heavily limit the viability of a network in Longman.
Sewage potential heat	The practical implementation of sewage heat recovery depends on the actual flow rates and temperature variations throughout the year. A detailed feasibility study would be required to validate expected energy output and ensure consistent performance. As SWH are already looking to utilise the asset this risk is considered to already be going through the mitigation process.
High portion of hard dig	High level of THC ownership opens multiple route options – helping to reduce impact and cost of hard dig.
Missing heat supply opportunities	In addition to the SWH site the Longman area could benefit from the planned electrolysis unit on the old landfill site north of the A9. Continued monitoring and engagement are key to benefiting from this potential asset (in the main part waste heat from the electrolysis unit). For Longman this heat could best be used outside of the area in the neighbouring City Centre. Understanding the scale and availability of these potentially large heat sources could be key for ensuring economic viability of heat network opportunities.

4.3 City Centre

4.3.1 Area overview

Inverness city centre is a one of the highest density areas in the city, with a large concentration of buildings with high heat demand. The area includes a mix of retails, offices and hotels, alongside several council -owned buildings, such as Inverness Castle, Inverness Library and Inverness Town House. Among those, the Eastgate shopping centre represent the largest heat load.

In addition, a major redevelopment is underway on Rose Street, involving demolition of an existing car park and retail units to make way for a new hotel, retails and student accommodation. As discussed previously, the new development is noted but as this is not a feasibility study demands are not benchmarked.

Buro Happold was commissioned in 2023 to assess the feasibility of a low-carbon heat network for the Castle area (for details see 3.1). Figure 4—10 provides the feasibility study boundary, proposed connections and heat network route.

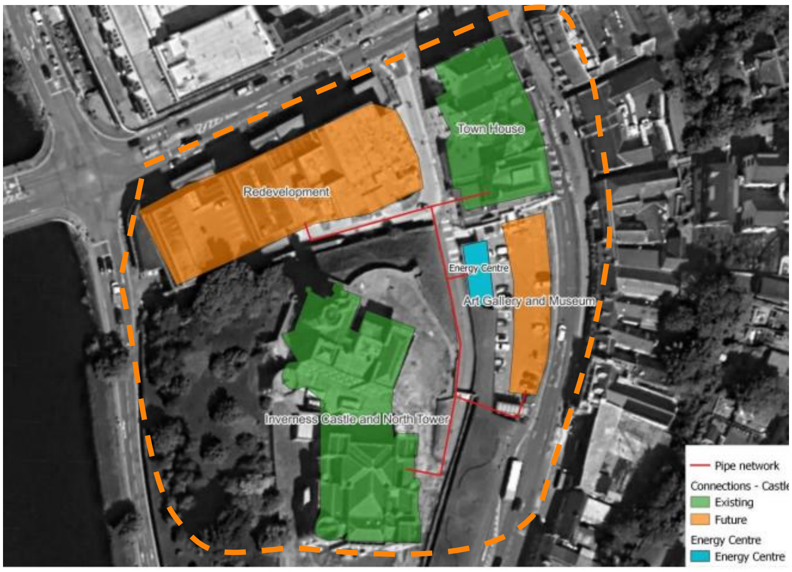


Figure 4—10 Inverness Castle feasibility study boundary, connections and heat network route[20].

As mentioned previously the heat network opportunity in the area is being pursued. A new energy centre, funded by the UK Government Levelling Up Fund, is currently under construction on Castle Street. The energy centre is deploying ASHP along with back up gas boiler and thermal storage to provide heat to the redeveloped Inverness Castle and the Inverness Town House[21].

4.3.2 City Centre Cluster

The City Centre area, with high building density and significant heat demand, is identified as a key area for heat network development, based on the LHD analysis described in section 3.3.

The initial proposed boundary initially encompasses the City Centre, expanding from the A82 in the north to the Inverness Castle area in the south. However, as previously detailed, a low-carbon energy centre is currently under construction on Castle Street. It is designed to supply heat to the redeveloped Inverness Castle and the Inverness Town House. It has been confirmed that the energy centre does not have the capacity to accommodate additional equipment and heating plant. As the Castle area is already integrating low-carbon heat sources, it is not considered priority for connection and was excluded from the proposed City Centre cluster. However, the Castle area could be considered for future integration, with the potential to link to the existing energy centre.

The proposed cluster also extends southeast to the Crown Avenue, which presents some challenge due to its higher elevation, which means additional pumping will be required. However, the area includes an academy, a retirement living complex and several council-owned low-rise flats, making it a viable for heat network connection consideration.

Figure 4—11 presents the LHD clusters and the proposed revised City Centre cluster boundary, with the left showing the initial proposed boundary and the right showing the updated boundary which now excludes the Inverness Castle area.

[20] Inverness Castle Feasibility Study 2023 Buro Happold

[21] https://www.highland.gov.uk/news/article/15438/work_set_to_get_underway_on_castle_street_energy_centre

Figure 4—11 LHD 4 MWh/yr/m and 8 MWh/yr/m bubbles and City Centre proposed heat network boundary; initial proposed boundary (left) and the updated boundary (right) (*Base map OS Crown Copyright*)

The City Centre cluster contains ~300 buildings, with an estimated 16 buildings exceeding 500 MWh/yr demand. The total demand is over 40 GWh/yr but this includes all buildings regardless of their typology or suitability for heat network connection, 4.3.3 provides more details of the demands assumed to be priorities for heat network connection.

As explained in section 3.7, buildings are considered for heat network connection based on factors such as scale of heat demand, typology and tenure as core or infill connections. Two assessments were performed:

1) A heat network consisting of only core connections – focusing on the high demand buildings to establish financial viability of the network
2) A heat network consisting of the core and infill connections – where additional buildings are integrated to improve network utilisation and efficiency

Key features of the City Centre cluster are shown in Figure 4—12, where the left presents a heat network with only core connections, right presenting a heat network with both infill and core connections.

As previously discussed, a major redevelopment is planned on Rose Street, involving the demolition of an existing car park and retail units with a new hotel, retails and student accommodation. While the benchmarked demand of the existing retail units on Rose Street has been included in the cluster analysis to provide a partial assumption for the new development, the exact demand figure remain unknown due to lack of the precise detail on building typologies and floor areas.

Figure 4—12 City Centre cluster heat network left only core connections and right both core and infill connections (*Base map OS Crown Copyright*)

Further detail on the heat network key heat demands, heat sources and distribution network along with high level capex are provided in the subsequent sections. Moreover, the key risks and potential mitigations identified for successful development of the heat network are addressed in section 4.3.6.

4.3.3 Heat demand and key loads

The City Centre cluster comprises different typologies, with the retails and hospitality being the most prominent in terms of both the number of buildings considered for connection and their contribution to the overall heat demand. The total heat demand within the cluster is estimated to be 40 GWh/yr (this includes small heat demands, often domestic, that were excluded based on the screening criteria outlined in the methodology). The core connections network is connecting circa 22 GWh/yr of the demand, while the network with both infill and core connections connects 35 GWh/yr of heat demand.

Figure 4—13 shows the total annual heat demand and its distribution across different building categories. In both network options, council-owned and public buildings accounts for relatively small share of total demand, representing less than 6% in the core connections network and under 9% in the core and infill connections network.

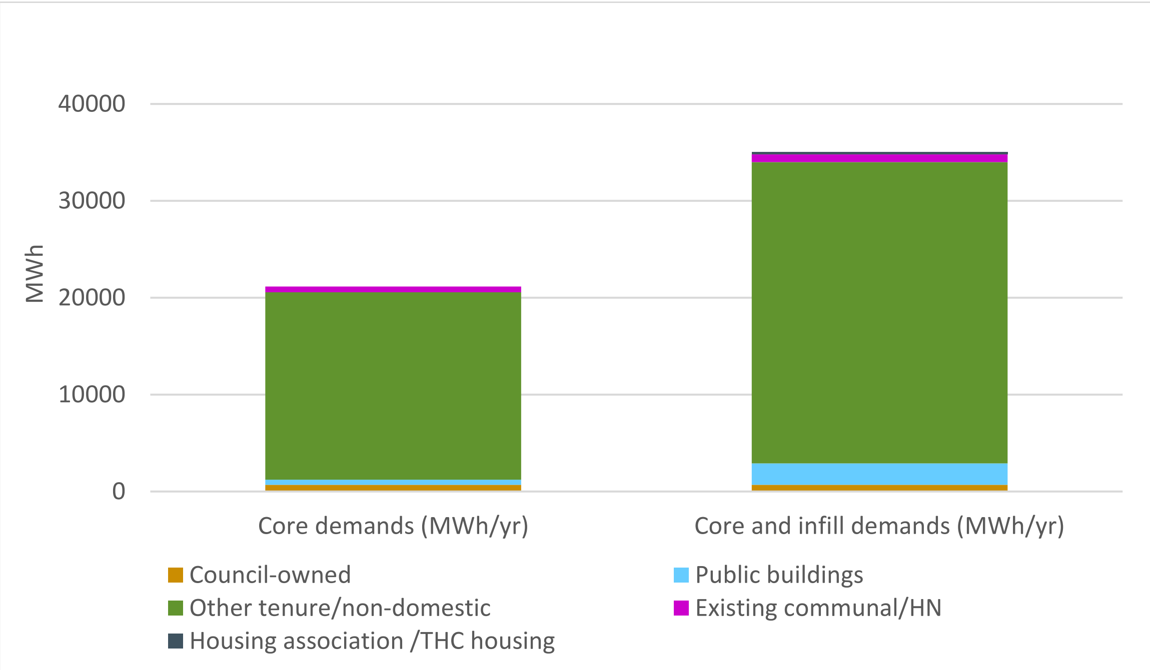


Figure 4—13 Heat demand based on the connection typologies defined in section 3.5

Further details of the key heat demand are provided in Table 4—9. The top anchor loads account for an estimated 20 GWh/yr, with Eastgate shopping centre being the largest demand in the cluster with over 6 GWh/yr demand.

Table 4—9 Key anchor loads in City Centre cluster

Building name	Building connection category	Building typology	Annual heat demand (MWh)	Data source
Eastgate shopping centre (consists of a number of buildings)	Other tenure/non-domestic	Retail	6400	SHM

Mercure Hotel	Other tenure/non-domestic	Hotels	3219	SHM
By the Bridge accommodation / Holiday let	Other tenure/non-domestic	Hotels	2610	SHM
The Royal Highland Hotel	Other tenure/non-domestic	Hotels	2207	SHM
Pentahotel	Other tenure/non-domestic	Hotels	1390	SHM
Morrison Supermarket	Other tenure/non-domestic	Retail	1161	SHM
TK Maxx Department store	Other tenure/non-domestic	Retail	965	SHM
Travel Lodge Hotel	Other tenure/non-domestic	Hotels	850	SHM
Marks and Spencer	Other tenure/non-domestic	Retail	730	SHM
Mixed-use building in Baron Taylor’s St with communal heating	Existing communal/HN	Domestic	580	SHM
Wasps Inverness Creative Academy	Public buildings	Education	516	SHM

4.3.4 Heat sources and energy centre

No significant waste heat source is identified in the City Centre area that could supply heat to the City Centre Cluster. There is also potential to utilise WSHP due to proximity to the River Ness. The feasibility of this remains uncertain, as there is insufficient data on key factors such as river temperature variations through the year, flowrate and depth fluctuations. A more detailed study is required to assess the viability of this option and to evaluate the practical limitations of installing equipment and water abstraction. Additionally, the area near the Ness is not likely to be a priority for heat network build out, making the strategy for a heat network in this area challenging if it is the selected heat source.

The primary heat source is proposed to be a large-scale ASHP. Due to the dense City Centre environment, available space for an energy centre is limited. The Rose Street planned redevelopment site has been identified as a suitable location for the energy centre, as it allows for streamlined planning and infrastructure work alignment and it serves as a trigger for enabling heat network development.

ASHP have a lower COP than WSHP, meaning electricity costs will generally be higher. However, WSHP often come with higher capital and maintenance costs, making their suitability more dependent on the scale of the network and funding available.

Gas boiler is included for back-up and peaking plants due to their low cost, compact size, and rapid ramp up. However, to meet the long-term goal of full decarbonisation by 2045, gas boiler must be replaced by low-carbon alternatives, such as electric boilers. Electric boilers will have an elevated running cost compared to gas due to the relative difference in price and also require substantial headroom on the electricity network.

4.3.5 Heat network characteristics

Figure 4—12 presents the proposed network route for both options: the core connections (left) and the combined infill and core network (right). The proposed network has been developed using the Steiner tree methodology (as detailed in section 3.6), which determine the shortest possible routes while following existing road networks to minimise the construction complexity.

The core network spine includes a main trunk of pipework running along Rose St, Maragaret St, and Academy St with branches to key demand sites such as the Inverness Library, Spectrum Centre several hotels. The network splits into two branches at Academy St, with one branch heading east to the Eastgate Shopping Centre and on heading to west to supply heat to a number of hotels. Another branch from the Crown Rd, extending down Crown Avenue, serves the inverness Creative Academy. Pipe network construction in the City Centre cluster presents additional challenge due to high urban density and limited access which leads to increased pipework cost compared to other clusters with more suburban areas.

A summary of the key network parameters including the total heat demand, network length and LHD for both networks is provided in Table 4—10.The City Centre cluster shows a LHD of 7.9 MWh/yr/m with core connections, suggesting strong potential for network expansion. The core and infill network, which extends network to additional buildings, has a lower LHD of 5.5 MWh/yr/m, indicating viability even with further expansion.

Table 4—10 City Centre cluster summary of key network characteristics.

	Core	Core and infill
Total demand (MWh/yr)	21540	35000
Network length (m)	2.7	6.4
LHD (MWh/yr/m)	7.9	5.5

As detailed in section 3.9, a simplified techno-economic model was utilised. The model incorporates the pipe length data (including soft dig/suburban/dense urban environment), major obstacles, the annual heat demand by building typologies. It creates a heating profile and annual load duration curve to size the low-carbon plant and back-up plant. The ASHP size is estimated to be around 4.9 MW for the core network and 8.2 MW for the core and infill network. In both heat network options, over 79% of heat demand is expected to be met by heat pump, and the remaining demand is supplied by the gas boiler peaking plant. Table 4—11 provides an indicative capital cost and estimated carbon savings compared to a gas boiler counterfactual for both networks.

Table 4—11 Indicative cost and carbon savings for the City Centre indicative heat network

	Core	Core and infill
Capex £m	22.2	44.3
Carbon saving TCO2e over 40 years	131690	214130

The planned development on Rose Street, along with Inverness railway station area planned development and potential SSEN cable upgrade work, could be the key trigger for enabling heat network development in the City Centre. This opens up the possibility for energy centre locations in the area, which is spatially constrained. It also introduces new demands, which could be key connections for a heat network. Finally, the cable upgrade can help reduce the cost of pipework trenching and minimise disruption – avoiding the same road being closed on multiple occasions in relatively quick succession.

4.3.6 Key risks and mitigations

Table 4—12 below outlines key risks, constraints and potential mitigations for the City Centre heat network opportunity.

Table 4—12 Key risks and mitigations for the City Centre

Risk / constraints	Mitigation
Electricity network capacity	The nearest SSEN electrical substation (Inverness Substation, south of the cluster, across the river) is currently unconstrained. However, the Dalneigh substation is overloaded. Early engagement with SSEN is required as part of a full formal application in determining network capacity in the area. Based on engagement with THC SSEN have planned upgrades in the area, including cabling.
High level of hard dig	Planned SSEN trenching for cables and other developments should be coordinated for heat network deployment. Based on THC engagement this is already being considered and is thought of as a catalyst for realising the heat network opportunities in the City Centre.
Buildings compatibility for heat network connection	For the new development, engagement with planned developments is required to ensure secondary systems are connection ready to DHN. For existing buildings, enabling works on the buildings that currently operate at high temperatures to ensure heating system compatibility. Enabling works may include design and contractor works to replace existing heat emitters (radiators and fan coil units) to operate at lower temperatures.
Lack of space for an energy centre and limited waste/ low carbon heat potential	Rose Street redevelopment key trigger point to allow energy centre location. Potential import of heat from the Longman area could reduce the emphasis on infrastructure in the area, which is important given the higher cost of land and lower availability of space. Linking the two areas would help improve demand diversity and could potentially increase the size of thermal store available to the City Centre (enabled by the greater space in Longman). Additionally, this interconnection will allow greater access to low cost heat than within the city centre area.
Heat demand and heating system data accuracy	There is a risk that the heat demand estimates may be inaccurate as some of them are benchmarked. Moreover, the key connections are assumed to be all gas boiler and technically suitable to join the heat network. A feasibility study with stakeholder engagement is required to validate and confirm the assumptions and address potential complexities.
Listed building connections	There are several listed buildings in the City Centre. Physical alteration works to the buildings to accommodate pipework and heat off take substations would need to be considered on a building-by-building basis along with the existing heating systems, which are understood to be included within the listed protection.

Relatively few strategic key loads	Eastgate is one of the key pulls for a heat network into the centre. Again, early targeted engagement is key. Including understanding suitability for connection.
Many private sector heat demands	Requires focused engagement to ensure suitable interest for deployment. Whilst Eastgate represents one strategic connection there needs to be concerted early engagement to key loads such as the hotels in the area.
Low level of THC land ownership	Optimise routings and strategically route to minimise the number of landowners who require engagement.
Not fully utilising existing assets	The new energy centre near the museum does not have capacity to serve the network area. Interconnection of the two energy centres is considered in the final strategy.

4.4 Raigmore

This section is not as detailed as others with the accompanying feasibility study providing detailed analysis of the area. An overview of the heat demand across the area is provided in Figure 4—14.

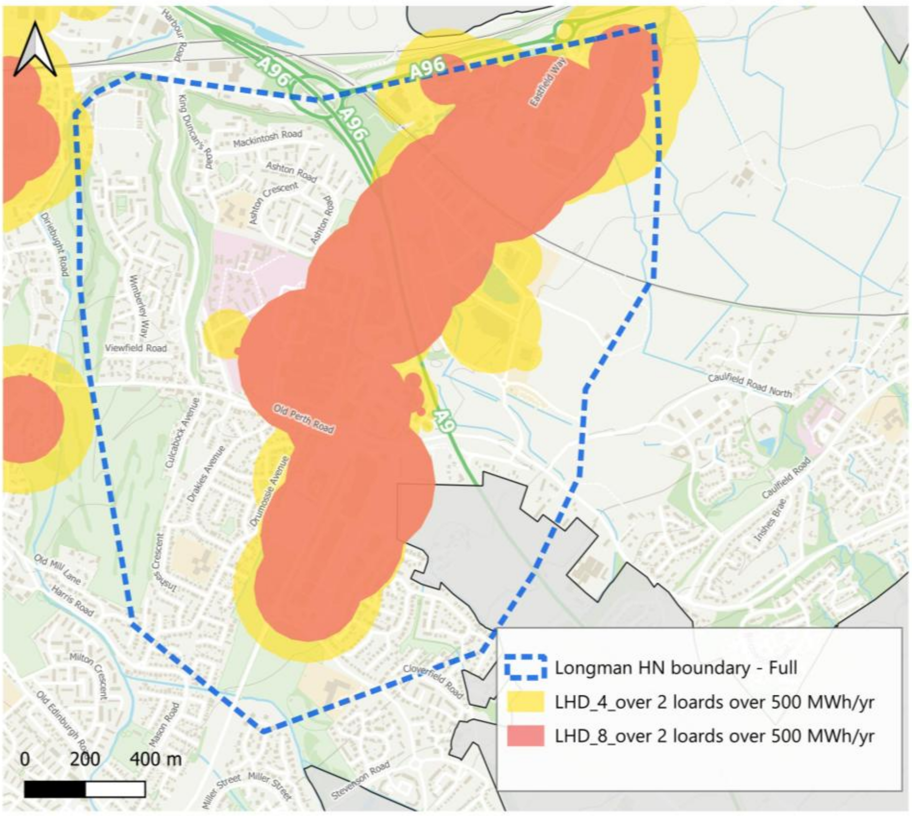


Figure 4—14 LHD 4 MWh/yr/m and 8 MWh/yr/m bubbles and Raigmore proposed heat network boundary (*Base map OS Crown Copyright*).

The Raigmore area is split by the A9, meaning the linking of the whole area could be challenging. Additionally, initial assessment of heat resources suggested there were relatively few options for heat supply in the area[22], meaning there was no specific driver for connecting all demands into one network given the increased costs likely to be incurred by the road crossing. As such the area was split into an East study and a West study. Maps of the two areas are provided in Figure 4—15 and Figure 4—16 respectively.

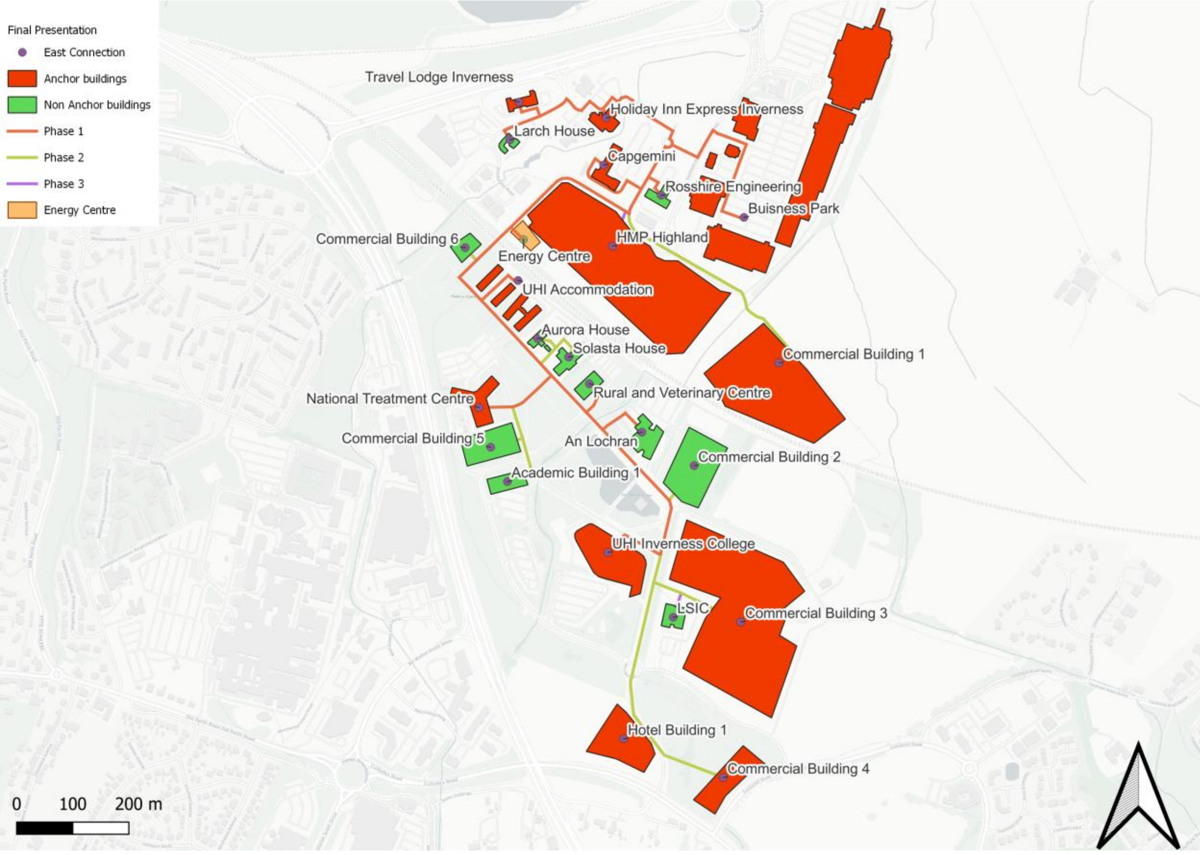


Figure 4—15 Raigmore East network overview

[22] Although updates to the SWH website during the study indicated that there is a potential heat supply from a large sewer, however, the study indicated similar economics to an ASHP.

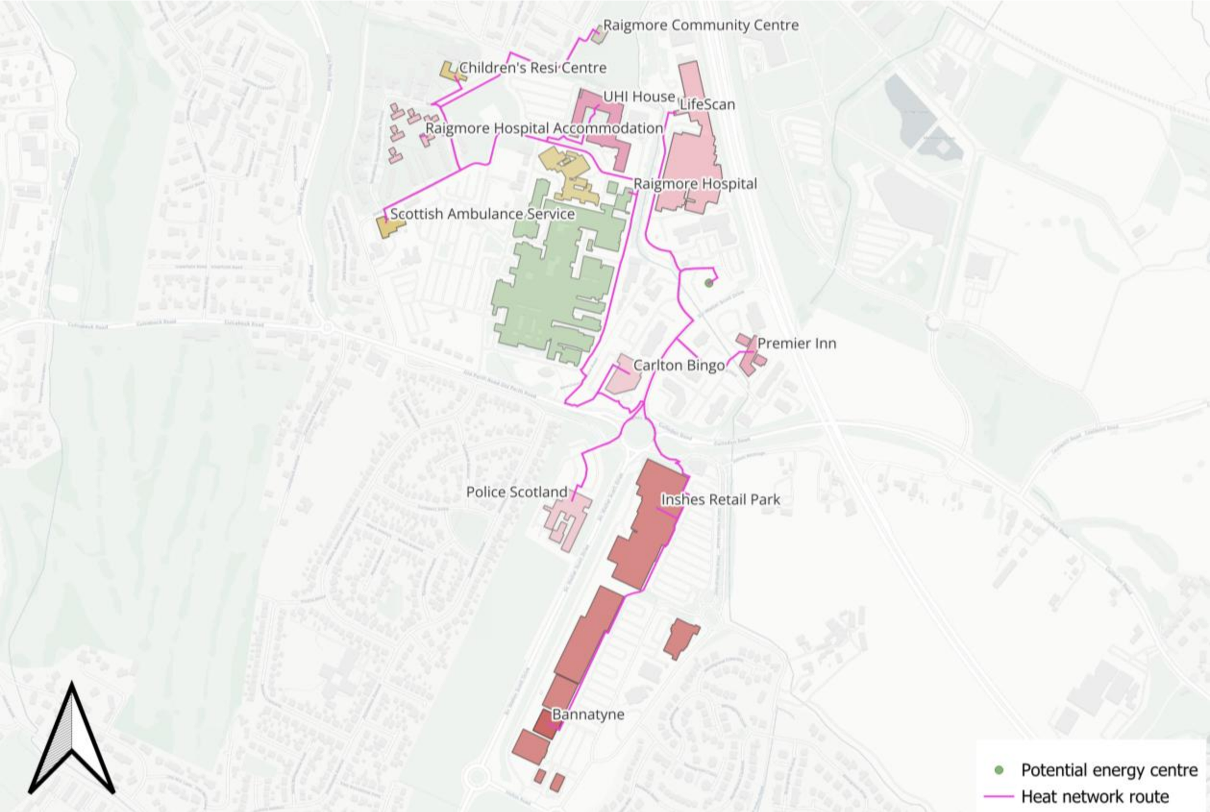


Figure 4—16 Raigmore West Network overview

The East side was decided as the final focus of the feasibility study due to more active stakeholder engagement during the feasibility study. The results indicated a network was viable with funding support, an IRR of 12% with 50% CAPEX funding was the output of the techno-economic model. The network and deployment approach is highly reliant on future developments in the are linked with the Freeport.

The West side is in a large part dependent on the NHS Raigmore Hospital – due to being the largest demand in the area and strategically located near the centre of any network routing. However, repeated attempts for engagement during the feasibility study were unsuccessful. After the study competition there is now seen to be increased interest from the NHS. As such the West side also appears to be attractive for heat network development.

The characteristics of these networks are summarised in this report in section 6.4, with more detail in the feasibility study. Section 6.4 also captures a theoretical full Raigmore network. The interest of the hospital may make a full Raigmore network more attractive and as such it is captured as a third option for the Raigmore area in the following sections. Additionally, if the full area is considered it provides an option for a heat network developer to phase deployment across the two sides of the A9 based on the timing of the new demands. This can be attractive from an investment perspective, with a large final network but a spread of capital investment.

5 Multi Criteria Analysis

After the different potential heat network zones are identified and characterized there is a need to compare and understand their viability for deliverability within the context of the KPIs outline by Highland Council. This is done using a multi-criteria analysis (MCA) approach. This characterizes the potential heat network zones based on various criteria. The MCA allows different levels of priority or weighting to be placed on certain criteria, helping to assess how much of a priority opportunity each potential heat network zone represents.

5.1 Assessment criteria

In total 20 different assessment criteria for the MCA were decided upon. These are based on the specified KPIs and the available data at a potential zonal level. These assessment criteria are described by theme (decarbonisation, deliverability, economic, and social) in sections 5.1.1 to 5.1.4. Within each of these sections the different criteria and their importance are described. This includes how important each criteria is to a private sector delivered heat network or a public sector (delivered network with a focus on Highland Council involvement).

5.1.1 Decarbonisation

The decarbonisation theme considers potential heat savings based on assumptions on current heating systems and also considers the low carbon heat supply opportunities in the area. A summary of the assessment criteria used is provided in Table 5—1.

Table 5—1 Summary of assessment criteria to explore the decarbonisation theme in the MCA.

Assessment criteria	Description	Importance to private sector delivery	Importance to public sector delivery
Carbon saving	Calculates the carbon dioxide saving using the DESNZ Heat Network Zoning tool or in the case of Raigmore the recent feasibility study. This is strongly linked to the heat demand in the zone.	Some heat network providers have internal targets relating to decarbonisation. Legislation is also driver of decarbonisation. Whilst private sector will decrease carbon it is not going to be the reason a particular heat network opportunity is selected over another.	With carbon reduction targets, particularly in their own estate, it is more likely to be a driver for public sector delivery than private sector.
Low carbon heat source (number and viability)	Considers the number of potential heat sources and how viable these are. A high score would be based on several low carbon heat sources, which are easily accessible.	Can be a key enabler for deployment. Rather than the low carbon nature the cost of the heat source will be a key consideration. For example, energy from waste even though it has a higher carbon footprint is likely to be favoured over a heat pump solution (because of lower cost). If a low carbon heat source is available at a lower cost than air source heat pumps this is likely to be a major driver for selection.	Similar considerations to the private sector.
Low carbon heat source potential supply	This focuses on the quantity of heat available and the economics of this compared to an air source heat pump. For example, a river source heat pump would not be able to score full marks in an MCA	Indicator of the feasibility of deployment. A high quantity of available low carbon heat is a positive. Possible purchase of the asset or other contractual	Similar importance to the private sector for network viability but generally lower

	as the economics of this potential supply does not offer a large improvement compared to air source heat pumps. In denser urban areas where space for large air source heat pumps is more constrained a greater weighting would be given to the quantity of available heat, however, in Inverness only the City Centre opportunity is spatially constrained.	arrangements for a key heat source are likely to be an area of interest.	likelihood for purchase of heat source.

5.1.2 Deliverability

The deliverability theme covers many assessment criteria. There can be a cross over between some of these items and the economic criteria, however, duplication is avoided to avoid inflating the importance of one criterion without making this an active decision. A summary of the assessment criteria used is provided in Table 5—2

Table 5—2 Summary of assessment criteria to explore the deliverability theme in the MCA.

Assessment criteria	Description	Importance to private sector delivery	Importance to public sector delivery
Council land	Based on the percentage of Highland Council owned land in each area. This is an important factor as it can aid and help de-risk pipework deployment.	Positive as one major and easy to engage land owner, easing pipe routing deployment.	Key opportunity for the Council to be a major stakeholder and influence the network - particularly if coupled with a high number of Council demands.
Demand from Highland Council buildings	This captures the demand from Highland Council buildings and also considers the percentage of overall demand from these buildings. The total heat demand from all loads is used to consider revenue but the demand from Highland Council buildings impacts deliverability as such buildings have less risk associated with likelihood to connect. Thus, a high demand from Highland Council buildings indicates a high likelihood of connection and ease of connection negotiation.	Easy stakeholder to engage, helping to derisk deployment as more likely guaranteed connection.	High level of Council influence means timing, strategy and ownership options for the Council are strongest. Also allows for easier tie in with local Council building decarbonisation targets and strategy. This is seen as a major positive for a network in which the Council has a stake.
Demand from public sector buildings	This is assessed in the same manner as Council owned buildings and for similar reasons.	Very similar to Highland Council buildings. Easy stakeholder to engage, helping to derisk deployment as more likely guaranteed connection.	Similar to the private sector development - still an important positive weighting but not as significant for Council involvement as their own buildings.
Dig type	The dig type impacts the level of disruption as well as the cost of the pipework deployment (this latter point is captured in the CAPEX). A high level of soft dig (e.g. playing field or footpath) is far less disruptive than hard dig (e.g. city centre roads). The DESNZ Heat	Key cost and delivery complexity, needs to be managed carefully to avoid negative public perception. Less intrusive dig is always preferable.	Possibly even more significant for the public than private sector, due to road disruption commonly being associated with the Council. Consideration of other planned road closures and

	Network Zoning tool considers soft, sub-urban and urban dig - the assessment for this work aligns to this with a high level of hard dig being scored negatively and a high level of soft dig positively.		maintenance to reduce impact.
Number of connected buildings	Details the number of buildings connected in each scenario. The accompanying strategic report provides information as to the type of buildings connected in each scenario. This impacts both the economic elements as this impacts revenue but also the deliverability as a large number of properties derisks the network. Consequently, the number of connections is captured in the deliverability whilst the demand is in the economic section.	Having a large number of potential connections (so long as they are of a reasonable size - this is a screening criteria) can help spread the risk, as if one load does not connect it does not impact the network. It can also allow some phasing of deployment which is a positive from a private sector perspective, as it can help spread capital investment.	Similar to the private sector, however larger networks with more connections will be harder to manage.
Number of existing heat networks/communal systems	This uses a combination of Home Analytics and the Scotland Heat Map and some local data gathering to identify existing communal and heat network systems. These existing networks are likely to connect into larger schemes and may also have available plant room to aid deployment, improving deliverability. Additionally, depending on their scale and central government legislation there may be a requirement to connect to wider networks.	Similar consideration to other large loads, dependent on scale and ownership but their presence is a positive.	Similar to the private sector, although there is even greater impact of ownership and social factors such as fuel poverty. These would need to be explored on a case-by-case basis, but it is not a major opportunity in Inverness due to a low number of existing heat networks and communal systems.
Number of Highland Council buildings	Is based on the total number of Highland Council connections. As with demand from Highland Council buildings this helps de-risk connections, improving deliverability.	Similar to demand from Council buildings. Having a large number of demands can also help spread certainty of different areas of the network being deployed, this needs to be explored spatially.	As with demand form Council buildings this can be a key driver for a high level of Council involvement. Similarly to the public sector it can help determine the extent of a network in an area.
Number of public sector buildings	This is assessed in the same manner as Council owned buildings and for similar reasons.	Similar to the impact of numbers of public sector buildings.	Very similar impact to the private sector but having a greater level of influence will often increase significance.
Planned growth in the area	Draws on planning data, considering the number, type and size of developments. A high number of new developments can provide an opportunity for simplified connections (rather than relying on retrofit). New developments can also offer opportunities for hosting a plant room - particularly if there is a high level of Council involvement.	This allows the ability to phase development, which is very attractive from a cashflow perspective. Additionally, new developments and demands are generally easier to connect and can be a trigger for deployment.	The cash flow is still important but generally less so than the private sector, the other factors are of a very similar level of significance.

5.1.3 Economic

The economic theme gives various indicators to the likely economic performance of a heat network in the potential zone. These values are indicative only and should not be used for investment decisions. A summary of the assessment criteria used is provided in Table 5—3.

Table 5—3 Summary of assessment criteria to explore the economic theme in the MCA.

Assessment criteria	Description	Importance to private sector delivery	Importance to public sector delivery
CAPEX/MWh thermal	This considers the total cost (derived from either the DESNZ Heat Network Zone assessment tool or feasibility studies) divided by the total demand in the area. This is used rather than a pure CAPEX to provide an indicator of how the system performs in terms of capital expenditure per unit of heat delivered. These costs are high level and indicative rather than a true financial model.	Being the main economic metric, this is key as it is an indicator of how quickly investment is likely to be paid back.	As with private this is a key factor, however, slightly lower rates of return can be acceptable due to loan and funding options in the public sector. So, whilst it is still significant generally a slightly lower importance than the private sector.
Demand from anchor loads	Considers the total thermal demand from anchor loads. These large consumers are key drivers of heat network economic viability. There is a risk if a large amount of demand is from one anchor load, if this does not connect it impacts the whole network viability.	A key metric, high demand from anchor loads means less onerous stakeholder engagement to deliver a viable network.	Important to consider but somewhat less so than the private sector. If large anchor loads are Council owned this makes it more significant, but these factors are also considered elsewhere.
Demand from connected buildings	The total heat demand (annual rather than peak) for the buildings connected in the scenario. This determines the likely heat sales and thus likely revenue.	A key metric shows the potential scale of the scheme. Private sector investment is more likely to be achieved for larger schemes due the potential scale of the final opportunity.	Whilst this can be important for public sector involvement it will be balanced by other factors, such as Council assets.
Linear heat density (MWh/m/yr)	This is based on the heat demand per meter of pipe from the indicative pipe routings generated during feasibility or the Steiner analysis (see the accompanying strategic report for details). The linear heat density is one of the key economic indicators for a heat network, with a high value indicating improved economic viability. Low heat densities can be offset by factors such as very cheap heat sources and easy dig.	Key early-stage indicator of network economic viability is a key concern to the private sector.	Economic viability indicated by this is highly important to public sector schemes (including ability to access funding) but can be somewhat offset by other factors such as a high level of their own estate being included, reducing costs or wider societal benefits such as addressing fuel poverty offsetting the relative importance.
Number of anchor loads	Provides a total count of anchor loads. These large single points of connection are a key economic driver of viability and pipework routing.	Very important a relatively high portion of large energy consumers helps viability of the network and eases engagement and delivery. A	Similar to the private sector, however, the public sector being more concerned with a high number of Council

		large number of anchor loads alongside a large anchor load demand helps increase network viability as if the network is too reliant on one large anchor load (such as the Maltings in Longman) the overall network viability is at significant risk of the large heat demand does not connect.	properties does reduce the relative importance, with number of core connections as well as items in the deliverability section significant related factors.
Number of core connections	Similarly to anchor loads core connections are an indicator of large loads that are likely to connect. For the core scenario this will be the same as the total number of loads in deliverability. Its inclusion in the economic section is similar to that of anchor loads.	Similar to anchor loads.	Similar to the private sector but slightly more important as it also accounts for ownership, weighting towards Council connections - which can help improve operating costs for the Council's Estate.

5.1.4 Social

The social theme considers fewer criteria than the others, in part as the level of analysis at this stage makes consideration of the more precise social impacts harder. However, social characteristics of the potential zone overall can be measured, with the two parameters explored detailed in Table 5—4.

Table 5—4 Summary of assessment criteria to explore the social theme in the MCA.

Assessment criteria	Description	Importance to private sector delivery	Importance to public sector delivery
Fuel poverty	Provides the average fuel poverty score in the heat network area based on Home Analytics. This does not consider heat network connection but rather the characterisation of the area as a whole. Areas with negligible or no housing (such as Longman) have a score of 0 for this indicator.	Whilst private sector heat network developers will consider fuel poverty abatement in an area it is unlikely to be a driver for them.	Can be a key target for encouraging deployment in an area.
Total social housing number	Provides a count of social housing in the area based on Home Analytics. Again, this does not consider connection to the heat network but rather the presence of this housing type in the area. Areas with negligible or no housing (such as Longman) have a score of 0 for this indicator.	Similarly to fuel poverty not often a driver. However, a high level of social housing would often be preferred to a high level of normal housing due to fewer stakeholders to engage.	As with the private sector can be seen as enabler, due to easy stakeholder engagement. Particularly when combine with high fuel poverty this is likely to be a driver.

5.2 Applying the assessment criteria

Based on values derived from the analysis carried out in the strategic work, an accompanying feasibility study for Raigmore, and a review of previous studies, each of the potential heat network zones is assigned a number between 0-1 in the MCA tool. With 1 being the potential zone performs as well as is feasibly possible against the desired criteria (for example, if the area was entirely owned by the Highland Council it would score a 1 against the *Council land* criteria) and 0 shows it does not contribute in any way to that criterion (for example, if there is no housing it will score 0 measured against fuel poverty). This approach was selected rather than a pure ranking for two key reasons, having relatively few potential zones limits the suitability of ranking, ranking does not differentiate in a useful way between two similar values (for example, a linear heat density of 6.2 MWh/m/yr at this level of analysis is not substantially different to one of 6 MWh/m/yr but a ranking would draw out a large difference).

The approach taken means that for many criteria none of the potential heat network areas would score the maximum of 1. An example of a reason for this is no highly economic heat sources were identified; these would typically include energy from waste plants or large data centres. However, it is the relative performance of each potential zone against the others that is most important for informing the strategy.

The accompany *Inverness strategic heat network support MCA tool* provides a breakdown of these scores. A video has also been recorded alongside the tool provide guidance on how it can be used. This is meant as an internal tool for THC.

The video includes a description of how the weightings of different criteria can be adjusted, this is also explored briefly in section 5.2.1. The MCA score between 0 and 1, alongside the different ratings are used to give each potential zone a percentage rating. It is important to note that the MCA tool is not used to screen out potential zones, this should be done through review of section 4, it is used to compare and prioritise the potential zones.

The values siting behind the MCA are relative to each other but not ranked. As a result even if a potential zone is the best performing in a certain characteristic it does not necessarily a value of 1. An example of this is related to social housing, none of the potential areas have particularly high level of social housing so no zones are scored the maximum value of 1. This avoids placing undue weight onto a characteristic, which may be of interest to THC but in reality none of the potential zones perform particularly well by this measure. Similarly, if all potential zones perform in a similar manner it is important that any minor differences are not over emphasised.

5.2.1 Applying weightings

The MCA tool is highly flexible allowing weightings to be adapted by the user. This includes a manual approach where the user can manually define the relative weighting of each of the twenty different criteria listed in section 5.1.

The simpler adaption method is to give a weighting to the different themes, these automatically splits the weightings even across each of the criteria in the theme. This theme based adjustment is done by altering the percentage split for each theme shown in Figure 5—1.

Theme	Percentage split
Decarbonisation	25
Deliverability	25
Economic	25
Social	25
Total	100

Figure 5—1 Screenshot of theme based MCA weighting adjustment table.

This is summarised, alongside the relative weighting it gives the various criteria in a graph below the table, the corresponding weighting to the above example are provided in Figure 5—2.

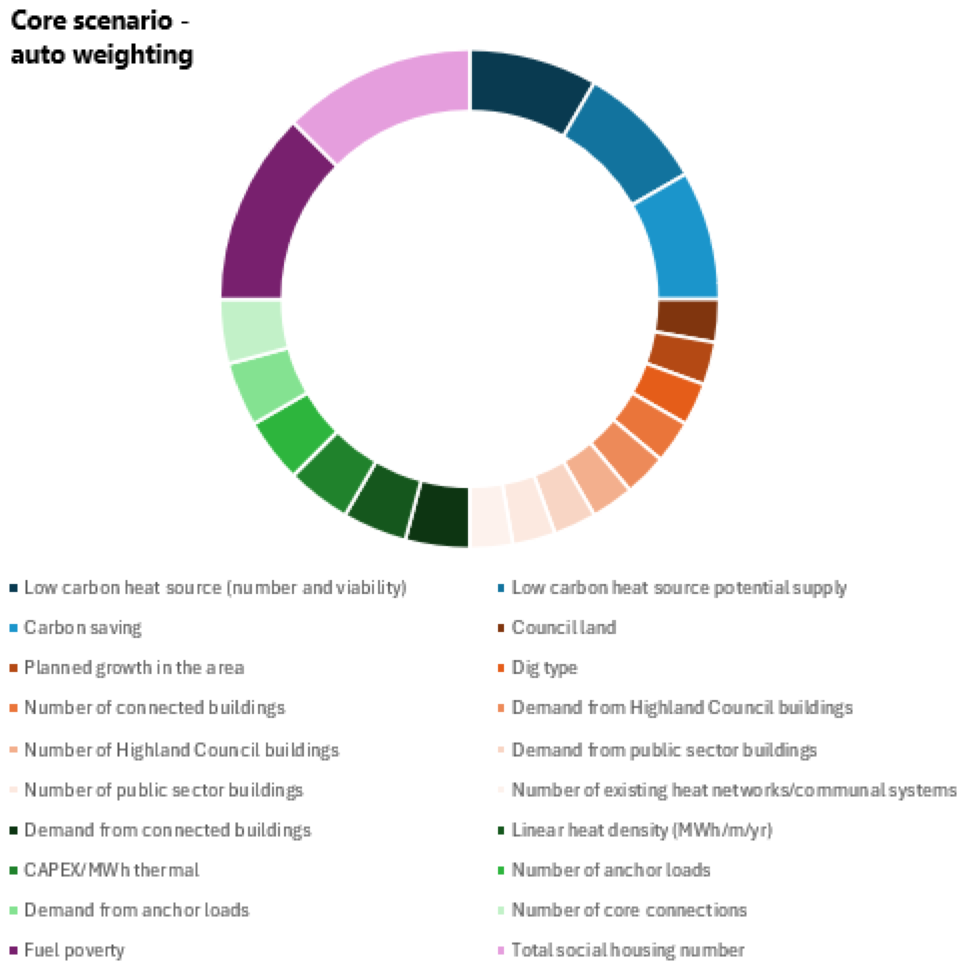


Figure 5—2 MCA theme weighting summary from an auto weighting approach.

It is likely that the greatest emphasis will be placed on deliverability and economic factors. If the percentage share is upped for these it is important to decrease the percentage shares for social and decarbonisation factors, the user should ensure these always add up to 100.

The manual adaption can be used to explore just one criterion or explore a combination of them these, an example is provided exploring just economic and deliverability factors in Figure 5—3.

Figure 5—3 MCA theme weighting summary from a manual weighting approach.

The application of these weightings will then give each potential heat network zone a summary score, with the theoretical maximum being 100%. However, as mentioned previously very few criteria hit the maximum score of 1 in the MCA and thus a score of 100% is not expected to be reached. Although it is purely an indication anything over 60% can be considered a good score, the interpretation of results is explored further in 5.2.

5.2.2 Interpreting results

An example of the scores achieved for some of the potential heat network zones is provided in Figure 5—4. This summary is for the same weightings as outlined in section 5.2.1.

Connection scenario and weighting criteria	West Bank	City Centre	Longman Full	Longman Full + Bairds	Longman West	Longman West + Bairds	Raigmore (combined)	Raigmore (West)	Raigmore (East)
Core auto weighting	59	44	26	39	22	37	63	54	34
Core manual weighting	60	46	23	51	19	52	54	45	42

Figure 5—4 Screenshot of MCA summary score.

The summary show that for the selected weightings the Raigmore combined network performs best in the auto weighting and West Bank for the manual weighting. For the manual weighting (which only considers economic and deliverability criteria) both the potential Longman zones which include Bairds Maltings perform better than City Centre. This is due to the presence of maltings increasing the quantity of heat demand and thus the overall economic performance.

The significance of Bairds Maltings does somewhat skew the MCA, being by for the largest overall load considered in the strategic analysis. It is useful to contrast the Longman zones with and without the Maltings – the difference in scores highlights how important it is at this high level of analysis for driving a zone.

In both selections the City Centre does not perform particularly well, despite having high heat density. This is due to multiple factors including the lack of public sector demands and also various factors relating to increased dig complexity. The potential alignment with SSEN planned work in the area may help improve the deliverability and its relative performance.

A summary of the relative scorings for the core and the core + infill scenarios are provided in Table 5—5 and Table 5—6 respectively – on the next two pages. As highlighted previously it is important to note that the different Raigmore networks examined have the same values for each scenario. The tables are colour coded (aligning to the colour palette outlined in Figure 5—1), with a greater depth of colour representing a higher score and more positive weighting.

Various sensitivities were assessed using the MCA tool to help inform the strategic summary in section 6.

Table 5—5 Summary of weighting criteria values for the core scenario - scored 0 to 1 based on measured data

Core Scenario Zone Assessment	West Bank	City Centre	Longman Full	Longman Full + Bairds	Longman West	Longman West + Bairds	Raigmore (combined)	Raigmore (West)	Raigmore (East)
Low carbon heat source (number and viability)	0.4	0.25	0.5	0.5	0.5	0.5	0.75	0.75	0.5
Low carbon heat source potential supply	0.5	0.25	0.75	0.75	0.75	0.75	0.5	0.5	0.5
Carbon saving	0.6	0.55	0.3	0.77	0.15	0.72	0.8	0.6	0.4
Council land	0.75	0.1	0.55	0.55	0.7	0.7	0.15	0.2	0.05
Planned growth/development in the area	0.05	0.4	0.2	0.2	0.2	0.2	0.7	0.6	0.85
Dig type	0.5	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Number of connected buildings	0.8	0.7	0.5	0.5	0.2	0.2	0.9	0.55	0.7
Demand from connected buildings	0.55	0.5	0.2	0.75	0.15	0.7	0.85	0.65	0.5
Demand from Highland Council buildings	0.75	0.15	0	0	0	0	0.2	0.2	0
Number of Highland Council buildings	0.6	0.15	0	0	0	0	0.3	0.3	0
Demand from public sector buildings	0.4	0.1	0.25	0.25	0.25	0.25	0.9	0.7	0.7
Number of public sector buildings	0.5	0.1	0.25	0.25	0.25	0.25	0.9	0.45	0.8
Number of existing heat networks/communal systems	0.3	0.25	0	0	0	0	0.2	0.2	0
Linear heat density (MWh/m/yr)	0.5	0.75	0.1	0.72	0.1	1	0.55	0.56	0.5
CAPEX/MWh thermal	0.65	0.4	0.2	0.8	0.2	0.8	0.4	0.42	0.4
Number of anchor loads	0.75	0.8	0.65	0.7	0.3	0.35	0.85	0.3	0.65
Demand from anchor loads	0.65	0.6	0.25	0.82	0.3	0.8	0.9	0.75	0.55
Number of core connections	0.8	0.7	0.5	0.5	0.2	0.2	0.9	0.55	0.7
Fuel poverty	0.7	0.8	0	0	0	0	0.5	0.5	0
Total social housing number	0.7	0.3	0	0	0	0	0.75	0.75	0

Table 5—6 Summary of weighting criteria values for the core + infill scenario - scored 0 to 1 based on measured data

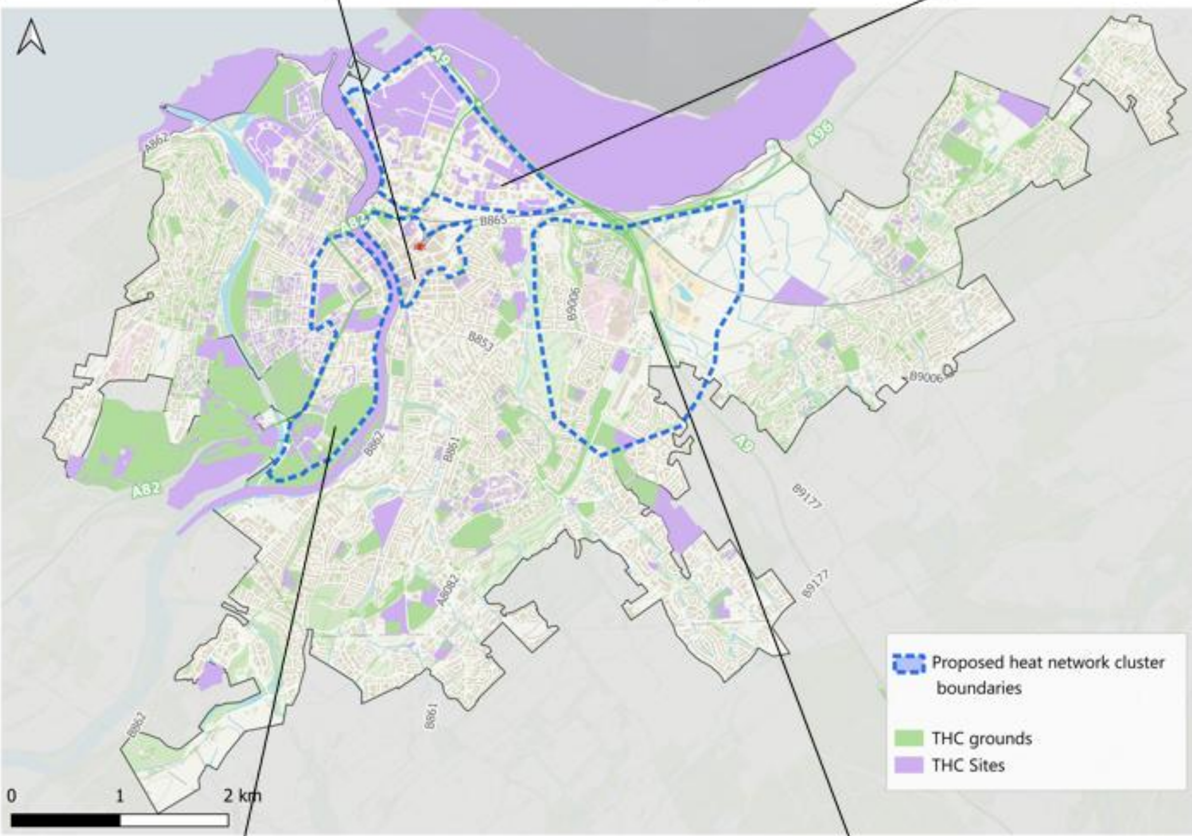
Core + Infill Scenario Zone Assessment	West Bank	City Centre	Longman Full	Longman Full + Bairds	Longman West	Longman West + Bairds	Raigmore (combined)	Raigmore (West)	Raigmore (East)
Low carbon heat source (number and viability)	0.4	0.25	0.5	0.5	0.5	0.5	0.75	0.75	0.5
Low carbon heat source potential supply	0.5	0.25	0.75	0.75	0.75	0.75	0.5	0.5	0.5
Carbon saving	0.7	0.68	0.5	0.82	0.2	0.74	0.8	0.6	0.4
Council land	0.75	0.1	0.55	0.55	0.7	0.7	0.15	0.2	0.05
Planned growth/development in the area	0.05	0.4	0.2	0.2	0.2	0.2	0.7	0.6	0.85
Dig type	0.5	0.25	0.3	0.3	0.3	0.3	0.3	0.3	0.4
Number of connected buildings	0.85	0.9	0.5	0.5	0.2	0.2	0.9	0.55	0.7
Demand from connected buildings	0.71	0.74	0.4	0.86	0.2	0.78	0.85	0.65	0.5
Demand from Highland Council buildings	0.77	0.15	0.1	0.1	0.05	0.05	0.2	0.2	0
Number of Highland Council buildings	0.75	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0
Demand from public sector buildings	0.45	0.2	0.3	0.3	0.2	0.2	0.9	0.7	0.7
Number of public sector buildings	0.62	0.62	0.45	0.45	0.3	0.3	0.9	0.45	0.8
Number of existing heat networks/communal systems	0.3	0.25	0	0	0	0	0.2	0.2	0
Linear heat density (MWh/m/yr)	0.4	0.55	0.11	0.55	0.12	1	0.55	0.56	0.5
CAPEX/MWh thermal	0.4	0.35	0.22	0.65	0.23	1	0.4	0.42	0.4
Number of anchor loads	0.75	0.8	0.65	0.7	0.3	0.35	0.85	0.3	0.65
Demand from anchor loads	0.65	0.6	0.25	0.82	0.3	0.8	0.9	0.75	0.55
Number of core connections	0.8	0.7	0.5	0.5	0.2	0.2	0.9	0.55	0.7
Fuel poverty	0.7	0.8	0	0	0	0	0.5	0.5	0
Total social housing number	0.7	0.3	0	0	0	0	0.75	0.75	0

6 Strategic overview and summary

There four areas examined for heat networks all have distinct characteristics, these are summarised at a high level in Figure 6—1 (please note the background THC areas indicate land rather than building ownership).

City Centre – high number of private sector stakeholders/demands, limited public sector land ownership, limited heat sources, trigger points include Rose Street/Network Rail related development and potential SSEN roadworks.

Longman – best heat source, active SSE and SWH partnership, high level of THC ownership, two large industrial demands key drivers, low level of public sector demand.



West Bank – high level of THC demand, high level of THC land ownership, east side high public land ownership (HIE rather than THC), relatively simple dig, good ability to phase.

Raigmore – high level of public sector demand, recent increased NHS interest, east side high public land ownership (HIE rather than THC), Freeport development key trigger point (generally high level of planned/ongoing development), possible SWH heat source.

Figure 6—1 High level summary of some key strategic items the four heat network areas examined.

A more detailed summary of each area is presented in sections 6.1 to 6.4, this includes consideration of factors including heat source, amount and type of demand, land ownership, trigger points for development, and economic indicators. One of the key indicators discussed is the £k/MWh (showing what the total CAPEX is against energy generation per annum). Providing a good indication (but not a full economic analysis) of how a heat network performs. As a general rule of thumb, a network would not be expected to achieve less than 0.7 £k/MWh (although less would indicate a highly viable network but such a low value is rarely observed) and anything more than 1 £k/MWh is likely to require optimisation. This is based on previous BuroHappold studies and reporting of heat network feasibility studies in England through Heat Network Zoning and the Heat Network Development Unit. Whilst feasibility studies provide more detailed economic measures, such as internal rate of return, this is a useful early stage economic indicator. It should be viewed alongside 21 different values are generated for each heat network scenario, that are reported – and form the basis of - the summaries provided below.

6.1 West Bank summary

A summary of key assessment criteria for West Bank is provided in Table 6—1. This considered alongside the greater detail provided in section 4.1 to give an understanding of the character of the West Bank. Although all the indicators are likely to be of interest LHD, CAPEX £/kW/MWh thermal and those relating to anchor loads are the most important form an economic perspective, whilst the Council land (share) and number of Highland Council buildings and number of public sector buildings are key from a deliverability perspective.

Table 6—1 West Bank summary of assessment criteria.

Assessment criteria	Core	Core + Infill
Linear heat density	4.62	3.5
Low carbon heat source number	ASHP, GSHP, WSHP	ASHP, GSHP, WSHP
Low carbon heat source potential supply	Medium	Medium
Council land (share)	46.80%	46.80%
Planned growth in the area	Low	Low
Carbon saving TCO2e over 40 years	158175	224748
CAPEX £m	20.3	37.1
CAPEX £k/MWh thermal	0.85	1.12
Fuel poverty (mean)	29%	29%
Count of properties with fuel poverty probability over 50%	162	162
Dig type (hard)	58%	64%
Number of anchor loads (>=500MWh/yr)	13	13
Demand from anchor loads (MWh/yr)	20339	20339
Number of core connections	23	23
Demand from modelled connections	24015	33213
Number of connected buildings	23	94
Demand from Highland Council buildings	13569	14291
Number of Highland Council buildings	8	14

Demand from public sector buildings	4565	5069
Number of public sector buildings	8	12
Total social housing number	419	419
Number of existing heat networks/communal systems	4	4

Despite having a relatively low LHD low dig costs help to keep costs down, with the core connections achieving a CAPEX £k/MWh of 0.85 (based on previous BuroHappold studies and DESNZ publications a CAPEX £k/MWh of 0.7-1 would generally be expected at this level of analysis for a potential heat network). The infill connections reduce the linear heat density indicating the size of the network needs to be constrained, at least initially, to maximise viability. The infill connections in the northern part of the West Bank increase the overall pipe length, with the loads being relatively small and the dig more challenging than other parts of the area (seen by the increase in % of hard dig).

The high Council influence both in terms of land and assets makes THC well placed to drive delivery of a heat network in the West Bank area. The high level of social housing and risk of fuel poverty means it is well aligned to a high level of Council influence. There is a risk in more commercially driven that these smaller domestic connections may not be a focus. Council influence should help ensure they are fully considered.

These housing connections and those around Eden Court and the Highland Council HQ would be the second part of the network if a phased approach is selected. The leisure centre area is a suggested first phase with early action to align to the planned work at the leisure centre.

The suggested approach for West Bank is to focus on the area between the southern area A82 and B861 and the river, with the only demand that is a focus for connection outside of this being the Inverness High School.

The heat source appraisal does not capture waste heat from the potential data centre in the area as the status of this project is very early stage. This is considered in later in section 6.6.

In conclusion the West Bank area presents a good heat network opportunity, with a high level of THC land ownership and large THC demands. The soft dig in the area offsets a relatively low LHD (but still above 4), this could be improved by a more optimised network design. The CAPEX £/MWh/yr measure of 0.85 for the core connections scenario is indicative of economic viability at this level of analysis.

6.2 Longman summary

The key assessment criteria are summarised in Table 6—2 in Table 6—3, covering the core and core + infill scenarios respectively.

Table 6—2 Longman summary of assessment criteria for core scenarios.

Assessment criteria	Longman Full	Longman Full + Bairds	Longman West	Longman West + Bairds
Linear heat density	2	7.4	1.97	11.61
Low carbon heat source number	ASHP Wastewater	ASHP Wastewater	ASHP Wastewater	ASHP Wastewater
Low carbon heat source potential supply	Medium/High	Medium/High	Medium/High	Medium/High
Council land (share)	38.30%	38.30%	44.30%	44.30%

Planned growth in the area	Low	Low	Low/Moderate	Low/Moderate
Carbon saving TCO2e over 40 years	62789	258888	34039	230710
CAPEX £m	17.5	27.7	9.38	19.23
CAPEX £k/MWh thermal	1.72	0.69	1.71	0.54
Dig type (hard)	67%	67%	67%	67%
Number of anchor loads (>=500MWh/yr)	12	13	6	7
Demand from anchor loads (MWh/yr)	9693	39693	5480	35480
Number of core connections	14	15	6	7
Demand from modelled connections	10180	40180	5480	35480
Number of connected buildings	14	15	6	7
Demand from Highland Council buildings	0	0	0	0
Number of Highland Council buildings	0	0	0	0
Demand from public sector buildings	2345	2345	1858	1858
Number of public sector buildings	4	4	2	2

Table 6—3 Longman summary of assessment criteria for core + infill scenarios.

Assessment criteria	Longman Full	Longman Full + Bairds Malting	Longman West	Longman West + Bairds
Linear heat density	2.15	5.2	2.37	10.22
Low carbon heat source number	ASHP Wastewater	ASHP Wastewater	ASHP Wastewater	ASHP Wastewater
Low carbon heat source potential supply	Medium/High	Medium/High	Medium/High	Medium/High
Council land (share)	38.30%	38.30%	44.30%	44.30%
Planned growth in the area	Low	Low	Low/Moderate	Low/Moderate
Carbon saving TCO2e over 40 years	129029	325753	50333	247538
CAPEX £m	33.75	41.97	12.48	22.2
CAPEX £k/MWh thermal	1.60	0.82	1.51	0.33

Dig type (hard)	67%	67%	67%	67%
Number of anchor loads (>=500MWh/yr)	12	13	6	7
Demand from anchor loads (MWh/yr)	9693	39693	5480	35480
Number of core connections	14	15	6	7
Demand from modelled connections	9965	51029	5480	38244
Number of connected buildings	47	48	16	17
Demand from Highland Council buildings	442	442	169	169
Number of Highland Council buildings	3	3	1	1
Demand from public sector buildings	2670	2670	2183	2183
Number of public sector buildings	6	6	4	4

Without Bairds Malting (the Tarmac plant was not captured in the analysis but from the strategic perspective can be grouped with the Maltings site in terms of messaging) the potential heat network performs poorly on key indicators such as LHD and CAPEX £k/MWh/yr thermal. The low-cost heat source in the area will help mitigate this to an extent, and there could be dig cost savings, but based on this analysis the economics would still be questionable – as the key LHD indicator will still be under 2.5 in all instances.

The addition of Bairds Maltings and the Tarmac plant are thus seen as key to making a network in the area financially attractive – reflected by the high LHD and low CAPEX £k/MWh/yr when the Maltings is included.

As discussed previously the West area is seen as the most promising area for deployment. The LHD increases with the infill connections, showing that these can be picked up without limited additional branches to the network. However, it also shows the importance of stakeholder engagement (much of which is private) to increase network viability.

THC has very limited heat demand in the area but does have a large share of land ownership, particularly around the strategic sewer pumping station (which is a source of low cost and low carbon heat). This means that THC could be a key enabler of a heat network in the area. This approach is enhanced by the SWH/SSE collaboration in the area, which is seen as the key driver for a heat network. THC influence will be useful for any wider strategic elements including the potential role of Longman for providing heat to the city Centre or as a path for wider heat transmission through the area.

In conclusion the strategic partnership between SWH and SSE is seen as a key driver for a heat network in Longman. The area has the best low carbon heat source identified in any of the heat network areas in Inverness, which improves the attractiveness of the area. THC being a key land owner in Longman is seen as a key enabler for heat network deployment. Without two large private sector industrial loads connecting the LHD and CAPEX £k/MWh/yr indicators perform poorly for the area, highlighting the importance of private sector stakeholder engagement at an early stage.

6.3 City Centre summary

The City Centre heat network opportunity is summarised in Table 6—4.

Table 6—4 City Centre summary of assessment criteria.

Assessment criteria	Core	Core + Infill
Linear heat density	7.77	5.57
Low carbon heat source number	ASHP, GSHP	ASHP, GSHP
Low carbon heat source potential supply	Low	Low
Council land (share)	9.70%	9.70%
Planned growth in the area	Moderate/High	Moderate/High
Carbon saving TCO2e over 40 years	129600	213782
CAPEX £m	22.94	45.66
CAPEX £k/MWh thermal	1.08	1.40
Fuel poverty (mean)	36%	36%
Count of properties with fuel poverty probability over 50%	44	44
Dig type (hard)	67%	67%
Number of anchor loads (>=500MWh/yr)	16	16
Demand from anchor loads (MWh/yr)	20457	20457
Number of core connections	17	17
Demand from modelled connections	21154	32640
Number of connected buildings	17	107
Demand from Highland Council buildings	697	697
Number of Highland Council buildings	2	3
Demand from public sector buildings	517	2193
Number of public sector buildings	1	12
Total social housing number	153	153
Number of existing heat networks/communal systems	3	3

The City Centre is typical of many heat network opportunities in urban areas of Scotland, with a high heat density (reflected in a LHD of 7.77 for the core connections). However, the dig complexity drives up the CAPEX £k/MWh value to over 1 in both the Core and Core + Infill scenarios. SSE have planned cable upgrades in the area which could act to decrease trenching costs for the heat network – dropping the CAPEX £k/MWh value. SSE's high level of interest should help achieve this alignment. There are also substantial public perception benefits for aligning the work, minimizing disruption and demonstrating a cogent strategy helping to build confidence.

Whilst there is not a high level of housing in the City Centre the properties that are there are seen as having a high likelihood of being in fuel poverty. As such it is important that these are not neglected from a heat network strategy in the area. The somewhat limited social housing would provide a good starting point for connection but there would also need to be engagement of the private housing sector. Fortunately, these domestic connections are unlikely to have a large impact on main pipe routing or sizing.

The relative lack of THC or broader public sector heat demands means engagement of anchor loads is likely to be more challenging. Early engagement of these private sector anchor loads will thus be key, to encourage sign up to the scheme. Thus, this is considered an important focus for understanding how viable a heat network is in the short term, as it is these large private sector loads that will be key to driving pipe routing in the area.

The relative low level of heat resource and space for ASHP means interconnection to Longman for heat could be important for driving viability. However, the Rose Street redevelopment and National Rail showing interest in hosting an energy centre means that for this level of study it is considered viable to heat the City Centre network without relying on broader interconnection (although this may not be the most attractive option). The Rose Street area is one of the few parts of the City Centre where THC own a substantial amount of land, which along with the strategic location make it well suited for an energy centre. Similarly to Longman this makes THC a key enabler for a heat network but the relative lack of influence in terms of demands means it is considered less of a focus for THC led development than the West Bank.

In conclusion the City Centre presents a good opportunity for a heat network with a high demand density. However, the dig complexity (with a high level of hard dig) indicates that the cost of network construction will be high – planned work by SSEN could help mitigate these costs by reducing the civils costs associated with digging up the roads. The heat network has little public sector influence in terms of land or demand ownership, increasing the complexity of stakeholder engagement. The planned development in the Rose Street area and planned work by National Rail creates an opportunity for constructing an energy centre in what is a spatially constrained area of Inverness. There is also potential to link with the Longman area, and its large waste heat sources, but this requires more detailed analysis; including the economics of such a connection and the amount of waste heat that will be used within the Longman area. If the majority of the heat is used in Longman (which is likely the case if the Maltings and Tarmac plant are connected) the quantity of low cost heat that can be supplied to the City Centre will reduce, reducing the benefit of interconnection.

6.4 Raigmore summary

A summary of the heat network options for Raigmore is provided in Table 6—5. It is important to reiterate Raigmore was appraised slightly different to the other three areas of Inverness. As such only one set of scenarios are presented for the three different heat network options.

The cost of crossing the A9 is not included in the Raigmore full network, this would depend on structural assessment of the Golden Bridge. Depending on the results of this the interconnection of the two sides of the A9 would be expected to cost in the range of £1-5 million based on the DESNZ indicative values provided in Table 3—3 (likely in the middle of this range).

Table 6—5 Raigmore summary of assessment criteria.

Assessment criteria	Raigmore full	Raigmore West	Raigmore East
Linear heat density	5.02	5.4	4.6
Low carbon heat source number	ASHP, GSHP, sewer	ASHP, GSHP	ASHP, GSHP, Sewer
Low carbon heat source potential supply	Medium	Medium	Medium

Council land (share)	12%	18%	1%
Planned growth in the area	Moderate/High	Moderate/High	High
Carbon saving TCO2e over 40 years	270611	191367	79244
CAPEX £m	54.34	26.04	28.3
CAPEX £k/MWh thermal	1.12	0.93	1.24
Fuel poverty (mean)	n/a	n/a	n/a
Count of properties with fuel poverty probability over 50%	n/a	n/a	n/a
Dig type (hard) – this is assessed differently to the other three areas	91%	100%	81%
Number of anchor loads (>=500MWh/yr)	20	8	12
Demand from anchor loads (MWh/yr)	45361	26381	18980
Number of core connections	38	15	23
Demand from modelled connections	48667	27917	20750
Number of connected buildings	38	15	23
Demand from THC	835.5	835.5	0
Number of THC buildings	4	4	0
Demand from public sector buildings	25362	12782	12580
Number of public sector buildings	24	6	18
Total social housing number	n/a	n/a	n/a
Number of existing heat networks/communal systems	n/a	n/a	n/a

This table is based on the results of the Raigmore feasibility study. This focused on the large loads which drive heat network viability. The lack of large blocks of flats means social housing numbers and fuel poverty were not captured as there were no domestic considered in the feasibility. Additionally, there was a heat network marked on the SHM in the Wimberley area – the MOD were engaged to provide more information, but no additional data was forthcoming. Based on a review of the area it was considered that the scale of the heat network was overestimated in the SHM (>1 MW of heat plant) and not considered as a strategic connection – this was also due to the lack of engagement from the MOD. It should be noted as they contain multiple buildings both the main Raigmore Hospital complex and the associated accommodation blocks could be considered heat networks. However, they are not included as heat networks and as the loads are captured elsewhere in the table they are not included in Table 6—5.

The considering of strategic demands means the factors associated with domestic properties are not captured in the Raigmore feasibility study (i.e. social housing number and fuel poverty). The main areas which would contribute to these numbers in Raigmore are in the northwest – in the Raigmore Estate and Wimberley areas. These contain both social housing and indicators of fuel poverty. Indicative values for these are included in the linked MCA tool.

The feasibility study assumed a high portion of hard dig, it is likely that with the nature of the Raigmore area this dig could be easier than modelled. This will help drive down costs and viability but even with this elevated cost assumption the feasibility study and associated options appraisals indicates with grant funding all of the network options in Raigmore could be economically viable. The increased engagement of the hospital is a key factor driving the improved viability on the network.

Although the summary table indicates a low level of THC land ownership it is important to reiterate the significance of HIE as a landowner, particularly on the East. Factors like this are why it is important to examine standardised outputs, like those in Table 6—5, as an initial indicator but to also consider more localised information and insights.

In conclusion the Raigmore area presents viable heat network opportunities. The engagement of the NHS will be key for driving a network to the West of the A9 where the LHD and CAPEX £/MWh/yr measures appear to be promising (5.4 and 0.93 respectively). On the East of the A9, the planned Freeport development will be key to driving a heat network, the LHD and CAPEX £/MWh/yr (4.6 and 1.24 respectively) indicate a slightly less favourable network. However, this is offset by a likely reduction in cost due to high dig costs being assumed in the area and the economic effectiveness of connecting a new site (the Freeport development). For both sides of the A9 there are large number of public sector anchor loads, meaning engagement is likely to be straight forward if the option is taken to progress the heat network opportunities. On the East of the A9 the high level of ownership by HIE will further ease the engagement process.

6.5 Interactions between heat network zones

When considering large scale strategic interaction between heat network opportunities it is important to understand the key drivers for interaction. These can be broken down to push or pull factors:

- **Push factors** relate to a drive to export heat from an area or a low-cost heat source acting to push interconnection in the area itself. This will generally be a large-scale heat source which either exceeds the heat demand nearby or is an area which is not well suited to heat network deployment.
- **Pull factors** are those which drive import of heat to an area. This will often be related to a highly attractive heat dense area. At the strategic level another pull factor could be the lack of heat supply potential within the area to meet the heat network opportunity. Other pull factors could be societal indicators such as fuel poverty – prioritising these areas for the lowest cost source of heat.

These are summarised for the different areas in Table 6—6. In Inverness there is generally a stronger set of pull than push factors within zones, which would generally lead to a lack of interconnection.

Table 6—6 High level summary of push and pull factors for different potential heat network areas in Inverness.

Area	Push factors	Pull factors
West Bank	Very few, potentially some benefit from the River Ness but would require detail assessment to demonstrate superior economics to ASHP or GSHP. High level of THC land ownership would aid broader push of heat if suitable.	High level of THC demands key driver for heat networks in the area.
Longman	SW pumping station is the most promising heat asset identified in Inverness. Potential route for electrolysis waste heat from adjacent hydrogen production site in planning. High level of THC land ownership allowing effective push of heat from the area.	Two large industrial demands but otherwise relatively few pulls for heat to the area.

	Justice Centre well located for a strategic connection for any push to wider heat interconnection. Large amount of available land near heat source provides space for a large EC and the potential for associated thermal storage.	
City Centre	Very limited push factors, no major heat sources and spatially constrained.	High heat demand density.
Raigmore	Some waste heat potential from the sewer was shown to perform in a similar manner to ASHP, ongoing SWH activity in Inverness may help drive down costs for this technology.	Large number of public sector anchor loads.

The Longman area is the only one with significant positive push factors out of the area. The geographic proximity to the City Centre, which would have the greatest difficulty generating heat locally, means that interconnection could be considered.

Challenges for this include the danger of a relatively low-density connection route through the Longman site to the City Centre. It will be important to maximise connections on this route (such as the Justice Centre) to help improve viability of the connection. The redevelopment in the Rose Street area of Inverness is also well located for any route connecting Longman and the City Centre, which would be important to consider in any detailed layout options for the network. There is increased complexity in strategic alignment over large, interconnected areas, which is considered further in 6.6.

Both the West Bank and Raigmore areas are, based on the findings of this work, initially better placed to consider in isolation. They have suitable land and heat sources to supply their own potential networks and there are good local pull factors in terms of heat demands and land ownership. For Raigmore although the feasibility study considered the East and West sides of the A9 separately it is still important to consider the area as a whole:

- The increased interest of the hospital since the feasibility study was completed helps derisk the West network.
- The large sewer main on the East side may become more attractive, with increased SWH work in the area potentially driving down costs – this heat supply could be the push factor required to connect the East and West sides of the A9.
- The larger total heat demand is likely to be more attractive to investors.

The final point relating to scale is a key driver for interconnection of opportunities and any zoning activities. In terms of scale (although this depends on the large industrial loads in Longman), the Raigmore area and the combined Longman and City Centre areas are of a similar scale. The West Bank area is smaller, but this is offset by the large number of suitable assets for connection and the ease of dig in the area for pipework.

6.6 Sequencing and heat network trigger points

All of the areas examined in Inverness show potential for heat network deployment. As discussed in sections 6.1 to 6.5 all the potential heat networks have specific benefits and challenges and how these are balanced and consider impacts their attractiveness. This section captures key trigger points for each area, many of which have been discussed previously, in Table 6—7 to Table 6—10 and then goes on to discuss how these influence sequencing of potential heat network zones and activity.

Table 6—7 Key trigger points for the West Bank heat network area.

Key trigger points
• Planned work at the leisure centre. • Understanding of heat supply technology in anchor loads and core connections. The replacement of heating systems will be a trigger point for connection for many loads, with a heat network connection not being available it could mean connection is not viable until end of life for the new heating technology. • The potential data centre could be an important waste heat source. Ensuring compatibility with any energy centre design should be considered. This could drive the price of heat down and could be a trigger for network expansion (it is considered likely that a first phase of West Bank could progress ahead of the data centre deployment).

Table 6—8 Key trigger points for the Longman potential heat network area.

Key trigger points
• The ongoing collaboration of SSE and SWH has already acted as key trigger point for this area. This has progressed interest faster than may be expected based on the other heat demand (rather than source) led opportunities in inverness. • Shared trenching captures a number of key trigger points in Longman. This includes a potential hydrogen pipeline and waste heat transmission from the electrolysis site on the old landfill site. Another being shared trenching with a private wire from the PV site in Longman (based around the pumping station). Finally, planned SSEN upgrades in the wider area may drive Longman interconnection (this is discussed further for the City Centre). • The interest of the Tarmac and Bairds Maltings sites will be a key trigger for deployment, without these the heat network potential in the area appears marginal.

Table 6—9 Key trigger points for the City Centre potential heat network area.

Key trigger points
• The Rose Street redevelopment is a key enabler for allowing for the centralised infrastructure of an energy centre in the spatial constrained City Centre. • SSEN have planned cabling upgrades in the City Centre. They have already expressed initial interest of using this as an opportunity for heat network installation, reducing the cost of pipework. • Understanding of key anchor load requirements and interest for heat network connection. Eastgate is the single largest demand identified in the City Centre and would create a strong network spine, with the route passing other key loads like the Royal Highland Hotel.

Table 6—10 Key trigger points for the Raigmore potential heat network area.

Key trigger points
• The Freeport developments are key to driving the heat network to the East of the A9. • Recent increased interest from the hospital and understanding of required timescales and onsite plans will be key to determining timings on the West. This should also consider the potential redevelopment of the Raigmore, which could be the required trigger for connection. • Planned electricity network upgrades in the area (focused in the West) could provide opportunity for shared trenching, acting as a trigger point for pipework deployment. • There is also understood to planned ongoing in the south of the area which could be a trigger point for connection to the Police Scotland site. It may be hard to align this with the likely rate of network deployment on the West. Thus, it is important to review the ambitions on the West side of Raigmore consider whether laying a pipe to futureproof for connection to the Police Scotland building.

These trigger points help inform key considerations for heat network sequencing in Inverness, these are summarised below:

- **West Bank** – suggested to be the first network to pursue, focusing on the area to the south of Bught Park. Planned activity in the area adds an element of time criticality. Key will be engaging the Ice Centre to understand the appetite for cooling, as this will influence energy centre design. The energy centre design will also have to consider future proofing for potential expansion across Bught Park. In terms of sequencing this expansion across Bught Park is considered to be most suitable at a later stage, focusing on early delivery in the south of the area to reduce complexity and ensure the time critical opportunities are not missed.
- **Longman** – understanding the full ambition of heat networks in the wider Longman and City Centre areas is key to sequencing. The potential interconnection and transmission of heat is key to ensuring pipes are suitably sized. Many items to determine the sequencing will be based on stakeholder engagement to understand the desire of demands to connect. Shared trenching opportunities during electricity network upgrades, may drive activity earlier than would normally be expected in a heat network with the characteristics and complexities of Longman and the City Centre. In terms of overall sequencing some early activity in Longman is considered likely, due to the drive of SWH and SSE, but wider strategy and realisation of the opportunity is likely to take longer. This could potentially align well with the potential additional waste heat supply from the electrolysis site going through planning.
- **City Centre** – the city centre has some of the greatest complexities and in terms of sequencing is thus likely to be slower to progress than the other opportunities in Inverness. The main driver for any early-stage activity in the area will be cable upgrades by SSEN, potential reducing pipework trenching costs. As discussed for the Longman area the laying of pipework ahead of guaranteed connections and strategy does create substantial risks in terms of upfront investment. The trigger point of the Rose Street redevelopment is going to be key for sequencing development in the City Centre area, understanding the heat demands that are likely to connect and their scale before the redevelopment is key to effective sequencing and heat network planning for the City centre.
- **Raigmore** – is an area with relatively simple stakeholders to engage (this was demonstrated during the feasibility study. The sequencing of the East is laid out in detail in the accompanying feasibility study. The Freeport connections are key to the network and the sequencing. In the West loads are more well established and a network could potentially progress more rapidly, the engagement of the hospital at the end of the study and their ambitions will be a key actor and driver of timings in the West.

6.7 Next steps

There are large number of potential actions for progressing the heat network opportunities in Inverness, THC are exploring other opportunities outside Inverness but Inverness was the focus of this work. Some suggested actions, a few of which are already ongoing, include:

- **Consideration of delivery models** – an introduction to the options for these were provided in a workshop by Buro Happold at the end of the strategic study. Separately, Addleshaw Goddard are providing support to decide on delivery models for the different opportunities in Inverness. This will help determine the different actions for THC in the different heat network opportunities and how to progress through zone designation and delivery and bringing the opportunity to market.
- **Decision on indicative heat network zone boundaries** – this is linked to delivery models. It is suggested that both West Bank and Raigmore should be individual zones. For West Bank its relative isolation and the high level of THC demand in the area would suggest a different delivery model to the other opportunity areas. For Raigmore even though the feasibility focused on the East there could still be potential to connect both sides of the A9, particularly as the hospital is now more engaged. Additionally, the full Raigmore area is more likely to be of interest to private investment as it is of a larger scale and having the option of different

distinct areas and phases of development is likely to be of interest to developers. For the City Centre and the Longman area the decision needs to be as to whether the areas should be considered as one or two potential heat network zones. The available heat from the pumping station and the availability of waste heat from the potential hydrogen site are key influences. If it becomes apparent Longman has large volumes of cheap heat it become suitable to group the two areas, to help reduce deployment complexity. This increase in heat demand scale is also likely to increase the desirability for investors.

- **Building Assessment Reports** – the identification of key heat demands in the opportunity areas should be a driver for BARs. For West Bank in particular this is seen as a focus for THC activity, understanding the heating systems and likely replacement timetables for equipment is key to building a cogent strategy for the area.
- **More detailed analysis of West Bank** – this should initially be focused in the southern area of the network. This area has the most pressing trigger point with the work at the leisure centre being an opportunity for initial deployment. There are multiple actions, three being: a utility survey, greater understanding of a potential energy centre location, future proofing for expansion and connection of any additional heat sources (e.g. the potential data centre in the area), and appraisal of heat supply technologies (this could include more detailed consideration of the Ness as heat source including insights from the Glen Mhor project, GSHP, and engagement with SWH to ensure there is not sewer potential).
- **Stakeholder engagement** – each potential zone has key stakeholders to engage, some like SSEN are key for all (to ensure network capacity is available for low carbon heat) whilst others are more localised, some key ones being:
    - In Raigmore it is important to engage with the hospital in the West and in the East the Freeport stakeholders are important to engage as well as HIE and the new prison. More details of these and other stakeholders are provided in the feasibility study.
    - In the City Centre there are multiple private sector loads key to the network viability. For the energy centre location National Rail are willing to set aside land as part of the Rose Street development, based on conversations with THC. Continued engagement with SSEN is required to ensure opportunities align with planned cable upgrades.
    - For Longman the Maltings and Tarmac plant are key for driving a network in Longman. The potential waste heat from hydrogen is also key to monitor through stakeholder engagement (and align any pipework). SSE and SWH are already pursuing a heat network in the area and are as such the key stakeholders driving the heat network. Continued understanding of their ambition and strategy is key to the overall strategy for both Longman and the City Centre.
    - West Bank is the most dependent on internal stakeholders at the Council and related bodies like High Life Highland.

These key next steps as well as items identified elsewhere in the report, most notably in sections 6.5 and 6.6, form initial actions to help take these heat network opportunities forward in Inverness. The opportunity to align with other activity in Inverness is seen as a key driver for Highland as a local authority to progress with large scale strategic heat networks. This building of a supply chain and expertise in the area will help realise the wider heat network vision outlined in section 2, attracting interest and helping the exploration of opportunities across the wider local authority.

Appendix A – overview of heat sources considered

Table A—1 provides a summary of different low-carbon technologies applicable to heat networks providing a description of each technology and its context for use. Each technology is assessed against nine different parameters, helping to determine the appropriate technology, considering the scale of the network, cost implication, operational risks and local context. These parameters are:

- Network scale suitability – examines which scales of heat network the technology is suited to. These are small (generally communal and some discrete or campus networks), medium (generally discrete or campus schemes) or large (city scale systems or large district schemes). These are represented by a S, M or L respectively.
- CAPEX – this relates to the capital cost of installing the system.
- OPEX – the operating cost. This includes consideration of fuel expenditure and maintenance.
- Technology risk – this considers the risks associated with the technology, assessing if there are likely to be any complications or uncertainty with deployment.
- Carbon saving – the emissions associated with the different technologies. Whilst all technologies considered are low carbon compared to fossil fuels they are assessed compared to the Scottish electricity grid, which due to the high presence of renewables can often considered to be zero carbon.
- Local environmental impact – this considers local impacts of the technology, the most common being NOx emissions associated with combustion technologies.
- Security of fuel supply – this refers to how reliable the low carbon heat source is, this can either be a fuel (such as woodchip) or the sensitivity to factors like weather.
- Precedent – how frequently the technology has been deployed in a heat network context. The focus is on a UK context.
- Geographic sensitivity – how reliant the technology is on local context for deployment. This can either be related to a resource or constraints such as air quality impact.

The listed criteria provide detail on some of the aspects to consider in making an appropriate technology choice. These parameters are assed using a Red-Amber- Green (RAG) analysis:

- **Red** - High level of consideration required – large sensitivity
- **Amber** - Moderate level of consideration
- **Green** - Little need to consider – similar in nearly all contexts

In this instance the red does not necessarily mean the technology is not viable, but the factor is key to consider in detail.

Table A—1 Low carbon heat sources matrix

Low-carbon Heat Technologies and description	Network scale suitability	Capex	Opex	Technology Risk	Carbon saving	Local env. impact	Security pf fuel supply	Precedent	Geographic sensitivity
Air source heat pump: An air source heat pump uses heat from the outdoor air giving it flexibility in design which has led to its large-scale deployment across the world.	S M L								
GSHP – closed loop: Closed loop ground source heat pump (GSHP) utilise the thermal energy stored in the surface of the earth. The ground is heated by exposure to sunlight and/or proximity the earth's core and maintains a relatively consistent temperature over the year as soil compositions are not as exposed to seasonal change. A closed loop system heats a working fluid, usually glycol, around an extraction loop. The ground transfers the heat through uninsulated pipework to	S M L								

the circuit raising the fluid temperature. Once the working fluid passes over the evaporator and cools, it returns within the same loop to be heated again.									
GSHP – open loop: Open loop ground source systems utilise the thermal energy stored in aquifers beneath the surface of the earth. The aquifer is heated through proximity to the earth's core. This provides a relatively consistent temperature over the year as aquifers are not exposed to seasonal changes in atmospheric temperature. An open loop system extracts the water from an aquifer, once cooled by the evaporator, the water is reinjected back into the aquifer at a different location.	L								
Bivalent source heat pump: A bivalent system utilises multiple sources of heat for a separate heat pump unit. This provides flexibility in design depending on availability of source but also can allow the system to run efficiently throughout the full year. For example, a heat pump unit with a separate evaporator and closed loop ground source array can run the evaporator unit during warmer days and use the ground array during colder periods. The separation of the heat pump unit and sources allows for more flexible installation and efficient heat management, especially in larger or more complex heating setups.	M L								
WSHP – closed loop: Closed loop water source heat pumps (WSHP) utilise thermal energy stored in a body of water such as a loch, river, or the sea. The water is heated through exposure to sunlight and the ground beneath the body of water. A closed loop system heats a fluid, usually glycol, around an extraction loop submerged within the water body. The water then transfers the heat through uninsulated pipework to the circuit raising the fluid temperature. Once the heat transfer fluid passes over the evaporator and cools, it returns within the same loop to be heated again**.**	M L								
WSHP– open loop: Open loop water source heat pump utilise the thermal energy stored in a body of water such as a loch, river of the sea. The water is heated through exposure to sunlight and the ground beneath the body of water. An open loop WSHP system extracts heated water from a water body and once cooled by the evaporator, the water is reinjected back into the source at a different location.	M L								
Waste heat recovery: A heat recovery heat pump is used to enhance the heat that would otherwise be wasted from industrial and commercial processes (e.g., exhaust air from data centres cooling, exhaust air from tubes ventilation shaft). Through the heat recovery process, this heat can be captured and utilised for heating supply. Many waste heat sources are low-grade, and heat pump can be employed to upgrade this heat to suitable temperature. In some instances, the heat pump may not be required.	M L								
Wastewater heat recovery: Low-grade heat recovery systems utilise the thermal energy stored in effluent water from industry, common sources include effluent from wastewater treatment plants, cooling water from data centres, breweries, dairies and abattoirs. Cooling water is particularly effective as the elevated source temperatures allow for heat pumps to operate at greater efficiencies and the energy demand for cooling is mitigated.	M L								
Sewer heat recovery heat pump: Sewer heat recovery utilises the thermal energy present in wastewater flowing through sewer networks, typically originating from domestic or commercial sources but can also include drainage water. In these systems, wastewater is extracted from a mains sewer line before reaching the wastewater treatment works. The constituency of wastewater requires additional infrastructure including screening and potentially maceration before a heat exchange process.	M L								
Substation waste heat recovery: Captures heat from the transformer cooling systems on substations. This is most suited to large substations and those with specific cooling systems, oil cooled generally being the most suitable. There is a general switch towards cooling systems that are less suitable for heat recovery, but long asset lifetimes mean they are often viable to consider. There is often a level	M L								

of seasonality and daily variation in heat availability, but this often matches relatively well to heat demand.	
Minewater source heat pump: Mine water systems utilise pumped water from disused mine shaft systems. The mine water is at an increased and constant temperature after being geothermically heated. These high temperatures allow for a low running costs of the heat pump. In some instances, mine water is already being extracted by the coal authority to limit contamination to drinking water aquifers. This risk assessment is for solutions where drilling is required. Drilling to the exact depth of the mine system is complex and entails a very high risk and cost, if performed incorrectly, there is a potential to contaminate flows of natural water.	L
Biomass boiler: Biomass boilers are using organic materials such as wood pellets, chips, agricultural wastes as a fuel to generate heat. They can be used outside areas where there are air quality concerns such as air quality management areas, and in locations where there is space and access for a woodchip or wood pellet store.	S M L
Biomass CHP: Use of biomass (similar to the biomass boiler) to generate heat and power.	M L
Hydrogen boiler: The hydrogen boiler utilises hydrogen as its fuel, which can be either 100% hydrogen requiring a full conversion of the existing natural gas grid to accommodate hydrogen or a blend of natural gas and 20% hydrogen. When burned, hydrogen produces heat and water vapor. Hydrogen produced from renewable electricity (green hydrogen) would be considered to be renewable.	S M L
Direct electric boiler: Uses electricity to heat water. This has a very high operation cost compared to other technologies due to the far higher efficiency of heat pumps and the lower fuel price of natural gas. Consequently, it is not seen as a standalone decarbonisation for heat networks.	S M L
Thermal store: This often takes the form of large water tanks, although there are more complex and high-density storage materials being explored. Thermal stores are key a key part of most heat networks, ensuring improved operation and heat generation technology optimisation. Increasing the size of thermal store can be a key mechanism to avoid electricity network reinforcement and benefit from low electricity prices.	S M L

While air source heat pumps (ASHP) perform well in RAG analysis, they generally have lower coefficient of performance (COP), meaning greater electrical input is required. Other heat pump technologies may offer higher COP and lower operating costs. However, they often come with higher capital and maintenance costs, making their suitability more dependent on the scale of the network.

Suitable waste heat sources and low carbon technologies are determined for each cluster following a screening of each area for identifying suitable technology.

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