A roadmap to achieve 5th generation heat networks in the UK

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5th International Conference on Smart Energy Systems
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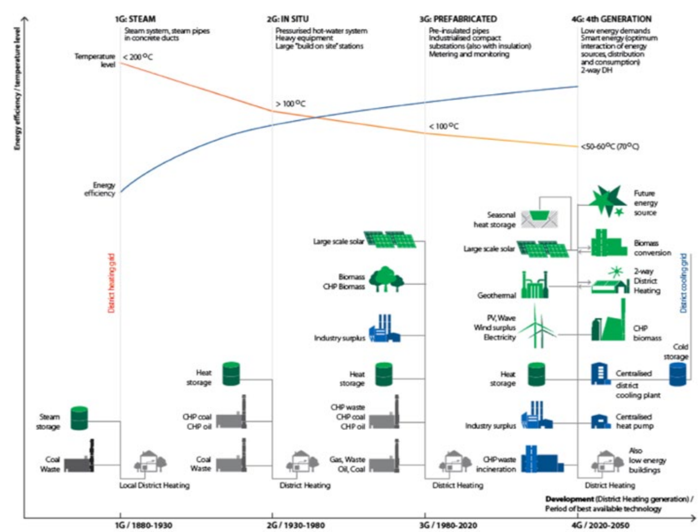
PLYMOUTH CITY COUNCIL

4DH

Interreg North-West Europe HeatNet NWE

Background

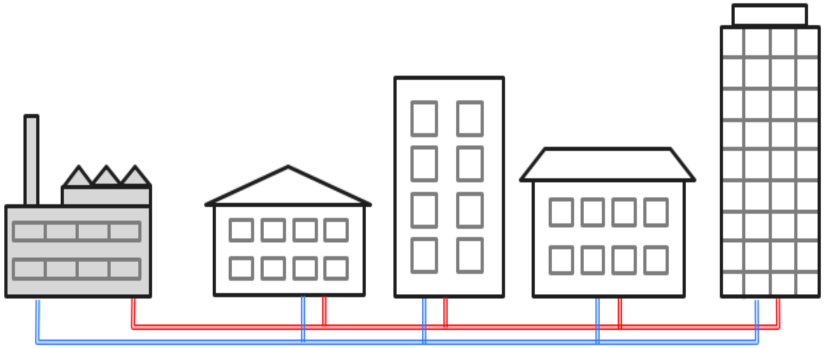
- 20% of UK's greenhouse gas is Space Heating & DHW
- Heat Networks & Heat Pumps are key to decarbonising UK heat
- Lower temperature 4th & 5th generation HNs offer a way to do this
- EU HEATNET project has identified the what, why, and where of 4th & 5th generation DHC
- Two complementary Roadmaps (Plymouth & UK) provide a pathway to encourage 4DHC & 5DHC
- But what do we mean by 4DHC/5DHC?
- Lund definition (2014) sets out a progression from 1st to 4th generation
- The HEATNET roadmaps give clarity on categorisation of 4DHC/5DHC and steps to encourage implementation



(Lund et al)
(2014)

The UK heat network landscape

- Heat networks are a key solution in high energy density areas
- Cooling demand is rising rapidly
- UK electricity grid decarbonisation makes heat pumps a low carbon approach

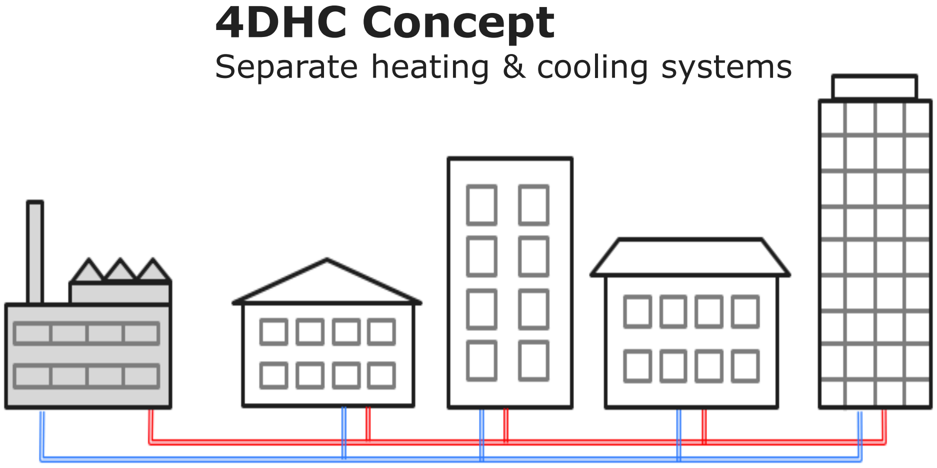


- UK district heating is often driven by the 80/70ºC nature of heating systems
- UK DH is stuck somewhere between 2DHC and 3DHC
- CIBSE/ADE CP1 Heat Network Code of Practice and Heat Trust Scheme are giving greater confidence around heat networks
- What will these 4th and 5th generation heat networks look like and what are the benefits?

Types of heat network

4th Generation DHC

- Traditional centralised shape - energy centre supplying heat outwards to buildings
- Supplying at ~55-45ºC with a wider ΔT and return temperatures ~25-15ºC



- 4DHC needs supplementary boosting for DHW
- Cooling would be a separate system
- No interchange of heat between buildings is possible

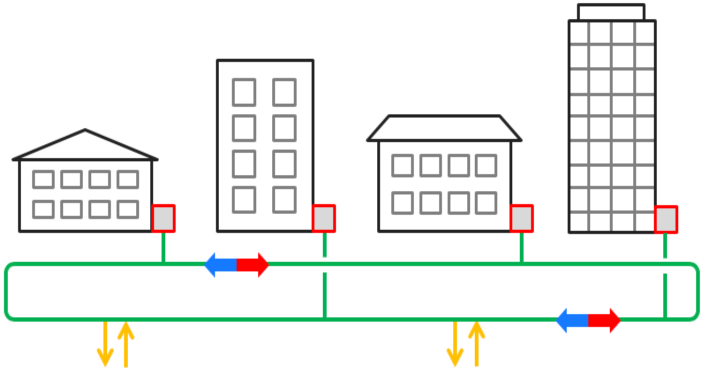
Types of heat network

5th Generation DHC

- Non-traditional shape with decentralised heat pumps supplying heat along ultra-low temperature headers
- Spine/backbone preferred (ambient loops may be possible in smaller systems)
- Supply at <45ºC (more like 20ºC) the ΔT is less relevant with return temperatures around 25-15ºC

5DHC Concept

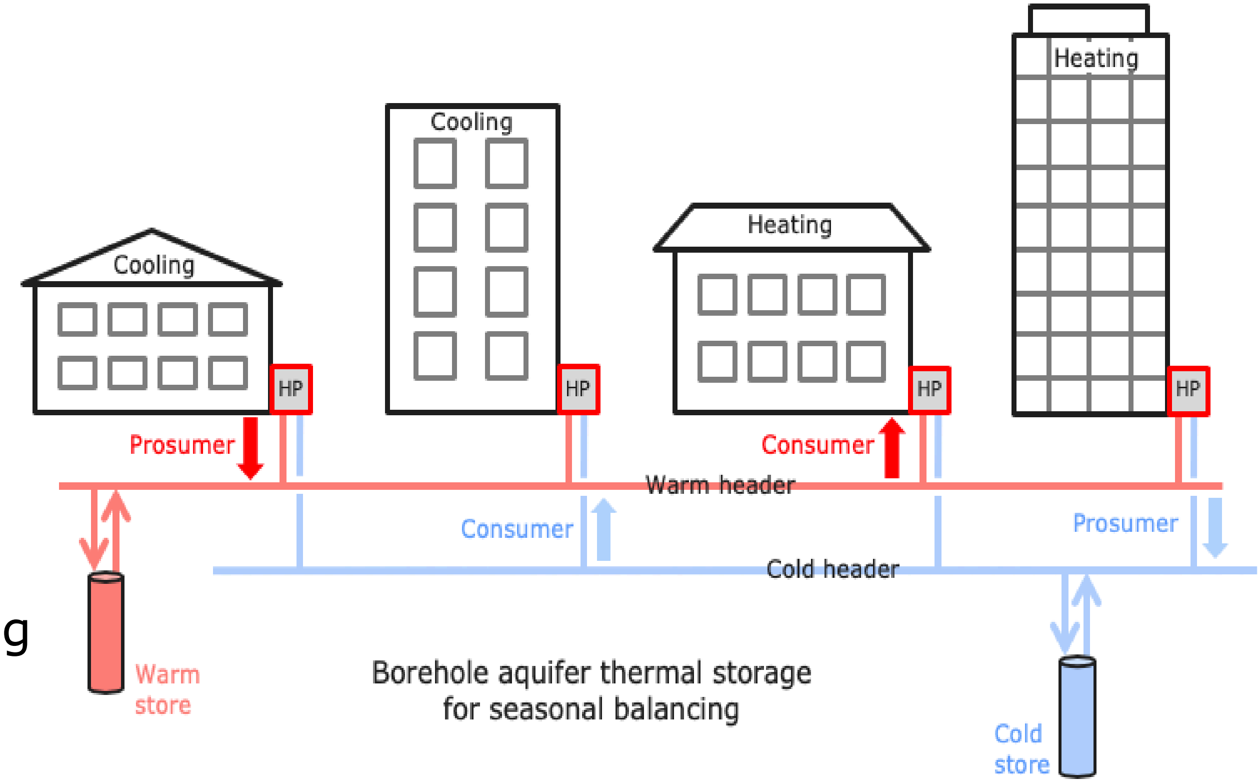
Heating & cooling in one system



- Un-insulated plastic pipework, very low heat losses and longer pipe runs
- Seasonal thermal storage to balance the spine temperatures
- 5DHC always needs DHW boosting
- 5DHC has built-in cooling supply and can interchange heating/cooling between buildings

What is a 5th generation heat network?

- Low temperature headers act as heat source for multiple decentralised energy centres that take-out and feed-in heat
- Requires a means of balancing heat in the headers, when all buildings are in heating mode for instance



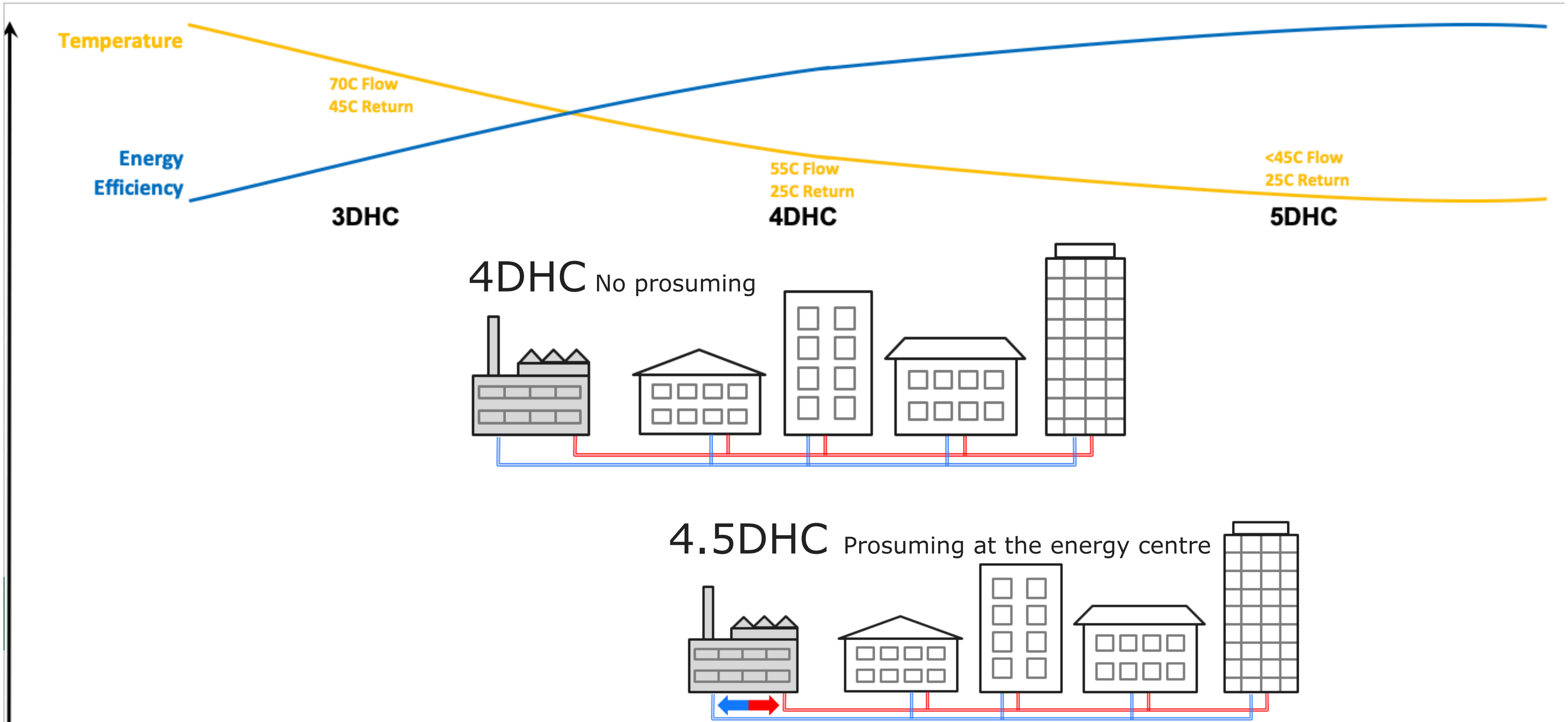
5DHC provides a single integrated 'plug-and-play' heating & cooling system allowing buildings to be 'prosumers' across the network

This gives flexibility in timing & temperature for developers

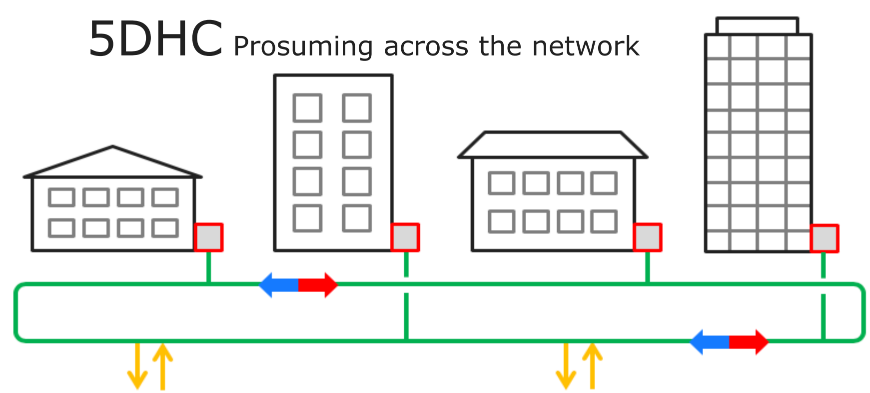
5DHC is a good solution where there is a significant mix of cooling and heating demands, allowing prosuming across the heat network itself

The progression of heat networks

(This acknowledges and builds on work by Lund et al)



It is clear from that there is a progression/transition path from 3DHC to 4DHC due to the similar system architectures (topologies) involved. However, whilst 5DHC appears to be the next logical step, it has quite different shape, structure and approach. For discussion purposes, we have retained the term 5th generation (5DHC) but it should probably be viewed as an entirely different type of DHC altogether.



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The progression of heat networks

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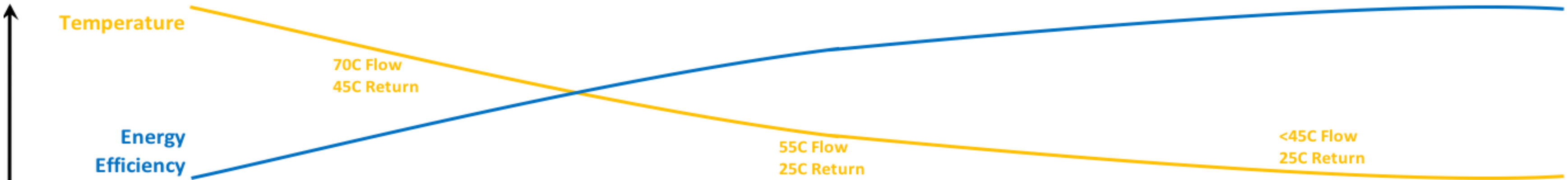

	3DHC	4DHC	5DHC
DEFINITION			
Topology	- Traditional - Single Energy Centre supplying heat outwards	- Traditional - Single Energy Centre supplying heat outwards	**VERY DIFFERENT APPROACH** - NOT traditional DH design or central energy centre - Decentralised plant supplying spine/clusters/buildings - Supplying heat along a spine/backbone - Low temperature headers (not an ambient loop)
Temperature	- Supply at 70-60C [60C min to supply DHW] - Wide ΔT - Return temperatures 50-40ºC - Weather compensated to 60ºC	- Supply at 55-45C - Wider ΔT - Return temperatures 25-15C - Not weather compensated	- Supply at <45C - ΔT Less relevant - Return temperatures 25-15C - Not weather compensated
Pipework	- Well insulated, pre-insulated pipework	- Highly insulated, pre-insulated pipework - Plastic pipework	- Un-insulated pipework? Very low losses, longer runs? - Plastic un-insulated pipework
Storage	- Significant thermal storage	- Very large thermal storage	- Seasonal thermal storage - Some short term thermal storage
DHW	- Can supply DHW directly	- Will need supplementary boost to supply DHW	- Will need supplementary boost to supply DHW
Cooling	- Cooling would be a separate system	- Cooling would be a separate system	- Built-in cooling in a 2-pipe system
Heat interchange	- No interchange of heat between buildings	- No interchange of heat between buildings	- Interchange of heating/cooling with balancing mechanism - Buildings are then prosumers
ADVANTAGES		- Reduced operating costs and carbon emissions - Lower heat losses - Longer pipe runs? - Greater plant efficiency - More opportunity for heat pumps - More opportunity to use waste/renewable heat sources - More opportunity for simultaneous Heating & cooling?	- Even lower operating costs and carbon emissions - Supplies both heating & cooling - No need for separate cooling system - Interchange of heating & cooling - heat recovery between buildings - Buildings pick-off/inject, so less load dependent? - Can add buildings more easily - Heat losses become almost irrelevant - Longer pipe runs covering wider areas - Even greater plant efficiency, particularly Heat Pumps - More opportunity to use waste/renewable heat sources
DISADVANTAGES		- Larger pipework - Greater pumping costs - Requires DHW boost - Less storage density - No opportunity for energy exchange between buildings across the network	- Larger pipework - Greater pumping costs - Requires DHW boost - Less storage density
APPLICATIONS		**Mainly a new-build technology but with specific solutions for existing buildings where necessary** - New build (relatively easy) - Deep retrofit (straightforward) - Existing Buildings & Retrofit Lite - Boost to 80/70ºC with high temperature HPs - Slightly more opportunity for simultaneous Heating & cooling (conventional HPs)?	**More flexible/connectable plug and play LAN approach with built-in cooling and interchange of energy between buildings** - New build (easy) - Deep retrofit (easy) - Retrofit Lite (relatively easy) - Boost with conventional temperature HPs - Existing buildings (straightforward) - Boost with high temperature HPs - Built-in simultaneous Heating & Cooling (using conventional HPs) - Seasonal storage using boreholes

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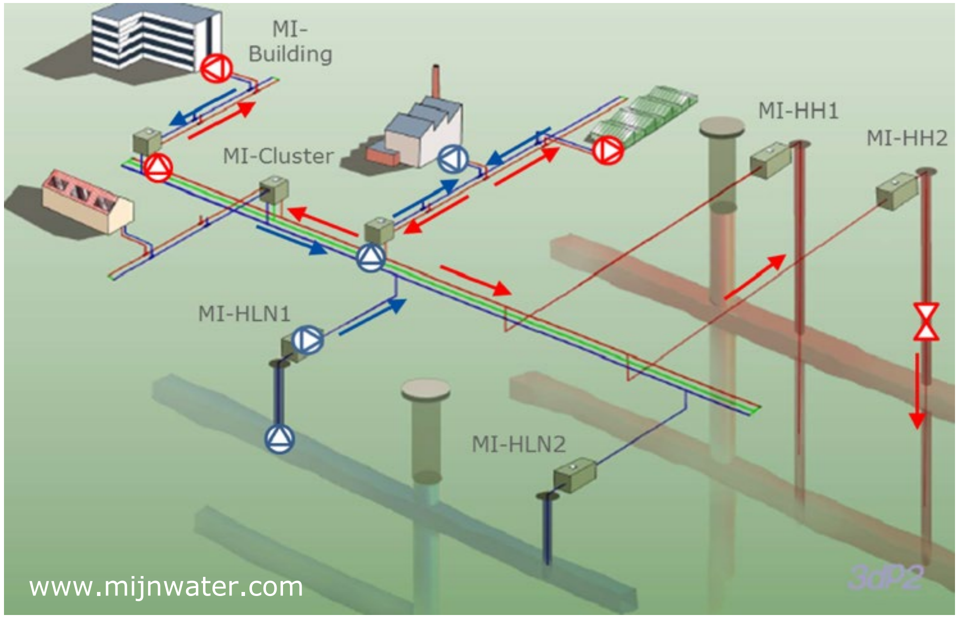
5th generation case study – Heerlen, Netherlands



The Minewater project in Heerlen, Netherlands is a working 5th generation DHC scheme. The scheme uses decentralised heat pumps and is based around mine water from a warm mine and a cold mine with a spine (backbone) as shown opposite.

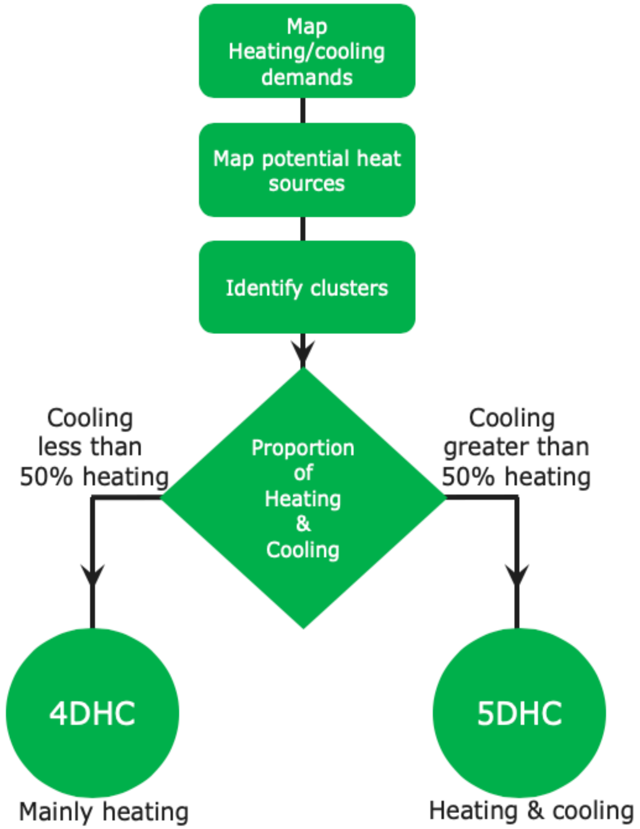
Phase 2 of the scheme (Minewater 2.0) allowed the operators to take full control of the distributed heat pump plant rooms storage and controls. This allowed a lot more operational plant optimisation including energy exchange across the spine (prosuming) between buildings. This turned the approach into a heating/cooling supply scheme and promoted exchange of energy.

Minewater 3.0 is now introducing demand side response controls, gradually making the scheme a smart grid that interacts with the electricity market.

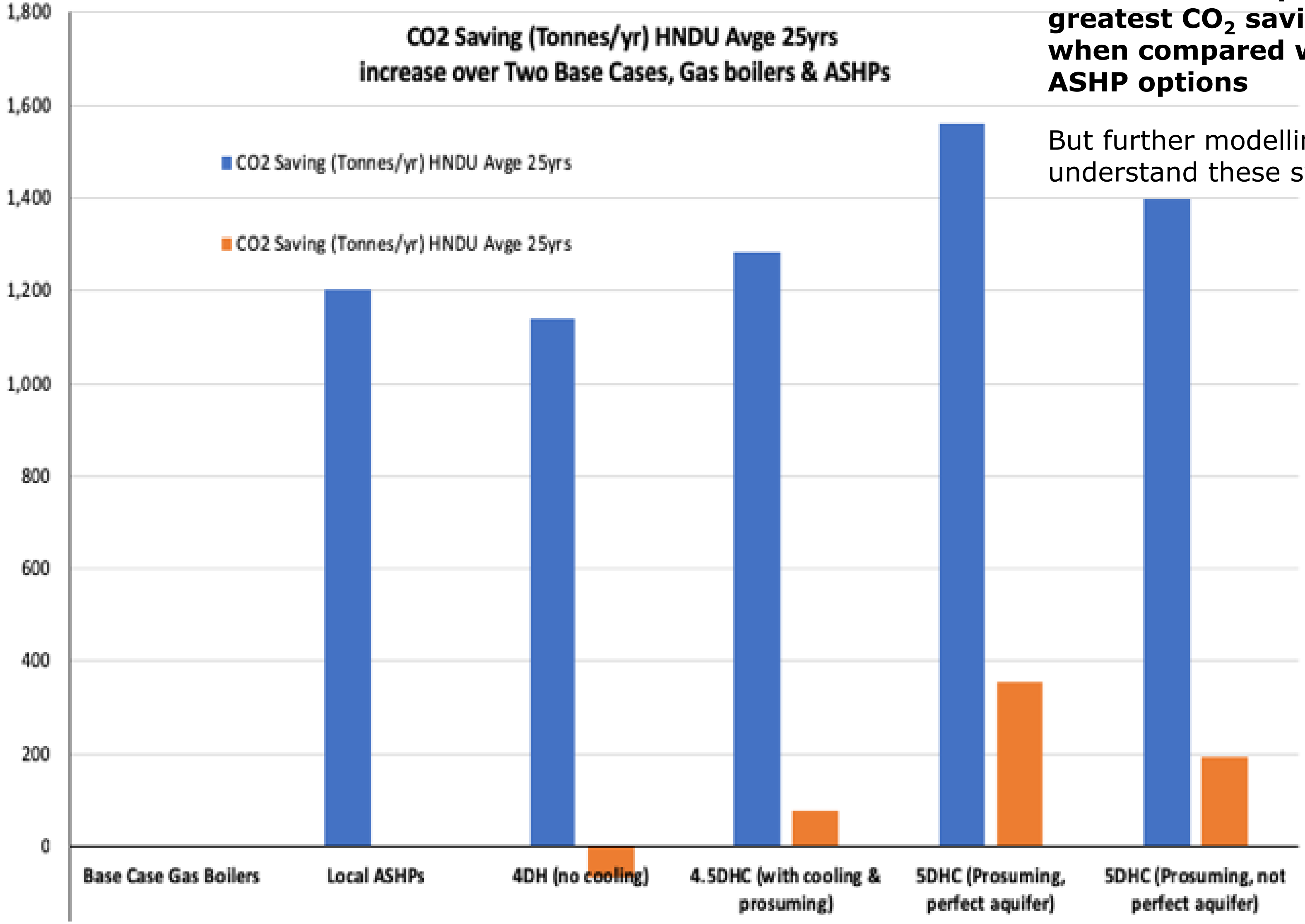
- The approach is based on balanced heating and cooling loads to exchange energy (prosume) as much as possible. The backbone is not an 'ambient loop' but is two main warm/and cold headers with a common return. This allows better hydraulics and avoids buildings on the end of a single pipe loop being starved of heating or cooling.
- Ultra low temperature networks like this need a means of balancing the spine temperatures when they get too hot or cold. In this case the minewater itself provides the seasonal storage balancing mechanism but other approaches are possible e.g. borehole aquifer storage. All mine wells are bi-directional to act as heat dumps/sources.
- Interchange of heating/cooling takes place on the backbone and buildings are seen as both demands (consumers) and suppliers (prosumers) with the overall spine and plant rooms controlled by the scheme operator.
- Local short term storage/buffers in cluster/building plant rooms smooth the operation of decentralised heat pumps. Local temperature boosting provides DHW using small heat pumps in the buildings.
- Pipework extends long distances compared to a 3rd generation heat network due to the low heat losses (flow is insulated) and plastic pipework is used were possible.
- A key part of the approach is to introduce energy efficiency measures including insulation to bring buildings down to Heerlen temperatures. Rather than dismissing existing buildings as too high temperature, the approach is to 'insulate them down to the Heerlen scheme.
- Heerlen began through local authority ownership and is unlikely to have come about otherwise. The diminishing availability of natural gas has also been as a driver, and this issue is used in promoting the heat network approach.

Where to implement 4th and 5th generation heat networks

- New build developments would be a relatively easy fit with 4/5DHC
- But still need DHW temperature boost
- Existing buildings probably still need ~80/70ºC maybe more of a challenge for 4/5DHC
- 4DHC is a good solution where the demands are mainly heating
- But 4DHC is a 4-pipe solution and has to be designed to lowest common denominator buildings i.e. at the highest heating temperatures
- 5DHC is a good solution where the demands are both heating and cooling
- 5DHC temperatures bring even wider sources and heat recovery opportunities into play
- Changes the approach to heat mapping and feasibility



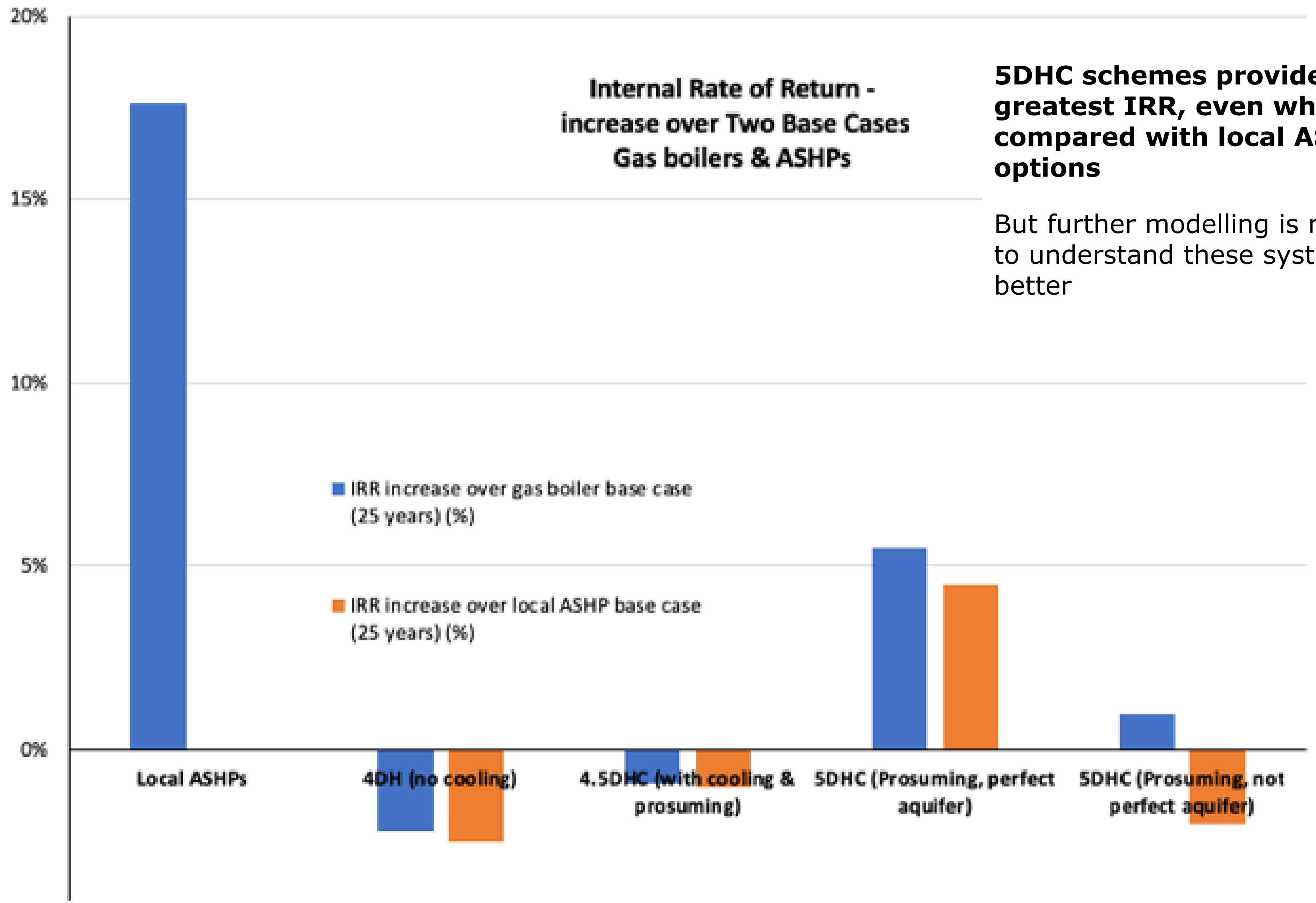
Potential economics of 4th and 5th generation heat networks



5DHC schemes provide the greatest CO_2 savings, even when compared with local ASHP options

But further modelling is needed to understand these systems better

Potential economics of 4th and 5th generation heat networks



5DHC schemes provide the greatest IRR, even when compared with local ASHP options

But further modelling is needed to understand these systems better

Benefits to building owners

	BAU	3DHC	4DHC	5DHC
PLANNING	Increasingly difficult to obtain planning permission	Planning permission should be straightforward	Planning permission should be even easier	Planning permission should be easier
TIMING	Development can go ahead at any time	Heat network requires careful timing	Heat network requires careful timing	Plug & play allows development can go ahead at any time
BUILDING REGULATIONS	Other measures required to achieve Part L	Lower Part L requirements	Even lower Part L requirements	Even lower Part L requirements
AIR QUALITY	Local air quality issues from gas boilers	Improved air quality compared to gas boilers	Improved air quality compared to gas boilers	Improved air quality compared to gas boilers
CAPITAL COSTS	Capital costs for traditional plant	Avoided capital costs of plant	Avoided capital costs of plant	Avoided capital costs of plant
ENERGY CENTRE	Space required for local plant rooms	Space required for centralised energy centre	Space required for centralised energy centre	Space required for plant rooms but centralised energy centre avoided
GAS SUPPLY	Annual gas safety check compliance	No gas safety check	No gas safety check	No gas safety check
FLUES	Individual flues required for boilers	No flues required	No flues required	No flues required
ELECTRICAL SUPPLY	Significant supply capacity for e.g. ASHP	Reduced electrical supply compared to distributed ASHPs	Reduced electrical supply compared to distributed ASHPs	Reduced electrical supply compared to 4DHC heat pumps
COOLING	Separate plant for cooling requiring space & capital costs	Separate plant for cooling requiring space & capital costs	Separate plant for cooling requiring space & capital costs	Built-in cooling with no additional capital requirements
RUNNING COSTS	Full costs	Reduced running costs & cost of heat	Even lower running costs & cost of heat	Even lower running costs & cost of heat
CARBON EMISSIONS	Higher carbon emissions	Lower carbon emissions	Even lower carbon emissions	Even lower carbon emissions
MAINTENANCE	Full O&M liabilities/ costs	No maintenance liabilities	No maintenance liabilities	No maintenance liabilities
REPLACEMENT COSTS	Capital costs for replacement plant	Avoided capital costs of plant	Avoided capital costs of plant	Avoided capital costs of plant

The temperature and timing for building connection is often a major reason not to connect to DHN

5DHC allows a more 'plug and play' approach that can address these developer issues

Selling comfort not heat

- Traditionally responsibility ends at the HIU
- Operators frustrated due to poor design/operation of internal building systems
- High return temperatures often traced back to problems outside the DHN operators remit
- Key to 5DHC is taking control of distributed plant rooms
- Allows full scheme optimisation and encourages prosuming across the network
- The more prosuming between buildings, the lower the operating costs (and carbon savings) that can be passed onto consumers

A new business model   'Selling comfort not heat'

- 5DHC changes the lines of responsibility for the operator and consumer
- Opens up opportunities for new ways of selling heating & cooling
- Potentially a huge step forward for new business models to come forward around heat networks

A solution for cooling

- 5DHC offers a way forward, a single system to supply/exchange both heating & cooling

Local Authority roadmap for 5th generation heat networks

2020

- Include Low Temperature Building Zones in Supplementary Planning Guidance (SPG) to develop 4DHC and 5DHC areas/corridors that offer preferential planning approval – give clear signals that these areas will grow
- SPG to include DHN connection future proofing of all new and refurbished buildings
- SPG to insist on following CIBSE/ADE Heat Networks Code of Practice CP1 (2019)
- Discourage resistive heating through less preferential planning approval with greater scrutiny
- Publish a local ‘connections guide’ covering policy, technical and legal DHN guidance

2025

- Early adoption of 150g/kWh to lower overall building carbon targets
- No new non-domestic buildings should connect to the gas grid, and should instead rely on low-carbon heating systems
- Continue grants and preferential planning approval to help buildings move to 60/40ºC
- Even more rigorous planning scrutiny/hurdles for proposed resistive heating buildings

A NEW LOW TEMPERATURE BUILDING ZONE

- All new and refurbished buildings to be less than 60ºC
- Grants to help existing buildings to move to 60ºC

THE PLYMOUTH RULE

UK Policy roadmap for 5th generation heat networks

2020

- Introduce SAP10 (and SBEM) 233g/kWh with lower overall building carbon targets
- Signal 150g/kWh and insist on all DHN following CIBSE/ADE Heat Networks Code of Practice CP1 (2019) from 2025
- Early adoption/signals no new homes should connect to the gas grid
- Retain the RHI for heat pumps and encourage prosuming buildings
- Grants to help Local Authorities set up 'heat delivery bodies'

2025

- Introduce SAP11 (and SBEM) 150g/kWh with even lower overall building carbon targets and enhanced DHLFs
- Set up a HEAT REGULATOR and include 4/5DHC in their remit
- No new homes or non-domestic buildings should connect to the gas grid
- Signal 2030 phase out of new-build and replacement gas boilers
- Make resistive heating a much harder option in Building Regulations
- Grants to help buildings move to 60/40ºC and encourage prosuming buildings

Conclusions

- Defined 4th and 5th generation heat networks with advantages and disadvantages
- 5DHC is best where there is a heating and cooling demand, 4DHC is a better solution where the demand is mainly heating
- 5DHC is single heating and cooling system with lower pipe costs, potentially covering longer distances
- Buildings on a 5DHC scheme become ‘prosumers’ that exchange heating/cooling across an ultra low temperature network
- Balancing aquifer thermal storage is necessary in 5DHC, but boreholes can be built-out gradually alongside the buildings, as and when developments occur
- 5DHC could allow operators to ‘sell comfort not heat’
- Possible local authority and UK policy roadmaps have been proposed to encourage 4th and 5th generation heat networks

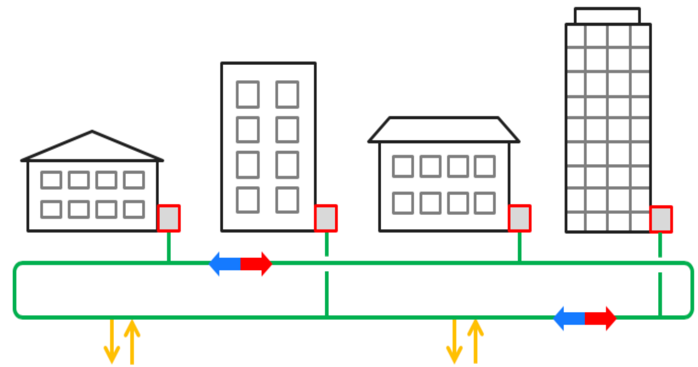
Conclusions

- 5DHC offers a ‘plug-and-play’ approach giving timing and temperature flexibility, whereas 4DHC has to be designed to the worst common denominator building temperature
- Modelling indicates that 5DHC schemes provide the greatest IRR and CO_2 savings, even when compared with local ASHP options

Overall, 4DHC and 5DHC have significant potential to reduce carbon emissions and provide greater flexibility to building owners/developers aiming to connect

HEATNET

Interreg North-West Europe
HeatNet NWE



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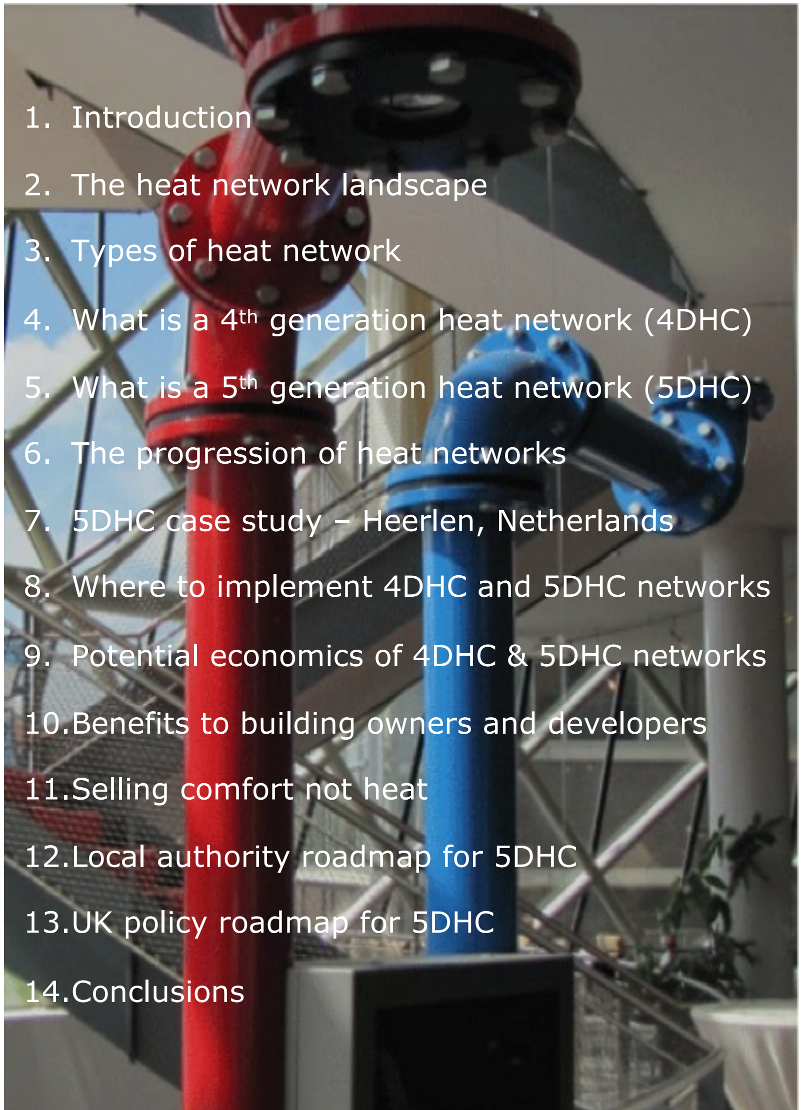
Summary



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5. What is a 5th generation heat network (5DHC)
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8. Where to implement 4DHC and 5DHC networks
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13. UK policy roadmap for 5DHC
14. Conclusions

Picture courtesy of Minewater BV

Space heating and hot water account for over

20%

of the UK's greenhouse gas emissions and this is mainly burning gas in boilers

Heat networks and heat pumps will be a key part of decarbonising heat in the UK

Lower temperature 4th and 5th generation heat networks offer a way to deploy heat pumps to achieve this

4DHC is a good solution where the demands are mainly heating, but it is a 4-pipe solution and has to be designed to the worst common denominator buildings

5DHC is a different shape, with decentralised heat pumps on an ultra low temperature network

Allowing energy exchange between buildings

The temperature and timing for building connection is often a major reason for not connecting to district heating

5DHC allows a more 'plug and play' approach that can address these issues

5DHC is a good solution where there is a significant mix of cooling and heating demands, allowing prosuming across the heat network itself

5DHC schemes provide the greatest IRR and CO_2 savings, even when compared with local ASHP options

Overall, 4DHC and 5DHC have significant potential to reduce carbon emissions and provide greater flexibility to building owners/developers aiming to connect

Introduction

This roadmap is an output from HeatNet, an EU Interreg project to address the challenge of reducing CO_2 emissions. The HeatNet 4DHC project aimed to identify the potential for 4th generation District Heating and Cooling (4DHC) in Plymouth, along with the medium and long term opportunities in a wider UK context.

This roadmap looks at the what, why, and where of 4th and 5th generation DHC. This is one of two complementary Roadmaps (Plymouth & UK). These roadmaps provide a next steps pathway, in both a practical and a policy way to encourage 4DHC and 5DHC.

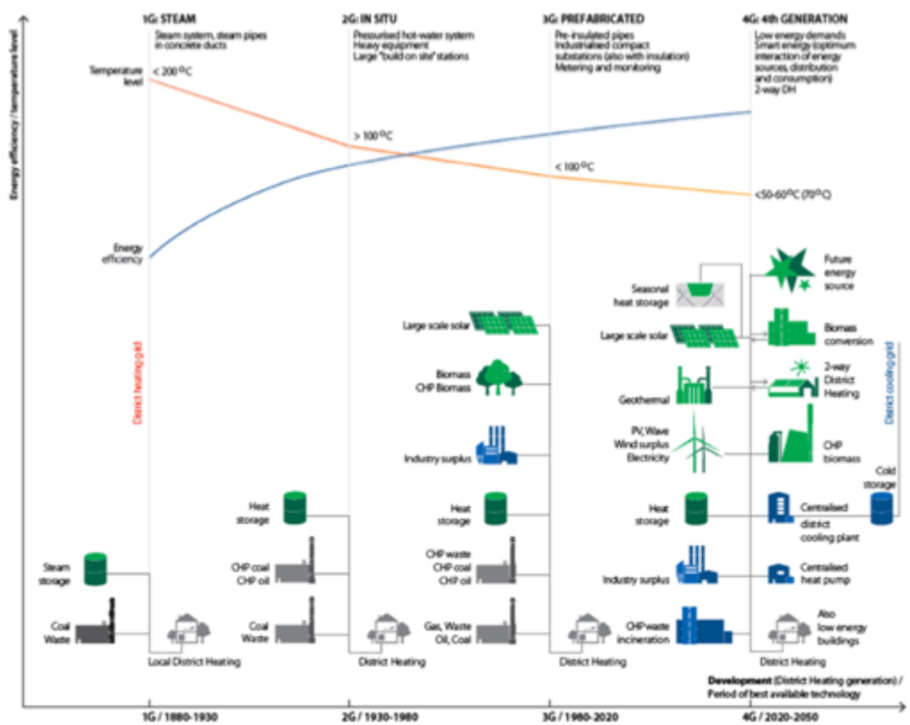
One of the key questions is 'what do we mean by 4DHC, how would we define it, and what would it actually look like'. The ultimate goal being the implementation of a scheme in Plymouth and the development of a roadmap which could help North West Europe move towards greater propagation of 4DHC systems.

Initially, the team led by Plymouth City Council took a working definition of 4DHC based on that from Lund et al, as shown opposite.

The Lund definition is widely recognised through the diagram shown opposite, setting out a progression from 1st to 4th generation. However, we believe this definition needs further clarification on the actual practicalities of topology, temperatures, opportunities etc and this roadmap provides more clarity on categorisation and definitions of 3DHC and 4DHC. This thinking has also given rise to an early definition of a 5th generation (5DHC) approach.

The Lund definition of 4th generation DHC:

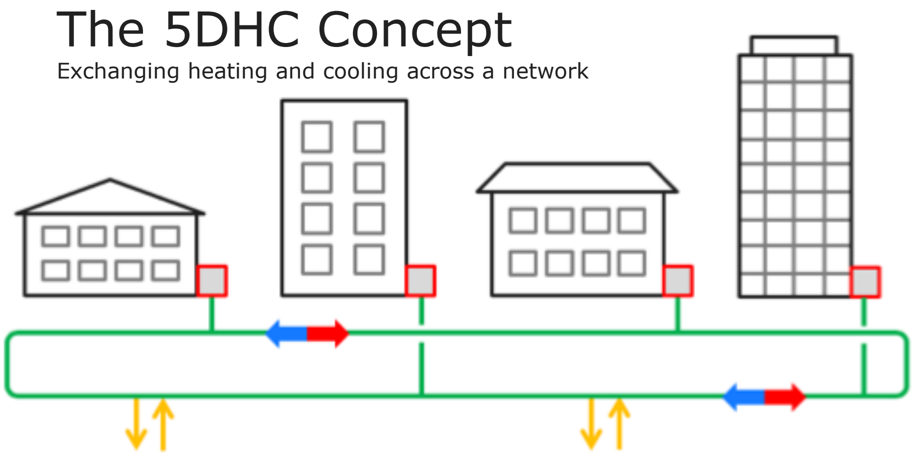
- *supply low-temperature (between 30-70ºC but generally 45-55ºC) district heating for space heating, domestic hot water and cooling to existing buildings, energy-renovated existing buildings and new low-energy buildings*
- *distribute heat and cooling in networks with low grid losses*
- *recycle heat from low-temperature and waste sources and integrate renewable heat sources such as solar and geothermal heat*
- *be an integrated part of smart energy systems (i.e. integrated smart electricity, gas, fluid and thermal grids)*
- *ensure suitable planning, cost and motivation structures in relation to the operation as well as to strategic investments related to the transformation into future sustainable energy systems.*



The heat network landscape

One of the main challenges for the UK over the next 30 years is how to decarbonise heat. Heat accounts for over a third of the UK's greenhouse gas emissions and the government has committed to reducing annual greenhouse gas emissions by at least 80% by 2050. A key part in the strategy is to encouraging the deployment of heat networks as a low carbon heating and cooling solution. In particular the UK government has introduced a £320M Heat Network Investment Programme to support this.

Heat networks are a key solution in high energy density areas. Also cooling demand is rising rapidly, partially as a results of warmer weather due to climate change. The UK electricity grid carbon factors have halved in recent years and further decarbonisation is making heat pumps a low carbon approach.



Unfortunately, UK district heating is often characterised and driven by the 80/70ºC nature of heating system design that has been part of the industry for many years. In some quarters there is still considerable resistance to moving away from these relatively high system/radiator temperatures. Much of the district heating in the UK could be regarded as stuck somewhere between 2DHC and 3DHC based on the Lund categories shown above. Initiatives like the CIBSE/ADE CP1 Heat Network Code of Practice and the Heat Trust Scheme are now beginning to change this thinking by providing investors/consumers improved standards and greater confidence around heat networks.

Current UK DH is often 2nd to 3rd generation supplying ~85ºC to meet the needs of existing buildings. Cooling is typically provided by separate systems, often local chillers rather than a district cooling system. Much of the UK DH sector is CHP based as the high value of electricity and relatively low cost of gas often makes it an economic solution. However, decarbonisation of the electricity grid means CHP is increasingly hard to justify based on carbon savings.

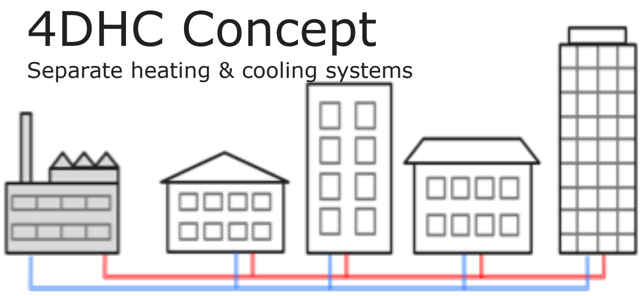
What do the future solutions look like? Decarbonisation of the grid is driving the electrification of heat. Many new buildings are also being designed around lower temperature heating systems, making heat pumps a more likely solution than gas based systems. The future for district heating is therefore likely to be lower temperatures and using heat pumps. What will these 4th and 5th generation heat networks look like and what are the benefits?

Heat networks and heat pumps will be a key part of decarbonising heat in the UK. Lower temperature networks offer a way to deploy heat pumps to achieve future reductions in carbon emissions.

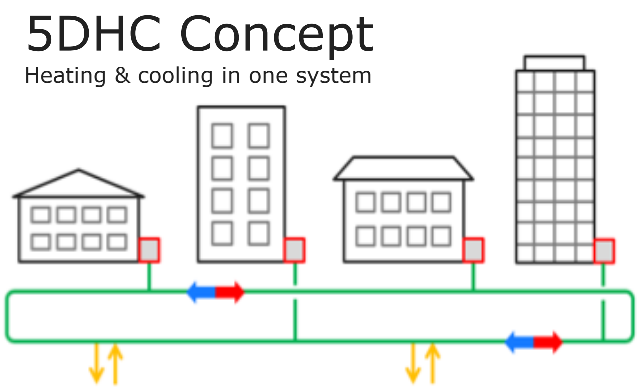
Types of heat network

3rd Generation DHC - Traditional centralised topology (shape) with an energy centre supplying heat outwards to buildings. Supplying at around 90-60ºC and return temperatures at around 50-40ºC, 3DHC would generally consist of well insulated, pre-insulated pipework with significant centralised thermal storage. 3DHC can supply DHW directly, but cooling would be a separate system. No interchange of heat between buildings is possible.

4th Generation DHC - Traditional centralised topology with energy an centre supplying heat outwards to buildings. Supplying at around 55-45ºC with a wider ΔT and return temperatures at around 25-15ºC, 4DHC would generally consist of highly insulated, pre-insulated pipework that is more likely to be plastic, with very large centralised thermal storage. 4DHC will usually need supplementary boosting to supply DHW, and cooling would be a separate system. No interchange of heat between buildings is possible.

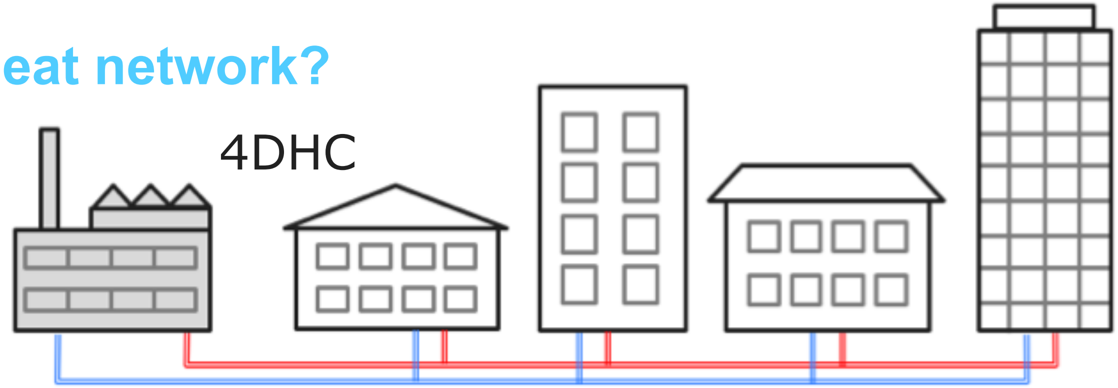


5th Generation DHC - Is a non-traditional topology with decentralised plant (usually heat pumps) supplying heat along ultra-low temperature headers in a spine/backbone (ambient loops may be possible in smaller systems). Supply at <45ºC, the ΔT is less relevant with return temperatures around 25-15ºC. 5DHC often consists of un-insulated plastic pipework with very low heat losses and longer pipe runs. 5DHC usually includes seasonal thermal storage to balance the spine temperatures and perhaps some short term localised thermal storage. 5DHC will always need supplementary boosting to supply DHW temperatures. 5DHC has built-in cooling supply and can interchange heating/cooling between buildings.



5DHC provides a single integrated 'plug-and-play' heating and cooling system allowing buildings to be 'prosumers' across the network.

What is a 4th generation heat network?



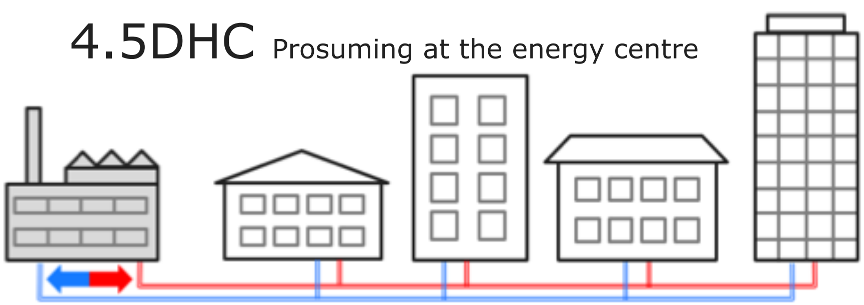
Topology – 4DHC is fundamentally the same topology/structure as a 3DHC design with a single energy centre and pre-insulated pipework supplying heat outwards to the demands. However, 4DHC differs significantly in having lower operating temperatures than 3DHC.

Operating temperatures – Generally 4DHC would supply at 55-45ºC which may then require a temperature boost in order to supply DHW. 4DHC would normally have wider ΔT's of 30ºC or greater. Return water temperatures may be designed to be as low as 25-15ºC. 4DHC systems could perhaps be weather compensated in Summer to reduce heat losses, providing the DHW boost can meet demand. However, this temperature reduction is less likely in 4DHC, the more that weather compensation is attempted, the more hot water boost is necessary to reach DHW temperatures.

Pipework – 4DHC would normally be highly insulated, pre-insulated pipework. However, the whole system could be run in cheaper plastic pre-insulated pipework which is also easier to install than steel (plastic pipework has reduced lifetime above ~70ºC).

Storage – 4DHC would generally have very large amounts of thermal storage capacity to smooth the demand and aid plant efficiency. Like 3DHC, this would be insulated hot water storage vessels. However, as temperatures are reduced, the storage capacity reduces so the tanks get larger, potentially presenting even greater location, aesthetics and planning issues.

Cooling – cooling would almost certainly be provided via a separate system. This means a 4-pipe system to achieve full 4DHC. It is notable that there is no interchange of energy between heating and cooling demands which is a key part of the Lund definition. So although the 4DHC approach meets the Lund requirements for a gradual reduction in temperature, it clearly does not distribute heat and cooling in networks with low grid losses. This is a key reason why a 5th generation category is necessary, where this energy exchange can occur across the network.



4DHC is a good solution where the demands are mainly heating, but 4DHC (with cooling) is a 4-pipe solution and has to be designed to the lowest common denominator buildings i.e. at the highest heating temperatures

A 4.5DHC option is possible to allow an exchange of heating and cooling at the energy centre

Advantages and disadvantages of 4th generation heat networks

Advantages include:

- Reduced operating costs and carbon emissions
- Lower heat losses due to lower operating temperatures
- Potentially longer pipe runs due to lower heat losses and cheaper pipework
- Greater plant efficiency due to improved heat transfer
- More opportunity for heat pumps, resulting in higher efficiencies at lower temperatures
- More opportunity to use low temperature waste/renewable heat sources

Disadvantages include:

- Larger pipework required to transfer the same amount of heat
- Greater pumping costs due to increased water volumes
- Requires some means of boosting temperature to supply DHW
- Larger storage volumes for the same amount of heat i.e. lower storage heat density
- No opportunity for energy exchange between buildings across the network, although exchange can occur at the energy centre i.e. 4.5DHC

4DHC Technologies include:

- High CoP heat pumps for new buildings operating at the 4DHC reduced temperatures
- High temperature (ammonia) heat pumps to supply existing buildings where 80/70ºC is still required
- Solar Hot Water temperatures become more compatible, with greater heat recovery potential as temperatures reduce
- CHP is generally a high temperature supply option and therefore less likely to play a part in 4DHC
- Condensing gas boilers could still be used as a top-up heat generator, but burning gas to provide heat at ~85% efficiency is less of a fit in a low carbon 4DHC strategy
- Biomass is highly unlikely to play a part in 4DHC, often requiring a continuous high temperature base load demand
- Cooling would still be provided by electric vapour compression chillers via a separate system.

4DHC Heat Sources include:

- Ground, Groundwater & Surface water would all play a greater part as heat sources in 4DHC, mainly due to lower temperatures providing higher heat pump CoPs
- Sewage treatment works and sewers could provide lower temperature heat sources for 4DHC heat recovery
- Industrial waste streams similarly provide greater opportunity for heat recovery
- Buildings with local large cooling demands (e.g. data centres) could provide a significant opportunity for local simultaneous heating & cooling using a single heat pump in one location i.e. 4.5DHC

What is a 5th generation heat network?

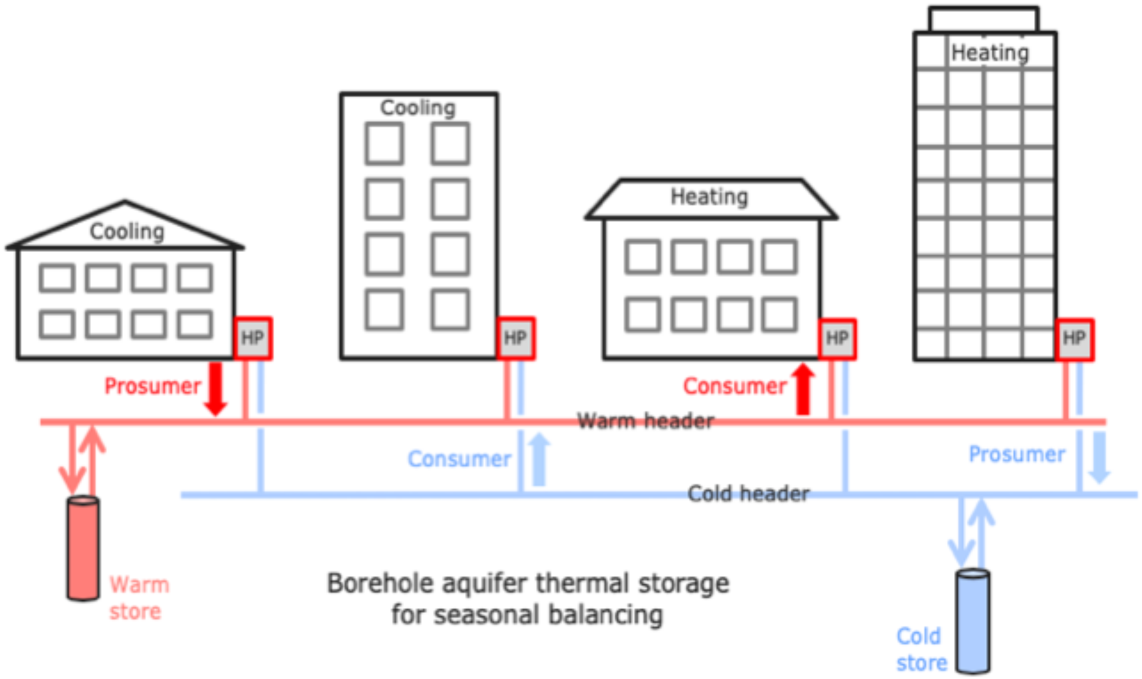
Topology – 5DHC is fundamentally a different shape/structure using a common two-pipe header system (spine) operating at even lower temperatures than 4DHC. The low temperature headers act as a heat source for multiple decentralised energy centres that take-out and feed-in heat.

This approach also requires a means of balancing the heat in the headers, when all buildings are in heating mode for instance. In Heerlen (see later), mine water is used to balance the 'backbone' but other balancing mechanisms are possible. Fundamental to 5DHC is the use of large long-term thermal storage as part of the balancing mechanism. 5DHC is the supply of heat along a spine with interchange of heating cooling between buildings and a balancing mechanism including seasonal thermal storage.

Essentially, the spine and long term thermal store become the heat source/sink for decentralised inputs and outputs of heat.

The scheme shown opposite uses borehole and aquifer thermal storage to balance the system with buildings acting as prosumers of heating/cooling. Boreholes can be built-out gradually alongside the buildings, as and when developments occur.

5DHC is a good solution where there is a significant mix of cooling and heating demands, allowing prosuming across the heat network itself.



5DHC schemes allows flexibility in terms of temperature and timing for building connections – a 'plug and play' approach.

Although we have retained the term 5th generation (5DHC) to allow easy differentiation and discussion, it is clear that 5DHC should be viewed as a different type of DHC altogether. Whilst 5DHC appears to be the next logical step, it has quite different shape, structure and approach to 3DHC and 4DHC.

Low temperature 'ambient loops' are possible if the loop has enough capacity to serve extremes. However, they are unlikely to operate well in larger schemes, as a loop makes it much harder to control heat and balance the system hydraulics than a header system. i.e. the last building on the loop could be starved of heating/cooling.

Other characteristics of 5th generation heat networks

Operating temperatures – Generally 5DHC would supply at less than 45ºC (often closer to 20ºC or less). 5DHC would not necessarily have wide ΔT's with 20ºC being sufficient, although wider ΔT's allow more heat to be carried in the same pipe. Return water temperatures may therefore be designed to be around 25-15ºC. 5DHC will always require a temperature boost in order to supply DHW but only the DHW volumes need to be boosted and this can be achieved locally. This might be achieved by individual booster heat pumps or a more centralised DHW system throughout each buildings.

Pipework – Because operating temperatures are so low, there is less need for pipe insulation as losses are very low anyway. The whole system could be run in cheaper plastic un-insulated pipework with significant capital cost reductions. The very low heat losses and reduced pipework costs can therefore lead to much longer pipework runs, potentially reaching buildings that would not normally be connectable.

Storage – 5DHC would generally have very large amounts of seasonal thermal storage capacity in order to balance heat in the spine. This could be aquifer or mine water storage or large purpose built underground stores. Some smaller short term thermal storage would be necessary in each decentralised plant room to smooth demand and enhance plant operation.

Cooling – Cooling would be provided from the same spine system. This means a 2-pipe system to achieve full 5DHC rather than a 4-pipe 4DHC system. This allows interchange of energy between heating and cooling demands in different buildings, meeting that particular part of the Lund definition.

Prosumer buildings - 5DHC is therefore a means to distribute heat and cooling in low temperature networks with low grid losses. Indeed, a key part of 5DHC design is to identify balanced loads where heating and cooling demands essentially cancel each other out. This fundamentally changes the way we think about heating/cooling supply in buildings. Buildings in heating mode then become 'prosumers' to supply cooling in other buildings, and vice versa. The idea of buildings as prosumers brings a requirement to balance demands across heat mapping, design and operation of heat networks, and changes the way we think about buildings.

This energy exchange is not a new idea, it was used in individual buildings on older Versatemp heat pump systems and is still used today in VRF systems. Small ground loop systems have also been developed to achieve this energy exchange, particularly in supermarkets. However, this energy exchange has not been achieved in the UK across large heat networks with energy exchange from one building to another.

Advantages, disadvantages of 5th generation heat networks

Advantages include:

- Even lower operating costs and carbon emissions than 4DHC
- Supplies both heating and cooling without the need for a separate cooling system
- Allows the interchange of heating and cooling between buildings, making buildings into prosumers
- Buildings take-out and feed-in heat making the system design less load dependent than a 3DHC or 4DHC topology
- Buildings can be added more easily without major changes to the spine/network. This could be viewed as a 'plug and play' onto a LAN. This can minimise timing issues that are often the downfall of more traditional heat networks
- Pipework heat losses can become almost irrelevant and insulation is often not required on the main heat network
- Cheaper pipework with low losses gives rise to potentially longer pipe runs covering wider areas, perhaps reaching buildings that would not normally be connectable
- Even greater plant efficiency, particularly heat pumps having very high CoPs
- More opportunity to recover waste/renewable heat sources such as solar water heating into the heat network
- Much greater opportunity for seasonal thermal storage which is not a feature of traditional heat networks

Disadvantages include:

- A 5DHC spine would require larger pipework to transfer the same energy. However, this can be minimised by balancing heating and cooling demands
- There are likely to be greater pumping costs due to the larger amounts of water being circulated
- 5DHC definitely requires some means of boosting temperature to supply DHW

5DHC Technologies include:

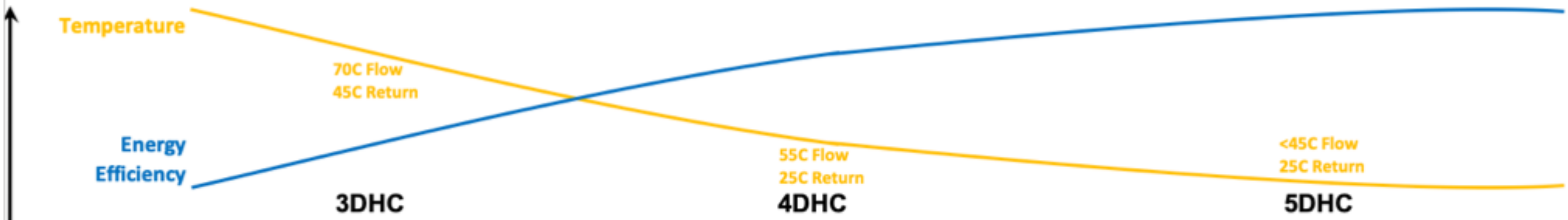
- Even higher CoP heat pumps, operating at the 5DHC reduced temperatures
- High temperature (ammonia) heat pumps to supply existing buildings where 80/70ºC is still required
- Solar Hot Water temperatures become even more compatible, with greater heat recovery potential as temperatures reduce
- CHP and biomass boilers are generally high temperature supply options and therefore unlikely to play a part in 5DHC
- Condensing gas boilers are much less likely to fit into a low carbon 5DHC strategy
- Electric vapour compression chillers should not be required on 5DHC networks

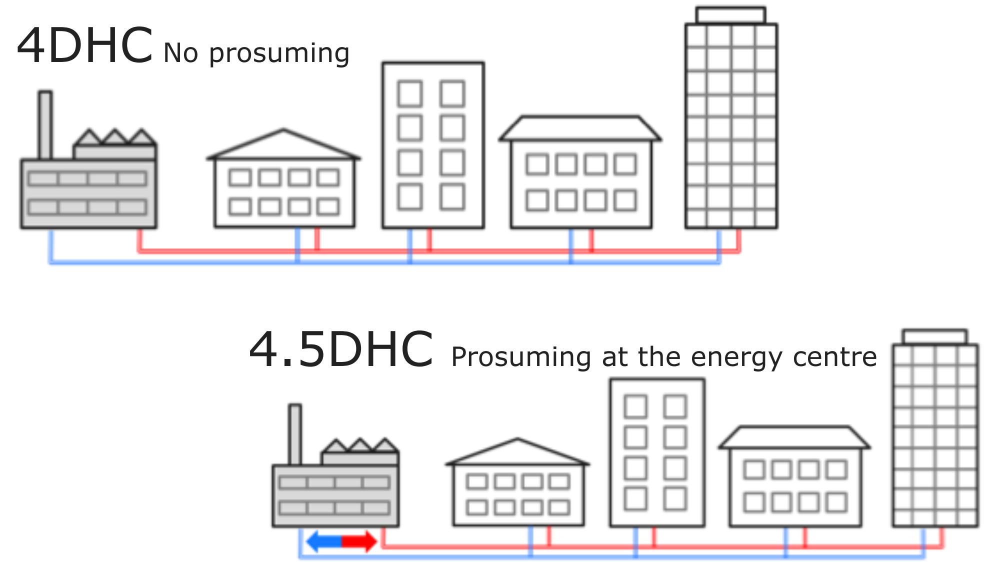
5DHC Heat Sources include:

- Ground, Groundwater & Surface water would all play an even greater part as heat sources in 5DHC
- Sewage treatment works and sewers would also provide heat sources for 5DHC heat recovery
- Industrial waste streams similarly provide even greater opportunity for heat recovery
- In general, the ultra low temperatures in 5DHC open up wider range of sources for heat recovery

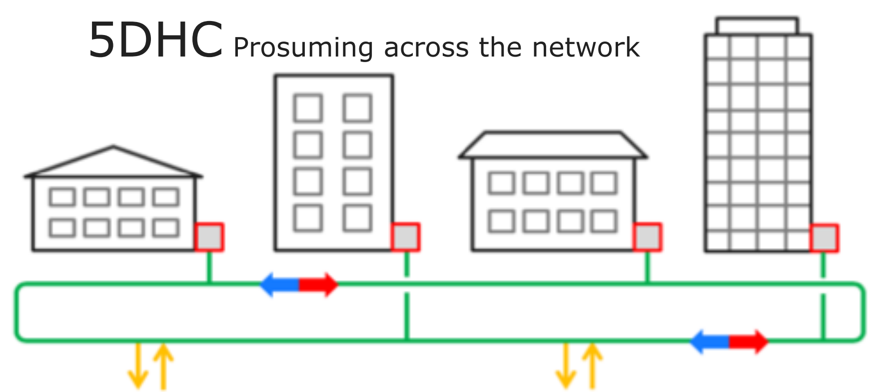
The progression of heat networks

(This acknowledges and builds on work by Lund et al)





It is clear from that there is a progression/transition path from 3DHC to 4DHC due to the similar system architectures (topologies) involved. However, whilst 5DHC appears to be the next logical step, it has quite different shape, structure and approach. For discussion purposes, we have retained the term 5th generation (5DHC) but it should probably be viewed as an entirely different type of DHC altogether.



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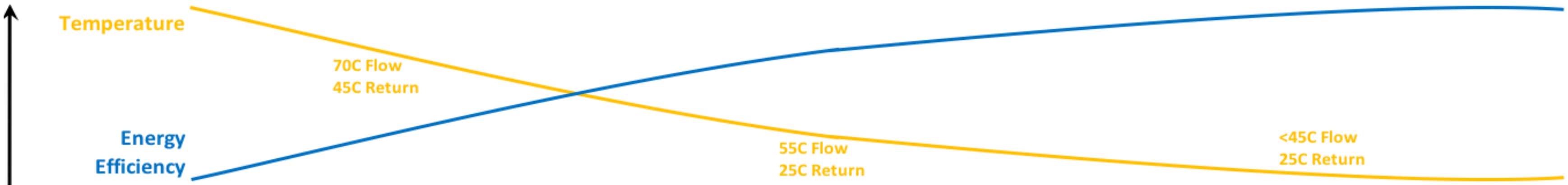
The progression of heat networks

(This acknowledges and builds on work by Lund et al)



	3DHC	4DHC	5DHC
DEFINITION			
Topology	- Traditional - Single Energy Centre supplying heat outwards	- Traditional - Single Energy Centre supplying heat outwards	**VERY DIFFERENT APPROACH** - NOT traditional DH design or central energy centre - Decentralised plant supplying spine/clusters/buildings - Supplying heat along a spine/backbone - Low temperature headers (not an ambient loop)
Temperature	- Supply at 70-60C [60C min to supply DHW] - Wide ΔT - Return temperatures 50-40ºC - Weather compensated to 60ºC	- Supply at 55-45C - Wider ΔT - Return temperatures 25-15C - Not weather compensated	- Supply at <45C - ΔT Less relevant - Return temperatures 25-15C - Not weather compensated
Pipework	- Well insulated, pre-insulated pipework	- Highly insulated, pre-insulated pipework - Plastic pipework	- Un-insulated pipework? Very low losses, longer runs? - Plastic un-insulated pipework
Storage	- Significant thermal storage	- Very large thermal storage	- Seasonal thermal storage - Some short term thermal storage
DHW	- Can supply DHW directly	- Will need supplementary boost to supply DHW	- Will need supplementary boost to supply DHW
Cooling	- Cooling would be a separate system	- Cooling would be a separate system	- Built-in cooling in a 2-pipe system
Heat interchange	- No interchange of heat between buildings	- No interchange of heat between buildings	- Interchange of heating/cooling with balancing mechanism - Buildings are then prosumers
ADVANTAGES		- Reduced operating costs and carbon emissions - Lower heat losses - Longer pipe runs? - Greater plant efficiency - More opportunity for heat pumps - More opportunity to use waste/renewable heat sources - More opportunity for simultaneous Heating & cooling?	- Even lower operating costs and carbon emissions - Supplies both heating & cooling - No need for separate cooling system - Interchange of heating & cooling - heat recovery between buildings - Buildings pick-off/inject, so less load dependent? - Can add buildings more easily - Heat losses become almost irrelevant - Longer pipe runs covering wider areas - Even greater plant efficiency, particularly Heat Pumps - More opportunity to use waste/renewable heat sources
DISADVANTAGES		- Larger pipework - Greater pumping costs - Requires DHW boost - Less storage density - No opportunity for energy exchange between buildings across the network	- Larger pipework - Greater pumping costs - Requires DHW boost - Less storage density
APPLICATIONS		**Mainly a new-build technology but with specific solutions for existing buildings where necessary** - New build (relatively easy) - Deep retrofit (straightforward) - Existing Buildings & Retrofit Lite - Boost to 80/70ºC with high temperature HPs - Slightly more opportunity for simultaneous Heating & cooling (conventional HPs)?	**More flexible/connectable plug and play LAN approach with built-in cooling and interchange of energy between buildings** - New build (easy) - Deep retrofit (easy) - Retrofit Lite (relatively easy) - Boost with conventional temperature HPs - Existing buildings (straightforward) - Boost with high temperature HPs - Built-in simultaneous Heating & Cooling (using conventional HPs) - Seasonal storage using boreholes

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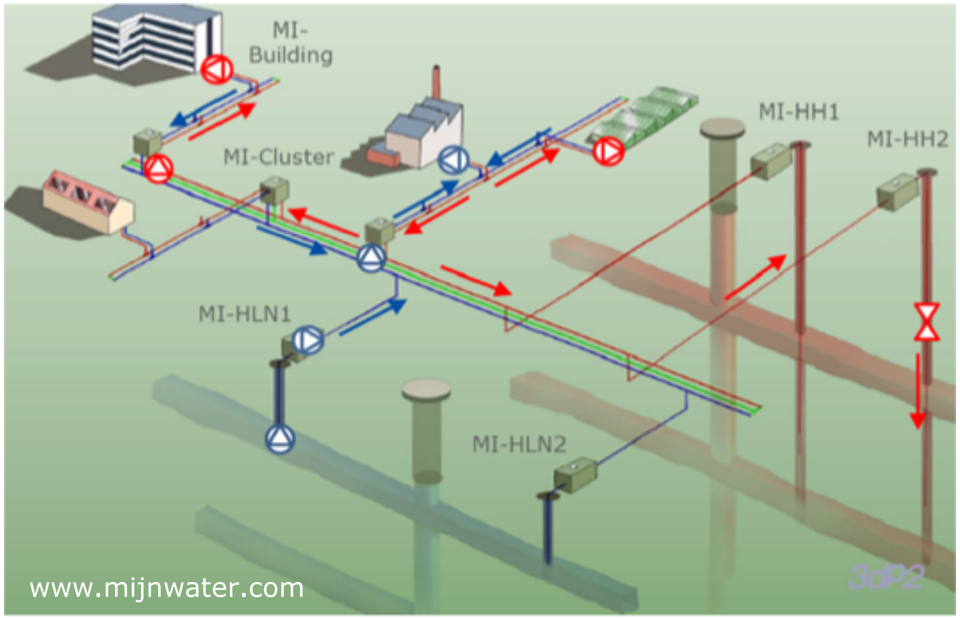
5^{th} generation case study – Heerlen, Netherlands



The Minewater project in Heerlen, Netherlands is a working 5^{th} generation DHC scheme. The scheme uses decentralised heat pumps and is based around mine water from a warm mine and a cold mine with a spine (backbone) as shown opposite.

Phase 2 of the scheme (Minewater 2.0) allowed the operators to take full control of the distributed heat pump plant rooms storage and controls. This allowed a lot more operational plant optimisation including energy exchange across the spine (prosuming) between buildings. This turned the approach into a heating/cooling supply scheme and promoted exchange of energy.

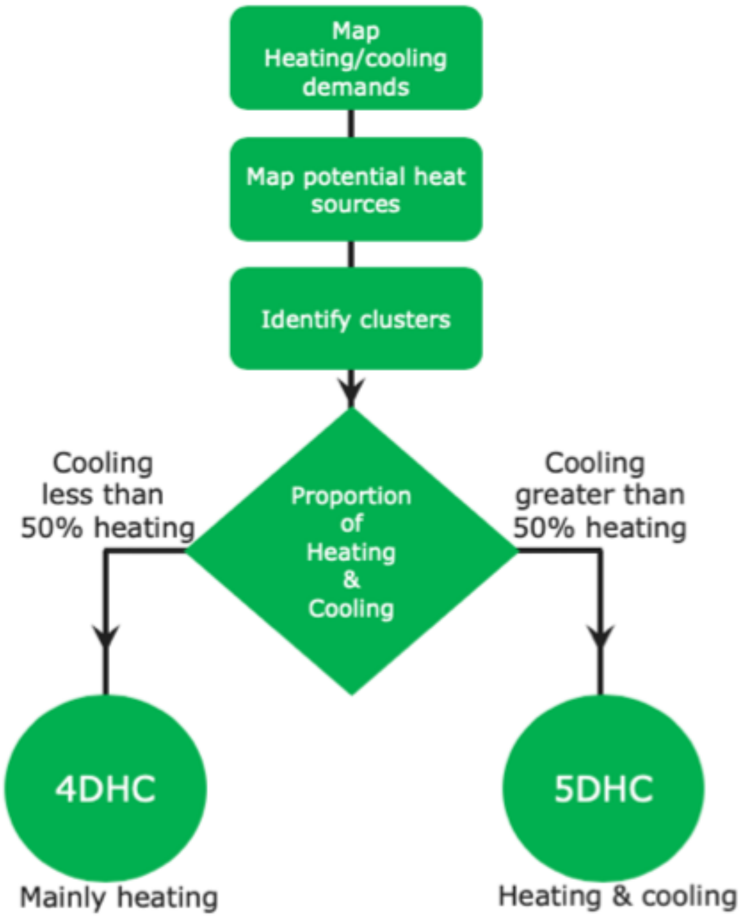
Minewater 3.0 is now introducing demand side response controls, gradually making the scheme a smart grid that interacts with the electricity market.

- The approach is based on balanced heating and cooling loads to exchange energy (prosume) as much as possible. The backbone is not an ‘ambient loop’ but is two main warm/and cold headers with a common return. This allows better hydraulics and avoids buildings on the end of a single pipe loop being starved of heating or cooling.
- Ultra low temperature networks like this need a means of balancing the spine temperatures when they get too hot or cold. In this case the minewater itself provides the seasonal storage balancing mechanism but other approaches are possible e.g. borehole aquifer storage. All mine wells are bi-directional to act as heat dumps/sources.
- Interchange of heating/cooling takes place on the backbone and buildings are seen as both demands (consumers) and suppliers (prosumers) with the overall spine and plant rooms controlled by the scheme operator.
- Local short term storage/buffers in cluster/building plant rooms smooth the operation of decentralised heat pumps. Local temperature boosting provides DHW using small heat pumps in the buildings.
- Pipework extends long distances compared to a 3^{rd} generation heat network due to the low heat losses (flow is insulated) and plastic pipework is used were possible.
- A key part of the approach is to introduce energy efficiency measures including insulation to bring buildings down to Heerlen temperatures. Rather than dismissing existing buildings as too high temperature, the approach is to ‘insulate them down to the Heerlen scheme.
- Heerlen began through local authority ownership and is unlikely to have come about otherwise. The diminishing availability of natural gas has also been as a driver, and this issue is used in promoting the heat network approach.

Where to implement 4th and 5th generation heat networks

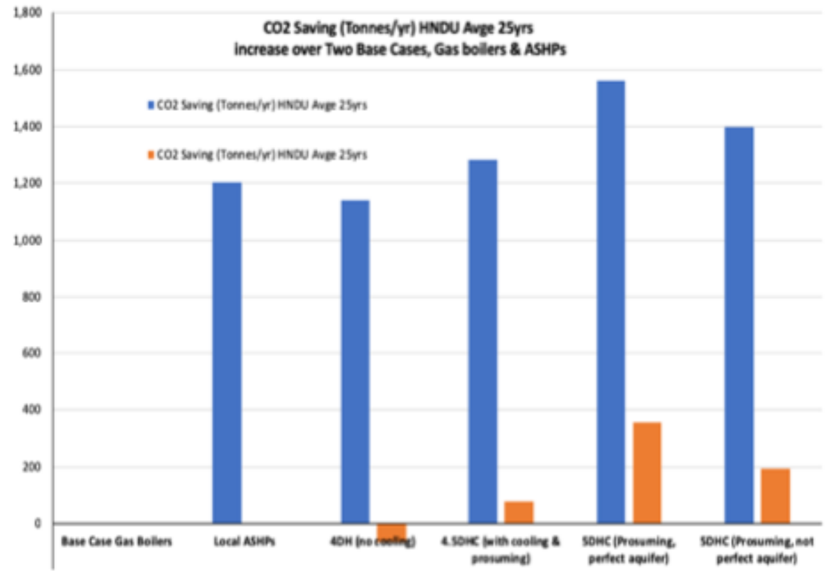
A move to lower temperature 4DHC would provide a change to the types of building that would be most applicable

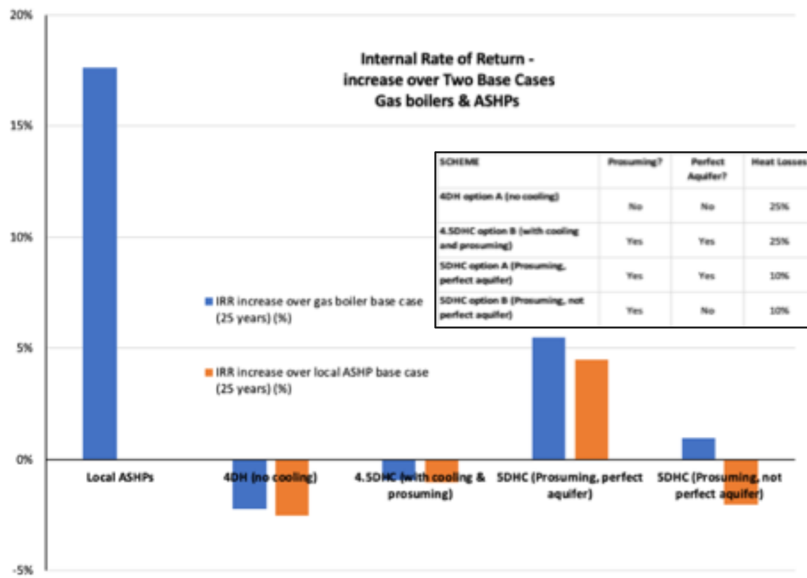
- New build developments would be a relatively easy fit with 4/5DHC as buildings can be specifically designed with appropriate low temperature heating systems
- Similarly, deep-retrofit buildings can be designed to match 4/5DHC temperatures
- Both of the above would still require systems to boost DHW temperatures at an individual dwelling level or at a more centralised building level
- Existing buildings and buildings undergoing retrofit-lite would probably still require higher temperatures, say 80/70ºC and are therefore more of a challenge for 4/5DHC
- However, higher temperature heat pumps could be used to boost to 80/70ºC in order to supply higher temperature heating systems in particular buildings
- 4DHC is a good solution where the demands are mainly heating, but 4DHC is a 4-pipe solution and has to be designed to the lowest common denominator buildings i.e. at the highest heating temperatures
- 5DHC is a good solution where the demands are both heating and cooling
- 5DHC temperatures bring even wider sources and heat recovery opportunities into play
- This does change the way heat mapping and feasibility is carried out, see opposite



Further work is necessary around the ideal distribution of heat pumps. When/if to cluster buildings – say three offices on one plant room OR say 100 individual homes. What is the ideal distribution/spacing/location of heat pumps?

Potential economics of 4th and 5th generation heat networks





SCHEME	Prosuming?	Perfect Aquifer?	Heat Losses	Cooling Network
4DH option A (no cooling)	No	No	25%	No
4.5DHC option B (with cooling and prosuming)	Yes	Yes	25%	Yes
5DHC option A (Prosuming, perfect aquifer)	Yes	Yes	10%	No
5DHC option B (Prosuming, not perfect aquifer)	Yes	No	10%	No

Based on the scheme being proposed in Plymouth, techno-economic modelling was carried out to compare 4DHC and 5DHC with both a gas boiler counterfactual (shown in blue) and a local ASHP counterfactual (shown in orange). Whilst this is very scheme specific, it does provide a useful indication of the potential economic balance between these systems.

- None of the schemes are economic without RHI or HNIP given the current electricity and gas prices. The taxation of these fuels unfairly favours gas use
- 5DHC(A) has the largest CO_2 savings (top graph) because of the low network losses and elimination of gas usage
- The 4DHC options require gas boiler top-up and have larger losses, these are negative factors for carbon emissions
- 4DH(A) increases carbon emissions over the local ASHP counterfactual due to network heat losses
- The only option with a positive IRR (bottom graph) is the 5DHC(A) scheme with RHI, although this is still below the standard public sector hurdle rate
- 5DHC has a capex advantage by not having to put in as large a heating and cooling network but instead has the borehole and water pipes. However, this capex benefit is largely lost because of the high capital cost of local DHW booster heat pumps

  5DHC options win because they have more heat pump capacity which inflates the RHI without compromising the capital costs. Decentralised 5DHC heat pumps are significantly cheaper per kWth than 4DHC heat pumps
- Lower 5DHC temperatures and the lack of a primary network mean there is a significant difference in heat losses, 25% for 4DHC versus 10% for 5DHC.

5DHC schemes provide the greatest IRR and CO_2 savings, even when compared with local ASHP options

Benefits to building owners and developers

	BAU	3DHC	4DHC	5DHC
PLANNING	Increasingly difficult to obtain planning permission	Planning permission should be straightforward	Planning permission should be even easier	Planning permission should be easier
TIMING	Development can go ahead at any time	Heat network requires careful timing	Heat network requires careful timing	Plug & play allows development can go ahead at any time
BUILDING REGULATIONS	Other measures required to achieve Part L	Lower Part L requirements	Even lower Part L requirements	Even lower Part L requirements
AIR QUALITY	Local air quality issues from gas boilers	Improved air quality compared to gas boilers	Improved air quality compared to gas boilers	Improved air quality compared to gas boilers
CAPITAL COSTS	Capital costs for traditional plant	Avoided capital costs of plant	Avoided capital costs of plant	Avoided capital costs of plant
ENERGY CENTRE	Space required for local plant rooms	Space required for centralised energy centre	Space required for centralised energy centre	Space required for plant rooms but centralised energy centre avoided
GAS SUPPLY	Annual gas safety check compliance	No gas safety check	No gas safety check	No gas safety check
FLUES	Individual flues required for boilers	No flues required	No flues required	No flues required
ELECTRICAL SUPPLY	Significant supply capacity for e.g. ASHP	Reduced electrical supply compared to distributed ASHPs	Reduced electrical supply compared to distributed ASHPs	Reduced electrical supply compared to 4DHC heat pumps
COOLING	Separate plant for cooling requiring space & capital costs	Separate plant for cooling requiring space & capital costs	Separate plant for cooling requiring space & capital costs	Built-in cooling with no additional capital requirements
RUNNING COSTS	Full costs	Reduced running costs & cost of heat	Even lower running costs & cost of heat	Even lower running costs & cost of heat
CARBON EMISSIONS	Higher carbon emissions	Lower carbon emissions	Even lower carbon emissions	Even lower carbon emissions
MAINTENANCE	Full O&M liabilities/ costs	No maintenance liabilities	No maintenance liabilities	No maintenance liabilities
REPLACEMENT COSTS	Capital costs for replacement plant	Avoided capital costs of plant	Avoided capital costs of plant	Avoided capital costs of plant

It is clear that new-build and deep-retrofit scenarios are the easiest applications of 4DHC and 5DHC. Developers are therefore key to introducing 4DHC/5DHC. This table sets out some possible developer incentives to move to 4DHC and 5DHC heat networks compared to a business as usual approach using gas boilers.

The temperature and timing for building connection is often a major reason not to connect to DHN. 5DHC allows a more 'plug and play' approach that can address these developer issues.

Selling comfort not heat

Traditional business models - In traditional and even 4th generation district heating the scheme operator is only responsible for heat reaching the building. Their responsibility ends at the building thermal sub-station or perhaps at a dwelling Heat Interface Unit. Many scheme operators are left frustrated that the poor design and operation of the internal building systems have a detrimental effect on their DHN performance. In particular, poor DHN return temperatures can often be traced back to problems that are outside the DHN operators remit e.g. high temperature heating systems, poorly insulated secondary pipework, poor heating control, poor HIU set-up etc.

5DHC taking overall control - A key part of a more decentralised 5DHC approach is that the scheme operator needs to take control of the distributed plant rooms to allow full scheme optimisation and encourage prosuming across the network. The operator can then optimise heat pump performance through good control and maintenance. Whilst also promoting greater exchange of energy between buildings. The more prosuming between buildings the lower the overall overall operating costs (and carbon savings) that can be passed onto consumers.

Buildings as prosumers – An essential part of 5DHC is therefore that the scheme operator must take full responsibility for the whole scheme including the decentralised heat pump plant rooms in order to allow management of the buildings as prosumers and balancing of the 5DHC headers/boreholes. Without this, prosuming is less likely and the benefits of 5DHC begin to fall away.

A new business model – 5DHC therefore changes the lines of responsibility for the operator and consumer. This opens up opportunities for new ways of selling heating and cooling. This might be better described as 'selling comfort not heat'. Consumers could then be offered a temperature based service without having to worry about maintenance and replacement. Although these new business models are possible with 4DHC, they are less likely. Whereas a comfort based service is almost built-in to the 5DHC approach. This is potentially a huge step forward for new business models to come forward around heat networks.

A solution for cooling – there is a significant increase in cooling demand, with changes in climate and consumer expectation being big drivers. How is this cooling going to be supplied in the long term? 5DHC offers a way forward as it is a single system to supply/exchange both heating and cooling.

The consumer would simply pay for a comfort level with less to worry about around replacement and maintenance.

The operator can take full control of the whole scheme, optimise the system and bring greater cost/carbon benefits through a comfort based offer.

Local Authority roadmap for 5th generation heat networks

2020

- Include Low Temperature Building Zones in Supplementary Planning Guidance (SPG) to develop 4DHC and 5DHC areas/corridors that offer preferential planning approval – give clear signals that these areas will grow
- SPG to include DHN connection future proofing of all new and refurbished buildings (based on Buro Happold connection templates)
- SPG to insist on following CIBSE/ADE Heat Networks Code of Practice CP1.2
- Early adoption of 'no new homes should connect to the gas grid' and should instead rely on low-carbon heating systems such as heat pumps
- Local grants and S106 agreements to help buildings move to 60/40ºC
- Greater enforcement of Building Regulations Part L
- Discourage resistive heating through less preferential planning approval with greater scrutiny
- Publish a local 'connections guide' covering policy, technical and legal DHN guidance

2025

- Extend the Low Temperature Building Zones to cover all new buildings, offer preferential planning approval to buildings able to act as prosumers
- Early adoption of 150g/kWh with even lower overall building carbon targets
- No new non-domestic buildings should connect to the gas grid, and should instead rely on low-carbon heating systems such as heat pumps
- Continue grants and preferential planning approval to help buildings move to 60/40C
- Even more rigorous planning scrutiny/hurdles for proposed resistive heating buildings

2030

- Local Authorities should becomes a single LTBZ where all new buildings must be less than 60/40ºC
- Early adoption of 100g/kWh with even lower overall building carbon targets
- SPG to include even greater encouragement of 5DHC and prosuming buildings

A NEW LOW TEMPERATURE BUILDING ZONE

- All new and refurbished buildings to be less than 60ºC
- Grants to help existing buildings to move to 60ºC

THE PLYMOUTH RULE

UK Policy roadmap for 5th generation heat networks

2020

- Introduce SAP10 (and SBEM) 233g/kWh with lower overall building carbon targets
- Include improved Design Heat Loss Factors for 4DHC and 5DHC in SAP/SBEM
- Signal 150g/kWh and insist on all DHN following CIBSE/ADE Heat Networks Code of Practice CP1.2 from 2025
- Early adoption/signals 'no new homes should connect to the gas grid' and should instead rely on low-carbon heating systems such as heat pumps
- Grants to help buildings move to 60/40ºC and encourage presuming buildings
- Retain the RHI for heat pumps and encourage prosuming buildings
- Develop standard SPG text and connection guidance to assist Local Authorities
- Grants to help Local Authorities set up 'heat delivery bodies'

2025

- Introduce SAP11 (and SBEM) 150g/kWh with even lower overall building carbon targets and enhanced DHLFs
- Set up a HEAT REGULATOR and include 4/5DHC in their remit
- By 2025 at the latest, no new homes or non-domestic buildings should connect to the gas grid, and should instead rely on low-carbon heating systems such as heat pumps
- Signal 2030 phase out of new-build and replacement gas boilers
- Make resistive heating a much harder option in Building Regulations
- Continue grants to help buildings move to 60/40ºC and encourage prosuming buildings
- Continue/review the RHI for heat pumps and further encouragement for prosuming buildings

2030

- Introduce SAP12 (and SBEM) 100g/kWh with even lower overall building carbon targets
- Begin phase-out of new-build and replacement gas boilers
- Begin phase-out of resistive space heating
- Continue grants to help buildings move to 60/40ºC and encourage presuming buildings
- Continue, but review, the RHI for heat pumps and further encouragement for prosuming

Conclusions

- This study has defined 4th and 5th generation heat networks more clearly (Typologies) and set out where these types of heat network might best be used (Applications). The work has also identified the advantages and disadvantages of the various 4DHC and 5DHC approaches
- 5DHC using decentralised heat pumps is best where there is a heating and cooling demand, 4DHC is a better solution where the demand is mainly heating
- 5DHC has even greater potential in new-build because of the lower temperatures involved. But higher supply temperature heat pumps can be used to serve existing buildings
- Both heating and cooling can be provided from the same 5DHC system using a 2-pipe system to achieve full 5DHC rather than a 4-pipe 4DHC system. 5DHC has lower pipe costs, potentially covering longer distances
- Buildings on a 5DHC scheme become ‘prosumers’ that exchange heating and cooling across an ultra low temperature network
- 5DHC offers a plug-and-play approach giving timing and temperature flexibility on same system, whereas 4DHC has to be designed to the worst common denominator building temperature
- Heat losses are one of the big differences between 4DHC and 5DHC, a key advantage of 5DHC, but both 4DHC and 5DHC require temperature boosting to supply DHW
- Balancing aquifer thermal storage is necessary in 5DHC, but boreholes can be built-out gradually alongside the buildings, as and when developments occur
- Modelling indicates that 5DHC schemes provide the greatest IRR and CO_2 savings, even when compared with local ASHP options. Further modelling is needed to better understand these systems.
- 5DHC could allow operators to ‘sell comfort not heat’ which is potentially a huge step forward for new business models to come forward around heat networks
- Possible local authority and UK policy roadmaps have been suggested to encourage 4th and 5th generation heat networks. These sit alongside a more specific roadmap to reach a specific 5DHC scheme in Plymouth.

Overall, 4DHC and 5DHC have significant potential to reduce carbon emissions and provide greater flexibility to building owners/developers aiming to connect

The HeatNet project

HeatNet is an EU Interreg project to address the challenge of reducing CO_2 emissions across North West Europe by creating an integrated transnational approach to the supply of renewable and low carbon heat to residential and commercial buildings.

This particular project in Plymouth forms one of the 6 pilot studies in the UK, Ireland, Belgium, France, and the Netherlands that HeatNet have funded. The project focussed on identifying potential 4th generation district heating and cooling schemes in Plymouth.

Plymouth City Council (PCC) appointed a main consultant (Buro Happold) to conduct an extensive project focussed on introducing 4DHC across the whole Plymouth area. PCC also appointed a 'Concepts Team' comprising Building Energy Solutions, Carbon Descent and Genius Energy Lab to work in parallel and directly with the main consultant in order to use the Plymouth outcomes to develop UK wide learning and guidance on 4DHC for the whole sector. The Concepts Team aimed to develop/standardise the widest possible ideas, concepts and approaches to introducing 4DHC/5DHC.

The Plymouth HeatNet project had 5 stages:

Stage 1 - Research and evaluation on 4DHC opportunities

Stage 2 - Heat Mapping

Stage 3 - Outline Design

Stage 4 - Techno-economic Analysis

Stage 5 - Transition Roadmap

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This report presents the Concepts Team outputs as a road map for 4DHC across Plymouth, other local authorities and the UK as a whole.

Just prior to publication of this roadmap, the Heatnet team became aware of a very significant piece of work on 5DHC:

5th generation district heating and cooling systems: A review of existing cases in Europe (Buffa S et al) (Renewable and Sustainable Energy Reviews) (February 2019)

This is an important and comprehensive parallel study and it is encouraging that it appears to be very much in line with our own independent findings. However, given the timing we were not able to take account of the work in any detail.

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The HEATNET partners in Plymouth

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