South West NET ZERO HUB

THE ROLE OF WASTE HEAT IN THE SOUTH WEST:

ESTABLISHING ALTERNATIVE LOW CARBON SOURCES IN HEAT NETWORKS

Report for: The South West Net Zero Hub

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1. INTRODUCTION

The aim of this project is to develop a map of waste heat sources for the South West Net Zero Hub[1] (SWNZH) region. This will provide strategic recommendations to decarbonise heat in the area using waste heat, as well as identify priority areas for the connection of heat networks to waste heat sources.

This project marks a significant step in achieving the SWNZH's mission of increasing the scale of local Net Zero projects delivered. The map of waste heat sources not only pinpoints the locations of waste heat but also provides information on their grades, originating sectors and available quantities. Visual presentation of this information, improves its accessibility, making it easier to digest the data available on waste heat, and spot opportunities. This tool will contribute to reducing uncertainty and speed up decision-making for selecting areas for heat networks. The tool can be further developed as information becomes available on new demands and sources.

The report recommendations, as well as the prioritisation of waste heat sources, will help to concentrate efforts on the most viable areas, making sure resources are invested in sites with the greatest potential for success. According to Element Energy[2], the technical potential for waste heat recovery in the southwest region is approximately 1.5 TWh/y. This report aims to highlight some of these key opportunity areas and provide guidance on the next steps to catalyse waste heat recovery in heat networks.

1.1.1 The South West Net Zero Hub

The South West Net Zero Hub (SWNZH) is a regional initiative that seeks to stimulate local investment in energy projects. It was established in 2018 as part of the Local Net Zero Hubs Programme by the Department for Energy Security and Net Zero (DESNZ) to support the identification, development, and implementation of energy projects across five English regions. The SWNZH is hosted by the West of England Combined Authority.

The SWNH has five core objectives: to increase the number, quality and scale of local energy projects being delivered; to provide regional leadership; and to liaise with DESNZ. These objectives are aligned with the national objectives of England to achieve net zero carbon emissions by 2050.

[1] The South West Net Zero Hub supports local authorities and communities in the southwest to play a leading role in decarbonisation and clean growth. About us - South West Net Zero Hub (swnetzerohub.org.uk)

[2] Element Energy: The potential for recovering and using surplus heat from industry (2014)

1.2 APPROACH

1.2.1 Data Sources

A detailed GIS (Geographic Information System) map has been created of waste heat sources across the region. Prior to mapping, the waste heat sources were categorised by grade of heat and scale of opportunity. Overlaid onto the waste heat map are additional layers showing existing and proposed heat networks, as well as some major heat users. The data sources that were available for inclusion within the GIS map are:

- Department for Energy Security and Net Zero[3];
- National Atmospheric Emissions Inventory (NAEI)[4] large point source emissions data;
- Digest of UK Energy Statistics (DUKES)[5] electricity data on power stations;
- UK regulator inventories' data[6] (specifically on HFCs).

The EU Reuse heat data set was available. However, this was excluded due to the majority of data points overlapping with DESNZ data, and investigation of specific data points revealed some inaccuracies in location.

Data sources that could be considered for improved utility of the SWNZH tool.

- EPC data[7]
- London South Bank University waste heat data[8]
- Barbour API (data available on housing developments)

The table below shows the number of data points available, and included in the mapping, from each data set. Where other data sets overlap with DESNZ, the data point is counted as DESNZ data.

Data source	Frequency	Types included
Department for Energy Security and Net Zero (DESNZ)	947	Chemical, Food & Drink, Mineral, Supermarkets, Waste Treatment, Power
National Atmospheric Emissions Inventory (NAEI)	27	Data Centre, Oil & Gas, Paper, printing & publishing, Food and drink, Mineral, Waste treatment, Power
UK regulator industries data	5	Food and drink
Other	1	Mine
Heat Network Planning[9]	57 networks – preconstruction 10 networks – operational/under construction	

Table 1 Quantity of data points for waste heat and heat networks included in the mapping tool.

[3] DESNZ Waste Heat Research proximity tool
[4] NAEI Emissions from large point sources, https://naei.beis.gov.uk/data/map-large-source
[5] DUKES 2022, https://www.gov.uk/government/statistics/electricity-chapter-5-digest-of-united-kingdom-energy-statistics-dukes
[6] Environmental regulators' emissions data for permitted sites from EA, SEPA, NIEA, and NRW (2021)
[7] Energy Performance of Buildings Data: England and Wales, https://epc.opendatacommunities.org/login
[8] LSBU Low temperature waste heat sources data, https://openresearch.lsbu.ac.uk/item/92wq6
[9] BEIS 2023: Heat Networks Planning Database, Heat Networks Planning Database - data.gov.uk

Waste Heat Sectors

The following table provides a brief description of each sectoral heat source in the data available. The relevant layer name on the GIS map is also provided, along with the waste heat hierarchy categories that are available for that sector in the southwest (as Low/Medium/High-Utility, see Waste Heat Hierarchy).

Sector Name	Layer Name on map	Brief description
Chemical industry	Chemical industry - Low/Medium Utility	Chemical manufacturing plants.
Food and drink	Food and drink - Low/Medium Utility	Food and drink factories and production sites.
Mineral industries	Mineral industries - Low/Medium Utility	Industrial sites such as asphalt and brickworks.
Supermarkets	Supermarkets - Low/Medium Utility	Supermarkets with significant cooling loads are a source of low grade heat. These would be suitable for integration into a 5^{th}-generation network.
Waste treatment works	Waste treatment works - High/Medium Utility, High Grade	Waste treatment facilities, predominantly Energy from Waste (EfW) and Mechanical Biological Treatment (MBT) facilities generate power from waste incineration.
Sewage treatment works	Sewage treatment works (STW)- Low/Medium Utility, Low Grade	STW are both drainage water and human waste treatment works.
Power station	Power station - Low/Medium Utility	Includes both major and minor power producers. At least seven of these will have significant utility. All are sources of low grade heat. There is one STOR facility (Short Term Operating Reserve) which would be used intermittently and is unlikely to be a reliable source of waste heat.
Paper, printing & publishing industries	Paper, printing & publishing industries - Medium Utility	Paper mills are a source of low grade heat.
Data Centre	Data Centre - Low Utility	The tool only includes one data centre within the NAEI data set. This is a sector with more potential in the southwest.
Oil & Gas	Oil & Gas - Low/Medium Utility, Low Grade	Includes oil & gas exploration and production, and processing & distribution of petroleum.
Oil & Gas	Oil & Gas - Low/Medium Utility, High Grade	Processing & distribution of natural gas.
Mine Water	Mine Water - Medium Utility	Only one mine water data point was available. This is the former Wheal Jane tin mine, which now has water pumped through for treatment.

Table 2 Description of each sectoral waste heat source

1.2.2 Data Interpretation and Readiness for Waste Heat Tool

The DESNZ data set was the only source that provided waste heat availability. Therefore, for all other data sets new points were included only where these were unique to the DESNZ data. Duplicate data points were found by calculating the distances on GIS between the closest data points, and then a second cross-check on the site names confirmed whether these points were duplicates. Where there was duplicate data across different sources, this was used to gap-fill any missing information on the mapping tool. For example, all DUKES power station sites were already covered in the DESNZ data, but fuel types and station capacity were included from the DUKES data when available.

1.2.2.1 Estimating quantity of waste heat

Estimating waste heat available from: UK regulator industries data

Several assumptions were used to estimate waste heat from sites included in the UK regulator industries data for Hydrofluorocarbon (HFC) emissions. HFCs are a class of refrigerants found in cooling systems, and the data set publicises large point source emissions for HFCs. These sources would mostly be large cooling systems, which transfer heat from the area being cooled to the surrounding environment.

Data points were only included where it was reasonable to estimate that the quantity of waste heat would correlate with the HFC emissions, and thus only data points where the HFC emissions should correlate with the cooling capacity. There is still a risk that large HFC leakage events would skew some of the data points.

The method used to estimate emissions from the HFC emission used a standard leakage factor of 8% for industrial refrigeration. This implies that per kg HFC emitted, there should be a refrigerant charge of 12.5 kg and at least 37.5 kW of waste heat.[10]

Estimating waste heat available from: NAEI emissions data

Where data was available for both emissions (NAEI) and waste heat, the ratio of kWh of waste heat to emissions was calculated for each sector type. This was then extrapolated to gap fill waste heat availability for NAEI emissions data (where data points were unique to the DESNZ data set, which already included waste heat availability). Since there are many unknown factors there is a risk that emissions do not correlate with waste heat availability, this methodology was only used to categorise the waste heat. The kWh figure estimated by this approach is not reported as this will be highly inaccurate.

Further details of investigating available waste heat from oil and gas sites are shown in the appendix.

1.2.2.2 Grade of waste heat

The grade of waste heat is the temperature of waste heat that is available. There is low confidence in the accuracy of waste heat temperature data, thus sectors are simply classed as high or low grade depending on whether the heat source temperature will need upgrading. The definitions employed in this work for high and low grade waste heat are as follows.

High grade is defined as a source that is unlikely to require upgrading to supply a 4th generation heat network. This is effectively a ‘free’ heat source as no additional energy input is required to upgrade the temperature. As a guideline, at least 60 degC source heat will be needed for a network flow temperature of 55 to 45 degC. Within the data available for the southwest, high grade waste heat includes 20 waste treatment works (incinerators, EfW and MBT) as well as a compressor station site within the Oil & Gas category. High grade heat is often available from industrial process sites, however, there were no high grade industrial heat sources in the data available.

[10] NAEI team expert judgement informed by: HFC Outlook version 6.18, Gluckman Consulting (2020)

Low grade waste heat are sources that will require an upgrade, usually by a heat pump, to supply a 4th generation heat network. This encompasses all other sectors, including the remaining Oil & Gas category sites.

1.2.2.3 Waste Heat Medium

Data was available on waste heat medium from only the DESNZ data set. For the remaining data sources, the waste heat medium had to be assumed based on similar known data sources as well as individual investigations of each sector.

The data provided from DESNZ classified waste heat medium into three types. Where possible the remaining data was also grouped into these mediums:

- Exhaust/hot flue gas;
- Refrigerant;
- Water.

To provide more detailed information on each sector, a ‘Site Type’ field has been added. This includes further subcategories in relation to the sectors; waste treatment works, Oil & Gas and Power Station. The definitions of all site types available will be found in the glossary.

1.2.3 Mapping Heat Demands and Waste Heat

Mapping Key: this shows the appearance of data points when the mapping tool is opened on google earth.

Figure 1 Key for data points shown on the mapping tool.

1.2.3.1 Waste Heat Hierarchy

The data gathered were first assigned priorities, based on the grade and amount of waste heat available. The waste hierarchies for each sector type are included in the layer names of the waste heat data (see waste heat sectors above). On the information associated with each waste heat point on the map, the category will be shown as 'Waste Heat Hierarchy' and 'Low/Medium/High utility'.

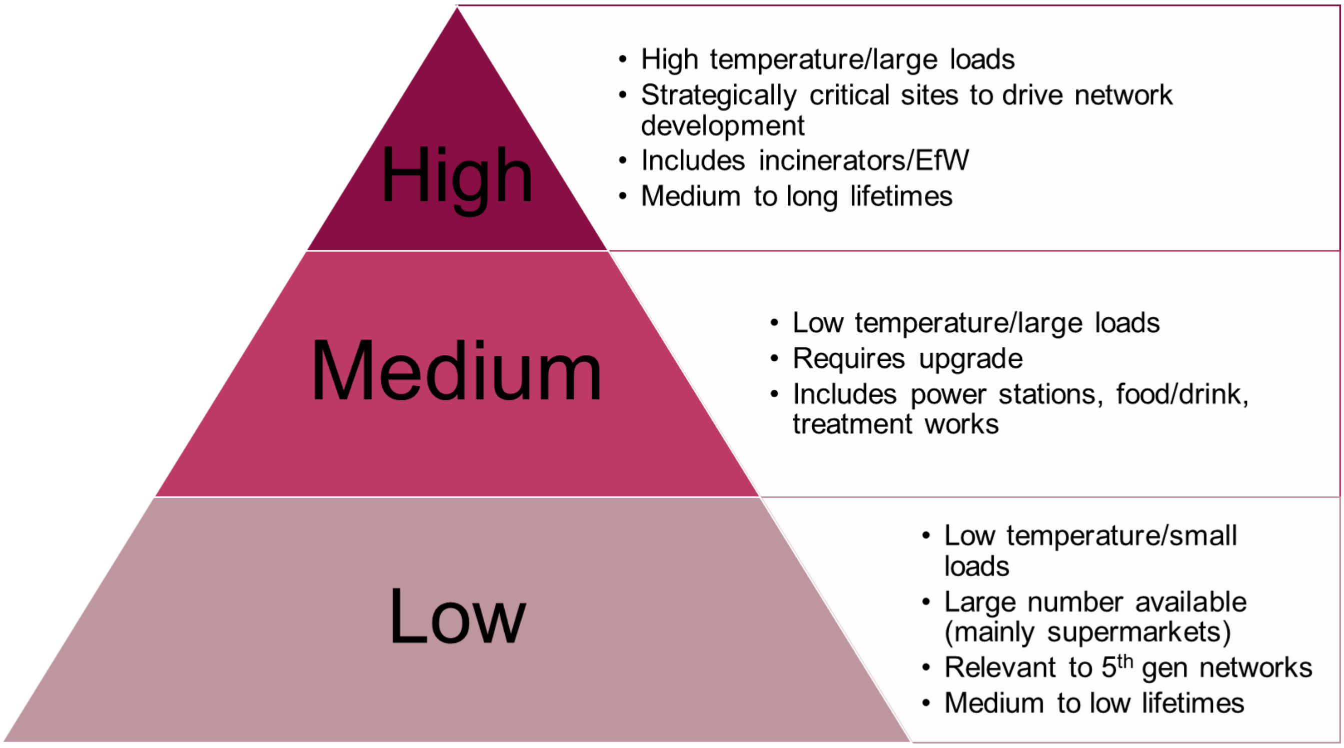


Figure 2 Waste Heat Hierarchy

1.2.3.2 Longevity of Waste Heat Sources

Assumptions were made on the longevity of the waste heat source, based on the site start date or decommissioning date where this was available and the site type. This is included as a data field on each point of the waste heat map. Longevity is graded as high, medium and low confidence that the heat source will be available for enough time to make recapturing the waste heat as part of a heat network viable. More detailed investigation of longevity confidence for power station as well as oil and gas sites are included in the appendix.

1.2.3.3 Heat Demands: Local Area Development Plans

Once waste heat availability had been mapped, the areas of the major waste heat clusters were identified. These were all in the main cities of the southwest. To improve the utility of the map for users, we have included local development planning areas marked in yellow. The planning development areas for Exeter and Plymouth are included on this version of the map. If further planning development areas were added at a later date, this would improve the utility of the map for collocating sources of waste heat with planned areas for development. This provides an opportunity for early intervention, prior to new developments being planned, to design in connections with waste heat sources.

Figure 3 Extract from mapping tool showing local planning development areas of Plymouth in yellow.

1.2.3.4 Heat Demands: Major Heat Users

The NAEI publishes emissions data from large point sources. The ‘commercial’ and ‘public administration’ sectors have been identified from this data as major heat users and included on the mapping, under the ‘Heat Users’ layer in yellow.

1.2.3.5 Heat Networks

Heat network data is obtained from the Heat Network Planning database[11] published in July 2023. This data source details the development status of each network from initial scoping to under operation. These development statuses have been broadly divided into two categories of ‘Pre-Construction’ and ‘Operational/Under Construction’, to create two distinct layers on the map. This will enable the user to easily identify networks that are at an early stage, with the best likelihood of successful intervention to design in the uptake of waste heat in the network. The ‘Pre-Construction’ layer is marked by the pink points on the map and ‘Operational/Under Construction’ sites are orange.

The mapping would be further improved if pipework route data was made available for drawing onto the map. At present the heat network location data are point sources, which limits its utility for assessment of the distance between a potential new user or new heat source to the network.

[11] BEIS 2023: Heat Networks Planning Database, Heat Networks Planning Database - data.gov.uk

1.2.4 Carbon Factor Methodology

To assess the benefits of recovering waste heat for a heat network, we need to take into account the carbon factor for any waste heat source. This can be used to compare the carbon emissions per unit of heat delivered with alternative heating options for a network. Detailed below are methodologies to calculate the carbon factor for the main sectoral waste heat source in the southwest (Energy from Waste) as well as a general methodology for any waste heat source where reusing the heat has no additional carbon impact.

General Methodology

For naturally occurring sources of heat, the carbon factor will depend on the equipment required to convert and upgrade the heat, including pumps, heat exchangers and heat pumps.

As an example, the majority of power station data sources suggest heat can be supplied at 40 degC. To assess the carbon factor, an sCOP should be calculated that considers the electricity for running the heat pump as well as electricity inputs for other equipment to pump the heat to where it is needed.

The carbon factor will be dependent on the efficiency of the heat pump *(sCOP)*, any distribution losses between the heat pump and the heat user (*dist. losses, %)*, any other electricity input required to distribute the heat *(aux. elec kWh)* for example through pumps as well as the electricity carbon factor *(elec kgCO$_2$/kWh).*

$$\frac{kgCO2}{kWh\ heat\ delivered} = (1 + aux.elec\ kWh) * (elec\frac{kgCO2}{kWh})/(sCOP * (1 - dist.losses))$$

Energy from Waste

The carbon factor for high temperature waste heat utilisation from Energy from Waste plants is currently assessed using BRE technical note to the SAP factors (see appendix).

When recovering low temperature condensate, the waste heat is zero carbon, and the carbon factor depends on the technologies used to upgrade and transport that heat. This is because, unlike when heat is extracted as steam at a high temperature, when using the low temperature waste heat there is no coinciding reduction in the efficiency of the EfW power plant. However, each case would need to be investigated depending on the specific plant as there may be technical issues with lowering the return temperatures back to the boiler.

One case study in Sweden[12] uses both steam (high temperature) and condensate (low temperature) waste heat from an Energy from Waste facility. At this site, the low temperature condensate goes through wet scrubbers to extract heat, which is then upgraded via a heat pump.

[12]Sysav's waste-to-energy plant, https://www.sysav.se/globalassets/filer-och-dokument/informationsmaterial-broschyrer-arsredovisningar-faktablad-rapporter-etc/broschyrer-och-arsredovisningar-pa-andra-sprak/heat-and-electricity-from-waste.pdf

1.3 RESULTS

1.3.1 Mapping Heat Demands and Waste Heat

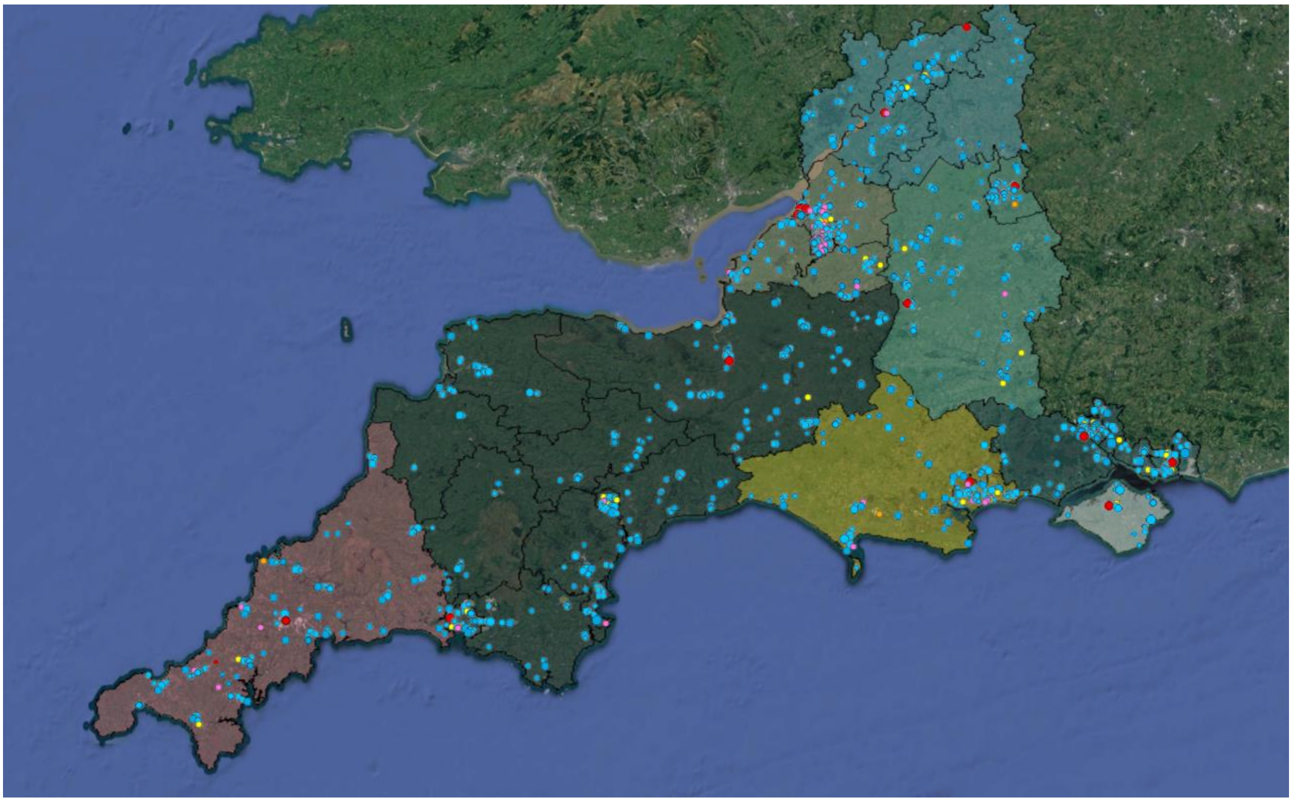


Figure 4 Extract from the mapping tool

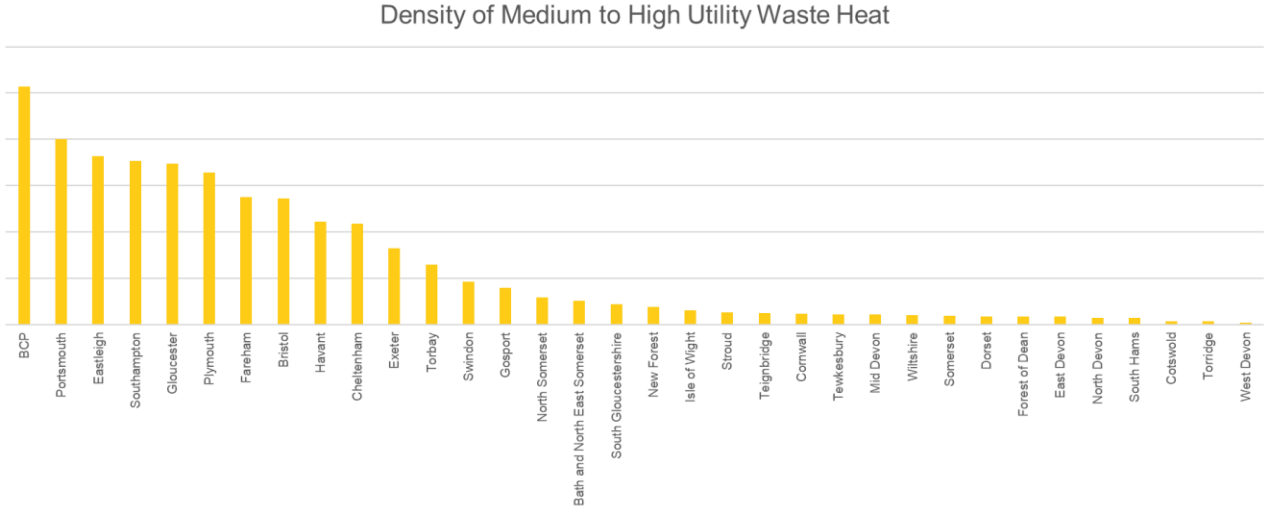


Figure 5 Density in number per m2 of waste heat sites in each Local Authority

1.3.2 Key Opportunities

According to the National Comprehensive Assessment[13] the technical potential of heat networks in the UK is around 20%, with the potential in the southwest estimated at 15%. The spread of population density across the southwest means that there is limited potential for heat networks outside the main city regions.

Where kWh waste heat available was shown in the data, there was a skewed proportion from power plants. This appears to be a key sector for further investigation.

Southampton (New Forest Local Authority)

ESSO's Fawley refinery is large, with ~ 248MW power capacity. There is potential for heat to be supplied to the adjacent GEO specialty chemicals plant. This was previously supplied by a small CHP network (also feeding another now-demolished chemical plant). Therefore, the infrastructure may be partially in place for connecting a new source of heat. While this appears to be technically feasible, each organisation will have its commercial priorities and it is far from certain that an agreement could be arrived at.

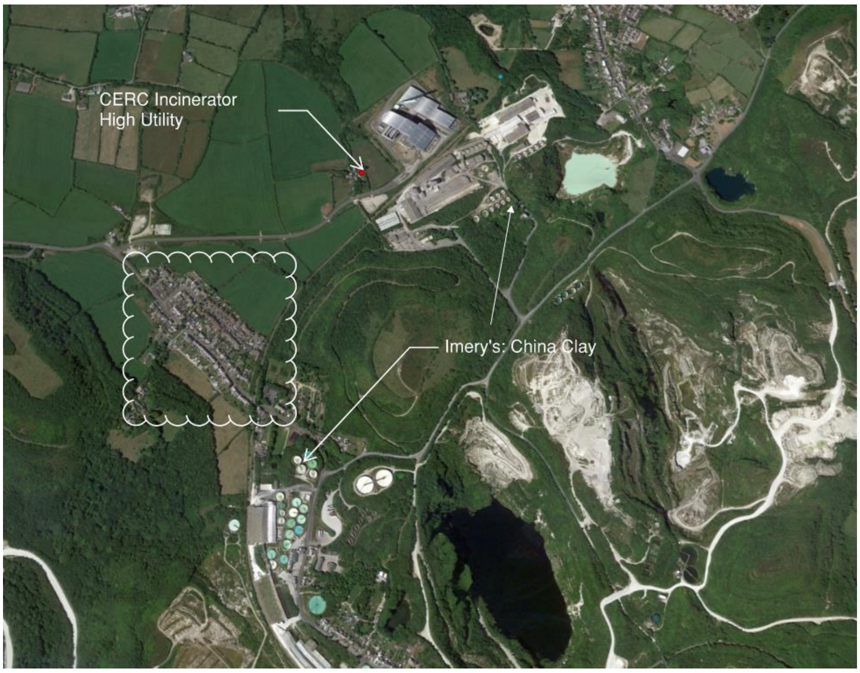
Marchwood EfW power station has a large quantity of high grade heat. This is available either as high grade steam, or as low grade condensate. There is also a sewage treatment works close to this site. The next steps include an investigation into whether there are any large heat users around this site, or across the river, with the potential to act as anchor loads. Southampton local planning authorities should be engaged to understand any plans for development around this area that might serve as a heat load.

[13] National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK

Cornwall (Cornwall Council)

There are many china clay processing sites across Cornwall. At these sites there may be potential for heat recovery from their CHPs, as well as via WSHPs from the water pools used to wash out the clay.

The West Carclaze Garden Village development is located near a china pool site. This development has recently proceeded with a combination of electric heating and air source heat pumps (ASHP)[14]. This would be a useful stakeholder to understand whether the china pools were investigated as a possibility to supply ambient heating, and if so, why they chose not to proceed down this route.



1.3.3 The Future Waste Heat Outlook

It is useful to understand the forecasted waste heat availability. The type and quantity of waste heat available in the southwest region are likely to change over the proceeding decades with the energy transition and associated policies. By anticipating where significant waste heat opportunities are likely to be, efforts can be focused on tapping into these as they become available.

[14] West Carclaze Developer Website, https://lhc.net/projects/west-carclaze-garden-village-st-austell/

1.3.3.1 Overall Picture

Up to now the economic viability of waste heat recovery is often low, due to the availability of relatively inexpensive natural gas in the UK and the high capital costs of recovering this waste heat. The one key element that will impact the business case for reutilising waste heat will be any changes to the counterfactual energy costs. In most of the UK gas is the main heating fuel, so a rise in the cost of gas will improve the business case for reutilising waste heat. The market cost of waste heat is tied to the cost of gas.

There is already policy support for Heat Networks through the Heat Networks Investment Pilot. In addition, there could be a financial benefit to a site that is under the UKETS which is producing waste heat that they are not using. If this heat is sent to a third party and this heat is metered, they can apply with the EA for some additional CO_2 allowances which can be used to offset their scope 1 emissions. This will create a financial incentive for sites with a source of waste heat to export this heat to a nearby heat network.

The price of electricity will also affect the drivers for reutilising waste heat, in particular for high grade heat producers. These have the option of either utilising the heat as heat or generating electricity. If the electricity prices remain high, then this would tip the scale towards generating electricity which the producer could use on site. Where a site does not already generate electricity, the high capital costs of generating electricity from heat mean that in the majority of cases reutilising the heat itself is much more economical.

1.3.3.2 Demand for waste heat

Changing heating and cooling patterns

One notable trend is the reduction in heating demands in new build properties[15], and a widespread increased need for cooling. This may reduce the viability of the connection of smaller loads to district heating.

Increased need for cooling may provide some additional waste heat recapture opportunities where there are significant cooling plants co-located with heating loads. The balance of heating and cooling is essential, especially and we work to decarbonise both elements of heating and cooling. We could look to do this through the deployment of large-scale ambient networks, whereby we can take waste heat from cooling into the ambient network, recirculate that energy and make it useful elsewhere. As increased cooling demand will mostly be over summer months where there is little opportunity to use the waste heat, to maximise the recycling of waste heat, networks can use the ground or aquifer as an inter-seasonal storage mechanism. Rather than taking waste heat and rejecting it to the atmosphere, we take that waste heat and transfer it around a network and make it useful elsewhere.

Integration of waste heat with DAC/CCUS sites

Future potential for the use of waste heat may come from Direct Air Capture or Carbon Capture and Storage sites. As these emerging technologies come online, they will likely be able to leverage waste heat in their processes.

Future heat demand estimates

In the UK the target for heat demand to be met by heat networks is set at around 18-20%, and we were hitting around 2% market penetration in 2018[16]. Estimates of the future potential fall between 10 and 40%[17]. This emphasises the need for strategic planning using heat zoning and mapping tools, like the one associated with this report, to develop networks in the coming years.

[15] The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings
[16] Market Report: Heat Networks in the UK, ADE, January 2018, Heat Networks in the UK_v5 web single pages.pdf (theade.co.uk)
[17] National Comprehensive Assessment of the Potential for Combined Heat and Power and District Heating and Cooling in the UK, 2015

1.3.3.3 Future waste heat types available

To ensure the sustainability of waste heat sources for a district heating network, we must assess which sectors will endure over time. Some processes are integral to any future scenario, giving us confidence in their long-term viability. Consequently, we can reasonably expect sectors with high longevity confidence to include waste-to-energy facilities, biomass plants, and water and sewage treatment sites.

There is also the potential for new types of sites to come online that are not represented in this mapping tool, such as hydrogen production sites or battery farms. Other site types we should expect to see more of include sites related to the grid upgrades required for the energy transition. This will mean new entry points to the grid and transformers (which may need to be cooled) and could become useful sources of waste heat.

We can expect that any fossil fuel-based sites are less likely to be available for waste heat in the long term in their current form. While some sites may remain with the use of different fuels or carbon capture, there is significant uncertainty about long-term waste heat availability. These sectors are fossil fuel power stations, oil and gas sites as well as CHPs.

1.3.3.4 Future outlook of waste heat sectors

Energy from Waste (EfW)

There has been a slight reduction in heat exported from EfW sites in the UK. This was equivalent to 115kWh_{th} per tonne of waste input in 2022. (In 2021 this was 123 kWh_{th} /tn). This heat exported is mainly used for industrial processes and a smaller portion is reused in district heating.

More EfW to operate in CHP mode

The sector with the most high utility waste heat in the southwest is energy from waste. The majority of these facilities are not currently operating in CHP mode, and therefore are not making use of heat as a by-product of electricity generation. In 2021 Defra stated that under ¼ of EfW facilities run as CHPs, and export the heat generated.[18] There are 20 waste treatment works within this data set, so this suggests that around 15 have unutilised potential to export waste heat. According to the main policy for waste in the UK, the 'Resources and Waste Strategy',

> "The gross efficiency of electricity-only facilities is about 27%. Much higher efficiency levels – typically of around 40% – can be achieved if EfW plants harness their heat offtake in addition to generating electricity. Many plants are already CHP-enabled but cannot find a customer for the heat that they produce."[19]

The UK Waste management plan intends to increase the number of EfW plants that operate in CHP mode.[18] This plan has also supported the development of a mapping tool that provides detail on EfW facilities and their heat offtake specifications.[20]

New EfW plants to come online

Tolvic[21] reports each year on Energy from Waste data collected in Annual Performance Reports submitted by operators. Their reporting has shown only two EfW sites that are in either construction or commissioning, in Somerset and IoW.

[18] Defra 2021 Waste Management Plan for England, Waste Management Plan for England (publishing.service.gov.uk)
[19] Resources and waste strategy for England - GOV.UK (www.gov.uk)
[20] Environmental Services Association, EFW Heat Network Prospectus (esauk.org)
[21] 'UK Energy from Waste Statistics -2022', Tolvik consulting, UK Energy from Waste Statistics - 2022 - Tolvik

Name	Location	Developer	Capacity (ktpa)
Isle of Wight EfW	Isle of Wight	Thalia	30
Bridgwater Resource Recovery	Bridgwater Somerset	Equitix/Iona	123

Table 3 EfW plants reported by Tolvic being in the construction or commissioning phase in the southwest

The report shows that the UK's EfW operational capacity has been gradually increasing since 2014, and this gradual increase is forecast to continue. However, the majority of this forecast capacity is likely to be outside the southwest region. The southwest only represents 3% of the capacity of sites in construction or commissioning in 2022.

Energy from Sewage (EfS)

There are 258 Sewage Treatment Works (STW) sites in the associated modelling tool data set. As this is low grade heat there has historically been techno-economic challenges for reutilising this type of heat. As waste heat recovery technologies mature, and are more effective at recovering low grade heat, EfS is likely to become an increasingly viable option for heat networks. There may be an increase in this opportunity type considering recent headlines suggest that the southwest is in need of new wastewater treatment sites.[22]

Nuclear

There is a potentially large source of free waste heat that will become available once Hinckley C is online. When this facility is operational it will reject heat to seawater. This heat is from the condensing of the steam produced from heat in the reactor and contains low grade heat that needs to be discharged. Timescales for this project are uncertain, but some recent reports suggest an anticipated completion year of 2027. The facility is not co-located next to any heat demand clusters, so it is unlikely to offer many opportunities for heat networks unless a local network is created for heating their onsite buildings.

Hydrogen Production:

Low carbon hydrogen 'will play a key role in the move toward net zero'.[23]There may be industries where it is beneficial to produce hydrogen on-site for use. For example, at airports, large chemical plants and additionally at ports if it is used as a fuel for shipping.

A 2021 study suggests that UK Hydrogen could produce 141TWh of waste heat by 2050.[24] For green hydrogen production using electrolysis, waste heat temperatures can vary between 40 to 80 degC. The other main method of producing hydrogen is via the steam methane reformation process. The same study cites that the main heat recovery opportunities from steam methane hydrogen production are from its auxiliary processes, such as compression and carbon capture. These would provide waste heat at around 35 degC, which would need upgrading to supply heat networks.

[22] https://www.theguardian.com/environment/2023/apr/27/south-west-water-fined-215m-for-dumping-sewage-in-sea-and-rivers
[23] Future Energy Scenarios | ESO - National Grid ESO
[24] Ministry of Foreign Affairs of Denmark: Heat recovery from hydrogen production

1.4 RECOMMENDATIONS

1.4.1 Next steps

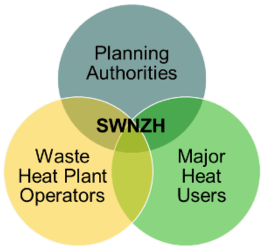


Figure 6 Key stakeholders

There is an opportunity for the SWNZH and local authorities to enable connections to be made between heat users and potential waste heat providers. They are in a position to act as a catalyst for the development of projects using waste heat. The hub and local authorities are trusted intermediaries who can make introductions between businesses, investors and developers. The hub can also advise organisations on the funding opportunities available.

Waste heat projects are most likely to be viable for new developments or substantial reinvestment efforts aimed at decarbonizing existing sites. During the planning phases of such projects, either the SWNZH or local authorities could be a point of contact. In this context, either the hub or LAs can leverage this mapping tool and engagement with third parties to spot and actively promote opportunities for reutilising waste heat in heat networks.

Outside this scope of work is looking into the natural sources of waste heat in the southwest region. It is recommended as a next step to investigating the level of heat recapture opportunity available from geothermal[25] and water sources in the region. This will highlight further renewable heating opportunities available for heat networks planned in the region, as well as potential blended opportunities with waste heat and natural heat sources.

Another sector not fully resolved in this scope is understanding waste heat opportunities from data centres. Data centres traditionally provide low temperature waste heat but advances in cooling technologies such as liquid cooling may allow much higher temperatures to be recovered.[26] Follow-up work should include investigating data centre locations, to determine where any are co-located with significant heating loads.

Actions for SWNZH

- Further investigation would be required to confirm where any identified opportunities are already being progressed, or where waste heat is already used on site. This will enable the shortlisting of priority sites that don't have the potential to use their own waste heat. The data provided for this tool has not accounted for sites where waste heat is already reutilised.
- Engage with the main local power stations in the southwest region to understand their plans through the energy transition, and how this will impact waste heat available.
- Engage with operators of the 16 high utility category EfW sites.
- Identify areas where permits have been granted to include within mapping in the future. It would be useful to strengthen relationships with planning authorities as well as the environment agency. This will enable the hub to continue to collect data on planned new developments, as well as be the first to know when any new discharge licences (for heated water) or waste incineration permits are granted.
- Stay informed of new funding opportunities.
- Continue building relationships with the different entities that may become part of a waste heat/district network opportunity.

[25] The-case-for-deep-geothermal-energy-—-unlocking-investment-at-scale-in-the-UK.pdf (northeastlep.co.uk)
[26] https://www.alfalaval.co.uk/media/stories/data-center-cooling/cooling-server-rooms/

1.4.2 Stakeholder Engagement

Alongside this report, a stakeholder list has been provided for the SWNZH to jumpstart the process of acting on the recommendations associated with this study. The key part of unlocking project opportunities will be starting to make those connections and getting third parties in a room together. The main list of stakeholders includes the sites classified as high utility on the waste heat hierarchy, as well as the major power stations that will have a high quantity of waste heat and other key stakeholders such as relevant planning bodies.

Case studies & learnings

In addition to the contacts listed in the associated stakeholder document, the hub should take advantage of lessons learnt from other projects in the region where waste heat is being reutilised.

- Plymouth is currently in the planning stages of building out a network to utilise waste heat, connecting to a number of sources including their EfW facility in Devonport.
- Bath and North East Somerset Council have used hot springs waste heat from Roman baths to heat the historic complex.[27]
- Bristol City Council is connecting its network to the Avonmouth EfW plant.
- A geothermal plant has recently been connected to the Eden Project. This could be a helpful stakeholder for insight in constructing large-scale innovative heating in the southwest. The hub may even be a useful intermediary to support the connection of further heating load clusters to the existing geothermal.

Transport and port authorities

To take advantage of the potential benefits of reutilising waste heat from hydrogen production, the production facilities need to be co-located near significant heat demand clusters. Therefore, it would be useful to engage with stakeholders likely to be interested in Hydrogen production as well as local planners. This would enable SWNZH to play a role before new plants are set up to influence site selection for maximising the potential reuse of heat.

The types of stakeholders relevant to this type of opportunity include airports (Bristol, Southampton, Exeter, Cardiff, Plymouth, Newquay) and ports (Bristol & Plymouth). For relevant case studies, and to understand lessons learnt it would be useful to engage with the project team working on the Port of Rotterdam hydrogen facility. This project includes plans to supply the waste heat to local heat networks.[28]

[27] CIBSE Taking the waters: recovering heat from the Roman Baths – CIBSE Journal
[28] Hydrogen in Rotterdam | Port of Rotterdam

APPENDIX 1 CARBON FACTOR METHODOLOGY

Energy from Waste – High Temperature

When waste heat is recovered from an EfW facility we are reducing the efficiency of the system to generate electricity. If you consider that the EfW site's primary function is to burn the waste, then the carbon accounted in reusing that heat is based on the reduction in electricity produced.

Therefore, for each plant, a 'Z factor', or heat to electricity ratio needs to be determined. This is ratio of how many units of heat generation are gained by decreasing electricity generation by one unit. The ratio will depend on the source temperature at which heat is extracted. The higher the source temperature, the higher the trade-off for a reduction in electricity produced. This is the only method referenced in the literature which using SAP 2012 (including 2012 grid electricity factors) and a Z factor of 10, gives a CF of 0.058kgCO2/kWh.[29] As a comparator the BRE methodology is applied using the greenbook[30] grid average carbon factors in the table below. The 10 and 20-year average are using the average electricity factors from 2023 to 2033 and 2043.

Electricity Carbon Factor	EfW Carbon factors (kgCO2/kWh)
SAP 2012	0.51
10-year av. (2023-33)	0.15
20-year av. (2023-43)	0.09

Table 4 EfW carbon factor for high temperature waste heat.

However, since 2013 any new EfW plants above a certain threshold must be set up as CHP ready, '*the Environment Agency would expect the use of CHP to be considered and implemented (wherever practicable)'*.[31] Then it could be considered that if the EfW plants are being consented as CHP plants, then the carbon should be calculated using the CHP methodology, which would require a bespoke carbon factor for each plant dependent on the make-up of waste incinerated. At this point however, the only published carbon methodology is linked to the electricity carbon factor as above.

Energy from Waste – Low Temperature

You may also be able to recover low grade heat from an EfW facility without degrading the electrical output. If this approach was preferred, then the carbon intensity would be based on the sCOP for upgrading this heat to a usable temperature.

Power Stations

Calculating the carbon factor for waste heat from power stations will depend on many factors specific to each power station. For example, if a Combined Cycle Gas Turbine (CCGT) operates normally, the waste heat is very low grade (30-50 degC) vapour from cooling towers. This would need to be upgraded by heat pumps for most uses. If waste heat is extracted from the turbine at high temperatures, it would reduce the amount of power generation. This would require the steam turbine to be 'CHP ready' and would avoid the need for heat pumps.

[29] BRE technical note – Modelling Energy from Waste Facilities, BRE_Technical_Note-Energy_from_Waste_Facilities_(ERF)_1.0.pdf (bregroup.com)

[30] Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal, Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK (www.gov.uk)

[31] Environment Agency (2013) - CHP Ready Guidance for Combustion and Energy from Waste Power Plants, Heading 1 (publishing.service.gov.uk)

APPENDIX 2 SPECIFIC DATA POINT INVESTIGATIONS

Estimating waste heat available from: NAEI emissions data for oil and gas sites

For the oil and gas sector, there were no waste heat kWh data in any data sets as this sector was not present in the DESNZ data. Therefore, each of these sites were investigated individually. These are briefly described below.

- The two oil field sites at Wareham and Wytch Farm Dorset have been in operation since the 1970s and have permits to extend to 2037. The Wytch farm site already takes advantage of some heat recovery from their gas cycle turbines, as their exhaust stacks include waste heat recovery units. There is also some refrigeration on site which may also present an opportunity for heat recovery.
- Wormington compressor station has a good lifetime confidence. It is expected to be in operation until 2049 as is a critical part of the gas distribution grid. Further investigation is required to determine the amount of waste heat available from this site. Improved efficiencies in the compression process may reduce the amount of waste heat available over time. Some compressor stations are able to reutilise their waste heat on-site.
- ESSO's Fawley refinery is very large with a 248MW power capacity. The refinery was commissioned in 1951 and Hythe gas works (this is the name of the site shown on the mapping) was commissioned in 1964. In its 'unfired mode', the waste-heat boiler produces steam without needing an external heat source, essentially using leftover heat from another process. At Fawley refinery in this mode, 150 tn/hr of high-pressure steam and 65 tn/hr of medium-pressure steam are produced. There is also a CHP unit on site.[32] In 2013 they installed a new boiler to use hot flue gases.

[32] CHP unit on line at Esso's Fawley refinery | Oil & Gas Journal (ogj.com), https://www.ogj.com/home/article/17215385/chp-unit-on-line-at-essos-fawley-refinery

Estimating longevity confidence and waste heat available from power stations:

As the largest quantity of heat in the southwest is available from power station sites, it was deemed appropriate to investigate these sites individually to provide more granularity on their longevity as well as further details of each plant for the tool.

- Avonmouth, Enersyst Limited

  This is a STOR (Short Term Operating Reserve) facility. Facilities like these meeting demand response needs of the national electricity grid may be unreliable sources of heat.

- Taunton, Hele Manor Limited

  An investment website states that this is a 20MW gas-fired electricity generation station which was incorporated in 2016.

- Bradon Farm Power Station, UK Power Reserve Ltd

  Bradon Farm Gen (Cantelo Nurseries) is a gas power plant operated by UK Power Reserve Limited with a total output of 9.70 MW.

- Peak Gen Southampton, W4B Renewable Energy Ltd

  There is limited information available regarding this power station. Since this is a renewables company that owns biomass plants, this site may have a biomass boiler with waste heat availability. Further research is required to determine technology type, and whether there are any waste heat opportunities.

- Gloucester, UK Power Reserve Ltd

  Let to UK Capacity Reserve Limited from 12th May 2015 and expiring on 11th May 2040 with a tenant's break clause on 31st December 2033.

- Fareham

  This is an IFA2 (Interconnexion France-Angleterre 2) project connecting the UK electricity network to France. This is a converter station for converting electricity between DC and AC. There will be some cooling required in this process for the heat that is generated, which may provide a useful waste heat source. However, improvement in efficiencies of this technology is likely to reduce the amount of waste heat extractable.

APPENDIX 3 GLOSSARY & ABBREVIATIONS

Abbreviations

BRE	Building Research Establishment
CCGT	Combined Cycle Gas Turbine: A power generation technology that uses both gas and steam turbines to maximize energy efficiency and electricity production.
CCUS	Carbon Capture, Utilisation and Storage
CHP	Combined Heat and Power
DAC	Direct Air Capture: The removal of emissions directly from the atmosphere.
DESNZ	Department for Energy Security and Net Zero (formerly BEIS)
DUKES	Digest of UK Energy Statistics
EPC	Energy Performance Certificate
EfW	Energy from waste: The controlled combustion of municipal waste or products derived from municipal waste in specialised plants specifically to generate power and/or heat from waste feedstock.
GHG	Greenhouse Gas
GIS	Geographic Information System: This has been used to visualize geographic data in the southwest as part of this project.
HFC	Hydrofluorocarbon
HP/MP steam	High and Medium-pressure steam.
KML	Keyhole Markup Language: An XML-based file format used for displaying geographic data in 2D and 3D maps, which is associated with Google Earth.
LSBU	London South Bank University
MBT	Mechanical Biological Treatment: A mechanical and biological process that treats mixed municipal solid waste.
NAEI	National Atmospheric Emissions Inventory
RRC	Resource Recovery Centre: A facility where waste materials are processed and recovered for reuse or recycling.
SAP	Standard Assessment Procedure: A method used to calculate the energy efficiency and carbon emissions of buildings.
STOR	Short-Term Operating Reserve: A service provided by power plants or other facilities to quickly respond to fluctuations in electricity demand, helping to maintain grid stability.
STW	Sewage Treatment Works

Glossary

Converter station	This converts electricity from AC to DC for efficient transmission across the grid network.
Incinerator	A facility for burning waste materials at high temperatures.

APPENDIX 4 GUIDANCE FOR USING THE MAPPING TOOL

The mapping tool is made available in GIS formats (such as ArcGIS), and as a KML file which will open directly onto Google Earth.

To open the KML file Google Earth must be downloaded as an application on your machine.

The image below shows the colour codes of points shown on the mapping tool when viewed through google earth.

Figure 7 Key for data points shown on the mapping tool.

<u>Functions available on Google Earth:</u>

Find the distance, between any two sites on Google Earth:

On Google Earth select Tools > Ruler > Line, then select any two points on the map and the distance will be calculated. If the path option is selected after the ruler, this will allow the distance of a specified path to be calculated which could be helpful for indicative pipework routes.

Create shapes:

Another useful function of Google Earth, which might help demarcate areas of interest or heat network zones, is the ability to draw boundaries or shapes onto the mapping tool. To do this add a polygon by selecting Add > Polygon, then click on the map to create the first point of your boundary. Continue to outline your boundary and double-click to complete the shape. This polygon will appear on the left-hand side and can be renamed or saved for later use.

<u>Interactive Data Point Details</u>

Once any point is selected an information pop-up will appear providing additional data for that site. The tables below show all of these additional data fields that appear for each site type.

1. *<u>Waste heat source sites:</u>*

The following field types are included in the pop-up when waste heat data points are selected (the blue and red points on the map). Not all fields have information populated for each data point. The heading of each pop-up will show the site name for that data point.

Field as shown on map	Details
FID	This is a unique code associated with all GIS data points.
Grade of Heat	Classed as low or high grade. High: High grade heat will not require upgrading to reach temperatures suitable for 4th generation heat network. These points are red on the map. Low: Low grade heat will require upgrading to reach the temperatures required. These points are blue on the map.
Qty Heat Availability	Quantity of heat available from the waste heat source: classed as low, medium or high. The size of the data point also reflects the quantity of heat available. High = >40GWh heat available Medium = <40GWh & > 2GWh Low = < 2GWh
Sector	See Waste Heat Sectors section for a description of each waste heat sector type. The full list of sectors is as follows: 1. Chemical industry 2. Food and drink 3. Mineral industries 4. Supermarkets 5. Waste treatment works 6. Sewerage treatment works 7. Power station 8. Paper, printing & publishing industries 9. Data Centre 10. Oil & Gas 11. Mine Water
Waste Heat Hierarchy	Classified as Low, Medium or High Utility based on the priority assigned to the waste heat source for a heat network. Further detail is found in the Waste Heat Hierarchy section.
Medium	Where available, this shows the medium of waste heat available for extraction. This will fall into one of three categories: • Exhaust/hot flue gas • Refrigerant • Water
Longevity	Longevity is graded as High, Medium or Low confidence that the heat source will be available for enough time to make recapturing the waste heat as part of a heat network viable.
Site Name	The name of the site is also shown on the heading of the additional information pop-up.
Water Temperature (°C)	The temperature of the water recovering heat from the medium of each source at the assumed source temperature.
Average estimated heat output (kW)	Average heat output from the source in kW.
Annual estimated heat capture (kWh)	Total amount of heat rejected by the source.

Field as shown on map	Details
Operator	Organisation operating the waste heat site.
Type	Some site data has further detail on the site type. This detail includes. 1. AGR (Advanced Gas-cooled Nuclear Reactor) 2. CCGT 3. Chemical 4. CHP 5. Converter Station 6. EfW 7. EfW Incinerator 8. Incinerator 9. MBT Incinerator 10. Oil & gas exploration and production 11. Power station 12. Processing & distribution of natural gas 13. Processing & distribution of petroleum products 14. Single cycle 15. STOR 16. STW 17. Treatment works
Primary Fuel	The main fuel type at that site, such as waste, natural gas or diesel.
Installed Capacity (MW)	Electrical capacity for power station sites only.
Year Commissioned	The initial year that the waste heat source site was commissioned.
Data Source	The original source for the data point.
Address	Address
Postcode	Postcode
Amount	GIS code representing Qty Heat Availability
LA_Area	The Local Authority area that the data point sits in.
LEP_Area	The Local Enterprise Partnership area that the data point sits in.

Table 5 Waste Heat Sources: Site information associated with each data point.

2. *Heat Network Planning Sites:*

The following table shows the field headings visible when the heat network planning data points are selected, the pink and orange points on the map. The heading of each pop-up shows the heat network site name. These fields are the same as are included in the source data, the heat networks planning database.

Field as shown on map	Details
Operator (or Applicant)	Name of operator or applicant.
Site Name	Name of development site.
Number of customer connections	How many customers will be connected to the Heat Network?
Number of buildings	How many buildings will be connected to the Heat Network?
Types of buildings	What types of building sectors will be connected to the Heat Network?
Technology Type	Type of technology (e.g., Gas Fired CHP, Air Source Heat Pump).
Secondary plant technology	A second type of technology (e.g., Gas-Fired CHP, Air Source Heat Pump).
Third plant technology	A third type of technology (e.g., Gas-Fired CHP, Air Source Heat Pump, etc).
Backup plant technology	A back-up technology type to support the main technology types.
Installed Capacity (MWelec)	Installed electrical capacity in megawatts (MWe).
Installed Generation Capacity	Installed thermal capacity in megawatts (MWth).
Primary Fuel type	The fuel type used for the Heat Network (e.g., Gas, Electric, etc).
Heat Source	The heat source supplying heat to the network (e.g., Mine water, Heat from Energy from Waste plants).
Temperature of heat supply (Celsius)	The temperature of the heat supply.
Cooling Enabled	Is the project capable of cooling output.
CHP Enabled	Is the project capable of combined heat and power output.
Length of distribution network (m)	What is the length of distribution network.
Development Status	• Scoping • Pre-Planning • Planning Application Submitted • Planning Permission Granted • Under Construction • Operational
Layer	The Heat Network Development data is divided into two layers. • Operational/Under Construction (orange data points on the map) • Pre-Construction (pink data points on the map)
Post Code	Post Code
X-coordinate	X-coordinate
Y-coordinate	Y-coordinate

Table 6 Heat network planning areas: Site information associated with each data point.

3. Heat User Sites

The following table shows the field headings visible when the heat user data points are selected, the yellow points on the map.

Field as shown on map	Details
FID	This is a unique code associated with all GIS data points.
Site	The site name.
Operator	The site operator.
Emissions/ tnCO2	Emissions published in the NAEI data for the site.
Easting	Location data.
Northing	Location data.

Table 7 Heat Users: Site information associated with each data point.

LA and LEP areas

The Local Authority and Local Enterprise Partnership regions are shown in two different layers on the map named 'SW_districts' and 'LEP areas'. These can be toggled on and off. The LEP areas appear as coloured regions, whereas the LA districts are shown as boundaries marked by a black line.

LEPs	LAs
1. Cornwall & Isle of Scilly 2. Heart of South West (HoSW) 3. Dorset 4. Solent 5. Swindon & Wiltshire 6. West of England Combined Authority & LEP 7. Gfirst	1. Bath and North East Somerset 2. BCP 3. Bristol 4. Cheltenham 5. Cornwall 6. Cotswold 7. Dorset 8. East Devon 9. Eastleigh 10. Exeter 11. Fareham 12. Forest of Dean 13. Gloucester 14. Gosport 15. Havant 16. Isles of Scilly 17. Isle of Wight 18. Mid Devon 19. New Forest 20. North Devon 21. North Somerset 22. Plymouth 23. Portsmouth 24. Somerset 25. South Gloucestershire 26. South Hams 27. Southampton

LEPs	LAs
	28. Stroud 29. Swindon 30. Teignbridge 31. Tewkesbury 32. Torbay 33. Torridge 34. West Devon 35. Wiltshire

Table 8 Full list of Local Authority and Local Enterprise Partnership regions in the South West Net Zero Hub