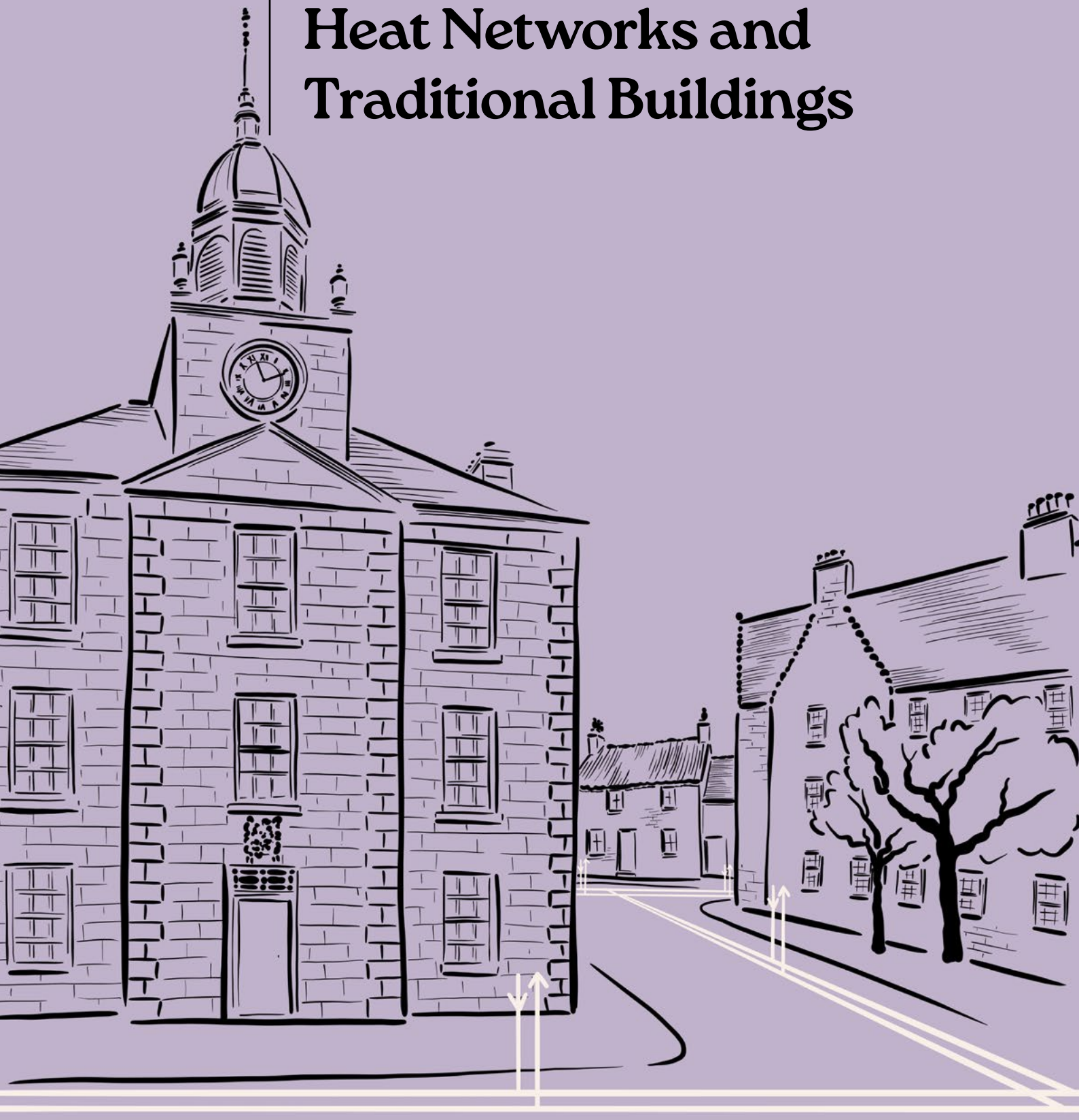
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Short Guide

Heat Networks and Traditional Buildings



HISTORIC ENVIRONMENT SCOTLAND | ÀRAINNEACHD EACHDRAIDHEIL ALBA

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Glossary

4G, 4GDH	Fourth generation district heating
5G, 5GDHC	Fifth generation district heating and cooling
ASHP	Air source heat pump
COA	Compulsory Owners' Association
ΔT, dT, delta T	The difference between two temperatures. In this guide, this refers to the difference between the flow and return water temperatures
Flow	Water flowing from the heat source
GHG	Greenhouse gas
HEPS	Historic Environment Policy for Scotland
HIU	Heat Interface Unit
HNTAS	Heat Network Technical Assurance Scheme
MWT	Mean Water Temperature – the midpoint between flow and return temperatures
NPF4	National Planning Framework 4
Return	Water returning to the heat source
TWh	Terawatt-hour; a large unit of energy – a trillion watt-hours
WBA	Whole building assessment

Introduction

Heat networks are likely to form an increasingly important part of Scotland's transition to low and zero direct emissions heating. They offer opportunities to make better use of renewable and recovered heat, support more efficient shared systems, and provide practical solutions for places where individual building-level technologies may be difficult to install. In historic and traditionally constructed buildings, however, the opportunities and risks need to be considered together. Successful heat network projects depend on careful design, early understanding of heritage significance, well-maintained fabric, effective user engagement and clear long-term management arrangements.

This Short Guide is intended to help building owners, occupiers, designers, local authorities, heritage advisers and heat network developers understand the main considerations when planning, designing, assessing, installing and maintaining heat networks in historic environments. It does not present heat networks as a single solution for every building or place. Instead, it sets out the questions that need to be asked and the ways in which technical performance, affordability, comfort and conservation can be balanced.

Taken as a whole, the publication provides a structured overview of the issues that shape heat network projects in historic and traditional settings, helping readers identify where specialist advice will be needed and how to support decisions that are technically robust, sensitive to place and aligned with Scotland's net-zero ambitions.

1. Policy background

1.1 Climate change and greenhouse gas emissions

Heat networks have long provided a means of distributing heat from a central source across a building in shared ownership, campus or much wider area. Today, the primary driver for the further deployment of heat networks is Scotland's obligation under the Climate Change Act 2019 to reduce greenhouse gas emissions to net zero by 2045.

Heat networks are expected to play a critical role. The Heat Networks (Scotland) Act 2021 sets a target for heat networks to supply 6 TWh by 2030, equivalent to 8% of Scotland's current heat requirements, and 7 TWh by 2035.

Heat networks address several outcomes in the Heat in Buildings Strategy (2021),[1] including:

- Heating our buildings no longer contributes to climate change.
- The cost of heating our homes and businesses is affordable and those occupying them have a high comfort level.
- The systems we use are smart and resilient and provide us with a reliable source of heat.
- Our indoor and outdoor spaces are filled with cleaner air.
- Our heating systems enable and efficiently use Scotland's renewable energy resources.
- Our heating systems enable the flexible and stable operation of our energy networks.

The development of heat networks in areas 'deemed suitable' is one of four 'low and no regret' solutions identified in the strategy. Suitability is based on many factors, including the density of heat demand, availability of renewable heat sources such as a river or heat from waste processing, and whether alternatives, such as individual air source heat pumps, are less practical or economically attractive.

The strategy recognises that historic buildings face particular challenges and constraints, and commits the Scottish Government to working with Historic Environment Scotland (HES) and related stakeholders.

The Scottish Government intends to introduce a Heat in Buildings Bill. The draft bill as published in November 2025 would modify the Heat Networks (Scotland) Act 2021 with regard to network licensing, for consistency with the Energy Act 2023, which sets out a Great Britain (GB)-wide heat network authorisation regime. In addition, the draft bill would strengthen powers to require a building to connect to a network,

1 https://www.gov.scot/publications/heat-buildings-strategy-achieving-net-zero-emissions-scotlands-buildings/

create a zone coordinator role, and empower ministers to simplify consents in some cases, such as in designated zones or for small-scale communal networks.

1.2 Spatial planning and planning history

The Heat Networks (Scotland) Act 2021 requires local authorities to identify areas likely to be suitable for heat network development. These areas are identified in Local Heat and Energy Efficiency Strategies (LHEES). HES has published LHEES guidance[2] for the consideration of traditionally constructed buildings and historic built environment.

The Heat Networks (Scotland) Act 2021 further gives local authorities, or the Scottish Government, the right to establish Heat Network Zones. The act also includes provisions for heat network licensing, consenting and permitting regimes that have not yet been introduced. The Energy Act 2023 sets out a heat network authorisation regime that will apply GB-wide.

Decarbonised heat is defined as a policy intent of National Planning Framework 4 (NPF4), and a desired policy outcome is that development is connected to expanded heat networks (Policy 19). Development of, or alterations to, historic buildings may therefore be expected to include connection to a heat network or to prepare for connection at a later date. Further, NPF4 Policy 7 intends to protect and enhance the historic environment, supporting the transition to net zero.

1.3 Historic environment and guidance

Scottish Government policy regarding historic and traditional buildings is largely devolved to HES. HES publishes the Historic Environment Policy for Scotland (HEPS),[3] which supports and directs all decision-making that affects the historic environment. HEPS sets out a series of six policies for the recognition, care and sustainable management of the historic environment. Among a range of challenges and opportunities facing the historic environment, it is acknowledged that climate change will have an impact and needs to be addressed.

HES has also set out its approach to the climate and nature crises in the document Pointing the Way to the Future.[4] This relates to HES regulatory and advisory services in the planning and other consenting systems.

The HES 'Managing Change' guidance notes support good decision-making in the historic environment. The guidance notes set out key things to consider when changes are proposed. This can include

2 https://www.historicenvironment.scot/publications/all/publication/?publicationId=b68831fb-5b84-44cb-a8ef-b16400a81129
3 https://www.historicenvironment.scot/protect-and-care/planning-and-guidance/policies-and-guidance/historic-environment-policy-for-scotland/
4 https://www.historicenvironment.scot/publications/all/publication/?publicationId=e9bd5276-9423-492b-9f3b-b04600b9c798

guidance on how to consider impacts on cultural significance, relevant national policy considerations, sources of more detailed information and technical guidance. These notes offer practical guidance, including in the context of heat networks, the importance of fully understanding the specific significance of the building(s) in each case; carefully planning and designing proposals to minimise the cumulative impact of aesthetic, archaeological, ecological, noise/vibration and other impacts; and addressing fabric energy efficiency.

1.4 Buildings in multiple ownership

Heat networks are expected to be an effective clean heating solution for many buildings in shared ownership. This includes traditional tenements for which an air source heat pump for each flat, although technically feasible, may present visual and noise issues.

Following the publication of the Heat in Buildings Strategy, it was acknowledged that tenements represent a particular challenge to both energy efficiency and zero emissions heating solutions. One of the main reasons is that communal measures are difficult to organise, especially when owners are at varied life stages and of varying ability and financial situations.

As a result, the Tenements Short Life Working Group was set up to report on Energy Efficiency and Zero Emissions Heating,[5] and its final report was published in late 2023. The report makes the important point that the existing condition of many properties is poor and that in any strategy, the priorities should be repair, maintenance, then energy efficiency and lastly clean heating technologies. It acknowledges the range of additional challenges faced by those within tenement and similar buildings and concludes with six recommendations:

1. Owners will require funding from government and access to finance because of the very high costs often involved and the wide range of ability to afford these measures. It does note the considerable economic and cultural opportunities provided by the work needed.
2. The Group supports the Scottish Government's proposals to take a phased approach to regulating tenement buildings as well as the proposal to establish compulsory owners' associations (COA).
3. A whole building assessment (WBA) for energy efficiency and zero direct emissions heating should be developed for all properties.
4. Current work streams by the Scottish Law Commission (including with regard to COAs) should be supported and properly aligned.
5. The Tenements Act should be further amended to support energy efficiency and clean heating measures.
6. Expert advice is required on traditional and protected buildings, as acknowledged in the Heat in Buildings Strategy.

5 https://www.gov.scot/publications/tenements-short-life-working-group-energy-efficiency-zero-emissions-heating-final-report/documents/

1.5 Consumer protection

Since it is extremely unlikely that rival heat networks will be developed to serve the same buildings, heat networks are a form of monopoly (or 'natural monopoly'), like electricity or gas distribution. While regulations on heat network metering have been in place since 2014, Citizens Advice[6] has highlighted further priorities for protecting consumers. These include clearer billing for unmetered consumers and protection against disconnection or eviction due to debt.

While the electricity and gas network monopolies have been closely regulated for many years, the Heat Networks (Market Framework) (Great Britain) Regulations 2025[7] represent the first significant consumer protections for heat networks and will come into force during 2026. Ofgem became the official regulator for heat networks on 27 January 2026 with a remit covering customer service, reliability of supply, transparent billing and fair pricing. Heat network operators and suppliers are required to register with Ofgem by 26 January 2027.

Consumer Scotland became the statutory advocate for Scottish heat network consumers in April 2025. Heat network consumers can access dedicated advice from Advice Direct Scotland[8] and the Extra Help Unit[9] at Citizens Advice Scotland, funded through Consumer Scotland.

6 https://www.citizensadvice.org.uk/policy/publications/priorities-for-heat-networks-consumer-protections-debt-and-affordability/
7 https://www.legislation.gov.uk/uksi/2025/269/memorandum/contents
8 https://advicedirect.scot/
9 https://ehu.org.uk/

2. Heat network technology – heat generation

The term 'heat network' refers to the distribution of heat using water and networks that can operate at different scales. A communal heat network supplies multiple properties in a single building. A district heat network supplies more than one building, with distribution pipework usually buried under streets and gardens.

Historically, most heat networks operated with high-temperature water or steam generated by the burning of fossil fuels. Now, driven by efforts to improve energy efficiency and reduce greenhouse gas emissions, there are two principal technologies: fourth generation district heating (4GDH or 4G) and fifth generation district heating and cooling (5GDHC or 5G). For each technology there are varied options for heat sources. Each technology has advantages and disadvantages, which need to be evaluated depending on the local context.

Both 4G and 5G can also be suitable for communal and district heat networks. All types of heat network, including 4G and 5G, district and communal, are subject to authorisation and zoning requirements consequent to the Energy Act 2023 and Heat Networks (Scotland) Act 2021.

This section describes the key features of each technology and the options available for generating heat.

2.1 Fourth generation district heating

Fourth generation refers to networks supplied by a central heat source, such as a boiler or large heat pump, with heat distributed at around 60–70°C.[10] This operating temperature is high enough to provide domestic hot water as well as space heating instantaneously. Heat is transferred from the network (the 'primary' circuit) to the individual circuit in each property ('secondary' circuits) through a heat interface unit (HIU) in each property. HIUs contain a heat exchanger and often meter the heat transferred to each property for billing purposes.

Today, gas boilers and gas-powered combined heat and power plants are commonly used as the heat source in the energy centre. Biomass fuel is used in some systems, including a number of smaller or communal systems using biomass boilers. To avoid greenhouse gas emissions and air pollution, the use of large heat pumps is more likely in future. Large heat pumps may source the heat from a river, such as at Queens Quay in Clydebank. Large air source heat pumps are also a possibility. However,

10 https://www.sciencedirect.com/science/article/pii/S0360544221007696



Figure 1. West Dunbartonshire Energy Centre at Queens Quay.



Figure 2. One of the two 2.65 MW river source heat pumps.

methods to effectively disperse large volumes of air chilled by the heat pump need to be considered, to prevent frost forming on external surfaces.

Sources of recoverable or waste heat, such as Energy from Waste centres, wastewater treatment plants, data centres and surplus heat from industrial processes, are potential main or complementary sources of heat. These heat sources can be low cost, with limited fluctuation in cost, benefiting customers and heat network operators. As the supply of waste heat may not match the seasonal variation in heat demand, an additional heat source may be required in winter.

The difference between flow and return temperature may be as high as 30°C, meaning a great deal of heat is transferred per cubic metre of water, flowing around the circuit. This means low volumetric flow rates and narrower pipe diameters with smaller surface area, mitigating the cost of both insulation and pipe heat losses.

4G is attractive as it requires few upgrades within each property:

- As heat is supplied at a high temperature, few, if any, emitter (radiator) upgrades or equivalent insulation improvements may be necessary. This is explained further in sections 4 and 5.
- As the flow rate is slow, due to the wide difference between flow and return temperatures, it is less likely that pipework in properties will need to be upgraded to larger diameters. This is explained further in section 4.
- Local hot water storage in each property is not required.

2.2 Fifth generation district heating and cooling

Fifth generation district heating and cooling networks, also called source networks or ambient loop networks, often operate at near-ambient temperatures of 10–25°C, and potentially up to 40°C if connected to a waste heat source. A heat pump in each property increases the temperature of this heat and transfers it to the space heating system and local hot water storage, such as a hot water tank. Rather than being an evolution of 4G, it is better seen as an alternative technology that may be better suited to some situations.



Figure 3. Water-to-water heat pump and hot water storage cylinder connected to a fifth generation district heating network.

Commonly, heat is sourced from the ground via boreholes. These boreholes circulate the network water as far as 200 metres below the surface. The heat source is ultimately the sun with rainwater taking heat underground, so rainfall patterns and ground conditions such as rock type and permeability affect network performance. As heat is replenished at a finite rate with a seasonal pattern, care is needed to ensure there is sufficient borehole capacity to cover winter heat requirements. The network and boreholes can be topped up using cost-efficient practices, for example, by taking waste heat from industrial processes or data centres and thereby providing a cooling service.

The difference between flow and return temperature in a 5G network may be quite narrow and perhaps as low as five degrees, but potentially up to 15–25°C. Therefore, a high flow rate (m^3 of water/hour) is required



Figure 4. Borehole drilling for a 5G network.

to deliver sufficient heat, necessitating larger diameter pipes. However, as these pipes do not need to be as thickly insulated, the cost can be comparable to that of pipes used in 4G networks.

In this system, the boreholes and distribution network may be owned and operated by a utility-like service provider, charging a flat daily rate in a similar fashion to the standing charge for the gas network. The end user buys electricity for the heat pump from the grid as usual.

An argument made in favour of 5GDHC is that, as there is no central heat generation energy centre, the network can be feasible at relatively small scale and added to in a modular fashion. Furthermore, the low pipework heat losses may suit heat demands distributed at lower density, such as areas of houses with gardens. Also, the end users have more control over the main operating expense, the electricity for the heat pump in each property, including choice of electricity provider.

Compared with 4G, 5G networks typically require greater interventions in each connected property. As well as a heat pump in each property, space is required for hot water storage, such as a hot water cylinder or heat battery. The higher flow rate, resulting from the narrower difference between flow and return temperatures, may necessitate more upgrades to network and building pipework. However, as flow temperatures for space heating and hot water can be customised per property, there is greater flexibility to optimise investments in fabric improvements, radiator upgrades and operating costs.

As the name suggests, in 5GDHC networks the heat pump in each property can be configured to operate in reverse, cooling the property and transferring the heat to the ambient network. This heat can be transferred back to boreholes, reheating the ground ahead of winter. Note that there are special considerations for the design of pipework and emitters to avoid the risk of condensation in cooling mode, which may threaten building fabric. These are not covered in this guide. Where there is risk of properties overheating, property owners in Scotland should first consider the use of external shading on windows, overnight ventilation and thermal mass before installing active cooling systems.

2.3 Assessing heat demand

It is important to reliably determine the required heat generation capacity: the ‘size’ of the heat source, based on both the peak load of each property on a very cold day and the diversity of heating profiles among the connected building types. Peak heat load is calculated by summing the estimates of heat transfer conducted through each building element plus the heat lost through ventilation and draughts, under the condition of target indoor temperature (typically 20°C) on a very cold day (conventionally -4°C in Glasgow, for example).

Conduction losses are based on the thermal transmittance (‘U-value’) and surface area of each wall, roof, floor, door and window. Reference tables of measured U-values for common fabric types are available from

Chartered Institute of Building Services Engineers (CIBSE). HES has also reported in situ measurements of U-values of traditional walls and glazing in Scottish buildings, which are often lower, meaning better insulating, than the CIBSE reference tables.

Ventilation losses can be estimated using ready reckoners, such as those provided in the CIBSE Domestic Heating Design Guide, which are based on field testing and take account of building age and factors such as the number of fireplaces. Ventilation losses can be more accurately estimated using airtightness tests in which the air flow is measured while the building is pressurised and depressurised.

The peak heat load of the combined network, which determines the required capacity of the heat source, depends on the diversity of heat loads in the network. For example, homes typically peak in the morning and evening, while schools and offices use more heat during the day. This 'load diversity' smooths out peaks, allowing the central plant to run more steadily and efficiently. Large, consistent users known as 'anchor loads', such as hospitals or swimming pools, provide a stable baseline demand, which reduces the risk of oversizing the system and improves financial viability.

3. Heat network technology – distribution

This section describes design principles and choices to be made for the trunk transmission from the heat source followed by connections to individual properties.

3.1 Network principles

The energy centre is the starting point for any network. This can include a plant room, network of boreholes, recoverable heat source or large heat pump. From here, water is circulated into the transmission network of pipes. Water flows to each building through branch connections where heat is transferred, reducing the temperature, before returning to the heat source to be reheated.

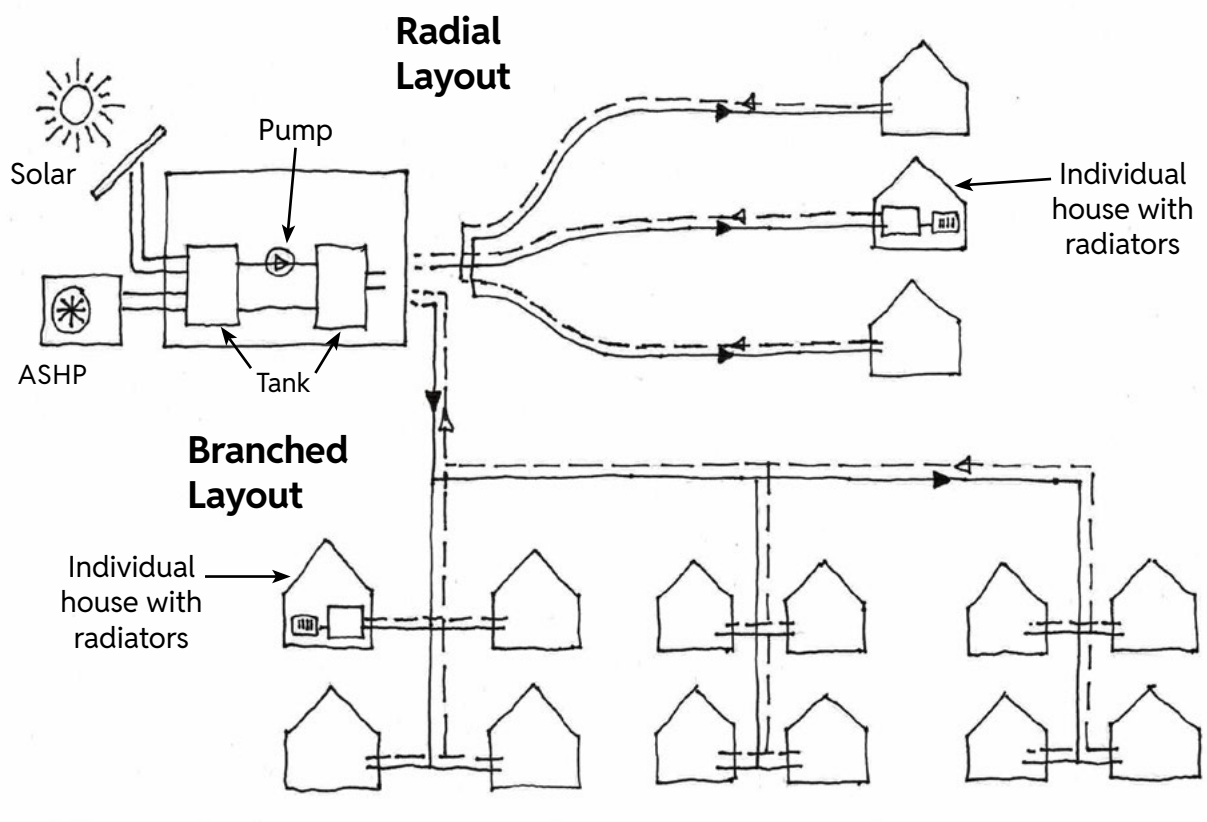


Figure 5. Distribution circuits with branched and radial designs. In a radial layout, each individual house is connected to the energy centre separately. In a branched layout, multiple houses are connected via one main supply pipe.

Decisions about transmission pipework design and specifications interact with choices on heat source operating temperatures, property-level heat emitters and fabric upgrades.

- Higher operating temperatures mean more heat lost from transmission pipework and/or more expensive, more thickly insulated pipes.
- Higher flow temperatures reduce heat pump efficiency, requiring more electricity to deliver a given amount of heat.
- Higher mean water temperature (MWT), the midpoint between flow and return temperatures, reduces the need to upgrade heat emitters, such as convector radiators, in connected properties. This is because the rate of heat transfer from radiators to rooms is dependent on the difference in temperature between the emitter and the air temperature. The MWT for modern domestic condensing gas boilers is commonly between 50°C and 65°C. Air source heat pumps will typically be configured for efficient operation with an MWT of 33–43°C on a very cold day.
- A greater difference between flow and return temperatures (dT) means more heat is transferred to the properties for every cubic metre flowing around the circuit. This allows lower flow rates, which require narrower, less expensive pipes. Narrower pipes have less surface area through which to lose heat, improving network efficiency. While 4G networks may have a dT of 30°C, 5G ground source heat pumps may have a dT of just 5°C, requiring much faster flow rates.

Network designers define target flow and return temperatures based on the technology employed, the heat requirements of the buildings and local constraints to upgrading emitters and fabric.

Pipework is selected to be large enough to meet peak heating requirements for the coldest days. Historic properties that do not have fabric improvements will have a higher peak load, requiring a network with greater capacity.

3.2 Distribution pipework

The standard method for distribution is pre-insulated district heating pipework. These pipes consist of a steel or plastic (PEX) carrier pipe, polyurethane foam insulation, and an outer protective jacket. Flexible twin-pipe systems are often used to connect smaller individual buildings while rigid steel pipes are common for the larger mains. Pipes going under roads may need to be steel. This applies to both 4G low-temperature networks and 5G ambient-loop networks, although 5G systems may operate at much lower temperatures and may be serving cooling requirements as well.

Heat loss in transmission is one of the most important design considerations. Losses reduce overall efficiency and increase bills for building owners and tenants.



Figure 6. Example of pipe cross-section.

Losses are influenced by:

- Operating temperature: higher flow temperature equals higher losses.
- Length of mains: compact networks perform better.
- Pipe size: larger diameters lose more heat per metre due to the larger surface area.
- Insulation standard: thickness and quality of factory-applied foam.
- Installation quality: poorly sealed joints and waterlogged trenches significantly increase losses.

For example:

- A 150-metre steel main operating at 80°C in wet ground could lose 15–20% of its heat if poorly insulated.
- The same run, using modern twin-pipe with high-grade insulation and lower flow temperatures (say, 60°C), might lose less than 8%.

In addition, systems that do not have 'flow control' and are continually circulating can incur large efficiency losses. This is often seen in summertime where a network is continually circulating to provide instantaneous hot water, but very few users are drawing off useful heat.

A good scheme designer may want storage for hot water in the dwellings to counter this. However, it can be difficult to relinquish the space in the properties if clients do not see a benefit in reducing circulation losses in their scheme.

Any above-ground pipework needs higher levels of insulation, typically 50–80mm or more.

In 5G ambient-temperature networks (typically 10–25°C), heat losses are substantially reduced, but insulation is still required to limit unwanted heat loss (winter ground temperatures can be 5–10°C) or heat gain from the ground when providing cooling.

Best practice guides for pipe and insulation dimensions are currently provided by the CIBSE in Code of Practice 1: Heat Networks: Code of Practice for the UK (2020).[11] This will be replaced by Technical Standard 1 (TS1) as part of the forthcoming Heat Network Technical Assurance Scheme (HNTAS).

3.3 Network routing

A shorter, straight line is ideal but is rarely possible with existing buildings. The route from heat source to building often winds through courtyards, down narrow lanes, or beneath paving.

Key challenges include:

Archaeology and heritage fabric: Excavation in medieval burghs such as Stirling or Edinburgh, or in the grounds of abbeys or churches often encounters archaeologically significant deposits. The risk of disturbance can be mitigated by using shallow ducts, rerouting along modern service corridors, or adopting above-ground pipework in basements.

Narrow streets and closes: Streets are often too narrow to permit wide trenching alongside utilities, such as in Glasgow's tenements or Edinburgh's Old Town. Flexible pipe systems with smaller trench widths may be necessary.

Surfaces and finishes: Lifting and reinstating cobblestones, setts, or Caithness slabs requires skilled conservation work. Where budgets are tight, alternative routes to rear facades may avoid these surfaces, such as through yards, gardens, or beneath modern tarmac. This can reduce cost and risk even if the pipe run is longer. Directional drilling or 'moling' can be used to avoid disturbing surfaces with some types of network.

It may sometimes be sensible to leave blanked (closed off) connections available for easier connection of additional properties at a later date. This might be done, for example, in a row of 10 cottages when 8 out of 10 of the owners sign up for a heat network and two owners are reluctant to connect. Experience has shown that when the network is seen to be working well, the remaining properties might ask to connect.

11 https://www.cibse.org/knowledge-research/knowledge-portal/cp1-heat-networks-code-of-practice-for-the-uk-2020-pdf

For historic areas, where trenches may be shorter but disruption more sensitive, twin-pipe systems offer faster installation and reduced excavation width. Their smaller footprint can be decisive in narrow closes or conservation areas where archaeological disturbance must be minimised. In this case a designer may use a radial design rather than a branched network to minimise disruption (Figure 5).

While most networks use buried mains, in some historic contexts this is not possible. Alternatives include:

- Basement routes: Linking buildings via vaulted basements or service corridors.
- Cloistered courtyards: Running visible but discreet insulated pipework along courtyard edges, sometimes encased in timber or metal ducts sympathetic to the architecture.
- Bridge crossings: Heat mains may be fixed to bridges across burns and trainlines. As well as having a visual impact this can add considerable cost. Train tracks and water courses often form the boundary of a heat network.

3.4 Connection to buildings

The final leg of transmission is the service connection into each building. Contractors will typically bring the distribution pipes right up to the exterior of the building, run them up the external facade and box in the connection where it enters the wall. This can be visually obtrusive and less efficient, as external pipe work is exposed to cold outside air.

Visual and structural impacts can be mitigated by using existing penetrations such as coal chutes and redundant vents. Alternatively, pipes can be routed under the footing of the building.

Moisture risks arise with 5G networks where the connection passes through the building's external envelope. Particularly if the loop is operating below the dewpoint, any poorly insulated pipework will attract condensation within walls, risers and other areas.

3.5 Hydraulic considerations

Transmission is not only about temperature; it is also about pressure and flow. Networks must maintain adequate pressure to push water through long mains. Building owners should be aware that any change of heating system to a more modern version may change the pressure and flow in the system, raising the risk of leaks. Particular care should be taken to ensure pipes do not burst in confined voids.

If a heat network were connected directly to the existing radiator pipework, the pressure may be too great and result in a leak. To avoid this risk, designers typically separate the new network from the building's existing pipework. In domestic properties connected to a 4G network,



Figure 7. Boxed-in connection to building.

the heat interface unit (HIU) typically provides this 'hydraulic separation' through a plate heat exchanger. In 5G networks, the individual heat pump in the property separates the primary and secondary circuits. Separation can also be achieved with a low loss header or, in some cases, a heat network substation. However, hydraulic breaks reduce efficiency so should not be used excessively. A good designer will balance these factors.

3.6 Monitoring and maintenance of distribution

Heat networks in historic settings need long lifespans with minimal disturbance. Monitoring of losses and conditions is therefore essential for:

- Leak detection: Many modern pre-insulated pipes incorporate alarm wires to detect moisture ingress.
- Temperature and flow sensors: Monitoring along the route helps identify inefficiencies before they become critical.
- Access chambers: If located discreetly, such as in gardens, these allow maintenance without repeated excavation of historic streets.



Figure 8. Access chambers in a 5G borehole network.

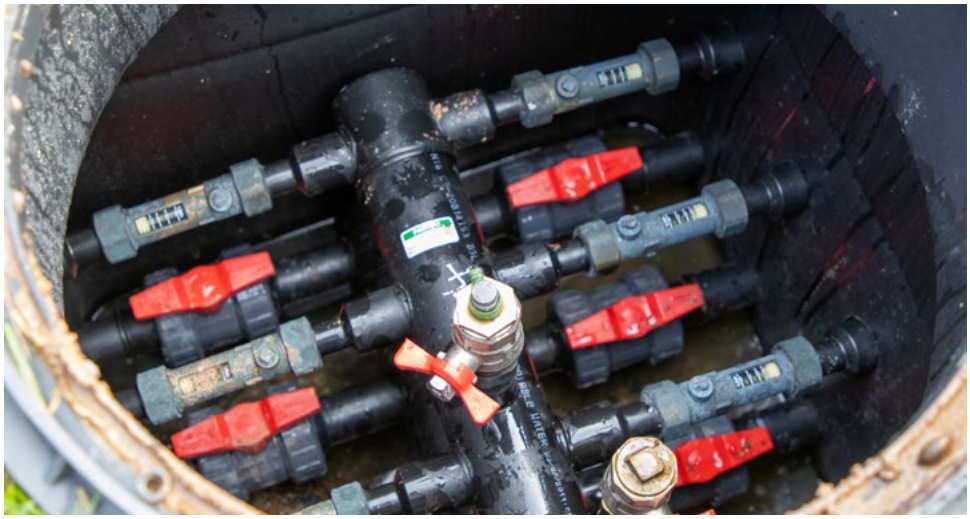


Figure 9. View inside the access chamber.

4. Heat network technology – consumer heat system

This section describes design considerations for distributing heat within a historic building connected to a heat network, then transferring the heat via emitters to the occupied spaces.

The distribution of heat within connected buildings is a critical aspect of heat network design. In historic and traditional buildings, this stage can present specific challenges due to architectural sensitivity, fabric constraints, and the need to balance energy efficiency with the conservation of significant features. Once heat has been imported from a district or communal network, it must be distributed to occupied spaces through a secondary pipework circuit.

Emitters transfer the heat from the water to the air, objects and people in the rooms through a combination of radiation and convection (air currents). Most modern heating systems in domestic settings use convector emitters, commonly referred to as 'radiators', which use the large surface area of the panels and fins to warm air and create a convection air current in the room. Emitters operating at low temperatures with large surface areas give off a greater proportion of heat as radiation rather than convection. Underfloor heating is an example of a radiant emitter.

4.1 Heat dissemination design considerations

The secondary system within each property connected to a heat network operates in a similar manner to a conventional wet heating system, such as a domestic gas boiler, but potentially with different operating temperatures. Building owners may need to adapt pipework and radiators to network operating temperatures and/or increase fabric thermal performance.

For example, the pre-existing heating system in a historic property may have operated at high flow temperatures, such as 80°C delivered by an old oil boiler. Historic radiators, such as cast-iron radiators, have little surface area, resulting in narrow flow-return temperature drop (dT) and, consequently, high flow rates and thicker pipes. In a scenario in which this building connects to a 4G network with wide dT and low flow rates but lower mean water temperature, there will be no need to upgrade pipework. However, it may be necessary to either add radiators for more surface area and/or reduce heat requirements through fabric thermal upgrades.

Conversely, consider a building currently operating with a condensing gas boiler with wide dT that connects to a 5G ambient loop with its own heat pump. The building owner may need to:

- upgrade to larger diameter pipework
- and either
  - ◊ improve fabric and/or upgrade emitters
  - ◊ or operate the heat pump at higher temperatures with some sacrifice in efficiency.

In traditional buildings, often characterised by thick masonry walls, high ceilings and intermittent occupation patterns, heat dissemination must achieve both comfort and fabric protection. Gentle, steady heat is often preferable to rapid fluctuations. Systems with a low operating temperature can provide stable background warmth, reducing the risk of condensation in the fabric while maintaining occupant comfort.

For buildings with infrequent occupancy and high thermal mass, such as churches, rather than sustain comfortable temperatures it can be better to deliver heat directly to people through radiant emitters. This saves energy by heating people rather than reheating and sustaining the temperature of the thermal mass in the stone walls and floor. In this approach, radiant emitters, such as underfloor heating or water-filled panel emitters with large surface areas, are employed.

4.2 Distribution pipework

Pipework routes are a major consideration in historic environments. Existing buildings seldom have dedicated service voids or risers, and interventions must respect the building's historic character. The designer should consider evaluating each route in consultation with conservation specialists to minimise intrusion and enable reversibility.

Older one-pipe radiator systems are inherently hard to control and inefficient and common in older properties, especially with modern low-temperature heat sources, because each radiator takes heat from a single loop. This requires a high flow temperature so that there is sufficient heat left in the system for the last emitters in the loop. These higher flow temperatures lead to lower system efficiency and higher operating costs. One-pipe systems should ideally be replaced or complemented by a new flow and return system.

Where possible, new pipework should follow existing service routes, floor voids, or basement and attic spaces. Care should be taken that pipework does not block airflow and cause condensation issues. Vertical distribution is commonly achieved via stairwells, service cupboards, or secondary spaces such as pantries or toilets. Chasing into stone or plaster walls should be avoided due to potential damage and moisture risks. Surface-mounted pipework may be acceptable if discreetly positioned and finished in sympathetic colours or 'boxed in'.

Careful thermal insulation is vital, both to reduce losses and to prevent local overheating in sensitive areas such as timber floors or panelling. Flexible pre-insulated multilayer composite pipe (MLCP) pipework can assist installation in constrained spaces.

4.3 Radiators and convectors

Radiators remain the most common means of heat dissemination in heritage buildings, offering controllable, relatively non-invasive installations.



Figure 10. A traditional column radiator connected to a one-pipe heating circuit, Couper Institute Library, Glasgow.

Compatibility with low-temperature systems

Traditional column radiators, often retained for aesthetic reasons, deliver less heat output at the lower flow temperatures required for best efficiency. Options include increasing radiator surface area or using fan-assisted convectors and/or under- or over-floor heating as a top-up.

Positioning

Radiators should be placed to encourage air movement and minimise cold downdraughts from windows. In historic interiors, they are often located beneath window reveals or within recesses. Care must be taken to avoid damaging skirtings, decorative plaster or historic finishes.

Aesthetic integration

Reproduction cast-iron or steel column radiators can be sympathetic to period interiors.

Control and zoning

Thermostatic radiator valves (TRVs) and electronic actuators enable room-by-room control without intrusive rewiring. Wireless or RF radio-based control systems are particularly useful where cabling routes are restricted.

4.4 Radiant heating: underfloor and surface

Underfloor heating (UFH) offers efficient operation at low flow temperatures and provides uniform comfort. Radiant heating is more effective in large or high-volume spaces because it warms people and surfaces directly rather than relying on heating the air. In big halls, churches or workshops, warm air from radiators quickly rises and stratifies near the ceiling, wasting energy and leaving occupants cold at floor level. Radiant panels or tubes deliver heat where it is needed, within the occupied zone, maintaining comfort with lower air temperatures and faster response. However, its suitability for historic buildings must be carefully assessed.

Construction compatibility

Many traditional floors (stone flags, timber boards or suspended joists) are integral to the building's significance and cannot be easily disturbed. Wet UFH systems require floor buildup and may alter ventilation patterns beneath suspended floors, increasing moisture risk. Where there are requirements to lift existing floors, it is advisable to consider low-profile retrofit systems.

Moisture considerations

Raised floor temperatures can alter the moisture balance of historic fabric. Hygrothermal analysis may be necessary to confirm that embedded pipes will not drive moisture into adjacent walls.

Alternative radiant systems

Where UFH is impractical, wall or ceiling-mounted radiant panels may be effective, particularly in large or high-volume spaces such as churches or halls. These deliver heat directly to occupants and surfaces with minimal air movement, maintaining comfort with lower air temperatures.

4.5 Hydraulic and control strategies

The performance of heat dissemination in historic buildings depends not only on physical installation but also on control and commissioning.

Zoning and time control

Many historic buildings have intermittent occupancy, such as offices, museums or places of worship. Zonal controls and programmable thermostats can prevent unnecessary operation, reduce energy use and preserve fabric.



Figure 11. Example of hydronic (water-filled) radiant heating panels attached to building columns.

Balancing and flow regulation

Correct balancing ensures uniform heat delivery and minimises temperature differentials. Balancing involves making adjustments to ensure every radiator or circuit in a heating system receives the right flow of water, to ensure the whole building heats evenly and efficiently. Dynamic balancing valves or differential pressure controllers can improve performance on multi-branch systems.

Monitoring

Integrating flow and return temperature sensors, heat meters and occupancy data helps optimise system efficiency. Wireless data logging avoids intrusive cabling.

4.6 Installation and maintenance access

Where a building has a high degree of significance, conservation oversight during installation is essential. Contractors should have experience working in listed or sensitive buildings. All penetrations through fabric should be recorded and made reversible. Future maintenance must also be considered: pipe joints and valves should remain accessible, and service routes documented for future reference.

5. Fabric first and heat networks

This section examines the importance of repairing and insulating buildings prior to connecting to heat networks.

5.1 Maintenance and fabric first

A sound, dry and well-maintained building is the first priority when considering fabric. Once this is achieved, it makes good sense to look at improving the thermal performance of a building as far as is practicable.

Whatever the heating system, the benefits of a well-maintained and thermally efficient building can include:

- Increase in comfort levels generally.
- Reduced energy bills.
- Reduced carbon emissions.
- Potential reduction in size, complexity and cost of building services required to provide heating.
- Quicker heating response times or smaller heat emitters.
- More efficient, lower operating temperatures.

However, a thermally efficient fabric can be more difficult to achieve with historic and traditional buildings due to a combination of costs, practical or technical issues, particularly in relation to moisture, and planning or listed building constraints linked to heritage significance. The issue becomes one of finding a balance between cost-effective fabric improvements and the optimal scale and cost of building services.

5.2 Balancing fabric improvement versus system efficiency

Provided that the building fabric is well maintained, the following measures are typically worth the investment, under the provision that works do not negatively impact heritage significance:

- Improvements in roof and ceiling insulation, often in loft spaces.
- Upgrading insulation to ground and exposed floor areas.
- Draughtproofing.

Thermal improvements to external walls and windows can be effective. However, they are often subject to greater technical problems (particularly in relation to managing moisture risks) and heritage scrutiny.

They can also be more costly to undertake. Guidance on all fabric improvements can be found in the HES Guide to Energy Retrofit of Traditional Buildings.[12]

In most stand-alone heating system improvements, such as a proposed heat pump for a single building, it is possible to establish a balancing or inflection point where the increasing costs of fabric improvement become uneconomic compared to the savings to be gained from a smaller heat pump or lower operating costs. With heat networks, however, it is not such a simple calculation.

In any heat network, there is a collective dimension: if one part of the network is particularly poorly insulated, it can have a disruptive effect on the efficiency of the overall system. For example, a poorly insulated historic building with high heat demand, connected to a network with otherwise well-insulated buildings, may require higher operating temperatures, resulting in increased losses across the network that will need to be fully anticipated and managed.

It is also worth noting that some buildings, such as churches, can have highly variable internal gains, intermittent use and part-time occupancy. When these characteristics are combined with poor thermal performance, it is particularly important for heat network designers to anticipate and accommodate the fluctuating load profile.

Ideally, a balance can be found between various factors:

- The cost and disruption of reducing heat loads through investments in fabric insulation.
- Reduced pipe heat losses and improved heat source efficiency at lower network operating temperatures for buildings with more efficient fabric.
- The cost and disruption of upgrading emitters (for example, larger radiators) to meet the heat requirement at the network operating temperature.

However, in a 4G network, this optimisation is generally constrained by the building that is hardest to treat, because of considerations such as reducing barriers to new connections. For example, is it reasonable to expect every owner in a tenement building to upgrade insulation and radiators? Or will the cost and disruption of such requirements deter them from connecting? Thus, operating temperatures may be similar to those of existing systems, such as gas boilers.

A further constraint in 4G networks is imposed by requirements to mitigate the risk of legionella through sterilisation at temperatures above 60°C, especially where there is local hot water storage.

These constraints drive 4G networks towards higher operating temperatures of around 60–70°C flow and 30–50°C return.

12 https://www.historicenvironment.scot/publications/all/publication/?publicationId=47c9f2eb-1ade-4a76-a775-add0008972f3

In 5G networks there is scope to optimise these choices property by property. For example, the heat pump in one property may be operated at lower, more energy-efficient temperatures than those in other properties if the owner has invested in more insulation and/or larger radiators. Local hot water storage, such as a thermal battery or hot water cylinder, is served at temperatures independent of the space heating requirements.

However, if the network demand is dominated by a single load, or several loads with similar daily heating patterns, then fabric upgrades to that load will have significant impacts on network design choices and viability.

5.3 Staged retrofit as a strategy

A common issue when contemplating any sort of heat network is the difference between the existing and the potential future heat demand of the networked buildings overall. The system needs to work for the current, uninsulated buildings, for example, but also be effective if they are later refurbished. Having a plan that clarifies existing and proposed heat loads helps designers understand the parameters and assess the implications of connecting additional buildings.

For traditional and historic buildings, the concept of a staged retrofit is becoming increasingly useful. This approach recognises that it may not be feasible to undertake all ideal measures simultaneously due to budgetary or practical constraints. A staged retrofit involves:

- implementing cost-effective, lower-impact fabric improvements early in the process.
- carefully designing initial measures to avoid compromising future interventions.
- creating a long-term plan that ensures compatibility with future upgrades and progress towards net-zero goals.

For instance, an initial retrofit stage might include insulating the roof and floor, improving airtightness, and installing a suitable heat network and emitters. Future stages could address more invasive measures, such as wall and window insulation, as funds and permissions allow. In the heat network context, staged retrofit should be coordinated with the phasing of network build-out and connection rollout.

6. Mitigating risks

This section describes approaches to mitigating risk to heritage in terms of visual appearance, historic building fabric and archaeological features (6.1), and mitigating technical performance risks (6.2).

6.1 Mitigating risk to heritage

Preparing a plan

The most important thing is to have a robust and detailed plan in place before works are carried out. The first step is to carry out a careful assessment of significance (NPF4, HEPS) and the existing building and its services before preparing a design for the heating installation.

This assessment should consider:

- the scope and nature of significance and any protections such as listing or conservation area designation. It is important that early dialogue is established with the local Conservation Officers and other heritage stakeholders.
- the main aspects of significance, prioritising those areas where any alteration would be unacceptable (or where improvements could be made, for example, by removing existing inappropriate services) and identifying areas of lesser significance where interventions may be more appropriate. Note that these areas could include external spaces and landscapes as well as buildings.
- existing service routes, where replacement with new service installations would normally have the least impact, as well as unused routes (for example, a cellar, storage areas or voids), which might have potential to reduce the impact of the new service equipment and pipe runs.

It may be necessary to prepare detailed method statements or undertake investigations due to specific risks, such as the digging up of sensitive landscape areas, gardens or pathways. In these cases, it is important to provide clear guidance to contractors/investigators on how to work within sensitive spaces generally, how to undertake such works with minimal damage and how to make good appropriately. Where possible, it is prudent to test installations in inconspicuous areas first. The plan should include drawings, specifications, schedules and method statements to ensure that all works are fully detailed to avoid ad hoc or on-site decisions being made without the necessary context.

In some cases, it may be appropriate to record the existing services before removal, and all new installations should be accompanied by detailed information, including clear labelling that allows for future maintenance, repair and removal. As-built drawings should include reference to fixings,

and the whole installation should be detailed and fixed with the principles of reversibility in mind.

A maintenance schedule will be required with regular inspections and checks carried out on all parts of the installation. Additional checks may be needed where there are particular risks, for example, in relation to leaks, condensate staining or particularly sensitive areas. In some cases, automated monitoring of environmental conditions may be appropriate.

It can be helpful to consider the risks to heritage from new installations under three headings.

Visual risks

Typically, a more energy efficient building will mean a smaller services system, which can mean less visual impact. All parts of the system can create unwelcome visual impact, including:

- External plant, equipment and housing, which can be located on, near or against buildings, but also on sensitive landscape areas, courtyards, routes or gardens.
- External pipe runs, risers and trunking, which can intrude on facades and rooflines.
- Internal equipment and housings, which require space, especially where these are newly installed.
- Internally visible pipework and equipment like radiators and controls, particularly in sensitive historic interiors.
- New penetrations through external and internal building fabric.

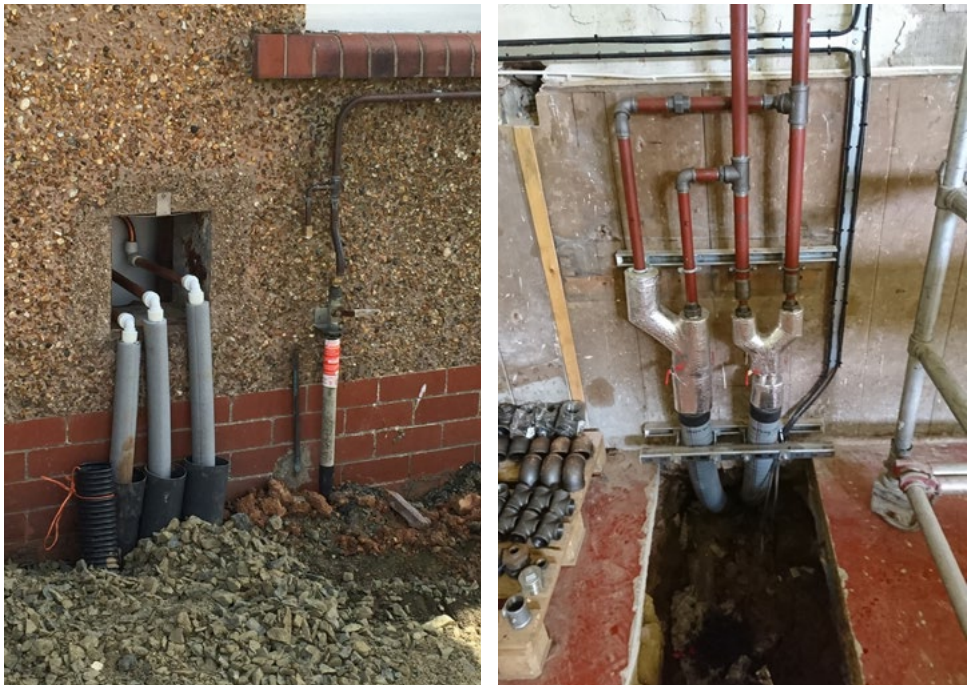


Figure 12. Left: An example of a network connection that is of poor aesthetic quality. Right: An example of a connection routed under a wall and rising in a discreet location inside the building.

Beyond a general reduction in size of the overall system, visual impact can be reduced through the following measures:

- Main elevations and the most sensitive external and internal elements and spaces should be avoided wherever possible, in line with the assessment of significance within the prepared plan.
- Where possible, minor elevations, obscured locations and relatively insignificant internal spaces should be used for new installations.
- It is often preferable to route new services into a building via the floor, entering internally rather than entering through an external wall penetration. However, this is not always practical.
- Existing service runs should be reused wherever possible.
- Previously unused and hidden routes can be beneficially brought into use where possible.
- Visible pipework should be neat and aligned with adjacent features and background.
- In some cases, carefully designed screening or housing can be used to reduce impact.
- In some areas, service runs can be hidden behind sensitive surfaces if these can be safely uplifted and replaced without risk of damage or disruption. Thus, cobbles can be lifted and relaid to run external pipe runs and some internal finishes can be removed and replaced.
- In all cases, it is important to consider future maintenance and repair, ensuring that future access is easy and minimises disruption and visual impact in the long term. The design of access hatches needs to be equally carefully considered.
- Where it is not possible to avoid visual impact in other ways, it can help to paint or otherwise decorate equipment or pipes, for example, to closely match the surrounding surfaces. Matt or darker surfaces can reduce reflection of light, which can be an issue in some cases.
- System design can be altered to reduce impact. For example, twin-pipe runs can help reduce excavation depths, while radial-pipe designs can reduce pipe dimensions in some cases when compared with branch layouts.

Structural and fabric risks

Installations can have unwelcome physical impacts on building fabric, and the following points should be considered:

- Penetrations and inappropriate location or design of fixings or supports can do physical damage to the building fabric. Examples include the location of fixings through decorative stone features, rather than adjacent mortar beds, or the use of unsuitable chemical fixings in sensitive areas.
- Building fabric may be excessively or inappropriately removed or altered to suit new service routes.
- Reversible fixings and non-penetrative supports (for example, clamps) can be used in some cases.

- Leaks from equipment or pipework can cause damage, especially when passing through organic or otherwise sensitive fabric. Risks are more problematic where leak detection and/or access is difficult.
- Inadequately insulated hot 4G network pipes can create warmth and cause drying in cool areas.
- Inadequately insulated 5G network pipes at ground temperature can cause condensation in warm areas, leading to damp, staining and mould, and indirect effects such as staining showing through thinner materials, salt migration and biological growth. These risks are particularly problematic where services are hidden or where access is difficult.
- Building entry is a major design issue. For example, the building entry can be fully hidden underground. However, this requires a bend and can impact the foundations (which need a structural engineer to assess) or could increase the condensation risk in the external wall and affect the DPC where one is present (Figure 13).

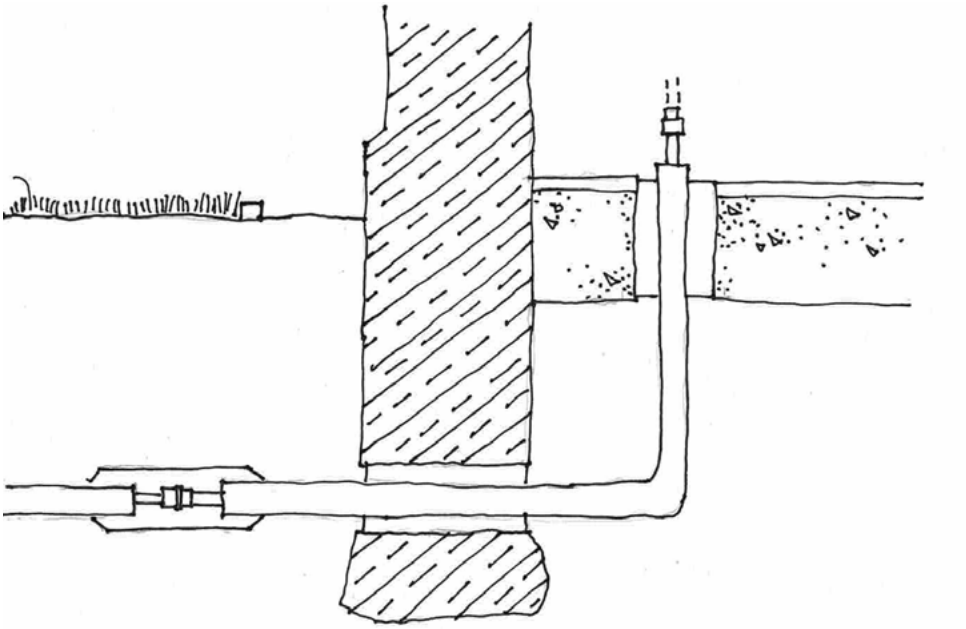


Figure 13. An example connection. To avoid visual impacts externally, the connection has been routed through the foundation and floor, potentially risking interior significance and structural integrity.

Detailed image description: A cross-sectional diagram showing a service connection brought into a building to minimise its visual impact on the exterior. The service pipe begins outside the building and connects to the wider network through an accessible waterproof connection chamber. From there, the pipe passes through an opening in the external wall below ground level and continues through the building foundation.

Once inside the building, the pipe changes direction and rises vertically through the building sub-base, floor construction and floor finishes before emerging at an internal connection point. Where penetrating the external wall and the floor structure, appropriate sealing and finishing is required to protect the building from moisture ingress, heat loss and other building performance issues.

Archaeological, environmental and ecological risks

Installations can have more than just visual impacts. In the case of scheduled monuments, scheduled monument consent will be required and will likely consider some or all of the issues below. Elsewhere, the following may be required:

- Excavation and installation of underground pipework could damage or indirectly affect archaeological remains. This risk would be identified in any plan and the area avoided, or suitable details agreed.
- In some cases, location or design of equipment externally could directly affect protected species and habitats. Surveying for nesting birds, bats or other species before roof/attic plant installation and scheduling works to avoid protected seasons may be necessary.
- Beyond the visual impact, installation of services in the ground can alter groundwater flow. For example, where new trenches are surrounded by pea gravel, they effectively work as land drains, altering the ecological balance of an area and potentially causing problems through the redirection of groundwater towards a building.
- Where soil type and vegetation are ecologically or culturally significant, care should be taken to ensure that suitable soil and reseeding are used when making good excavated external areas.
- Poorly conceived location or design of equipment could block, reroute or otherwise negatively affect rainwater management or the safe dispersal of snow, for example.
- Risks associated with condensation noted above could also occur externally, creating moisture and related problems such as staining and biological growth.
- To avoid indoor overheating, which is a human health risk, care should be taken to avoid excessive concentrations of hot pipework, for example, where all routes enter at a single point or close to a larger heat exchange unit.
- Noise is unlikely to be a major issue with heat networks, but any acoustic risks, such as may be associated with circulation pumps, should be assessed, and if unavoidable kept away from sensitive areas.

6.2 Mitigating services risks

As well as considering risks to the buildings and landscapes, it is important to ensure that the heat network itself is well designed, operates efficiently and is well understood and managed by those responsible for the property. The main risks arise from system design choices, the physical installation process, and long-term operation.

CIBSE's CP1 is an existing voluntary code of practice and provides the basis for a forthcoming technical standard, TS1. The HNTAS, currently in development, will provide a way for developers to demonstrate compliance with TS1. The Energy Act 2023 provides powers for compliance with HNTAS to be made mandatory.

Key risks

Legionella: Where there is domestic water storage, periodic sterilisation at >60°C is required to counter the risk of legionella. This is relevant to the local storage present in all 5G networks as well as any 4G networks with local storage.

Antifreeze: To reduce the risk of freezing, glycol is included in 5G ground loops. In addition, all network transmission pipework should be insulated. This is especially important where 5G pipework nears the ground surface and enters the building.

Hydraulic and control complexity: Unlike simple individual boilers, heat network systems rely on complex hydraulics arrangements such as differential pressure control and heat interface units (HIUs). There might also be weather-compensated controls that automatically adjust heating water flow temperature based on outdoor air temperature, increasing temperatures in colder conditions and lowering them in mild weather to improve efficiency. Incorrect design of flow rates or flow temperature can result in poor efficiency or system instability. Oversized pumps or poorly balanced circuits may raise noise, vibration or local overheating risks, affecting both comfort and building fabric.

User interaction and operational behaviour: Occupant expectations and control behaviour strongly influence performance. In traditional buildings, users with limited understanding of heat network operation may alter controls and reduce efficiency. Unnecessary manual intervention, such as disabling time controls or setting temperatures too high, can undermine system efficiency and strain plant capacity. Low system responsiveness combined with a lack of visible feedback often leads to dissatisfaction or inconsistent comfort.

Maintenance and monitoring challenges: Long-term maintenance can be difficult in complex buildings where access to service routes is restricted. Failure to maintain HIUs, valves and insulation can lead to water leaks, corrosion or microbial growth within circuits. Air ingress, sludge accumulation or inadequate flushing regimes are common failure points. Continuous monitoring of flow/return temperatures and energy metering is essential but can be hard to retrofit discreetly.

Technical risks are mitigated by careful design, commissioning, user engagement and planned maintenance.

Design optimisation

As described in earlier sections of this guide, early design choices are critical to system performance in the long term. Selecting between 4G and 5G technology will be dictated by the economics and practical feasibility of the local context.

Decisions around flow and return temperatures and flow rates are critical and need to be considered in relation to peak heat requirements, demand diversity and network heat losses. Furthermore, these choices must balance requirements to upgrade emitters, pipework and/or insulation in the hardest-to-treat buildings in the network.

For 5G networks, the combination of heat sources, such as boreholes and waste industrial heat, needs to be balanced against the required sizing and operating efficiency of transmission pipework and the heat pumps in each property.

Commissioning

Careful testing and optimisation of network configuration in the commissioning phase can prevent problems later. Risks arise when connecting the older distribution pipework in existing buildings to a new heat network with different operating temperatures and pressures. Old joints, valves and similar components can fail as the new pressure is experienced. Pressure testing should be carried out in stages until all pipe-runs have been assessed.

Network developers should commission hydraulic controls according to CP1/HNTAS standards. This includes verifying correct operation of pressure controls, bypass valves and pump controls for all heat sources under both full and low load conditions. Bypass valve setpoints should be checked to avoid unnecessary opening as this increases the return temperature, thereby reducing heat source efficiency.

User engagement

Control settings, including weather compensation, occupancy scheduling and temperature zoning, should be validated during a soft landing phase, allowing user feedback and system fine-tuning.

Clear labelling, user-friendly controls and training help ensure correct operation and prevent unnecessary user interventions. Users should receive clear guidance on expected warm-up times, setting target temperatures and the relationship between different control settings, such as between thermostats and thermostatic radiator valves.

Ongoing user support through building managers or digital dashboards helps maintain efficient, safe operation without intrusive intervention.

Planning for maintenance

Develop a planned preventive maintenance schedule covering HIUs, valves, strainers and insulation integrity. Include annual water-quality testing, filter cleaning and meter verification. Heat metering, remote monitoring and alarm reporting can identify temperature drift, leaks or pump inefficiency before damage occurs. All service access points should remain visible and documented for future works.

Responsibilities depend on the network boundary. The heat network operator or utility typically maintains central plant, distribution pipework, metering systems, and monitoring. Building owners or their property managers usually maintain in-building equipment such as HIUs, isolation valves, strainers, emitters and accessible pipework. In residential developments, individual dwelling components downstream of the HIU may fall to the property owner or tenant, while common risers and plant rooms remain under the building owner or management company. Contracts, wayleaves and heat-supply agreements should clearly define maintenance duties, access rights and response obligations.

7. Consent and permissions

Several different bodies contribute to the landscape of consents and permissions in Scotland:

- The Scottish Government sets overarching energy and planning policy, including the need to decarbonise through district and communal heating, while ensuring protection of the historic environment.
- Planning authorities are responsible for planning permission, listed building consent and conservation area consent under the Town and Country Planning (Scotland) Act 1997 and the Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997. These may all be relevant where heat network equipment is located within or adjacent to historic buildings, or where below-ground works could affect archaeological remains.
- HES acts as a statutory consultee on scheduled monument consent applications as well as planning and listed building applications relating to a Category A listed building. They are typically involved in applications affecting inventory battlefields or gardens and designed landscapes, developments requiring an environmental impact assessment (EIA), and significant proposed changes to Conservation Areas. HES also often works with developers and planning authorities in pre-application stages of major projects.
- Local authorities manage building control and environmental health departments. Building control approval is often required for plant rooms, pipework penetrations and associated building works, while environmental health may assess impacts such as noise or emissions.
- The Heat Networks (Scotland) Act 2021 includes provisions for heat network licences and consents as well as zones, permits and Building Assessment Reports. Many aspects of the 2021 Act have been largely superseded by the introduction of the Energy Act 2023. Scottish Government officials have been focused on implementing the Heat Networks (Scotland) Act 2021 in a way that is interoperable with GB-wide regulations, is proportionate and ensures the right networks are built in the right place and operated in the right way.
- Accreditation under the Microgeneration Certification Scheme (MCS) is necessary where public funding, such as the Home Energy Scotland homeowner grant, is to be drawn down for domestic heat pumps connected to fifth generation district heating and cooling.

Unlike some other clean heat technologies, heat networks do not usually fall within Permitted Development Rights (PDR). This is because they may:

- Cross the boundaries of multiple properties and public land.
- Require substantial above-ground structures such as energy centres, thermal stores, flues or kiosks.

- Involve significant interventions into the fabric of existing buildings (for example, risers and service penetrations).
- Affect the setting of listed buildings or the character of conservation areas.

For these reasons, planning permission is normally required for visible infrastructure, while listed building consent is required for any alteration affecting the special interest of a listed building. Underground works can also trigger archaeological requirements.

As with other low-carbon technologies, successful projects in historic contexts depend on sensitive design, clear supporting information and proactive engagement with all relevant authorities. Key points to consider when planning a heat network project in a historic environment include:

- Early engagement with planning officers and/or conservation officers is recommended to establish the scope of required consents. HES may be consulted on larger schemes at pre-application stage.
- Detailed submissions should include design drawings, heritage impact assessments, archaeological desk studies (if trenching is required) and noise or air quality assessments for plant.
- Building control approval is likely to be required for plant rooms, pipe routes and any internal works within connected buildings.
- Environmental health consultation may be necessary, especially for plant emitting noise or combustion flues.
- Landscape and setting considerations apply where above-ground infrastructure (such as thermal stores or kiosks) could affect the character of conservation areas or the setting of listed buildings.
- Reversibility is an important principle: proposals should demonstrate that intrusive works can be removed or adapted in future without permanent loss of historic fabric.
- Coordination is often more complex than with single-building technologies: permissions may be required across multiple sites, and works in the public realm may require road opening permits and separate consents.

Heat networks often involve excavation and installation of pipework across larger areas of land not owned by the applicant and for this reason may require additional legal investigation and resolution, for example, in relation to wayleaves for future access and maintenance.

7.1 Heat network zone (HNZ) requirements

Under the Heat Networks (Scotland) Act 2021[13] and associated regulations, including the Heat Networks (Heat Network Zones and Building Assessment Reports) (Scotland) Regulations 2023,[14] all local authorities in Scotland are required since 30 May 2023 to identify, review and designate HNZs: areas especially suitable for heat networks. In the Scottish Government's Heat Networks Delivery Plan (Review Report 2024), it is stated that in some circumstances, buildings within a designated HNZ may be required to connect to a heat network.

In November 2025, a draft Buildings (Heating and Energy Performance) and Heat Networks (Scotland) Bill[15] was published and included provisions to require qualifying buildings in a heat network zone to connect to a heat network or decarbonise their heating system. This is intended to support the development of heat networks and includes proposals that require certain buildings to decarbonise their heating systems when they are able to connect to a local heat network. These regulations are subject to the passage of the bill. Meanwhile, the Scottish Government's view is that buildings will be required to decarbonise their heating systems in the following circumstances:

- When they are located within a designated heat network zone.
- For non-domestic buildings only, and where they have an annual heat demand of over 100 megawatt hours (MWh) per year.
- Where they are not subject to an exemption (for example, the building is not planned for demolition or is already using a form of clean heating).

Several local authorities have published Local Heat and Energy Efficiency Strategies (LHEES), many of which identify significant opportunities for district heating. This means that where a Zone is designated and a building lies within or adjacent to one, planning policy already encourages or requires, in many cases, that new developments be 'designed and constructed to connect to existing heat networks' or allow for future connection in cost-effective ways.

For historic buildings, this could mean that connection becomes a condition of new development or alterations, including, for example, plant infrastructure or internal renovations, especially where the building is within an HNZ.

There will likely be exemptions or accommodation for certain circumstances, such as where connection is disproportionately expensive, where the fabric of the building would be severely altered, or where alternative low-carbon heating is more suitable.

13 https://www.legislation.gov.uk/asp/2021/9
14 https://www.legislation.gov.uk/ssi/2023/123/contents/made
15 https://www.gov.scot/publications/heat-in-buildings-plans/

7.2 Relevant legislation and guidance

- Town and Country Planning (Scotland) Act 1997[16]
- Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997[17]
- Heat Networks (Scotland) Act 2021[18]
- Draft Buildings (Heating and Energy Performance) and Heat Networks (Scotland) Bill[19]
- Heat Networks Delivery Plan: review report 2024 (Scottish Government)
- Permitted Development Rights for Microgeneration Technologies: Guidance (Scottish Government, May 2024)
- HES Policy and Guidance:
  - Managing Change in the Historic Environment series[20] (especially Setting, Roof Alterations, External Walls, Archaeological Sites and Monuments)
  - Designations Policy and Selection Guidance (2019)[21]
  - Guide to Energy Retrofit of Traditional Buildings[22]
  - Short Guide 11: Climate Change Adaptation for Traditional Buildings[23]
  - Short Guide 15: Air Source Heat Pumps in Traditional Buildings[24]

16 https://www.legislation.gov.uk/ukpga/1997/8/contents
17 https://www.legislation.gov.uk/ukpga/1997/9/contents
18 https://www.legislation.gov.uk/asp/2021/9
19 https://www.gov.scot/publications/heat-in-buildings-plans/
20 https://www.historicenvironment.scot/publications/managing-change-guidance/
21 https://www.historicenvironment.scot/protect-and-care/planning-and-guidance/policies-and-guidance/designations-policy-and-selection-guidance/
22 https://www.historicenvironment.scot/publications/all/publication/?publicationId=47c9f2eb-1ade-4a76-a775-add0008972f3
23 https://www.historicenvironment.scot/publications/all/publication/?publicationId=a0138f5b-c173-4e09-818f-a7ac00ad04fb
24 https://www.historicenvironment.scot/publications/all/publication/?publicationId=d91d661e-1c32-4cf0-bd9e-b33200a10b7e

8. Maintaining heat network systems

Effective maintenance is essential to ensure the safe, efficient and durable operation of heat networks. In traditional and tenement buildings, maintenance carries additional significance because building fabric, access constraints and ownership arrangements can complicate both routine servicing and long-term asset management.

8.1 Planned preventive maintenance

Heat networks depend on a hierarchy of components: a central energy centre, transmission mains, local interface units and distribution within each building. Each element requires routine inspection and calibration. Typical maintenance activities include:

- Water quality testing and inhibitor dosing to prevent corrosion and scale formation.
- Periodic flushing and strainer cleaning to maintain flow and temperature performance.
- Calibration of control valves, thermostatic heads and differential pressure controllers.
- Verification of heat meters for billing and performance monitoring.
- Periodic inspection of buffer or storage vessels, including stratification performance, temperature sensors, charge/discharge controls, internal corrosion protection, insulation condition and safety devices.
- Checking insulation integrity, expansion vessel pressure and safety valves.

These activities are generally carried out by a specialist energy provider or heat network utility company, which will bill for them. It is worth understanding the costs involved before entering into a long-term agreement with a provider.

These tasks must be documented within a planned preventive maintenance (PPM) regime compliant with CIBSE CP1 (2020) and BS EN 15316. In heritage settings, maintenance planning should also align with conservation management plans and access protocols to minimise disruption to occupants and fabric.

8.2 Traditional building materials

Traditional buildings contain construction materials that are sensitive to moisture, vibration and thermal change. Installation activities that disturb floors, ceilings or wall linings can introduce unintended damage or air leakage paths. Networks need good, reliable leakproof systems; push-fit fittings and related parts should not be used. Where possible, service components such as valves, meters and strainers should be positioned for easy visual access, typically within plant rooms, service cupboards or basement areas, rather than hidden within floor voids. Reversible fixings and clearly labelled isolation points allow maintenance without invasive works.

Pipework insulation must be regularly inspected to prevent condensation or overheating of adjacent timbers. Any leaks, even minor weeping at joints, can be harmful to lime plaster or timber joists. Regular temperature logging of flow and return lines helps detect gradual loss of performance before major intervention is required.

8.3 Maintenance in tenement heat networks

Tenement buildings present distinct operational challenges. Heat networks serving multiple dwellings require coordinated management across common and private spaces. Distribution mains often pass through communal stairwells or beneath floors of individual flats. This creates issues concerning access and liability, requiring clear communication.

A building-wide maintenance agreement or owners' association is essential to ensure shared responsibility for primary pipework and HIUs. The heat supplier (or factor) should maintain accurate as-built records and ensure all residents understand service routes and isolation procedures. Unplanned modifications by individual occupants, such as removing radiators or altering controls, can upset hydraulic balance and raise return temperatures, reducing overall network efficiency.

Because tenements often retain mixed building services, careful metering and monitoring are vital to distinguish between network faults and local emitter issues. Remote data collection from HIUs allows maintenance teams to identify anomalies before visiting a site, reducing disruption to occupants.

8.4 Training and soft landing support

Successful maintenance relies on competent personnel and informed users. Installers should provide comprehensive handover documentation, including operation manuals, valve schedules, and contact procedures for faults. A soft landing period, typically 6–12 months, enables fine-tuning of temperature control and response to user questions and feedback. In multi-occupant tenements, clear communication about setpoints, warm-up times and billing structure reduces dissatisfaction and helps maintain system efficiency.

8.5 Long-term asset management

Heat network components have varying life expectancies: pumps and valves 10–15 years, HIUs 15–20 years, buried distribution pipework up to 80 years if properly maintained. Lifecycle planning should be incorporated into the building's maintenance strategy, ensuring that replacement work can be undertaken with minimal disturbance to the fabric. Documentation, including drawings, photographs and service logs, should be stored with the building's conservation records for future custodians.

8.6 Decommissioning of a heat network

Decommissioning of a heat network should be planned as a controlled end-of-life process. This is rare, as properly installed pipework typically lasts 50–80 years. It involves safe isolation of the energy centre, controlled draining and disposal of treated water, removal or inerting of plant, and making redundant pipework safe in accordance with environmental and safety regulations. Interfaces with connected buildings must be carefully managed to ensure continuity of heating and hot water, typically by installing alternative systems before disconnection. Consideration should also be given to contamination risks, structural impacts of removing heavy equipment, and opportunities for repurposing plant rooms and service routes. Full records of isolation points, removed assets and any residual buried infrastructure should be retained for future reference. It may be better to leave assets in place rather than cause further disruption by removing them. It is more common to replace components over time through an ongoing asset replacement programme.

9. Conclusion

This Short Guide has demonstrated that heat networks can be a key part of efforts to make Scotland's traditionally constructed buildings more energy efficient and reduce overall carbon emissions. It is one of a series of similar guides which look at Retrofit; Air Source Heat Pumps; Climate Change Adaptation and a forthcoming guide on Embodied Carbon. In this context, heat networks are part of the overall strategy to reduce carbon emissions, with a range of interventions and technologies required. The importance of maintaining buildings should never be overlooked, with a wind and watertight building the foundation of any work to reduce carbon emissions.

This guide has looked at various challenges and opportunities in connecting traditional buildings to heat networks. Whilst careful planning and balancing various factors is important, what the guide has shown is that traditional buildings can be part of heat networks and that this can be central to Scotland's net-zero journey.

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