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District Heating - Jumping a generation

Case study of a 3rd generation CHP district heating system which got updated to a 5th generation system with a shared ground source heat pump system.

By Tim Taylor
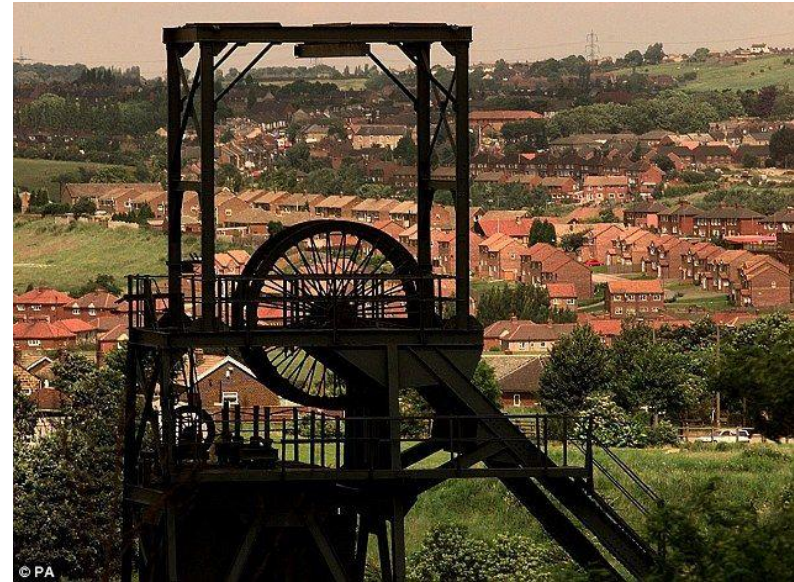
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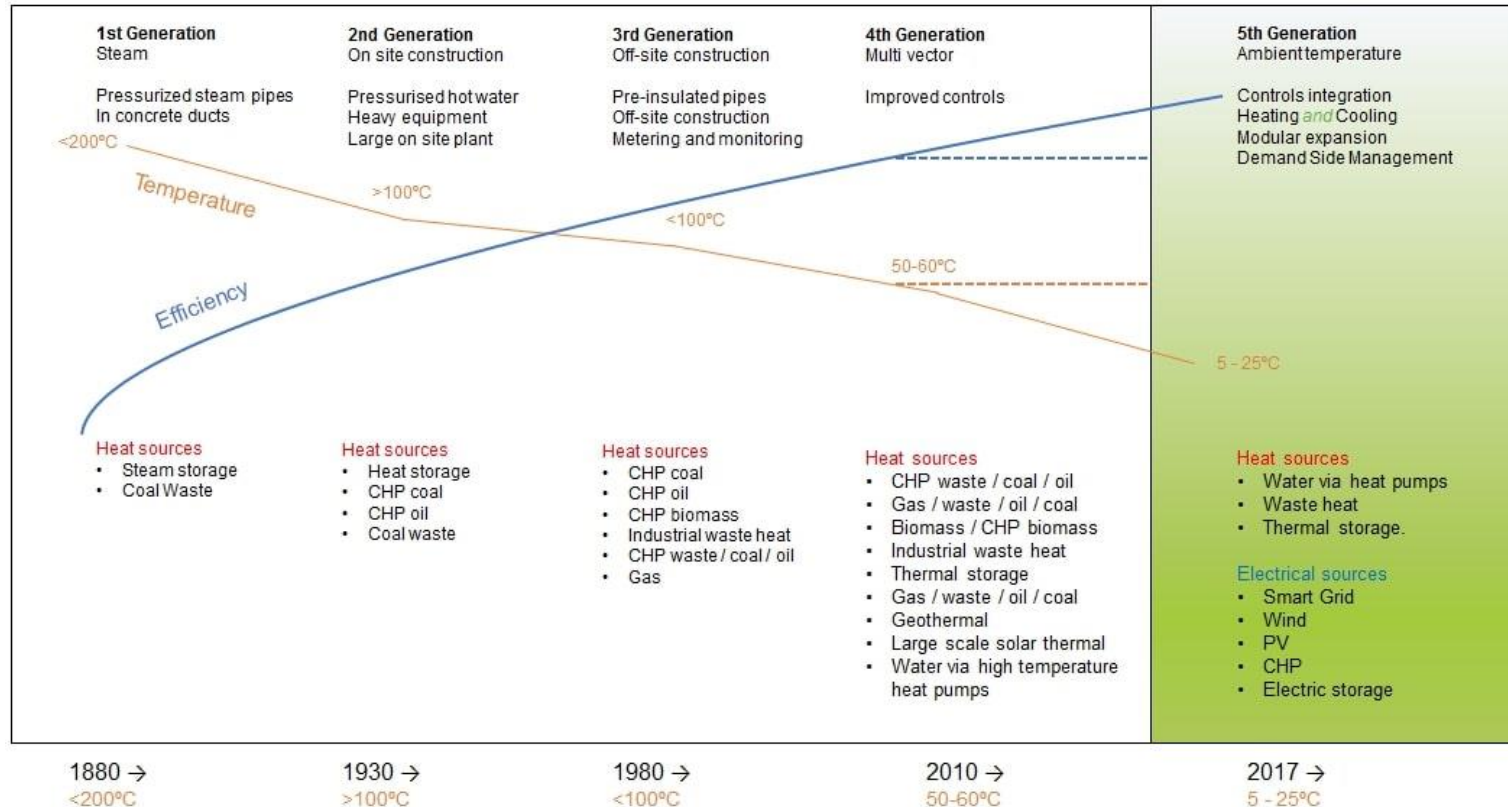
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What was the project brief?

- Client – Local Authority
- DH scheme for Town Centre (Civic Buildings)
- Update a District Heating Study from Year 2017
- Year 2021 to 2035 – Energy centre (CHP Units).
- Year 2035 – Energy centre (Renewable sources).
- Review and Improve:-
  - Energy centre design,
  - Underground pipework specification,
  - Heat network routes,
  - DH building connections,
  - Carbon savings,
  - Paybacks,
  - **I**nternal **R**ate of **R**eturn (IRR),

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District Heating Generations terms explained

1st Generation Steam	2nd Generation On site construction	3rd Generation Off-site construction	4th Generation Multi vector	5th Generation Ambient temperature
Pressurized steam pipes In concrete ducts	Pressurised hot water Heavy equipment Large on site plant	Pre-insulated pipes Off-site construction Metering and monitoring	Improved controls	Controls integration Heating and Cooling Modular expansion Demand Side Management

Temperature

Efficiency

<200°C   >100°C   <100°C   50-60°C   5 - 25°C

Heat sources
- Steam storage
- Coal Waste

Heat sources
- Heat storage
- CHP coal
- CHP oil
- Coal waste

Heat sources
- CHP coal
- CHP oil
- CHP biomass
- Industrial waste heat
- CHP waste / coal / oil
- Gas

Heat sources
- CHP waste / coal / oil
- Gas / waste / oil / coal
- Biomass / CHP biomass
- Industrial waste heat
- Thermal storage
- Gas / waste / oil / coal
- Geothermal
- Large scale solar thermal
- Water via high temperature heat pumps

Heat sources
- Water via heat pumps
- Waste heat
- Thermal storage.

Electrical sources
- Smart Grid
- Wind
- PV
- CHP
- Electric storage

1880 →	1930 →	1980 →	2010 →	2017 →
<200°C	>100°C	<100°C	50-60°C	5 - 25°C

Heat network trends to lower distribution temperatures and higher efficiency

Image courtesy of https://www.icax.co.uk/image_Fifth_Generation_Heat_Networks.html

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Figure 1: Carbon intensity of different technologies

As electricity decarbonises, should we continue burning fossil fuels in CHP engines to displace grid electricity?

Image courtesy of https://www.cibsejournal.com/general/power-of-good-future-of-uk-heat/

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3rd Generation System

- Air emissions.

- Noise.

- Planning permission.

- Less car parking spaces.

- Fossil fuel for 15 years.
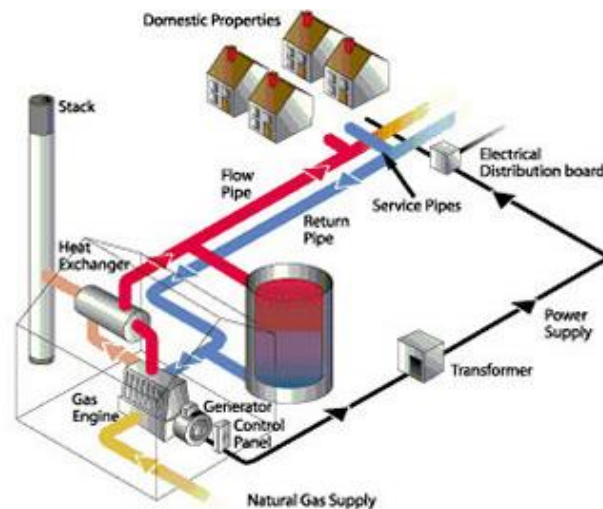
Energy Centre Car Park Location
One (1) x CHP engine rated 770kWe,
One (1) x CHP engine rated at 520kWe
Two (2) x thermal store capacity each rated 120m^3
Four (4) x gas boilers each rated 1500kW

One (1) off Heat Water Source Heat Pump rated at 1500kW
Replaced CHP engine in 2035

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5th Generation System

- Net zero carbon 1st day of install.

- Repurpose Plant rooms.

- No air or noise emissions issues.

- Additional cooling connections.
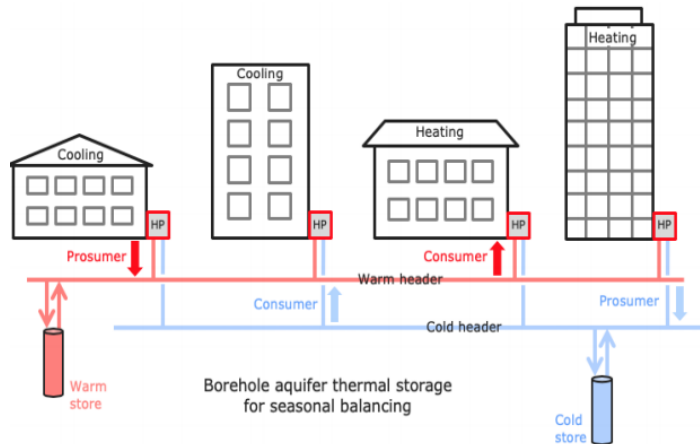
Pump run within council offices.
Twelve (12) x boreholes
Secondary side water source heat pump

Image courtesy of https://smartenergysystems.eu/wp-content/uploads/2019/09/17-3_PhilJonesSESAAU2019.pdf

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Revised Civic quarter District Heating Network

CAPEX = £7,810,455 (€8,541,033)

Total CO_2 Savings = 44,087 tonnes

DH unit price = 8p (15c)/kWh

Internal rate of return = 4.1%

Net Present Value = £244,031 (€266,857)

Project Lifetime = 40 years

Revised Ambient Loop Option

CAPEX = £9,909,012 (€10,835,886)

Total CO_2 Savings = 63,141 tonnes

DH unit price = 11p (12c)/kWh

Internal rate of return = 4.3%

Net Present Value = £675,938 (€739,164)

Project Lifetime = 40 years
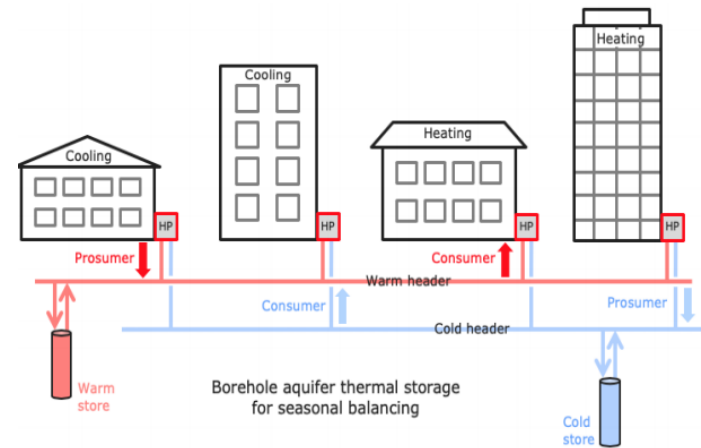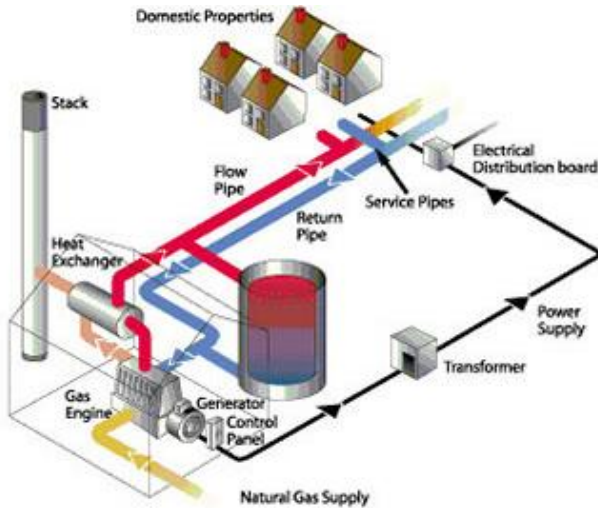
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Comments from grant funder?

Grant Funder – Uncertain domestic heat pumps can deliver flow temperatures at 80°C?

Sweco – Manufacturers available in the marketplace.

Future - Included data sheets and case studies on future reports.

Grant Funder – Concerns over adjustments of building's heating systems
(e.g. changing radiators to underfloor heating systems).

Sweco – All buildings need to be adjusted for DH adaption.

Future – Provide detail of typical secondary side system adjustments needed and its importance if not applied correctly.

Grant Funder – Considered COP = 2.5 too low, why not just fit, air source heat pumps (ASHP)?

SWECO – On ASHP's COP values will reduce below 2.5 during peak winter time when it -5°C ambient.

Future - Show comparison between air source and ground source during -5°C ambient air.

Grant Funder - Uncertainty of back up heating supply.

SWECO – Back up unnecessary, main point of failure would be electrical blackout at connecting building.

Future - Report to include available fail safes (e.g. batteries, standby generators, PCM thermal storage).

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Help from Industry?

Please send us :-

- Data sheets and brochures of water source heat pumps with output of 80°C
- Turnkey contractors with ambient loop experience
- Case studies of 5th generation ambient loop success stories
- Case studies of high thermal looses for badly installed 3rd generation systems
- Data sheets and brochures of industrial batteries and electrical storage
- Data sheets and brochures of PCM thermal storage

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