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Heat networks

Heat networks deliver heat from a central source to multiple users in a local area and can also deliver cooling. There is growing interest in their use in the UK because of their potential to reduce greenhouse gas emissions cost-effectively. A new market framework for heat networks is expected in 2022.

Overview

- Heat networks can reduce CO_2 emissions from buildings by using sources of low-carbon heat such as heat pumps or waste heat. Most currently use natural gas.
- They could technically deliver around 20% of UK heat by 2050, up from 2% today.
- Location and planning requirements, future heat demand, building design, costs and other commercial considerations are key.
- On average, customers are as satisfied and have equal or cheaper bills than gas and electric customers, but there have been poor customer experiences in the past.
- The UK Government is developing a heat networks market framework that will put consumer protection in place and aims to increase private investment.

Background

In 2016, generating and supplying heat was responsible for 37% of UK greenhouse gas (GHG) emissions.[1] A target to reach net zero GHG emissions in the UK by 2050 (CBP8590) will require that emissions from heating buildings be reduced to almost zero (Box 1).[2] Heat networks deliver heat to a number of buildings within a vicinity, and also can deliver cooling.[3] The Committee on Climate Change (CCC), an independent advisory body, has recommended developing heat networks to meet the net zero target, suggesting that 5 million homes could be connected by 2050.[2,7] There are currently around 14,000 UK networks with 480,000 customers,[8] though this accounts for less than 3% of heat demand.[9] Elsewhere in Europe their use is much more widespread.[3,10] The Department for Business, Energy and Industrial Strategy (BEIS) has suggested that heat networks could meet the heat demand of 17% of UK homes and 24% of commercial and public sector buildings by 2050.[11]

Box 1: Decarbonising heat

Most UK domestic heat is generated in gas boilers. Burning natural gas emits CO_2, a greenhouse gas (GHG), and in 2016 heating from all sources accounted for 37% of UK GHG emissions.[1] To meet net zero emissions targets, the CCC suggests that 80–90% of homes and all non-residential buildings must use low-carbon heat by 2050.[2] This is likely to be the most challenging aspect of reaching net zero.[4] There are two broad approaches to decarbonising heat generation:

- A greater use of electrical heating, particularly individual heat pumps that are not connected to heat networks.
- Using hydrogen and, to a lesser extent, biomethane in parts of the existing gas network (POSTnote 565).

Both are compatible with widespread heat network use, and a combination of these and improved building efficiency will be needed.[5,6] In any case, heat decarbonisation will entail substantial costs and changes to homes and buildings.

The 2017 industry Heat Network Task Force suggested that key challenges for increasing deployment include attracting greater private investment and increasing consumer acceptance of the technology.[12] Stakeholders also cite issues with planning policy and support for low-carbon heat technology. BEIS is due to implement a market framework to address these issues in 2022, and the Scottish Government is using devolved powers to develop the market.[9,13] This POSTnote outlines the technology underpinning heat networks, their potential heat sources, and considerations for new heat network installations. It also summarises user experiences and a future market framework.

Heat network technology

Heat networks provide multiple properties or commercial sites with heating and hot water from one or more sources. **Communal heat networks** heat two or more dwellings within one building (such as flats), while **district heat networks** connect multiple buildings. Existing UK systems are predominantly communal networks, but there is most interest in using district heat networks to meet deployment goals.

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Box 2: Heat network technology generations
Heat networks have been used for over a century. There have been several successive categories of technology 'generation', each becoming more efficient by transporting water at lower temperatures, causing less energy to be lost as waste. Most networks installed to date are **high-temperature networks**:

- **First- and second-generation** networks were mostly used before the 1970s and piped steam or pressurised hot water (>100°C), with high heat losses. Few still exist.[14]
- **Third-generation networks** emerged in the 1970s and use pressurised hot water (70-100°C). Most existing UK heat networks use third-generation technology.

Low-temperature networks are beginning to be installed:

- **Fourth-generation** networks operate at lower temperatures of around 40–60°C (a hot shower is around 40°C). They are better able to use low-carbon heat sources and result in less heat being wasted in pipes.[15] Older networks may be retrofitted with fourth-generation technology, though the energy efficiency of connected buildings often needs improving to do so (see below).
- **Fifth-generation heat and cooling networks** (or 'ambient loop systems') are at a pilot stage, and very few exist in the UK.[16] They seek to eliminate pipe heat loss by using water in the network at or close to ambient ground temperature, reducing or eliminating the need for pipe insulation. Each dwelling on the network uses its own heat pump (see *Heat pumps*) to raise the temperature of water in the network to that required to provide heating. The same heat pump can be used in reverse to put heat back into the network, cooling the building. Fifth-generation networks are designed to connect multiple low-carbon heat sources with a mixture of residential and commercial properties (which have differing patterns of heat and cooling demand) to share these loads efficiently.

Heat networks and their infrastructure generally consist of:[12,17]

- **One or more energy centres,** where heat is generated or collected from a central source (see *Sources of heat*);
- **Insulated pipes** connecting them to one or more buildings;
- **A heat exchanger** that transfers heat from liquid in these pipes to a secondary network of pipes within the building.

More modern networks generally include:

- **A heat interface unit (HIU)** that regulates the flow of heat into a dwelling, block or commercial unit;
- **A heat meter** that monitors the heat flow into a property.

Newer generations of network technology are being developed and installed (Box 2).[14] A 2016 study of 11 existing networks found that, on average, half of the heat transported through pipes was lost.[18] Newer designs use lower temperatures within the network, which reduces pipe heat loss and is better able to use heat from waste and renewable sources.

Sources of heat

Heat networks supply heat from one or more central sources that can be swapped with lower carbon alternatives over time, with no or minimal need to reinstall network infrastructure. Current UK networks are predominantly supplied by gas boilers (52%) and gas-fired combined heat and power (CHP, 32%).[19]

Boilers and CHP

A CHP plant combusts fuel to generate power, and captures and uses the waste heat (around half of the energy in the fuel) to heat buildings. Compared with a boiler, which does not generate electricity, CHP is more efficient and produces less CO_2 per unit of energy supplied (POSTnote 523). Most CHP plant and boilers use natural gas as fuel. A very small number use biomass such as wood pellets or food waste.

Boilers and CHP are used primarily in high-temperature networks (Box 2). Gas-CHP has conventionally been considered lower carbon than gas boiler central heating. However, as UK electricity production has increasingly decarbonised and other lower carbon heat sources become more widespread, the CO_2 savings that CHP provides have declined and will continue to do so in future. Recent updates to the way that building energy performance is measured make gas-CHP less favourable from an environmental perspective, but it is still the most commercially viable heat source under current policy.[9,20,21]

Heat pumps

Heat pumps use electricity to move ambient heat from a cold place to a warmer place while increasing its temperature. Air-source heat pumps move heat from outdoor air into a building or network, water-source heat pumps move heat from water (such as a river), and ground-source pumps use ambient heat in the earth (see below). Heat pumps warm a building by moving heat from outdoors inside but can also be used in reverse to move heat from indoors outside and provide cooling. When working efficiently they typically use 3–4 times less electricity than an electric heater. Small heat pumps can heat an individual home (not on a high-temperature heat network), but large heat pumps are increasingly used to provide heat to low-temperature networks (Box 2), such as a water-source heat pump in Glasgow that supplies heat from the River Clyde.[22]

Waste heat

Natural and industrial processes in the UK generate a substantial amount of surplus heat,[23,24] but most is currently wasted.[25] Waste heat is of increasing interest for use in heat networks, including:

- Energy from waste (EfW) plants, which combust municipal waste that would otherwise be landfilled;[26,27]
- Waste heat from industry, such as drying processes, boiler flue gases or exhaust gas streams from furnaces;[25]
- Commerce, such as data centres or supermarkets;[28,29]
- Infrastructure such as canals and rivers,[22] sewage treatment and metro systems.[30–32]

In some cases, the waste heat must be upgraded using a heat pump before being put into a network. Although the use of waste heat is growing,[33] several commercial barriers to wider development exist. These include a lack of incentives for waste heat owners to connect to networks, a low commercial value of waste heat, and the risk that the heat will not be available for the lifetime of the heat network itself.[34]

Geothermal

Underground heat can originate from the Earth's surface (such as from sunlight or urban heat) or from deeper in the core (which moves up to the crust). Geothermal heat can be captured and used in different ways:

- **Shallow geothermal**, up to a few hundred metres, can supply water at 10–40°C. Aquifer water from bore-holes and

warm water in abandoned coal mines are examples of this.[35] This heat can be provided to a low-temperature network.
- **Deep geothermal**, up to a few kilometres deep, brings fluid to the surface at 70°C or more. This heat can be put directly into a high-temperature network using a heat exchanger.

There is substantial geothermal heat available near the surface in parts of the UK, but these must coincide with built-up areas to be viable.[36] The need to drill deep bore-holes can be a large initial commercial risk. Southampton District Energy Scheme is currently the only UK deep geothermal source,[36,37] but there are plans to use deep geothermal heat in Stoke-on-Trent.[38] There are a small number of mine-water projects being developed.[39]

Thermal storage
Water storage tanks can be connected to heat networks to store heat over time and provide additional supply when demand is high.[40] For example, if a tank is heated overnight (during low heat demand) when energy prices are low, this heat can be used in the network during a morning peak in heat demand.[41] Water storage tanks require a lot of space; different mediums (such as paraffin wax) could be used to reduce space requirements but would be costlier.[40] Groundwater in aquifers could be used to store heat between seasons, though doing so is currently not commercially viable.[42]

Developing new networks
Location, potential heat demand, building design and cost need to be considered when developing new networks. Schemes may be developed by public bodies (such as local authorities), private developers, or public-private joint ventures.[43] Some projects encompass heat generation, distribution (via the network) and supply to customers, but these may also be separated out to different actors.[43] Planning considerations (Box 3), costs and other regulations have encouraged heat networks to be primarily developed in new buildings to date. Existing private buildings will need to be connected to networks to meet installation targets, but there is little incentive for them to do so. District heat networks can be expanded over time, and adjacent ones connected to each other to increase coverage.

Location of new networks
Dense urban areas are considered most suited to district heating systems because of lower infrastructure needs (such as piping) and therefore costs,[44–46] as well as more constant heat demand (see below). Where other options are more challenging, there can also be a role for networks in low-density or rural areas to provide low-carbon heat to homes not on the gas network.[47–49]

When planning a network, developers need to understand patterns of heat demand and potential heat sources in the area, particularly for waste heat. The Scottish Government and Greater London Authority have produced heat maps of Scotland and London, showing sources of heat demand and supply, as well as existing and planned networks.[50,51]

Heat demand in connected buildings
Developers must ensure that network infrastructure and heat sources can provide for consumers when creating or expanding a network. Network size must be planned in advance, as they run most efficiently and cost-effectively when heat demand in connected buildings is close to the maximum amount of heat that they can supply (when running at or close to full 'load').[12] There needs to be confidence that building owners will choose to connect in future, guaranteeing heat demand on an expanding network. With long project time frames, there is a risk of fewer users than expected connecting to an expanding network, of connected users using less heat than expected, or of the timing of users creating large peaks in demand. The Heat Network Task Force highlighted this 'demand risk' affecting cost efficiency as a key investor challenge.[12] Local authorities can help mitigate demand risk by initially connecting 'anchor loads' from public buildings that have a larger, more constant heat demand (such as hospitals and leisure centres).[62] Larger networks with a mixture of residential, public and commercial customers tend to be more efficient, as demand averages out across many heat demand profiles and becomes more constant.

Box 3: The planning system and Building Regulations
The planning system plays a key role when developing heat networks in new buildings, which must comply with energy efficiency requirements set out in Building Regulations.[52,53] MHCLG is currently consulting on updating the Regulations to improve the energy efficiency of new homes.[54] Planning policy is devolved, but local planning authorities (LPAs) across the UK must develop local plans setting local priorities.[55,56] Network developers usually require planning permission from the LPA,[57] but there is no mechanism for encouraging existing buildings to connect within the planning system nor the Regulations. New networks are most frequently developed in Scotland and London because of favourable planning conditions.

Scotland
Under Scottish Planning Policy, local authorities must develop Local Development Plans, identifying where heat sources and demand are situated close together and where heat networks and energy centres would be appropriate.[58,59] Following a 2017 consultation, Scottish local authorities are currently developing pilot Local Heat and Energy Efficiency Strategies (LHEES) that define **heat zones**.[59] These set out areas in which district heat networks would be appropriate for decarbonising local heat. Networks being developed in heat zones may be given certain support, such as:
- Developers not needing to apply for planning permission (being given 'permitted development rights') for network pipes and infrastructure;
- Public sector buildings being encouraged to connect;
- Mediation between large waste heat sources and network developers when they cannot reach an agreement;
- LPAs using planning powers to encourage connections.[59]

London
The Greater London Authority's (GLA's) London Plan encourages London boroughs to prioritise heat network development in Local Development Frameworks.[60,61] They must safeguard existing networks, identify opportunities to expand new or existing networks, and develop energy plans that identify sources of heat supply and demand and potential routes for networks. Developers may also be required to prioritise connections to existing or new networks.[60] Major building developments must connect to existing networks where feasible and investigate the possibility of using renewable or waste heat.[61]

Building design
A building's energy efficiency and heating system affect how easily it can connect to a heat network. Heat networks use the

same 'wet' system (using pipes and radiators) as existing gas boiler central heating systems. This can make connecting existing buildings relatively easy compared to retrofitting them with other low-carbon heating technologies.[2] However, most existing buildings are designed for high-temperature heating systems. To make better use of waste and renewable heat sources, buildings may need to be fitted with low-temperature heating systems.[14] To be able to provide sufficient heat in cold periods, these use larger radiators and pipes, or underfloor heating, and need a high building energy efficiency.[6,63]

In 2019, the CCC recommended that all new homes built are suitable for future low-carbon heating systems, which can include low-temperature networks.[46] Low-temperature networks must be installed in energy efficient buildings to operate effectively.[64] Adding networks into existing buildings would be made more costly if those buildings require energy efficiency upgrades.[6] Conversely, it may not be cost-effective to install a network in very efficient buildings that have low heat demand.

Cost and other commercial barriers

Heat networks are often complex projects, and generally have high initial capital costs (construction and financing) and long investment payback times.[65,66] Pipework, installation and connection account for most of the capital cost.[67] These can discourage deployment if other lower-cost heat technologies are available to developers or if local authorities lack familiarity or expertise.[45,62,66,68] Industry stakeholders have also raised concerns that the business rates valuation method for heat networks disadvantages them relative to other energy networks.[69]

User experiences of heat networks

Heat networks are disproportionately located in social housing, flats, smaller and newer homes, and urban areas.[70] Indoor temperature can be adjusted in a similar way to other central heating systems for the majority of existing and all new networks. A heat meter is generally used, but often at the building level rather than in individual homes,[71] which can lead to an inability to accurately measure consumption and inaccurate bills.[45]

Consumer protection is an increasing priority in the domestic heat network market, and there is consensus across stakeholders that statutory sector regulation would be beneficial. There are limited existing consumer protection regulations, and customers cannot switch suppliers in the same way as gas and electricity customers. The Heat Network (Metering and Billing) Regulations 2014 set basic requirements for suppliers around metering and billing.[72,73] A Heat Networks Code of Practice was published in 2015 to raise sector standards and will be updated in 2020.[74] Operators can also voluntarily register with the Heat Trust, an independent consumer protection scheme. Registered networks (roughly 10% of the total) must meet minimum customer service standards and customers on the networks have access to dispute resolution services.[75] However, there is currently no statutory regulator equivalent to other energy markets.

Because of concerns around poor consumer experiences, in 2017 the Competition and Markets Authority (CMA) reviewed the heat networks market. It found that, compared with gas or electricity heating customers, heat network customers were broadly as satisfied with their systems and that, on average, they had equal or lower bills.[45] However, it found that some customers faced poorer outcomes, such as higher bills and low network reliability, because of poor network design and build, an inability to switch suppliers and a lack of transparency in billing. It recommended that Ofgem, the gas and electricity regulator, be given powers to regulate services for domestic heat network customers.[45]

Developing a UK heat network market

It is estimated that £16bn of capital investment could be needed to meet heat network deployment targets by 2050.[8] In January 2018 the Industry Taskforce concluded that the two key challenges were attracting private investment and increasing consumer acceptance of the technology.[12] BEIS is currently consulting on a market framework to address these challenges, which it expects to implement after the closure of an existing subsidy policy (Box 4).[9,76] Industry and consumer groups suggest that key features of any market framework should mitigate demand risk, put in place consumer protections equal to gas and electricity customers and allow for future decarbonisation.[12,77,78] BEIS has indicated that it shares these broad objectives, but is not currently considering a 'demand assurance' model advocated by the Industry Task Force, or a Regulated Asset Base model.[9] It is exploring local heat network zones (Box 3) and changes to planning policy to encourage or enforce connection as key ways of increasing deployment.[9]

In March 2020, the Heat Networks (Scotland) Bill was introduced to the Scottish Parliament, which would require that operators obtain licences and consents, and that local authorities designate heat zones.[13,79]

Box 4: Current heat network policy

BEIS is expected to publish a Buildings and Heat Strategy in 2020 outlining the key steps it intends to take on heat through the 2020s.[80] Relevant UK Government policy includes:

- **The Non-Domestic Renewable Heat Incentive** provides a subsidy to applicants for every unit of renewable heat they provide to a heat network. It closes to applicants in 2021.[81]
- **The Heat Networks Delivery Unit** within BEIS provides advice and grants funding for local authorities in the early stages of setting up a network.[82] It has awarded £23m in grant funding and supported 150 local authorities.[83]
- **The Heat Networks Investment Project**, run by BEIS, will provide £320m across its lifetime (2015–2022) to projects that would otherwise not receive wider investment.[38] It is intended to help create the conditions for a self-sufficient market by 2022.
- **The Green Heat Network Fund**, announced in the 2020 Budget, will invest £270m to support new and existing networks adopt low-carbon heat sources across 2022–2025.[84]

The Heat Networks (Metering and Billing) Regulations are currently being updated to improve these processes.[85,86] Several equivalent Scottish Government policies exist.[87,88]

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