SPECIAL FEATURE

District heating: A real alternative?

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Crispin Matson looks at the potential advantages of district heating for the UK, where the technology is expected to meet 20% of the country's heat demand by 2030, and discusses the Gospel Oak project, one of the country's success stories.

District heating (DH) is currently experiencing a renaissance the UK. Implemented across Europe during the post war period, DH remains popular on the continent in places such as Germany, Scandinavia and much of Eastern Europe. DH in Denmark, for example, currently heats over 60% of homes with that number rising to 95% in Copenhagen.

In contrast, the UK, which saw significant growth in DH with the council housing boom in the 1950s–1970s, fell out of love with DH when the North Sea natural gas network was established in the 1980s. The tide is turning, however and the UK's energy future with regards to DH looks to be falling in line with the rest of Europe's. The last government funded, via DECC, over 140 DH feasibility studies to the tune of over £6m. The Government's Heat Strategy published in 2013 firmly placed DH as the preferable source of heating in urban areas by 2050.

Today's figure of 2% of domestic demand in the UK being fed by DH is predicted to rise to a figure of 20% by 2030. Why is this the case and what are the advantages of district heating?

First let's be clear about what district heating is exactly. The Building Research Establishment (BRE) defines it as "a pipe network that allows centralised heat sources to be connected to many heat consumers". The BRE notes that typically a DH network comprises three main components: "one or more energy centre(s), the pipe network itself; and connections to heat customers." It allows heat to be used from sources which would not normally be possible within individual dwellings or buildings.

DH advantages

The key advantages of DH are that compared to individual gas fired boilers, (the more common approach to heating dwellings in the UK), DH can deliver heat in a more efficient manner, more cheaply and with lower carbon emissions. It does this mainly by capturing thermal energy or heat that would otherwise be wasted. This wasted heat is primarily created as by product of generating electricity in power stations. Usually this is ejected into the atmosphere (via cooling towers) or to rivers. However, by generating electricity in Combined Heat and Power (CHP) plants the wasted heat can be recovered and used in a DH network.

CHP plants range in size from small 50 KWe plant up to very large ones at 250 MWe. They can be fuelled by natural gas (either in a combustion engine or using gas turbines) or they can be fuelled by biomass. Biomass CHP plants usually consist of boilers burning biomass, waste wood or straw to raise steam to feed steam turbines. This produces both electricity and heat for DH networks.

A further type of CHP plant are waste incinerator plants which are increasingly being used in the UK as an alternative to land fill

District heating: A pipe network that allows centralised heat sources to be connected to many heat consumers (Image courtesy of Shutterstock).

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sites for waste disposal. Again these can be used to generate both electricity and heat.

Waste heat might also be utilised from industrial or refrigeration processes. This is often at temperatures (typically below 40 °C) too low to be used directly for heating dwellings. However if this heat is connected to heat pumps then it can be upgraded to a higher temperature (typically over 80 °C). This can then be fed to a DH a system. Suitable low grade heat sources include sewage plants, canals, high voltage transformers, data centres etc. As the heat pumps are electrically driven, they provide a true low carbon source of future heat when coupled with electricity generated form renewables such a photovoltaic solar cells or wind turbines.

A final source of heat (only) are biomass boilers which can produce heat with a low carbon content. Biomass fuel has exacting handling and storage requirements. This makes biomass boilers more economic at a large scale (typically greater than 1 MW) and thus more suitable for connection to a DH system.

DH can use heat from a number of these different sources. In this way, as we progressively move towards a low or zero carbon future, new low carbon sources of heat can be connected to these thermal networks as new technology and waste heat sources become available.

Cheap heat, low emissions

Depending on the exact nature of the DH system and its exact heat source the cost of delivering heat to an individual customer can be as little as 6p/kwhr. This compares to an equivalent figure of 10p/kwhr for gas heating (i.e. including fuel cost and the cost of replacing/installing the necessary capital equipment).

Similarly the carbon emissions from heat generated in a DH system can be as little as 60 kgsCO_2/kwhr compared to the equivalent figure of 240 kgsCO_2/kwhr for gas heating system using individual boilers.

The main barrier to DH is its initial capital outlay. This includes the cost of extracting or upgrading the heat from the central CHP plant or waste heat source, the cost of installing the pipework network within the ground (usually DH pipes are run under roads alongside other utilities) and the cost of connecting the system into individual buildings. Again costs vary from scheme to scheme but typically the cost of running DH pipework in an urban area can be £1000 m^{-1} with a typical connection cost to a 2 bedroom flat at approximately £1000 each.

The key to realising a successful DH scheme, therefore, is to minimise the capital cost but maximise the number of customers connecting to the network. This is ideally done by keeping the central heat source as close as possible to the maximum number of dwellings. One simple way of analysing this is by looking at the density of dwellings in any one urban area. If it is above 8 dwellings per hectare then a DH system could be viable.

A further consideration is the cost of operating the DH system. Many lessons have been learnt since the first DH systems were installed in the mid-20th Century and modern networks. Costs can be kept down by effective design of the system hydraulics, keeping the volume of water circulated around the system to a minimum to satisfy the actual (as opposed to the maximum) overall heating demand. Variable speed pumps linked to multiple heat sources, which are only bought on line when the overall system demand requires them, are key components in a successful DH system design.

The other key consideration is to minimise heat loss from the pipework distribution. Again, this can be achieved by good design and should not exceed 5% of the total system heating capacity. Modern DH pipework is now installed with prefabricated insulation, minimising the likelihood that this will be damaged during construction.

Most DH networks start as relatively small systems serving up to 100–200 dwellings. Typically these systems will consist of a single heat source (often a gas fired CHP plant), a set of distribution pumps, the DH pipework itself consisting of flow and return pipes and connections to individual dwellings. These final connections usually consist of a plate heat exchanger combined with a heat meter. The amount of heat delivered to each dwelling is controlled according its combined hot water and heating demand.

These smaller networks can then be expanded over time to serve much larger communities up to 10,000 dwellings or more. On these larger systems it is possible to have a number of different heat sources which all feed into the same system. These heat sources can be activated to match the fluctuating overall demand of the system.

Typically the base or summer load of a DH network is that required to meet the hot water demand of all the dwellings or buildings. In winter this will rise to meet both the hot water and the heating demand. CHPs and heat pumps are usually used to meet the base load with gas-fired boilers only brought on when the heat demand peaks in times of very cold weather. In addition, large thermal stores (which can be up to 20,000 m3 in volume) can be used to store surplus heat to be used to smooth out and match the fluctuating heat demand pattern.

The length of the DH network again typically starts at 1–2 km. As the system network grows these distances grow accordingly. One of the largest systems at the moment is that in Copenhagen, Denmark which extends up to 20 km in length.

As technology advances DH systems are becoming more and more efficient and provide a real tool by which to move to a zero carbon future. With the DECC pushing for their development all those involved in the renewable energy industry should start analysing their potential as part of an integrated renewable energy mix.

Gospel Oak: A district heating success story

The Gospel Oak project originated in 2012 when MITIE (now part of Utilyx) appointed Ramboll to carry out the detailed design of a district heating scheme in the London Borough of Camden.

MITIE's involvement with Camden started when it was appointed by the Royal Free NHS Trust to install and run a 5 MWe gas-fired Combined Heat and Power plant (CHP) in the Royal Free hospital. This was designed to achieve both energy savings and approximately 93,000 tonnes of CO_2 reductions over a 15-year period. At the same time Camden council were separately investigating alternatives to upgrade the heating infrastructure to a number of large housing estates situated close to the Royal Free hospital.

These housing blocks had originally been built in the 1960s and their heating systems were nearing the end of their normal