Appendix A - District Energy Networks

How do we Decarbonise?

While the UK has made considerable progress in cutting emissions over the last three decades (emissions in 2018 were down 40% vs.1990), the majority of this progress has been achieved in the electricity and waste sectors. These sectors have relatively few participants and these stakeholders have been able to implement improved technological solutions at scale, as large assets come to the end of their life. This has been supported by a policy framework which has allocated the costs to consumers.

While the power sector has made significant progress towards decarbonisation, other sources such as transport and heat, still have much to do. With over 30% of Carbon emissions associated with heating the UK building stock, it is essential that this issue is tackled.

Progress in decarbonising how we heat the UK's buildings has been slow. The scale of the challenge is complicated due to the number of stakeholders and the number of competing technological solutions.

To address this in new build properties, government announced phasing out of gas boilers starting with new homes from 2025. The next update to building regulations is also focussing on either heat pumps or heat networks as a solution.

Analysis by central government and the Committee on Climate Change shows that meeting the UK's Climate Change targets will see around 20% of the nation's homes getting their heat from a heat network and so the UK will see substantial expansion of heat networks over the next 30 years.

Heat Networks, or District Energy Networks (DENs), are local, decentralised energy infrastructure. Due to their geographic reach, they are able to tap in to, and harness energy from otherwise wasted sources of heat and distribute it to a wide area.

It is important to understand predictions for the future energy mix and not just the future of heat. Due to the rapidly decarbonising electrical grid, many heating systems are looking to use electricity. However, with other sectors, such as transport, also expected to increasingly rely on the national grid, there will be an increasing amount of pressure on our national infrastructure.

What is a District Energy Network?

The standard approach to providing energy to buildings in the UK is relatively inefficient. Heat and cooling are usually generated at a building scale typically with gas boilers for heating and chillers or air conditioners for cooling, limiting the use of low and zero carbon technologies. Electricity is usually generated at power stations that are remote from the point of use, leading to inefficiencies from wasted heat produced in the generation process and the losses associated with transmission. District Energy Network (DEN) offers an alternative to this arrangement, generating and distributing heat and /or cooling to a number of buildings in an area and, depending on the generation equipment, also producing electricity locally. Generation plant, which is located in a centralised location, generates hot water and /or chilled water which is then distributed via underground highly insulated pipework to the connected buildings.

Instead of individual boilers, each building has a heat interface unit (HIU) which transfers heat from the network to a local building distribution system. Schemes can range in size from simply linking two buildings together, to spanning entire cities. In some countries the use of district heating is widespread – in Denmark around 60% of the country's homes are connected to heat networks, including a scheme which supplies the whole of Copenhagen. For power a local 'private wire' electricity network is installed to connect the generator to customers; this type of generator to customer connection avoids national, regional and/or local transmission and distribution infrastructure and the associated costs.

Generating and distributing heat at a district scale allows lower carbon forms of heat generation to be used which would not be viable at a building scale, including the capture and delivery of waste heat from power generation, energy from waste, or the transition to technologies such as combined heat and power engines and heat pumps.

The figure below helps illustrate the structure of a typical heat network, identifying some of the key terminology used throughout the report.

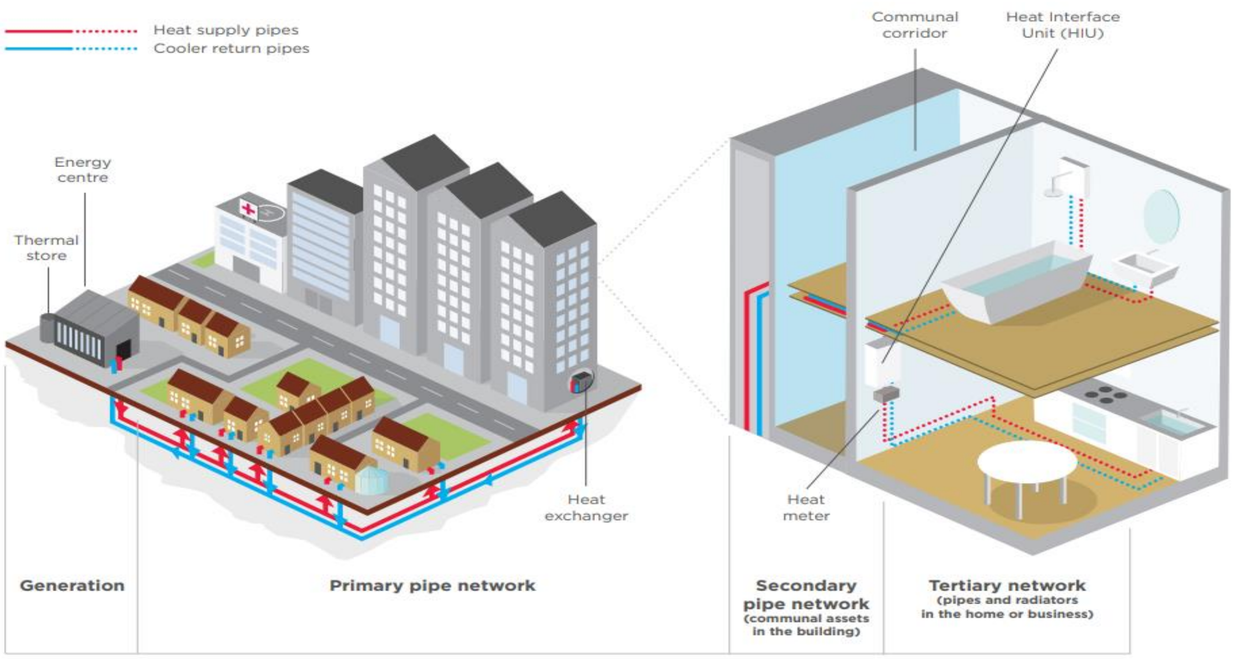

Figure 1: Illustration of a Typical District Heat Network[1]

District Heating Network (DHN)

District Heating Network (DHN) is the distribution of thermal energy (Low Temperature Hot Water (LTHW)) from a central source to a number of different buildings where it is used to provide space heating and hot water.

Where buildings have conventional wet heating systems, connection to district heating can be straightforward. Potentially only minor changes to the building's secondary side distribution systems are necessary; the existing boiler could be removed or decommissioned and replaced with a heat interface unit (HIU) which transfers heat from the DH Network (DHN) to the local building distribution system. Compatible temperatures and operating regimes however do need to be established.

Energy Generation Technologies

There is a wide range of low and zero carbon (LZC) energy technologies that can be deployed in a district energy network. The LZC energy generation technology (also known as primary energy source) is usually accommodated within the energy centre and is typically designed to supply 75-92% of the annual heat demand, with the remaining heat demand being provided by top-up/back-up gas boilers. The LZC plant is further supplemented by thermal storage which allow the output from the LZC plant to be optimised.

The following LZC generation technologies can be applicable to district heating, depending on the location in question:

- Gas fired combined heat and power (CHP)
- Biomass or biofuel fired CHP
- Energy from waste
- Anaerobic digestion
- Biomass and biofuel boilers
- Deep geothermal
- Air, water and ground source heat pumps
- Solar thermal

[1] Source of Image: https://www.theade.co.uk/resources/what-is-district-heating

The choice of heat generating technology that is employed in a network depends on a number of technical, financial, environmental and deliverability factors.

Areas with large concentrated heat loads present significant opportunities for the installation of a DHN. High heat density areas are made up by groups of buildings and/or a single, or collection of anchor load(s). ‘Anchor’ heat loads are deemed to be buildings (or a group of buildings in an estate, e.g. hospital) that comply with one or more of the following criteria:

- Buildings with a high level of heat consumption (e.g. hospitals and care homes);
- Buildings with a stable, constant and predictable level of year-round heat consumption (e.g. swimming pools); and
- Buildings over which the Council has a high degree of control or influence to support the connection to a DHN, since it is often easier to secure customers for a DHN if there is consent from related institutions.

Distribution Network

Heat distribution pipework consists of a pair of pipes, one carrying the flow water from the Energy Centre to the consumer at temperatures of around 60°C to 85°C and the other pipe carrying the return water after the heat has been extracted, the return water temperature is normally between 40°C and 60°C. The pipes used in DHNs comprise of an inner carrier pipe of either steel or polyethylene. These inner pipes are contained within a larger plastic pipe with the intervening volume filled with foam insulation. Pipes can be either single (Figure 2A) or twin pipes (Figure 2B). Twin pipes combine the flow and return pipes within a single outer pipe.

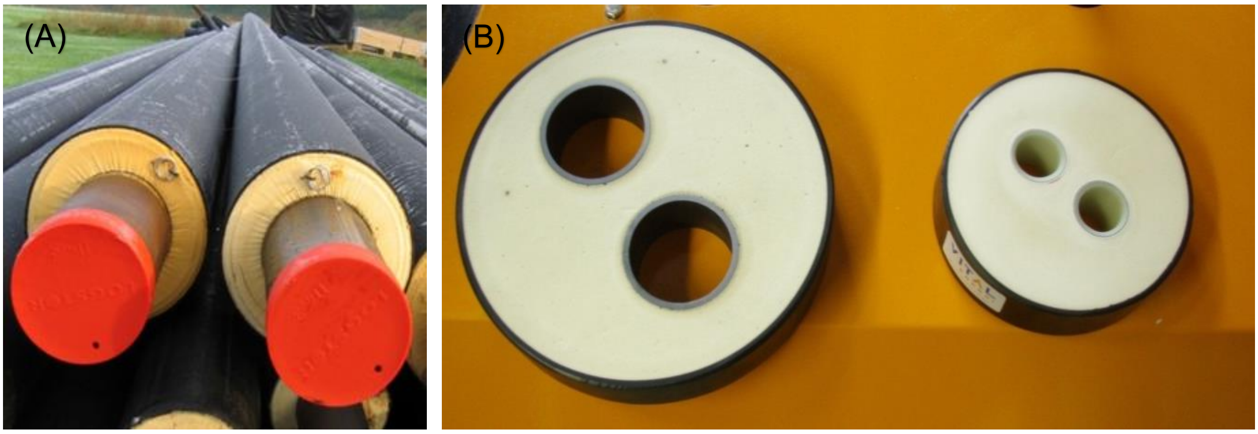

Figure 2: Examples of Pre-Insulated DH Pipework: (a) Steel Single Pipe (b) Plastic Twin Pipe

District Cooling Network (DCN)

District Cooling Network (DCN) is distributed in the form of chilled water through a network of insulated pipes to different buildings to supply demand for cooling. Chilled water (typically 6°C flow/12°C return) is used in central cooling units such as air handling units, or in local units such as fan coil units or chilled beams. Chilled water can be generated in different ways: through conventional electrically driven vapour compression chillers; or via absorption (i.e. heat-driven) chillers. Both of these could be utilised in providing DC services.

Private Wire Network (PWN)

Combined heat and power (CHP) or cogeneration technologies refers to the simultaneous generation of heat and electricity from the same process. The lower carbon electricity generated by the CHP is distributed via an underground private wire network (HV Cables) and used to supply a number of connected customers along the heat network. Any surplus electricity generated (not required by the buildings connected) is exported to the grid, providing an additional revenue stream.

The private wire network is usually routed to follow the same course as identified for the district heating pipework and is installed within the same trenches, however the private wire network may be less extensive serving a smaller number of buildings selected on the basis of magnitude of electricity demand and ownership.

What are the Benefits of a District Energy Network?

District Energy Network offers a number of environmental and economic benefits over the conventional energy generation/supply. Key benefits include:

- **CO_2 emissions reductions** – the combination of more efficient generation and the ability to use alternative technologies and fuels means that district energy network will provide significant CO_2 reductions.
- **Opportunity to build a revenue stream** – The sale of energy to local users can be a sustainable source of revenue. This revenue can attract investment from the private sector, who could transfer some, or all, of the financial risk of projects from the public sector.
- **Emissions reductions in hard-to-treat buildings** – where retrofitting fabric improvements to existing stock is challenging (e.g. for listed buildings), district energy provides an alternative method by which to reduce CO_2 emissions.
- **Reduced environmental taxes** – policies such as the Carbon Reduction Commitment (CRC) and the EU Emissions Trading Scheme place a value on CO_2 emissions (effectively a carbon tax). It is expected that the effect of such policies may increase in future as the pressure to reduce emissions increases and the cost of emitting CO_2 rises.
- **Reduction in energy prices** – increased efficiencies can lead to reduced energy costs for customers. This can mean improved competitiveness for local businesses and reduced energy bills and the alleviation of fuel poverty for households.
- **Alleviation of fuel poverty** – in some cases district energy networks can offer special lower tariffs to households at risk of being in fuel poverty. The cost of offering reduced tariffs may be offset by increasing prices to other customers or by using other income streams to provide a subsidy.
- **Energy security** – the higher efficiencies combined with the ability to provide alternative forms of heat generation means that DENs can increase energy security and reduce reliance on third party energy suppliers.
- **Local dividends** – profits from the sale of energy from district energy networks may accrue to local authorities, communities, and/or businesses when they are stakeholders, rather than wholly to national or international businesses.
- **Local economy** – the construction and operation of a network can create employment opportunities and opportunities for local businesses to be involved in the supply chain.

Glossary

Name	Description
DEN	District Energy Network: includes district heating, private wire, and possible district cooling
DH(N)	District Heating (Network): a system where a centralised heat generating plant (using any one of a range of technologies) provides heat to surrounding buildings in the area by means of a network of insulated pipes carrying hot water or steam.
Energy Centre	Location of the energy generating plant for a district energy network.
LZC Technology	Low Zero Carbon Technology. The LZC technology is usually deployed as the primary energy source of the district energy network.
Thermal Store	Thermal Stores are large vessels which store hot water – these maximise the output from the LZC heat source by storing energy when there is low demand. Generally, only the LZC plant is utilised to charge the thermal store. Thermal Stores are commonly located within or just outside the Energy Centre near the LZC plant; however, they can also be placed at other locations on the network.
Top-up/Back-up Gas Boilers	District heating schemes are commonly designed with additional generation which provides back-up in case of planned or unplanned maintenance work. In addition, as the LZC heat technologies are sized to supply the base load, the back-up plant also serves as a top-up system in periods of peak demand Natural gas boilers are normally selected as the back-up/top-up plant, this is due to many factors, including among others: technology maturity, low cost, low risk, no requirement for fuel storage, ability to modulate to the heat demand and rapid response.
Flow Pipe	Also known as Supply Pipes, are pipes carrying the flow water from the Energy Centre to the consumer at temperatures of around 60°C to 85°C.
Return Pipe	Pipe carrying the return water from the consumer back to the Energy Centre after heat has been extracted. The return water temperature is around 40°C to 65°C.

Heat Exchanger	System that provides hydraulically separation and transfers the heat between the primary heat network (pipework from energy centre to the customer's building) and the secondary heat network (pipework within a building).
HIU	Heat Interface Unit (HIU) is a system that provides hydraulically separation and transfers the heat between the secondary side (pipework within a building) and the tertiary side (pipework within a dwelling).
CO_2	Carbon Dioxide
ESCO	Energy Service Company: a commercial entity which typically operates and maintains the plant associated with a DHN (or potentially other forms of generation). They would also normally bill any user of the DHN.
Heat Density	Measure of the heat demand in an area i.e. annual heat demand per square meter (MWh/year/m^2).
Private Wire	These are electricity networks owned and operated outside of the transmission or distribution system. This might be a wire system from a CHP generator to buildings to supply electricity.