KPMG

Waste Heat Beneath Our Feet

Unlocking hidden wastewater heat resources in the transition to green towns and cities

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Thames Water

Purpose

This report, co-authored by KPMG, a leading professional services firm, and Thames Water, the UK's biggest water and wastewater services provider, sets out the significant role that wastewater heat could play in decarbonising towns and cities across the country.

As the UK aims to accelerate progress towards Net Zero, delivering on the decarbonisation of heat challenge will be critical. Whilst a range of low-carbon technologies will have a role to play, water companies are uniquely placed to unlock a sizeable, renewable and currently untapped heat resource and have an exciting opportunity to be part of the solution.

This report seeks to highlight the potential scale of the opportunity to recover wastewater heat resources and the benefits and challenges associated with developing this emerging low-carbon technology. Drawing on analysis by KPMG and Thames Water, this report identifies a set of key asks for policymakers, that can help bring this market to fruition at scale in the UK.

Contents

Forewords

At Thames Water, we're taking pioneering steps to change the way energy is created and used in the UK, making us an important player in the energy transition.

We are living through a period of great change and challenges. Against the backdrop of climate change and the threat it poses to our way of life, we are also facing an unprecedented global energy crisis – triggered in part by a sharp rise in demand for natural gas as the world emerged from the COVID-19 pandemic and supply uncertainty linked to the war in Ukraine. The UK relies on imports for over half of the natural gas we use, meaning we are directly and immediately exposed to global fluctuations in prices. This exposure has placed significant pressure on consumers' pockets, playing a key role in driving the cost of living crisis we are seeing today.

Whilst support with energy bills is designed to provide short-term relief the country must also look to tomorrow to ensure we have a long-term plan for UK energy sovereignty. A plan where economic growth and protecting the environment, through decarbonisation, can and must go hand in hand.

The UK has more than 28 million homes and the majority of these are currently heated by gas boilers. Changing how we heat our homes and buildings is essential to ending our reliance on gas, reducing our exposure to global markets and stabilising future energy bills, whilst also achieving our decarbonisation targets.

Reducing the country's dependence on gas will take time and a range of low-carbon heating solutions, but right now, a wasted resource is flowing through the pipes beneath our towns and cities. Every time you take a hot shower, or use a washing machine, heat is literally pouring down the drain.

This heat doesn't need to go to waste. By using a combination of heat recovery technologies and heat pumps, thermal energy in the wastewater network can be captured, harnessed and reused to keep our homes and buildings warm. This is a fact not lost on the public who overwhelmingly support recovering this heat as well as the wider aim of moving to lower carbon sources of energy.

By recovering waste heat found across Thames Water's network alone, it could be possible to establish a citywide heat network capable of providing heat and hot water for around 1 million homes in London and the Thames Valley – this is equivalent to 40% of the energy produced by Hinkley Point C Nuclear Power Station. As well as delivering a much-needed source of local, renewable heat, there is a huge opportunity to support communities across the country by creating tens of thousands of green jobs.

We're living through a period of great change and challenges. Big challenges require big ideas, and this is an exciting opportunity the UK cannot afford to waste.

Tony Vasishta
Chief Executive Officer
Thames Water Ventures

Delivering Net Zero is one of the greatest challenges facing the world today. The UK has in many respects led the way when it comes to making progress on power sector decarbonisation and is now halfway to Net Zero. However, we need to rapidly transform the way we heat our homes and buildings to remain on track towards our decarbonisation goals.

The UK's housing stock is incredibly heterogenous. Not only do we have some of the leakiest homes in Europe in terms of energy efficiency, but we also have some of the oldest buildings, with properties spanning multiple generations. All of these factors serve to make the decarbonisation of heat especially challenging as there is no one-size-fits-all heating solution for all properties.

A mosaic of different technologies will have an important role to play, with the mix of heating systems tailored to meet both regional and local needs. Whilst there is significant debate on the role of heat pumps and hydrogen, low-carbon heat networks are often overlooked. Green heat networks that harness energy from a range of heat sources including wastewater have growing potential to be an important part of the solution.

It is essential that we focus on decarbonising the energy system in an efficient way that makes best use of domestic renewable resources and is least cost for consumers, especially in the context of the ongoing cost of living crisis. Unlocking low-carbon, wastewater heat that is currently lost to the environment right across the country has the potential to bring significant carbon savings and consumer benefits, whilst promoting the shift towards a more circular, efficient energy system.

Decarbonising the way we heat our homes and buildings will require bold solutions. With the right policy and regulatory support, we have the opportunity to build on best practice and lessons learned from around Europe and harness the major potential of wastewater heat in accelerating the transition to green towns and cities in the UK.

As the Head of KPMG's Energy and Natural Resources practice, I believe in the important role that companies can play in driving the energy transition. This report shines a light on the emergent opportunity for water companies in particular to unlock hidden wastewater heat in the transition to Net Zero.

Simon Virley CB
Vice Chair and Head of Energy and Natural Resources, KPMG in the UK

Executive Summary

The heat decarbonisation challenge

Solving the challenge of decarbonising heat will be critical in achieving the UK's Net Zero target. Space and hot water heating in homes and buildings accounted for almost a quarter of total UK emissions in 2019[1]. Over 23 million homes, which equates to around 85% of the UK's housing stock, are currently connected to the gas grid and use natural gas boilers for heating. The vast majority of these heating systems will need to be replaced with low-carbon alternatives in the next 10-15 years for Net Zero to be achieved.

However, future choices of heating systems will be driven by a range of factors including practicality, cost and consumer preferences – and not all properties will be suitable for these heating systems. Low-carbon heat networks, that can harness a range of different clean heat sources, will also be key in the transition to green homes and buildings, particularly in high-density urban areas where other clean alternatives may be less viable. The Climate Change Committee projects that heat networks could deliver 18% of the UK's heating demand by 2050, up from around 3% today[2]. BEIS similarly project that heat networks have the potential to supply between 36-38% of London's heat demand[3].

However, the majority of heat networks currently in operation use gas-fired Combined Heat and Power (CHP) technology. There is a growing need to unlock green heat resources at scale and move away from fossil fuel-based systems. Water companies are uniquely placed to accelerate this transition as heat from billions of litres of wastewater is currently lost to the environment every day. This heat from wastewater is a significant, renewable and untapped resource, that with appropriate support, could play a major role in decarbonising UK towns and cities.

Abundant green wastewater resources are currently untapped

A range of water and wastewater processes capture or create heat through operational activities at wastewater treatment works, sewers, reservoirs and boreholes. This heat can be harnessed and does not need to be wasted. If recovered, this heat could be used to supply clean heat to local homes and buildings via heat networks. Waste heat can be recovered using a heat exchanger and used as the source for a large heat pump, before the heat is distributed to end customers through a network of pipes.

The scale of the opportunity to recover wastewater heat resources is significant. Thames Water's operational activities alone could potentially deliver up 10 TWh of waste heat from wastewater treatment works and sewers each year[4]. This sizeable and low-carbon resource could play a major role in supporting the shift to green heating systems, with the potential to supply around 1 million homes[5] with heating and hot water, which equates to over 20% of London's total domestic heat demand.

Moreover, whilst this technology is relatively new in the UK, wastewater heat recovery is currently taking place at more than 500 sites around the world[6]. In fact, in many major cities around Northern Europe and Scandinavia, where heat network markets are more developed, heat from wastewater is already playing an important role in supplying homes and businesses with low-carbon heating today.

As over 300 towns and cities across the UK have declared a climate emergency and set ambitious Net Zero targets, there is growing interest in wastewater as a clean, local and abundant source of heat. A wide range of organisations including local authorities, housing associations, housing developers, commercial property owners, heat network investors and developers are all looking to understand how to unlock this emergent market at pace and scale in the UK.

The Climate Change Committee projects that heat networks could deliver 18% of the UK's heating demand by 2050, up from around 3% today.

1 BEIS (2021) Heat and Buildings Strategy.
2 Climate Change Committee (2022) Progress in reducing emissions. 2022 Report to Parliament.
3 BEIS (2021) Opportunity areas for district heating networks in the UK.
4 10 TWh of heat demand served using 7 TWh of heat from wastewater.
5 Based on average heat demand of 10,000 kWh / year. The weighted average annual heat demand of properties in London in 2020 was 12,900 kWh / year based on BEIS (2020) National Energy Efficiency Data-Framework: consumption data tables 2020. This report assumes a high level of energy efficiency in line with planned government investment in insulation and energy saving measures and that the majority of homes served by heat networks are purpose-built or converted flats.
6 Net Zero Building Centre, School of the Built Environment and Architecture, London South Bank University (2021) Opportunities to decarbonise heat in the UK using Urban Wastewater Heat Recovery.

Wastewater heat could deliver significant carbon and affordability benefits, whilst promoting growth of a circular economy

Carbon savings – delivering up to 10 TWh of renewable heat from wastewater could achieve around 1.8 million tonnes of carbon savings every year compared with natural gas boilers, the equivalent to planting 90 million trees.

Affordability for consumers – using local, low-carbon sources of heat will reduce consumers' exposure to future international gas market volatility, providing longer-term certainty on price and potentially bringing affordability benefits whilst also supporting the transition to a more secure energy system underpinned by domestic heat generation.

City-wide transformation – capturing heat from a wide range of sources that are currently untapped - including wastewater, industrial processes, data centres, disused mines and rivers - could truly transform the decarbonisation of heating in towns and cities at scale across the UK.

Reduced pressure on the energy system – using local heat resources can support a whole systems approach to delivering Net Zero, by reducing the pressure on the electricity and gas networks to adapt at scale and deliver new low-carbon infrastructure.

Local green jobs – developing wastewater heat projects will promote economic growth by creating green jobs at scale, requiring a range of skillsets in the energy and water sectors. Delivering up to 10 TWh of renewable heat using resources from Thames Water sites has the potential to create 75,000 jobs across London[7].

There is a need to move beyond planning individual projects towards delivering a coordinated, whole systems approach.

Overcoming challenges to wastewater heat recovery

Whilst wastewater heat recovery technology is proven and projects are being deployed commercially at scale in Europe, unlocking the benefits of this emergent market in the UK will require the industry and government to work together closely, at both a national and a local level.

Every heat network is different and shaped by a range of location-specific factors. Aligning sources of recoverable wastewater heat with local demand will require coordinated planning on a project-by-project and a city-wide basis, involving collaboration between a wide range of stakeholders including local authorities, planning bodies, housing associations, developers and commercial and residential customers.

Equally, heat networks supplied by wastewater are most viable when delivered in large, interconnected clusters, that are more economic than standalone, discrete projects. There is a need to move beyond planning individual projects towards delivering a coordinated, whole systems approach that considers how to decarbonise heat across a whole town or city in the most efficient and cost-effective way. If implemented appropriately, heat network zones could play an important role in actively aligning wastewater heat sources and demand but there is more to be done to realise city-wide schemes.

Whilst there are key challenges to overcome, with appropriate support, there is truly an opportunity to unlock significant carbon and economic benefits, that the UK cannot afford to waste.

7 UK Energy Research Centre (2022) Green job creation, quality and skills: A review of the evidence on low carbon energy. Assumes 16 jobs created per £ million invested, using the average value for energy efficiency in buildings and analysis of the scale of investment required in wastewater heat networks to deliver 10 TWh of heat demand.

Key asks for policymakers to unlock the potential of waste heat resources

Policy ask	Key actions
1 Provide a clear, long-term signal on the role of heat networks and local energy systems in the transition to Net Zero.	• Set an ambitious 2030 target and roadmap for low-carbon heat networks, including those supplied by waste heat, that provides the market with the confidence needed to invest in the sector.
2 Develop the evidence base for deployment of waste heat in the UK.	• Establish the evidence base on waste heat and review how best to incorporate the recovery of waste heat into new and existing heat network policies. • Recognise the value of waste heat and approve a mechanism for determining a fair market value for the water industry for transfer pricing related to wastewater heat. • Identify the scale of the opportunity for heat networks in UK cities through updated assessments of the local opportunities for heat networks, including those supplied by waste heat.
3 Deliver a plan for the creation of the green jobs required at scale in the heat network sector.	• Focus on green jobs and skills and commit to developing the skills base needed for the rollout of heat networks at scale.
4 Introduce a regulatory framework that accommodates waste heat.	• Embed waste heat into the incoming heat networks regulation outlined in the Energy Security Bill. • Define the boundary between energy and water regulation in relation to wastewater heat and clarify the roles of Ofgem and Ofwat. • Define the scope of permitted development rights in relation to the rollout of low-carbon heat networks.
5 Incentivise investment in low-carbon heat networks supplied by waste heat.	• Accommodate waste heat in current and future capital funding programmes. • Implement a unit-based incentive that goes beyond upfront capital support and deliver a business model that enhances investor confidence in the market whilst providing a degree of revenue certainty. • Review the business models for delivery of city-scale heat networks.
6 Adopt a city-scale approach to developing heat networks.	• Recognise the potential role of water companies in optimising city-scale use of wastewater heat. • Set a 2026 target for city-wide pilot projects, including those that draw on wastewater heat.

Part 1
Harnessing waste heat sources at scale will support the transition to green homes and buildings

The heat decarbonisation challenge

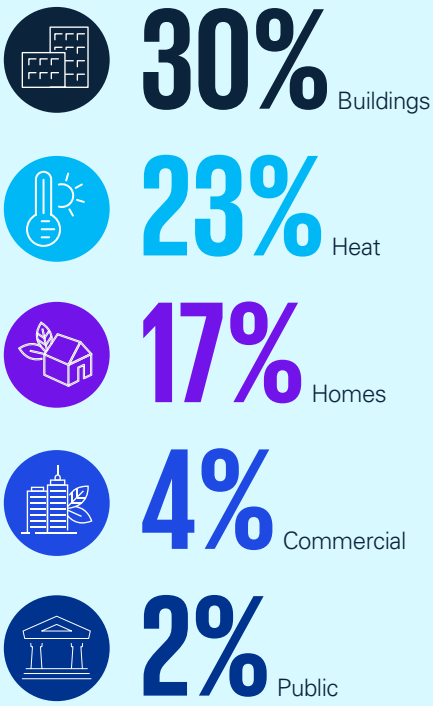
The UK has set an ambitious and legally binding target to reach Net Zero carbon emissions by 2050. Decarbonising heating in homes and buildings, which accounted for 23% of UK emissions in 2019, is one of the biggest challenges to achieving Net Zero[8] See Figure 1.

Around 23 million homes (c.85% of the UK housing stock) are currently connected to the gas grid and use natural gas for space and water heating. Approximately 5 million further homes are 'off-gas grid' and use a mix of oil, electricity and biomass heating. The majority of these heating systems will need to be replaced by low-carbon alternatives in the next 10-15 years if the UK is to reach Net Zero and remain on track to achieve its interim, five-yearly Carbon Budgets.

There is no one-size-fits-all solution that works perfectly for all property types, and a variety of different clean heating technologies will have a role to play in decarbonising homes and buildings. The debate around the future mix of heating solutions in the UK primarily focusses on the relative strengths and challenges associated with electric heat pumps and hydrogen-ready boilers. However, low-carbon heat networks, that bring the benefit of being compatible with a range of different clean heat sources, will also be key in the transition to green homes and buildings.

Every day, heat that is found naturally in billions of litres of wastewater is currently lost to the environment. Recovering this heat from wastewater at scale would unlock a significant, untapped and renewable heat source, that could play a major role in decarbonising towns and cities across the UK.

Figure 1: UK carbon emissions in 2019



Source: BEIS, Heat and Buildings Strategy

8 BEIS (2021) Heat and Buildings Strategy.

The policy context

Achieving the UK's Net Zero commitment by 2050 will require targeted policy support for a range of different clean heating technologies. The Climate Change Committee's latest Progress Report highlighted the need to accelerate plans for the decarbonisation of heat if the UK is to meet future Carbon Budgets[9].

The UK Government has increasingly recognised that heat networks have an important role to play in the future mix of heating solutions and predicts that the sector has investment potential between £60 billion to £80 billion by 2050.

To support the creation of the market conditions required to accelerate the deployment of heat networks, the UK Government launched the Heat Network Transformation Programme. This includes the Green Heat Network Fund, a £288 million capital grant scheme designed to support local authorities, heat network developers and investors in designing and building low-carbon heat networks across the country.

The Energy Security Bill also outlines plans to introduce heat network zones in England from 2025. These zones will be designated areas in which heat networks are identified as the most cost-effective solution to decarbonising heating, with certain types of buildings required to connect within a given time frame. By aligning local heat resources with demand, the Government is aiming to provide the market with a degree of certainty on the level of local demand to support investment decisions. Local authorities are likely to be responsible for coordinating these zones following a pilot programme in 28 English towns and cities, and will have an important local and regional role to play in driving the transition to greener buildings.

Equally, the Bill sets out proposals to bring in regulation to safeguard consumer standards on quality of service and price, and put in place technical limits on carbon emissions for heat networks going forwards.

However, whilst there is growing support and an increasingly positive outlook for low-carbon heat networks, the opportunity to utilise waste heat resources at scale is not yet fully considered by current policies and regulation.

National Grid Energy System Operator outline their Future Energy Scenarios that in any credible pathway to Net Zero, there will need to be at least 5.3 million homes and buildings connected to heat networks by 2050

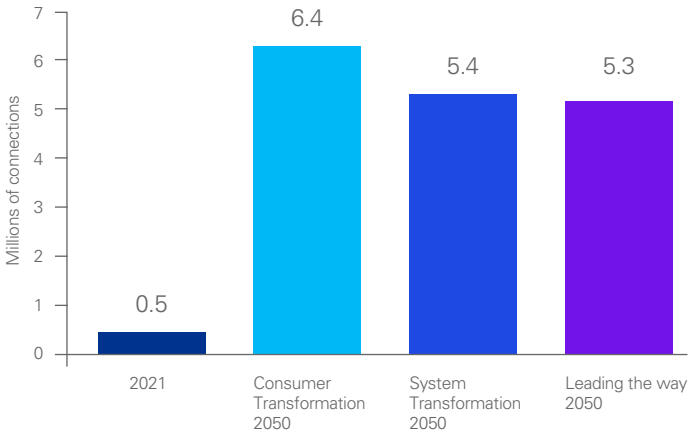
Progress

There are around 14,000 heat networks that supply 500,000 homes in the UK today. Whilst wastewater heat recovery is already in operation in Galashiels, with a similar scheme in development in Worthing, the interest in this emergent market is growing at pace. National Grid Energy System Operator outline in their Future Energy Scenarios that in any credible pathway to Net Zero, there will need to be at least 5.3 million homes and buildings connected to heat networks by 2050, with this number potentially rising to as many as 6.4 million in one scenario see Figure 2[10].

The Climate Change Committee similarly highlights that heat networks could deliver up to 18% of the UK's heating demand by 2050, a ninefold increase from approximately 3% today.

Therefore, whilst heat networks currently make up a relatively modest portion of the UK's heating mix, the market has major growth potential as a critical solution in the transition to green homes and buildings – and waste heat could be an important heat source for future district heating schemes.

Figure 2: Heat network connections in Net Zero scenarios to 2050



Source: National Grid Energy System Operator, Future Energy Scenarios 2022

National Grid Energy System Operator outlines a range of credible pathways for the future of energy between now and 2050 each year based on the latest consumer, policy and technology trends. Figure 2 projects the number of residential and commercial connections to district heat networks by 2050.

Whilst heat networks currently make up a relatively modest portion of the UK's heating mix, the market has major growth potential as a critical solution in the transition to green homes and buildings.

9 Climate Change Committee (2022) Progress in reducing emissions. 2022 Report to Parliament.
10 National Grid ESO (2022) Future Energy Scenarios.

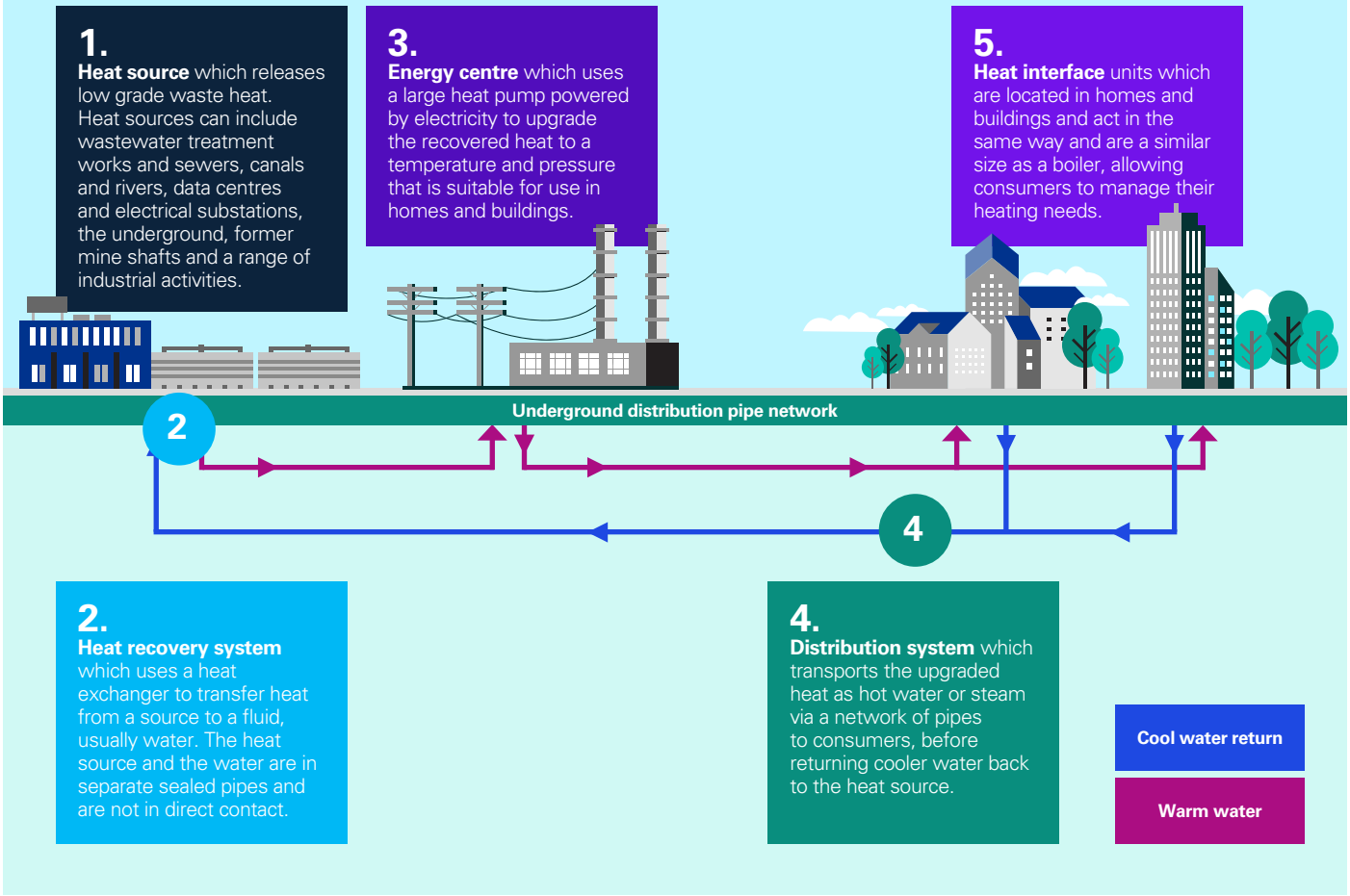
Part 2
Abundant green wastewater heat resources are currently untapped

How do heat networks supplied by waste heat work?

A range of human activities and natural processes create surplus heat that is currently lost to the environment from industry, data centres and electrical substations, the underground, canals and rivers and former mine shafts. Similarly water and wastewater treatment processes capture or produce excess heat that could be used to deliver clean heat to local homes and buildings via heat networks.

Heat networks are systems of insulated pipes that distribute heat from a central source to a number of residential and commercial end customers. These networks have the benefit of being compatible with a range of different heat sources and can utilise thermal energy in the air, the ground or in water.

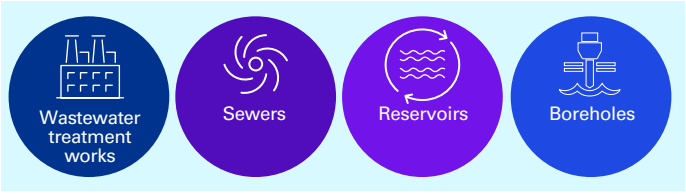
Heat networks are typically made up of five main elements



These networks have the benefit of being compatible with a range of different heat sources and can utilise thermal energy in the air, the ground or in water.

Sources of waste heat

Water companies are well placed to play a key role in the decarbonisation of towns and cities by harnessing extensive heat resources that can be recovered from a range of different sites across their operational estates, including wastewater treatment works, sewers, reservoirs and boreholes. As these resources are in essence by-products of the standard day-to-day operational activities of water and wastewater companies, they have the benefit of being both low-carbon and renewable.



Unlocking waste heat opportunities in water

By enabling the recovery of these heat resources, water companies have a significant opportunity to play a key role in shaping the energy transition and supporting the shift to low-carbon heating systems.

If this heat can be aligned with sources of local demand, the scale of the opportunity is sizeable. Waste heat from Thames Water's wastewater treatment works and sewers has the potential to meet up to 10 TWh of heating demand each year, enough to supply heating and hot water to around 1 million homes, which equates to over 20% of London's entire domestic heat demand. Even further excess heat can be recovered from reservoirs and boreholes.

Harnessing wastewater heat could be particularly beneficial for energy consumers and the wider energy system in high-density urban areas, where other low-carbon alternatives, such as heat pumps, are less viable, in part due to space constraints.

Waste heat from Thames Water's wastewater treatment works and sewers has the potential to meet up to 10 TWh of heating demand each year, enough to supply heating and hot water to around 1 million homes, which equates to over 20% of London's entire domestic heat demand.

Case study

Beckton

Thames Water owns and operates Beckton wastewater treatment works, the largest of its kind in Europe. Located in the London Borough of Newham, the site treats the wastewater of almost four million Londoners.

It is one of 15 wastewater treatment works that Thames Water operates across the Greater London area and southern England.

Huge volumes of large wastewater are treated at the site every day, creating a significant opportunity to recover and harness excess renewable heat. Heat recovery from this treatment works alone has the technical potential to meet up to 3.2 TWh of heat demand, which could supply heating to over 320,000 London homes.

Waste heat recovery at Beckton could also have a transformative impact on the decarbonisation of heat in London, with the potential to deliver over 550,000 tonnes of carbon savings each year compared with natural gas boilers.

What does delivering 10 TWh of heat demand look like?

40
large heat networks connected to wastewater treatment works

200
sewer heat recovery projects

c.1,000
kilometres of heat networks

Assumes that on average each large-scale heat network connected to a wastewater treatment works serves around 140 GWh of heat demand per year and that each sewer scheme meets around 20 GWh per year of demand from a mix of residential, commercial and bulk supply customers.

Learning from European experience

Whilst this technology is relatively new in the UK, wastewater heat recovery is currently taking place at more than 500 sites around the world[11]. In fact, in many cities around Northern Europe and Scandinavia, where heat network markets are more developed, heat from wastewater is already playing an important role in supplying homes and businesses with low-carbon heating.

For example, water and wastewater companies are working closely with energy utilities in major cities in Sweden, Denmark and Germany to embrace the potential benefits that heat from wastewater can bring for consumers and the environment. These schemes are not restricted to trials and demonstrators and are now being delivered commercially and at scale, providing a snapshot of the potential that could be replicated here in the UK.

As over 300 towns and cities across the UK have declared a climate emergency and set ambitious Net Zero targets, in some cases decades earlier than the national 2050 target, there is growing interest in wastewater heat as a clean, local and abundant source of heat. Thames Water was approached by over 30 organisations seeking to access wastewater heat in 2021 alone. Local authorities, housing associations, housing developers, commercial property owners, heat network investors and developers are all looking to engage with water companies and understand how to unlock this emergent market at scale in the UK.

As over 300 towns and cities across the UK have declared a climate emergency and set ambitious Net Zero targets, in some cases decades earlier than the national 2050 target.

Case study

Sweden

Sweden has been using locally available heat to supply homes and businesses for decades. The country aims to become carbon neutral by 2045 and has found district heating and cooling systems an effective way to drive progress towards achieving ambitious environmental targets.

Wastewater heat is already playing a key role in providing space and hot water heating in cities across Sweden. For example, in Uppsala, around 95% of all properties are supplied by district heating[12]. Waste heat recovery has been in operation since 1981, with heat exchangers and heat pumps used to extract energy from the treated wastewater of a sewage plant nearby.

Similarly, in Gothenburg, a facility of four heat pumps with a combined capacity of 160 MW extracts heat from a range of sources, including a nearby wastewater treatment plant. This facility has significantly reduced the carbon footprint of Gothenburg's district heating system, in particular during the winter months when the system was previously more reliant on natural gas boilers and gas-fired CHP units.

Helsingborg is a further example of a city where heat pumps utilise treated water from the sewage system to supply both district heating and cooling. The local district heating company expanded the district cooling grid in 2017, with use of absorption cooling technology enabling the delivery of cooling to offices and commercial buildings.

Cities across Sweden have already unlocked renewable heat from wastewater at scale. Local sources of heat are playing an important role in shaping the transition to lower carbon homes and buildings and this model presents tangible opportunities for replication in the UK.

11 Net Zero Building Centre, School of the Built Environment and Architecture, London South Bank University (2021) Opportunities to decarbonise heat in the UK using Urban Wastewater Heat Recovery.
12 Vattenfall (2022) Power plants: Uppsala.

Case study

Denmark

Denmark has one of the most developed markets for heat networks in the world. The widespread use of district heating systems and CHP, supported by progressive national energy policies since the 1970s, has proved to be a successful way of improving energy efficiency and tackling climate change.

Copenhagen is home to one of the largest city-scale heat networks in the world, with 98% of the city's buildings supplied by 21 municipal and community-owned local networks[13]. Recently, several natural gas networks in the city have been replaced by district heating, and the heat networks are expanding further to supply new areas being developed in and around the city.

Danish projects have showcased the potential for the recovery of waste heat at scale from urban sources in multiple major cities. In 2017, operation of a 10 MW electric heat pump, utilising heat from wastewater to produce district heating, commenced in Kalundborg[14]. At the time, it was the largest heat pump facility in Denmark, replacing two obsolete oil-fired boilers and providing local, renewable heat for consumers.

However, recovering waste heat to supply homes and businesses is not restricted to wastewater. Denmark is a pioneer in waste heat recovery and is proving the case for harnessing a range of other local sources, including seawater and industrial processes. For example, a 50 MW heat pump facility in the port city of Esbjerg will use sea water for district heating[15]. This large-scale project is currently being developed and will see the fossil fuel based plant currently used to supply district heating taken offline by 2023.

Case study

Germany

The German energy transition kickstarted in 2010, when the country announced its major Energiewende plan, aiming to make the energy system more efficient and renewable. To support the transition, German policy has strongly supported the expansion of district heating networks. More recently, Germany announced a €3 billion subsidy scheme to support the construction of low-carbon heat networks that use at least 75% renewable energy[16].

In Berlin, an 2,000-kilometre district heating network already provides heat for 1.3 million households[17]. The city has recently seen the construction of Germany's largest district heating storage facility – a 56 million litre energy storage tank in Reuter West[18]. The facility will flexibly integrate waste heat from a range of sources including industrial processes and wastewater, to supply heat to people's homes.

Equally, Germany has been at the forefront of innovation on waste heat recovery, with multiple projects that harness energy from wastewater operational across Germany. From 2012 to 2016, three demonstrator projects in Cologne showcased the potential for heat recovered from the sewer network to supply homes and businesses as part of the EU-funded Combined Efficient Large Scale Integrated Urban Systems (CELSIUS) project.[13]

The Cologne demonstrators recovered heat from wastewater using heat exchangers and pumps, supplying heat to more than 1,300 local schools and buildings. The programme highlighted the high potential for replication of this solution, as more than 84% of the EU's population is connected to a sewer network – a share that increases in urban areas, making heat from wastewater a particularly viable solution in high density towns and cities.[13]

13 ReUseHeat (2017) Experiences from other urban waster heat recovery investments.
14 BEIS (2018) Heat Networks Investment Project: Case study brochure.
15 Danish Board of District Heating (2021) Pursuing a 100% fossil free heat production with zero loss of applied resources.
16 European Commission (2022) State aid: Commission approves €2.98 billion German scheme to promote green district heating.
17 Vattenfall (2022) Vattenfall explores strategic options for its Berlin heat business.
18 Vattenfall (2021) Vattenfall is building Germany's largest district heating heat storage facility in Reuter West.

Part 3
Wastewater heat could deliver significant carbon and affordability benefits, whist promoting a circular economy

Unlocking significant carbon savings

Recovering renewable heat from wastewater processes delivers sizeable carbon emissions reductions compared with fossil-fuel based alternatives. Although UK heat networks supplied 14 TWh of heat in 2018, only 1 TWh of this supply came from low-carbon sources as gas CHP technology has previously been one of the most widespread heat sources[19]. Whilst heat networks are a viable solution for many high-density urban areas, low-carbon heat sources are not always available locally. Scaling up heat recovery from wastewater could contribute to plugging this gap by enabling the decarbonisation of existing heat networks and delivering a low-carbon heat source for an array of new build projects. Equally, sewers networks are extensive beneath UK towns and cities, presenting a real opportunity to align waste heat sources with demand in metropolitan areas.

Delivering 10 TWh of heat demand could save around 1.8 million tonnes of carbon emissions.

10
TWh of heat demand (equivalent to 40% of the energy generated by Hinkley Point C Nuclear Power Station)

1 million
Homes supplied with renewable heat

c.1.8 million
Tonnes of CO2 savings annually

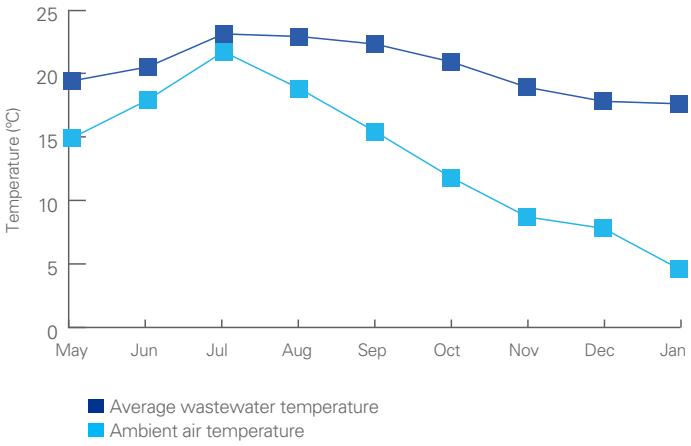
90 million
Equivalent to planting 90 million trees every year

75,000
Green jobs

Heat from wastewater has the potential to be more efficient than other low-carbon alternatives such as large air-source heat pumps. Unlike the ambient air temperatures, wastewater temperatures are stable throughout the whole year, allowing wastewater source heat pumps to operate at higher efficiencies and optimise performance.

Figure 3 highlights that whilst average wastewater and ambient air temperatures are similar during the peak summer months, air temperatures can be significantly lower than wastewater temperatures during winter. This means that to deliver the same heat output, a large air source heat pump would need to use significantly more electricity than a wastewater source heat pump.

Figure 3: Comparison of average wastewater and outside air temperatures



Source: Net Zero Building Centre, School of the Built Environment and Architecture, London South Bank University

Wastewater temperatures were monitored as part of the Home Energy for Tomorrow (HE4T) project which explored the potential for waste heat recovery from London sewers. Figure 3 compares the average monthly wastewater temperatures at a sewer site in central London with the ambient air temperatures between May 2018 and January 2019.

Equally, by recovering heat that has already been produced by water and wastewater treatment processes, this makes efficient use of energy resources already in the system and encourages a shift towards a circular economy approach. Recovering and reusing residual waste heat has the potential to reduce the total demand for generation of other heat sources, such as renewable electricity to power heat pumps and hydrogen, creating benefits for the wider energy system.

19 Climate Change Committee (2022) Progress in reducing emissions. 2022 Report to Parliament.

Unlocking local heat sources can benefit consumers

Heat networks that use local, low-carbon sources of heat are not exposed to international gas market price volatility, unlike the majority of heating systems in homes and buildings today. By reducing the exposure to international price shocks, local heat networks supplied by heat from wastewater have the potential to provide greater long-term price certainty and be a more affordable solution for consumers.

Whilst the heat pumps used to upgrade wastewater heat are powered by electricity, which will remain linked to international commodity prices, this exposure is likely to fall as the UK targets a decarbonised electricity system underpinned by domestic renewable generation by 2035.

Equally, connecting to a heat network may be more viable and less disruptive for consumers than installing other low-carbon alternatives, particularly in high-density urban areas. Not all properties are suitable for individual heat pumps, in part due to the high energy efficiency levels required, so choices of heating system will need to be tailored to regional and local needs. For example, 42% of homes in London are either converted flats or terraced properties[20]. Many of these buildings are likely to be space constrained, making installation of an individual heat pump practically challenging.

Scaling up to deliver city-wide transformation at least cost

Wastewater heat networks are most viable when delivered in large, interconnected clusters. Heat networks have a particular advantage for newbuild developments and in high-density urban areas, where a large number of properties can be retrofitted and connected efficiently. Larger coordinated schemes are more economic than standalone, discrete projects, as the capital and operating costs fall with scale. This has the potential to lower costs for consumers and reduces the need for grants and subsidies by up to 40%.

Equally, the opportunity to recover waste heat is not restricted to Thames Water or to water companies. There is an opportunity to capture residual or waste heat from a wide range of sources that are currently untapped right across the UK, including industrial processes, data centres and electrical substations, disused mines and rivers.

Capturing and storing residual heat and dispatching it at times of peak demand will help to smooth the curve on the wider energy system, whilst also supporting local network balancing.

Public support for waste heat

69%

of Thames Water customers support building district heat projects locally

72%

of Thames Water customers support wastewater district heating after hearing a full briefing on what it means for them and their community

Opposition is extremely limited at 5% of Thames Water customers[21].

Reducing the pressure on the wider energy system

Recovering local sources of heat will reduce the burden on the wider energy system.

As there is increasing pressure on the electricity and gas networks to adapt at scale and deliver the infrastructure required to enable Net Zero, use of local heat resources could reduce the constraints on the other networks as part of a whole systems approach.

Heat networks fed by local wastewater heat resources will not only reduce the requirements for electricity transmission and distribution in towns and cities that are already grid constrained, but could also limit the peak load on the system through thermal storage. Capturing and storing residual heat and dispatching it at times of peak demand will help to smooth the curve on the wider energy system, whilst also supporting local network balancing.

Creating local jobs

Growing the wastewater heat networks sector will create green jobs requiring a range of skillsets from across both the energy and water sectors.

The UK Government predicts that the heat networks industry could attract between £60 billion to £80 billion investment by 2050. Embracing the opportunities to develop wastewater heating projects will create long-term jobs in designing, building and operating these networks in towns and cities right across the UK.

In London alone, delivering 10 TWh of heat demand could create 75,000 green jobs[22] in the energy and water sectors.

20 Department for Business, Energy and Industrial Strategy (2018) National Energy Efficiency Data Framework.
21 JL Partners Polling for Thames Water (May 2022)
22 UK Energy Research Centre (2022) Green job creation, quality and skills: A review of the evidence on low carbon energy. Assumes a central value of 16 jobs created per £ million invested.

Part 4
Overcoming challenges to wastewater heat recovery

Managing local differences

In overcoming the challenges of delivering local infrastructure district heat projects, start with a strong base of public support – they can be extremely popular. In polling, 69% of Thames Water customers support building district heat projects local to them with only 8% actually opposed[23].

Every heat network is different and shaped by a range of location-specific factors. These include the availability of heat resources, local geography and infrastructure, and the type and scale of consumer demand.

In practice, heat resources only have value if there is a local offtaker willing to pay for them. Aligning sources of wastewater heat with local demand in the most efficient, cost-effective and technically feasible way will require coordinated planning on both a project-by-project and a city-wide basis.

This will involve engagement and consultation with a wide range of stakeholders including local authorities, planning bodies, housing associations, developers, and commercial and residential customers.

Minimising the impacts on the regulated water businesses

The primary duty of water and wastewater companies is to deliver their core services for water customers. Water companies will need to ensure that any recovery of waste heat does not disrupt their core services or lead to higher operational costs for their regulated business, as well as securing a fair market value from heat network projects for accessing waste heat resources.

Heat sources primarily the water and wastewater companies that own wastewater treatment works, sewers and other waste heat resources

Customers which could include local authorities, housing developers, social housing providers, the NHS, universities, offices and other local businesses

Investors which could include local authorities, energy companies, private funds or national Government where grant funding is available

Delivery partners such as local authorities, specialist heat network developers, energy service companies and subcontractors across the supply chain

Consents that include local planning authorities, the Environment Agency and the Highways Agency and Network Rail where road or rail crossings are involved

23 JL Partners Polling for Thames Water (May 2022)

Navigating regulatory uncertainty

The supply of heat recovered from wastewater is in many ways unique from a regulatory perspective, as it must comply with both energy and water regulation.

There are key regulatory uncertainties at the boundary between the energy regulator, Ofgem, and the water regulator, Ofwat. For example, it is important to balance the need for heat to be affordable for energy customers, whilst also ensuring that water customers see the benefits of their wastewater being used. How these benefits should be split between heat and water customers is unclear, as current regulation is not designed specifically for opportunities which cross both the water and the energy sectors.

The regulatory framework should support and incentivise use of wastewater heat resources that can bring sizeable carbon, affordability and resilience benefits for consumers and the wider energy system in the transition to Net Zero.

Accessing the economies of scale

Wastewater heat networks are most viable when delivered in large, interconnected clusters. Larger coordinated schemes are more economic and less dependent on subsidies than standalone, discrete projects. There is a need to move beyond planning individual projects towards delivering a coordinated, whole systems approach that considers how to decarbonise heat across a whole town or city in the most efficient, cost-effective and technically feasible way. UK Government plans to create heat zones could help, by aligning local heat sources with demand, but further clarity is needed on how these zones will consider and support the recovery of wastewater heat resources.

Building new partnerships

Unlocking the potential of wastewater heat to transform the heat networks market and shape the transition towards green towns and cities will require new and collaborative partnerships across the energy and water sectors.

A broad range of technical, commercial and customer engagement skills are needed to effectively recover, upgrade and supply wastewater heat to consumers. These schemes will have to bring together water companies that are experienced in operating and maintaining wastewater treatment works and sewers, as well as experts in designing, building and operating low-carbon heat networks.

This will involve novel partnership structures, commercial arrangements and ways of working between players in the water and energy sectors.

Unlocking wastewater heat on a city scale

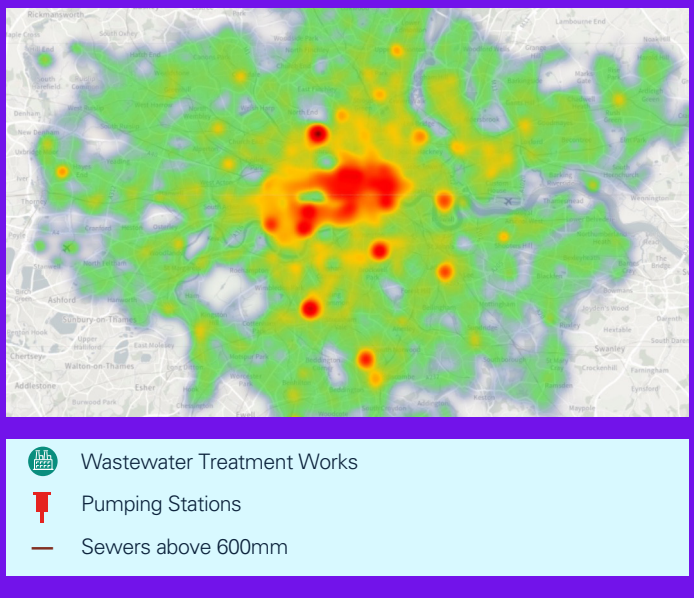
Heat from Thames Water sites has the potential to meet up to 10 TWh of demand each year, the equivalent to heating around 1 million homes. Recovering this heat on a city scale would take time, but could play a significant role in the shift towards green homes in London.

Aligning local heat sources and demand is key to unlocking the benefits of waste heat. In central and north London, there is close alignment between the locations of trunk sewers and demand. There is the potential to build a patchwork of energy centres and heat networks along the trunk sewer mains that are interconnected over time, serving areas of high residential and commercial demand across the City and the West End – whilst potentially connecting to existing heat networks that use other sources of low-carbon heat.

Outside of the city centre, there is an opportunity for extensive suburban heat networks to grow out from large wastewater treatment works such as Beckton and Mogden. Whilst aligning local heat demand with wastewater heat resources may be more challenging in the suburbs, the opportunity is sizeable – waste heat from Beckton alone could serve up to 3.2 TWh of demand.

Map of sewers and wastewater treatment works in London and the surrounding area

Map of heat demand in London and the surrounding area[23]



23 Greater London Authority (2022) London heat map

Part 5
Key asks for policymakers to unlock the potential of waste heat resources

Policy ask	Key actions
1 Provide a clear, long-term signal on the role of heat networks and local energy systems in the transition to Net Zero.	• **Set an ambitious 2030 target for low-carbon heat networks** – introduce a roadmap for the deployment of low-carbon heat networks, including those supplied by waste heat, that provides the market with the confidence needed to invest in the sector at scale.
2 Develop the evidence base for deployment of waste heat in the UK.	• **Establish the evidence base on waste heat** – BEIS to publish a call for evidence on the use of waste heat and review how best to incorporate the recovery of waste heat into new and existing heat network policies. • **Recognise the value of waste heat** – Ofwat to approve a mechanism to determine a fair market value for the water industry for transfer pricing related to wastewater heat, which is not a public resource. • **Identify the scale of the opportunity for heat networks in UK cities** – combined authorities in major metropolitan areas (e.g. Greater London Authority, Greater Manchester Combined Authority) to deliver updated assessments of the local opportunities for heat networks, including those supplied by waste heat.
3 Deliver a plan for the creation of the green jobs required at scale in the heat network sector.	• **Focus on green jobs and skills** – BEIS to commit to developing the skills base needed for the rollout of heat networks at scale e.g. by providing funding to train heat network engineers.
4 Introduce a regulatory framework that accommodates waste heat.	• **Embed waste heat into heat networks regulation** – Ofgem to ensure that the incoming regulatory framework for heat networks outlined in the Energy Security Bill accommodates the use of low-carbon waste heat sources. • **Define the boundary between energy and water regulation in relation to wastewater heat** – clarify the roles of Ofgem and Ofwat and the ways in which both water and heat customers can appropriately benefit from the use of wastewater heat. • **Define the scope of permitted development rights** – outline the scope of permitted development rights in relation to the rollout of low-carbon heat networks.
5 Incentivise investment in low-carbon heat networks supplied by waste heat.	• **Accommodate waste heat in current and future funding programmes** – outline how live capital grant programmes (e.g. the Green Heat Networks Fund) specifically consider applications from waste heat projects and clarify the longer-term support available for the waste heat market. • **Implement a unit-based incentive that goes beyond upfront capital support** – deliver a business model that enhances investor confidence in the market and provides a degree of revenue certainty (e.g. outputs subsidy model, RAB model, cap and floor) and consider the options for long-term business rate exemptions for low-carbon heat networks. • **Review the business models for delivery of city-scale heat networks** – BEIS to assess the mechanisms needed to overcome the barriers to city-wide development (e.g. the challenge of aligning anticipatory investment in infrastructure with local demand) of low-carbon heat networks and present a preferred business model.
6 Adopt a city-scale approach to developing heat networks.	• **Recognise the potential role of water companies in optimising city-scale use of wastewater heat** – ensure that incoming heat network zoning legislation accounts for the complementary role that water companies can play in coordinating the use of waste heat resources across their networks. • **Set a 2026 target for city-wide pilot projects** – BEIS to introduce a target number of large-scale pilot projects, including those that draw on wastewater heat, to be underway by 2026 and provide innovation funding to the awarded zones.

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