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REFRIGERATION AIR CONDITIONING HEAT PUMPS

sirach
Innovation in heating, energy storage and cooling technologies

Why low-temperature networks are important to our future

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WARWICK

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LoT-NET

1. Context
2. A bit of history
3. Where district heating and cooling! is heading

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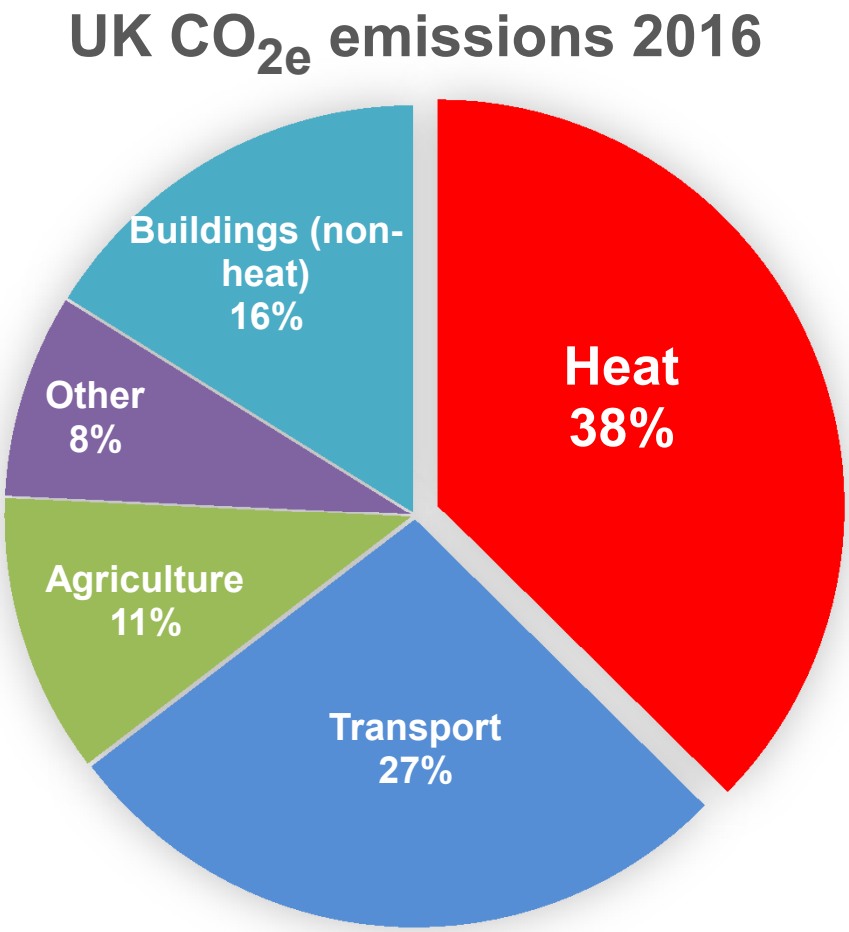
1. Context



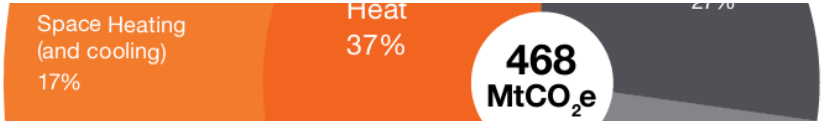
Source: Clean Growth - Transforming Heating Overview of Current Evidence December 2018, BEIS

1. Context

UK CO_{2e} emissions 2016

- Nearly half of the energy we use in the UK is used for heating of one sort or another

- Significant uptake of low carbon heat technologies is required to meet the 2050 targets

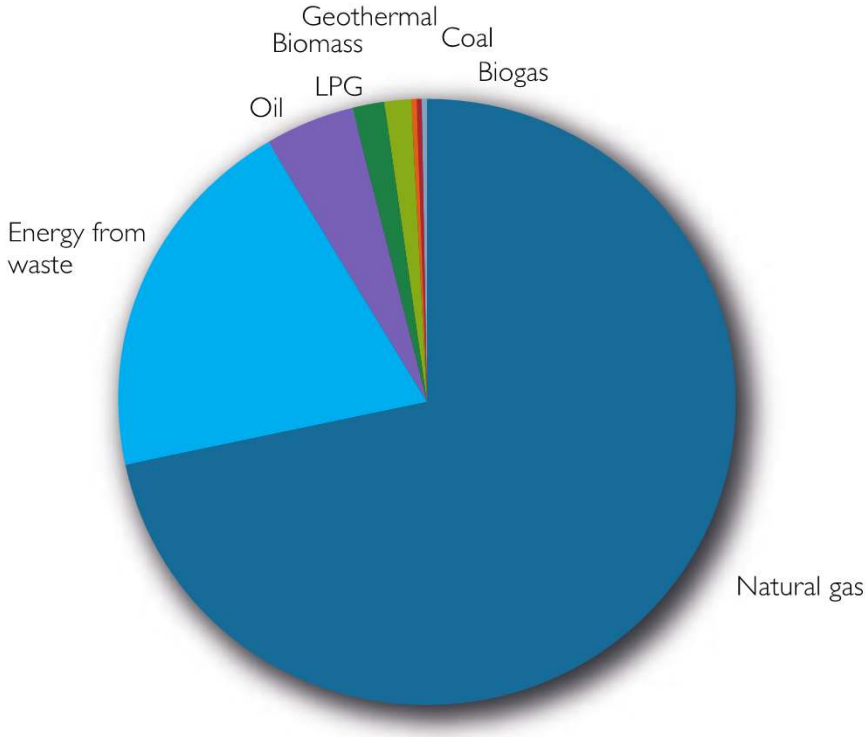


- Committee on Climate Change project that 25TWh of heat will need to be utilised by heat networks if we are to meet carbon budgets cost effectively.

Committee on Climate Change – Fifth Carbon Budget - https://www.theccc.org.uk/wp-content/uploads/2015/11/Committee-on-Climate-Change-Fifth-Carbon-Budget-Report.pdf
LCICG Heat Technology Innovation Needs Assessment(2016) - http://www.lowcarboninnovation.co.uk/working_together/technology_focus_areas/heat/

1. Context Why heat networks in the UK?

- Lowest cost low carbon heat generally comes at scale – need a network to deliver the heat, particularly in urban areas
- Models show a range of deployment projections from 14 - 43% by 2050
- Committee on Climate Change (CCC) central scenario for the 5th carbon budget shows heat networks serving 18% of buildings heat demand in 2050 (81TWh), saving 15.1MtCO2e/year
- An 8-10% compound growth rate is required even to meet the lower end of these trajectories (from 2% growth rates today).

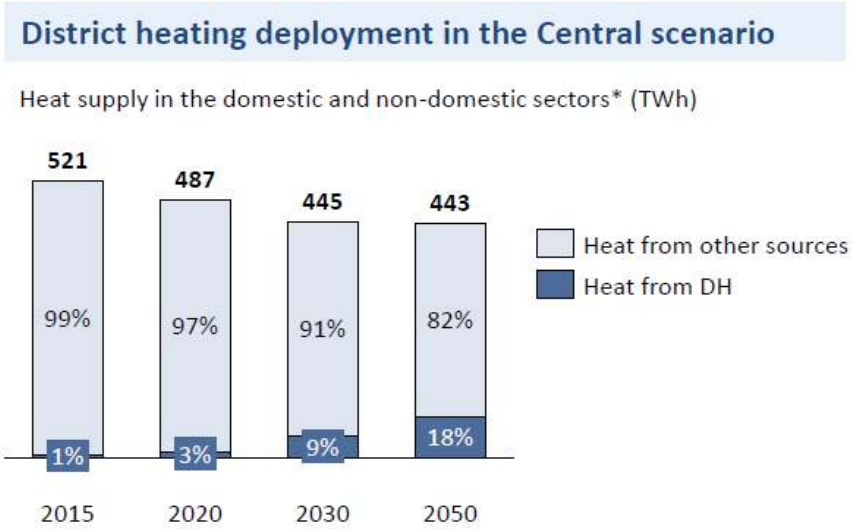


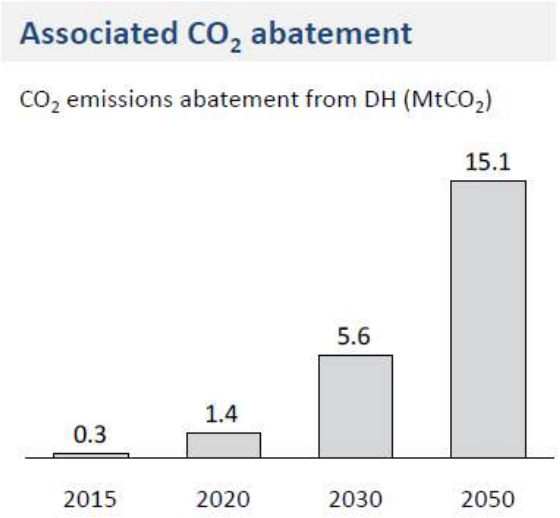
- Today: approx 2000 larger heat networks in the UK, supplying 2% of buildings heat

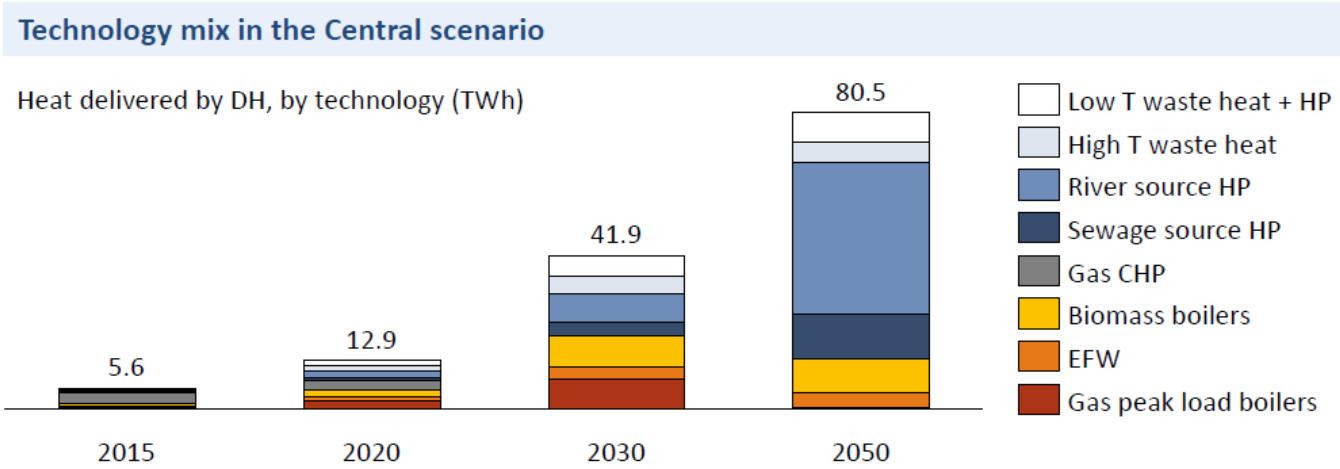
UK government support to heat networks – update Briefing to Liveable Cities Conference - BEIS Heat Networks Team
16 June 2017

1. Context

Modelling for the CCC by Element Energy confirms role for district heating: will return to this later, it could be a bit conservative…







2. History

1st Generation – USA 1880's first (New York), then Paris

- Avoided dangerous gas explosions etc in individual boilers in apartment blocks
- Superheated Steam up to 300°C! – direct condensation in radiators
- Used in Europe until 1930s

Invented by Birdsill Holly
(1820 -1894)

By Unknown - http://lockportcave.com/birdsill-holly/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=46035718

2. History

2nd Generation from 1930s to 1970s

- Pressurised hot water c. 110°C
- Pipes in concrete ducts
- Bulky shell and tube HEX, valves
- Many in old Soviet bloc.
- A few still in operation
- Utilised CHP for better efficiency and comfort

Moscow heat supply system

- 15 large CHP plants,
- 70 district and local heating plants (DHPs and LHPs), and
- 100 local boilers (LBs).Table 1, below, shows their capacity and production.
- 2300 km of pipes with an average diameter of 570 mm, and
- 21 booster pump stations.
- Inside city sub-districts, Mosgorteplo operates over 4600 sub-stations and Mosteploenergoover 1200.
- From the sub-stations, secondary networks (5645 km!) transfer heating and domestic hot water to buildings. Individual apartments generally had no meters,

Table 1. The Moscow heat supply system

	Heat capacity	Heat production	
	Gcal/h	Million Gcal	Percentage
CHP plants	32,250	79.9	77%
District and local heat plants	13,700	22.7	22%
Local boilers	250	0.4	<1%
Total	46,200	103	

Source: https://www.quora.com/What-type-of-home-heating-systems-did-they-use-in-the-Soviet-Union

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2. History

3rd generation from 1970s – ‘Scandinavian district heating technology’

- Hot water normally less than 100°C
- Prefabricated insulated pipes in ground
- Compact plate heat exchangers
- Standard in many counties both new and replacement of 2nd generation systems
- Motivation: after oil shock, focus on efficiency via CHP and alternative fuels.

Insulated pipes to connect a new building to University of Warwick's campus-wide combined heat and power system

By Mike1024 - Photographed by Mike1024, Public Domain, https://commons.wikimedia.org/w/index.php?curid=2901200

2. History

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District heating substation with a thermal power of 700 kW which insulates the water circuit of the district heating system and the customer's central heating system

2. History

Energy Procedia 116 (2017) 26–38

4th Generation from now

- Lower temperature hot water delivered (sometimes direct) c. 50°C return 25 °C
- Low temperature radiators / underfloor heating
- Smart heat network
- Possible use of waste heat, heat pumps, solar, geothermal, biomass…

Hyvinkää (Finland)

Low Temperature District Heating for Future Energy Systems, Dietrich Schmidt et al

2. History

4th Generation from now

Lystrup, Denmark

- 50°C delivery, 25 °C return
- Direct conection
- 40 flats 2.2 or 2.6 kW load
- Underfloor heating

Low Temperature District Heating for Future Energy Systems, Dietrich Schmidt et al
Energy Procedia 116 (2017) 26-38

2. History

4th Generation from now

Ludwigsburg, Germany

- Extension of existing network
- ‘Low-Exergy’ sub grid
- Integtates solar thermal energy

Low Temperature District Heating for Future Energy Systems, Dietrich Schmidt et al
Energy Procedia 116 (2017) 26-38

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5th Generation: The future?

- Low temperature heat distribution circuit – (no need for expensive insulation)
- Heating & cooling – (provided by a heat pump in each building)
- Demand side response – (to reduce cost of electricity and reduce carbon emissions at peak times)
- Thermal energy storage – (to extend the benefits of using Demand Side Response)
- Integration of waste heat opportunities – (from any building that rejects heat above ambient ground temperature)

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

5th Generation: The future?

- Low temperature heat distribution circuit

  Near ambient temperatures for lower loss / lower cost of insulation/installation

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

5th Generation: The future?

- Heating & cooling – (provided by a heat pump in each building)
  - Heat pump from circuit - low ΔT = high COP
  - Buildings built to higher standards need less heating in the winter, but need cooling in summer – not provided by CHP-based networks.
  - More efficient for cooling to be provided by heat pumps rejecting heat to ambient ground temperature circuit rather than air.
  - Heat rejection into the ambient ground temperature circuit increases its temperature: this is beneficial for those buildings that need heating.
  - Heat extraction from the ambient ground temperature circuit reduces its temperature: this is beneficial for those buildings that need cooling.

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

5th Generation: The future?

- Demand side response
  - Buildings that choose to shift the timing of their electricity demand for heating (or for cooling) can earn income from the Grid by responding to changing electricity prices within each 24 hour cycle.
  - This requires a sophisticated control system and a plan to balance the temperature of the thermal mass of the building to maintain comfortable internal temperatures to suit the occupants while earning income from the Grid.

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

5th Generation: The future?

- Thermal energy storage

The capacity to earn revenue from Demand Side Response can be extended where electrification of heating and cooling is used in conjunction with thermal energy storage : heat can be stored when the price of electricity is low (as it often is at night) and used during the day when peak electricity prices would have applied.

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

5th Generation: The future?

- Integration of waste heat opportunities

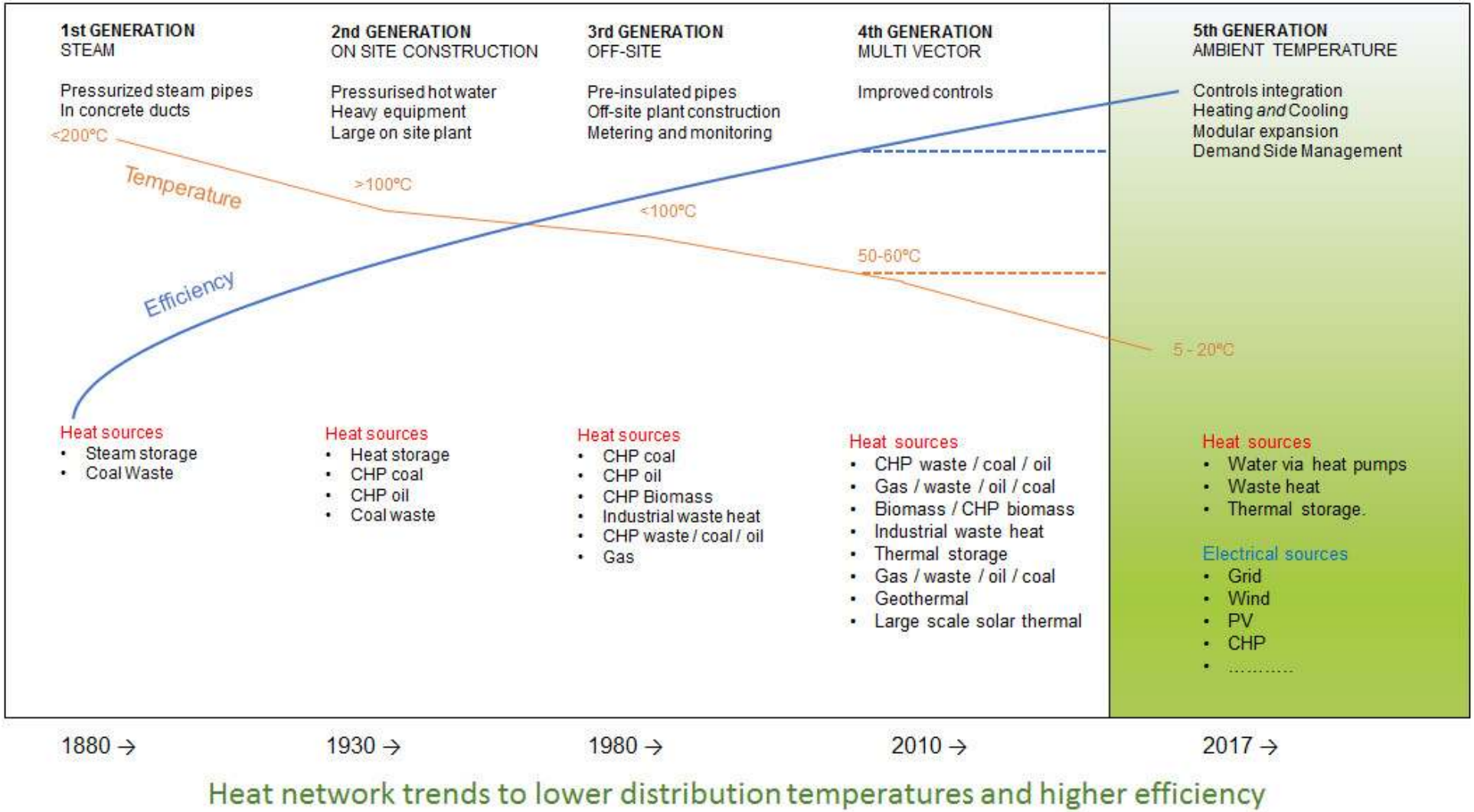
A low temperature circuit allows the opportunity to gather heat from **any** source of waste heat in the district:

- Industrial processes
- Cold stores and supermarkets
- Sewage
- London Underground …

A low temperature circuit allows the opportunity to reject heat to **any** user of waste heat in the district: a Heat (and Cool) Sharing Network

https://www.icax.co.uk/Fifth_Generation_District_Heating_Networks.html

Summary of the five generations



Heat network trends to lower distribution temperatures and higher efficiency

Aalborg Universitet "Progression of District Heating – 1st to 4th generation" Thorsen, Jan Eric; Lund, Henrik; Mathiesen, Brian Vad, 2018

- BEIS estimate that heat networks could supply 20% or more of building heat demand by 2050.

- Heat networks have previously used high temperature hot water to serve buildings and processes but now 5th generation networks seek to use much lower temperatures to make more sources available and reduce losses

- Lot-NET will research integration of low temperature (LT) networks with heat pump and thermal storage technologies to maximise waste and ambient heat utilisation in low or zero-carbon solutions

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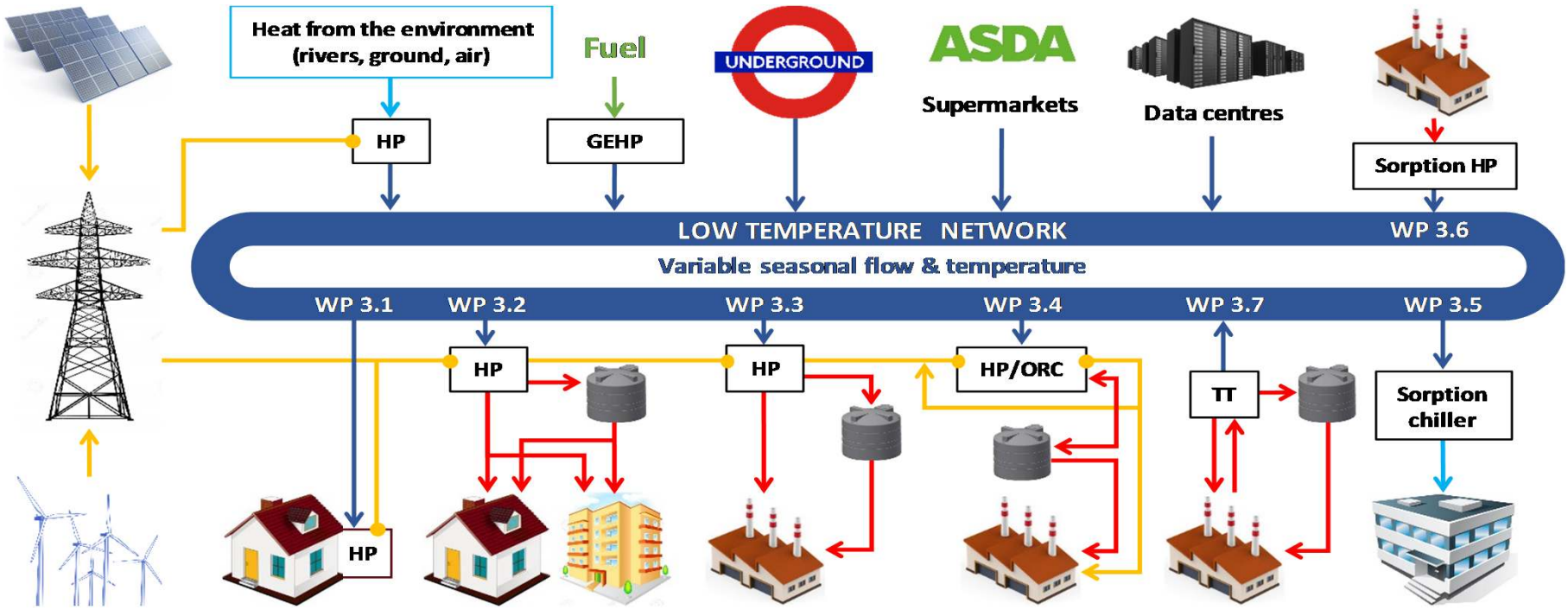

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Thanks for your attention!

Questions??