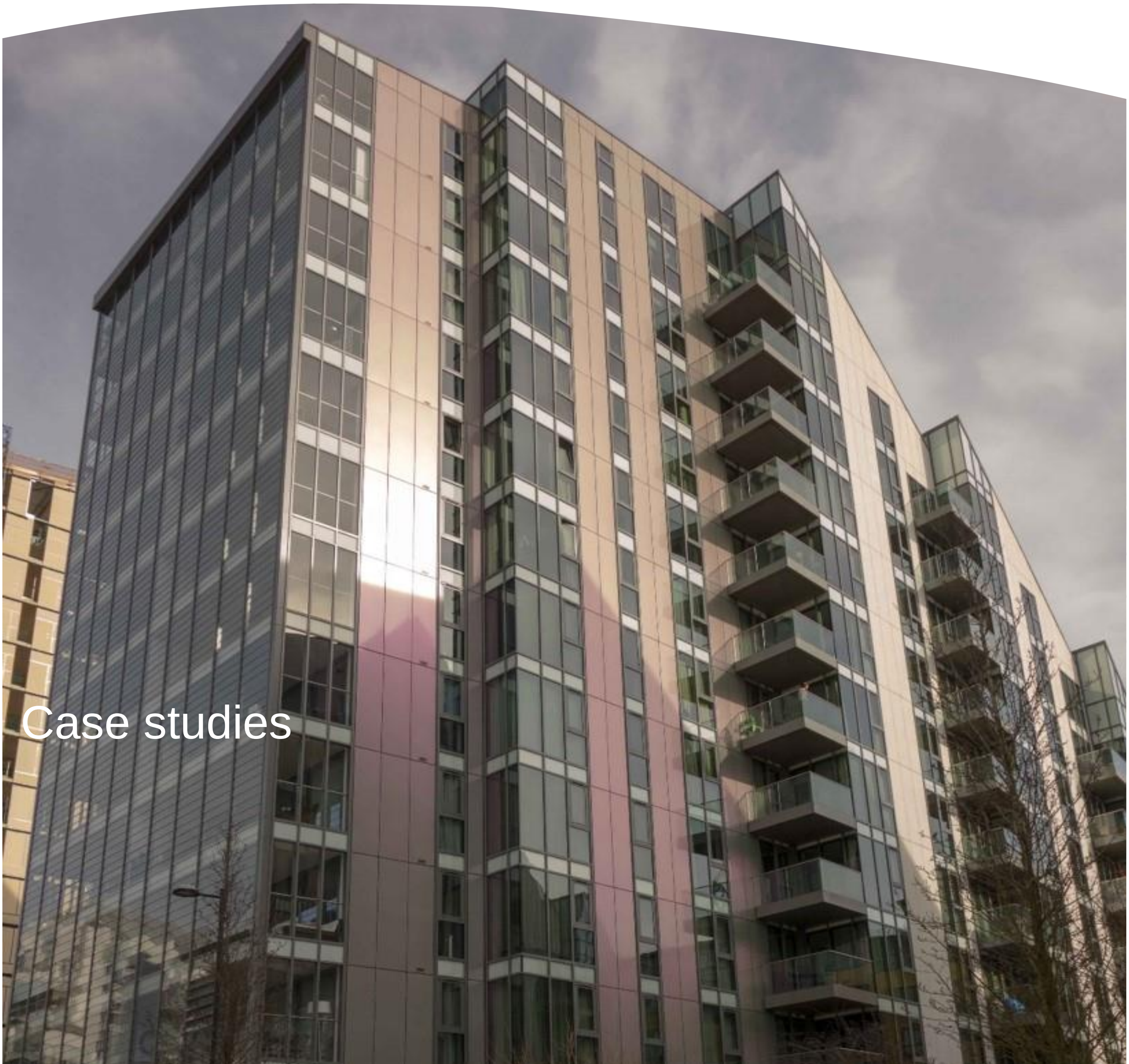
Department of Energy & Climate Change

Heat pumps in District Heating



Heat Pumps in District Heating

Case Studies

This document was prepared for DECC by Element Energy and Carbon Alternatives and accompanies 'Heat Pumps in District Heating: Final Report'.

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Acknowledgements

The authors are grateful for the input of the following organisations to the material and images in this document:

Cofely

Friotherm

IFTech

South Derbyshire District Council

Heat Pumps in District Heating: Case Studies

URN 15D/538

Case Study 1: Helsinki

Context

Helsinki has a well-established district heating and cooling network, supplying 90% of the city's heat demand and an increasing proportion of cooling demand, and covering a range of customer types. Although the heat network is mostly heated by gas-fired CHP and the cooling network by absorption chillers, new plant such as heat pumps and storage can be and are being integrated. In 2006, 84 MW of heat pump capacity was integrated into the existing system, covering 4% of the network's total heat and 33% of total cooling load.

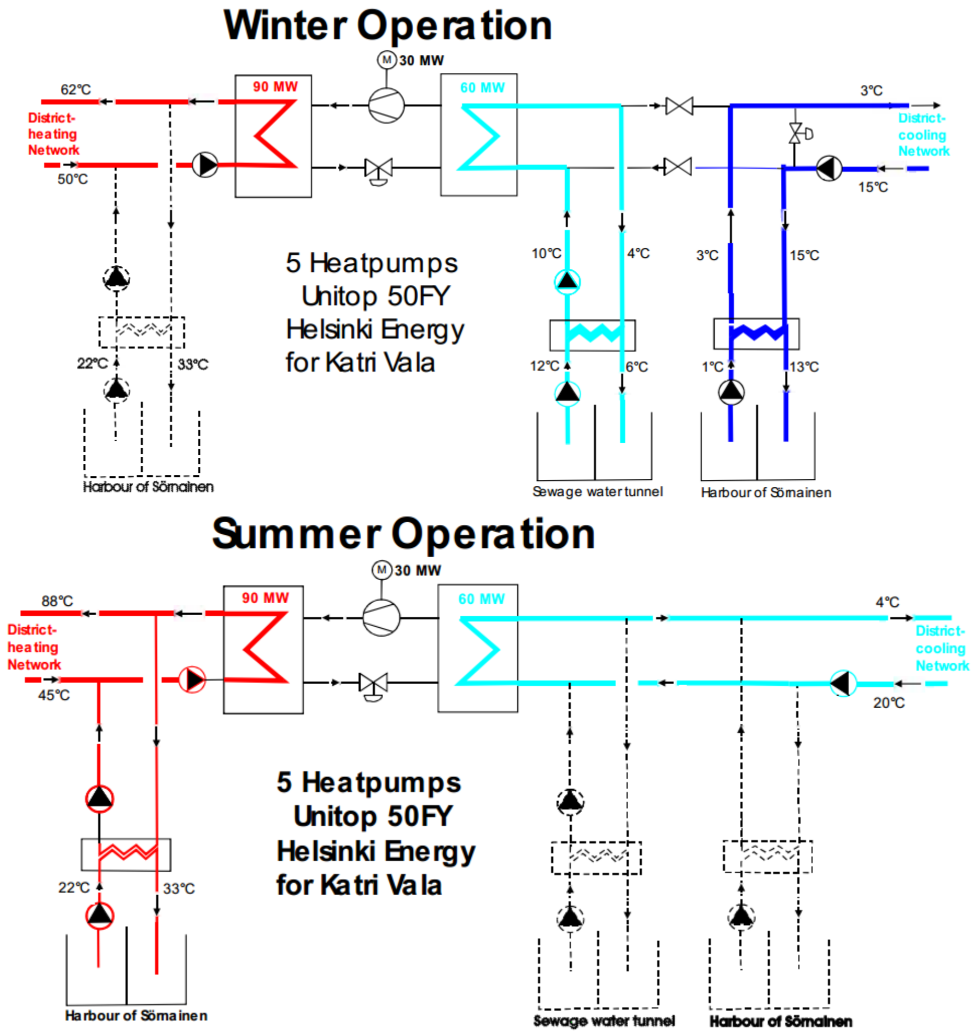
How does the scheme work?

- Five 16.8 MW heat pumps are connected to both the heating and cooling networks. Their operation varies seasonally as explained below, and is shown in the schematic on the following page.
- *Winter:* In winter heat is recovered from sewage and used to preheat the district return flow from 50°C to 62°C. This is lower than the network temperature, but in this way the heat pump can run more efficiently. All cooling is provided directly from sea water (free cooling), so the heat pumps are not used to meet this demand.
- *Summer*: In the summer the heat pumps operate to meet the cooling loads, with the heat extracted from the cooling network used to heat the heating network to the summer operating temperature (88°C). Heat from the cooling network in excess of the heating network heat demand is rejected into the sea.

Why were heat pumps chosen over other heating technologies?

The heat pumps were installed firstly because of their low cost of heat compared to gas boilers/CHP and secondly since a source of cooling was needed for the district cooling network. The installation is economically attractive without specific support for renewable heat generation. Similar installations are being installed in other district heating/cooling systems in Finland.

Schematic diagrams of the operation of the Helsinki heat pump system in winter and summer operating conditions

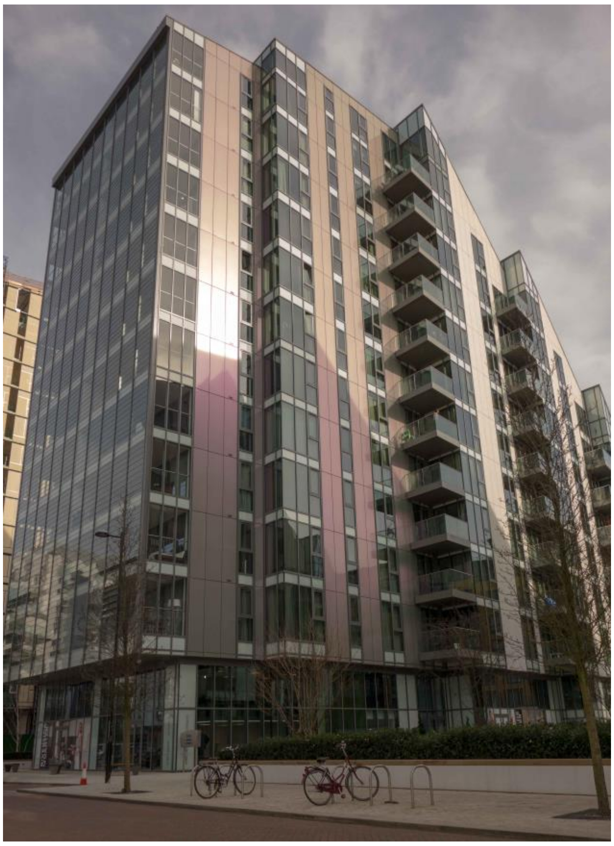


Key heat pump technical parameters

		Winter	Summer
Installed plant	Number of heat pumps	5	
	Refrigerant	R134a	
	Heat pumps used	Friotherm Unitop 50FY	
Heating	Heat pump supply temperature	62°C	88°C
	Source	sewage	seawater
	Source temperature	10°C	22°C
	Max heat output	83.9 MW	90.6 MW
Cooling	Supply temperature on cold side of heat pump	[not used]	4°C
	Max coolth output	[not used]	60 MW
Performance	COP (heating)	3.51	2.96

Case Study 2: Wandsworth Riverside

Context



Wandsworth Riverside Quarter is a development of apartments on the banks of the Thames in south-west London. The development will provide 504 apartments and substantial commercial and leisure space when fully built out. The first apartments were occupied in 2013.

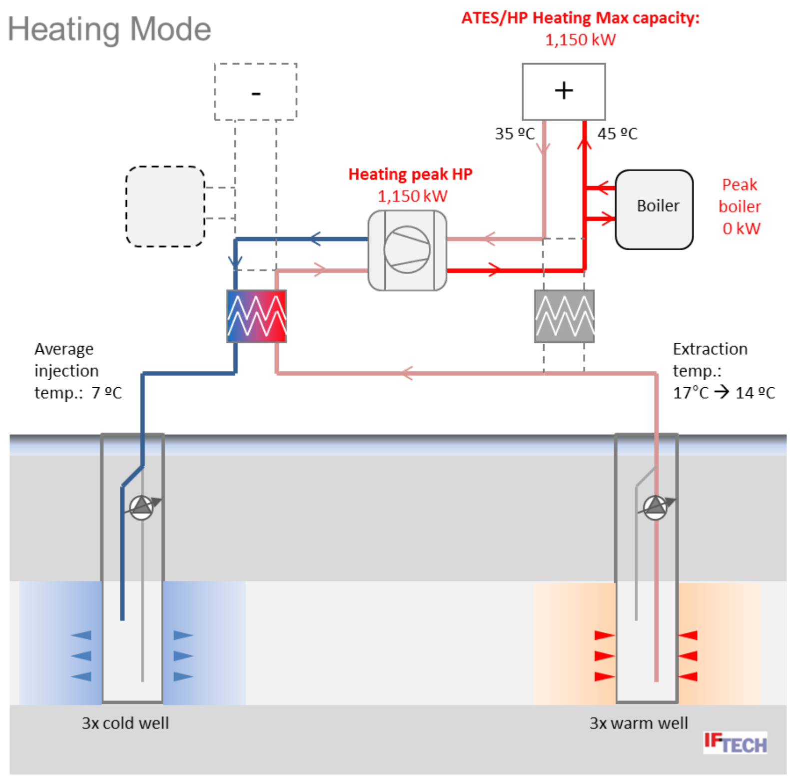
An Aquifer Thermal Energy Storage (ATES) system has been installed in Phase 1 of the development, providing both space heating and cooling to the mixed-use buildings. Heat supply for domestic hot water and heat pump back-up comes from gas boilers and a gas CHP.

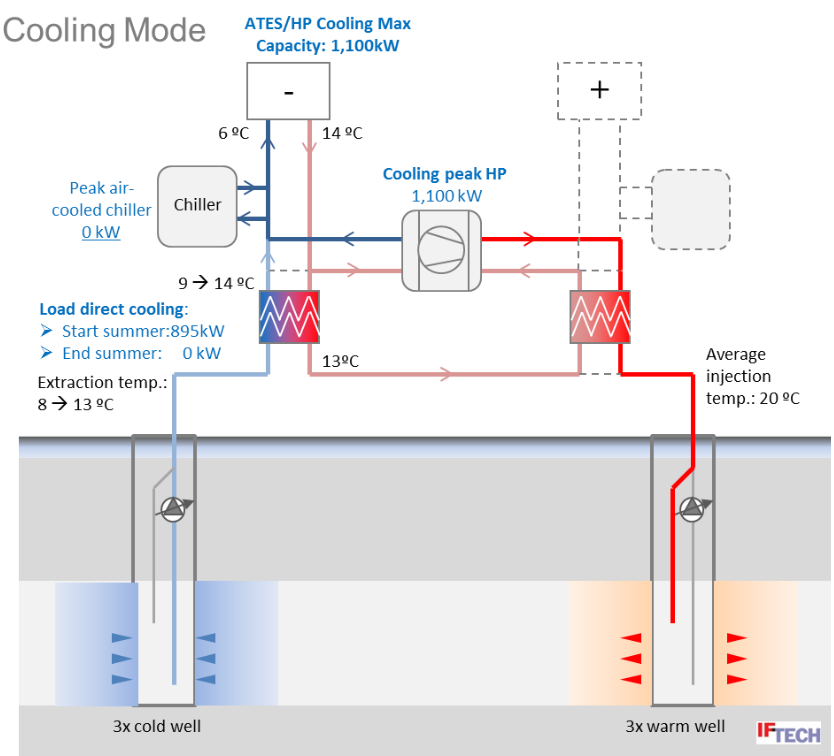
An ESCO now operates the heating and cooling system, and is working to optimise the design and controls to achieve the maximum benefit from the heat pumps and ATES.

How does the scheme work?

The scheme consists of three heat pumps coupled to an aquifer below the site via an open-loop system of 8 x 120m deep boreholes. The heat pumps supply a peak cooling capacity of 2.25 MW and a heating peak output of 1.2 MW. The aquifer warms over the summer due to the injection of the waste heat from the cooling loads, leading to better heat pump performance in winter. In the winter the aquifer is cooled as heat for the space heating is drawn out, and this cooling of the aquifer leads to higher cooling COPs during summertime operation. Under ideal design conditions, the aquifer is cold enough to directly cool the space cooling circuit. Heat is distributed via separate distribution pipework for space heating and DHW supply, operating at 45/35°C and 75/55°C respectively.

Schematic describing operation of the system in heating and cooling mode (Source: IFTech)





Why were heat pumps chosen over other heating technologies?

A key driver for the ground source heat pump system was the need to meet the renewable energy requirements of the London Plan[1]. The accessible aquifer system also provided an efficient solution to the problem of where to reject heat from the use of chillers.

Key heat pump technical parameters

		Winter	Summer
Installed plant	Number of heat pumps	3	
	Refrigerant	R134a	
	Heat pumps used	J&E Hall WHP 602	
Heating	Heat supply temperature	45°C	45°C
	Source	aquifer	aquifer
	Source temperature	14°C	16°C
	Max heat output	1.2 MW	N/A
Cooling	Chilled supply temperature	6°C	6°C
	Max cooling output	N/A	2.2 MW
	COP (heating) COP (cooling)	Design: 4 <12	N/A Design: 8

[1] Policy 4.7, *The London Plan Spatial Development Strategy for Greater London (Consolidated with Alterations since 2004)*, Feb 2008.

Case Study 3: Duindorp

Context

The heat pump system at Duindorp (The Hague, Netherlands) was installed during the construction of 789 apartments built in 2009. The novel system was developed to lower the energy costs and environmental impacts when old housing on the site was replaced by new. The housing provider, Vestia, has a track record of innovation and was keen to try a new approach.

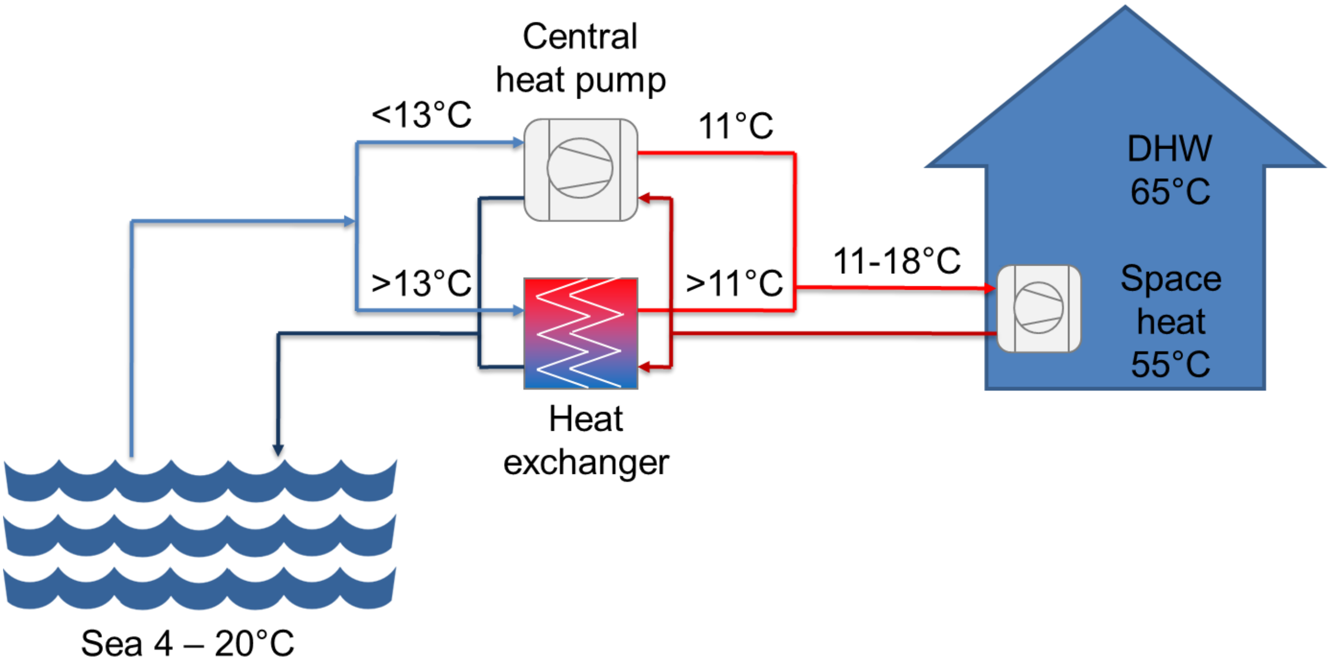
How does the scheme work?

The system consists of a central seawater heat pump, a low temperature network maintained between 11ºC and 18ºC and individual water-to-water heat pumps in each apartment. The individual heat pumps use the low temperature network as their heat source and raise the temperature to 45ºC for underfloor heating and 55-65ºC for DHW. The provision of heat to the network varies seasonally as follows:

- *Winter:* In winter, the central heat pump raises the temperature of seawater from 6ºC to 11ºC. It is distributed through the network at this temperature to provide the heat source for the building-integrated heat pumps.
- *Summer*: In summer, when the sea temperature is warmer than 11ºC, the central heat pump is not needed and the district heating network temperature is maintained by direct heat exchangers.

This system brings a number of advantages. The low network temperature ensures very low network heat losses, but is high enough to avoid the need for antifreeze in the supply to individual apartment heat pump systems. Further, the district heating circuit can be used in the summer for cooling. However, the installed capital cost of the system represented an additional cost of approximately €5,500 per dwelling compared to a conventional heating system.

Simple schematic of the Duindorp system configuration



Key heat pump technical parameters

		Central heat pump		Individual heat pumps
		Winter	*Summer*	*Year-round*
Installed plant	Number of heat pumps	2 central heat pumps		1 per apartment
	Refrigerant	Ammonia		Not known
	Heat pumps used	York PAC 163HR		IVT (no longer in business)
Heating	Heat supply temperature	11°C	HP not used when sea above 11°C	Underfloor at 45°C DHW up to 60°C
	Source	Seawater	-	District heating network
	Source temperature,	3°C	Up to 20°C	11-20°C
	Max heat output	2.4 MW		6kW per apartment
Cooling	Cooling provided?	No		No
Performance	COP (heating)	11	Heat pump not used	3

Case Study 4: Brooke Street

Context

Brooke Street is an off-gas grid development on the edge of a rural village in South Derbyshire. In 2012, eighteen local authority flats (built in 1982) were connected to a new district heating scheme, to replace their previous electric storage heaters. A set of ground source heat pumps are used to supply the heat network. When the heat network and heat pumps were installed, the flats also received building fabric insulation upgrades to improve their thermal efficiency.

How does the scheme work?

Three blocks of six flats are served from three ground source heat pumps coupled to a common ground loop served by 28 boreholes, each 100 metres deep. The system provides space heating and hot water to each flat. The flats were all retrofitted with low temperature radiators so that the space heating supply temperature can be kept as low as 55°C. The system temperature is raised to 60°C for a period every night to heat the DHW cylinder to mitigate Legionella risks. Two plant rooms have been installed, one serving six flats and the other serving twelve flats. Each heat pump also has a 100 litre thermal store.

Image of one of the blocks of flats connected to the Brooke Street district heating system ground loop.

Why were heat pumps chosen over other heating technologies?

Since this development is not connected to the gas grid, heating options include electric heating or other fuels such as oil and biomass. The previous heating strategy had been all-electric, through storage heaters. Residents had made numerous complaints about the high running cost of these systems and the low level of control they had over their operation. The council was interested in exploring renewable energy solutions and obtained an RHPP grant to cover part of the cost of the heat pump in district heating installation.

Key heat pump technical parameters

Installed plant	Number of heat pumps	3
	Refrigerant	R134a
	Heat pumps used	Dimplex 40kW
Heating	Supply temperature	Up to 60°C
	Source	Ground
	Source temperature,	6-10°C
	Max heat output	120 kW
Cooling	Cooling provided?	No
	COP (heating)	Design: 3.2

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URN 15D/538