Techno-economic analysis of low-temperature district heating network implementation in the city of Nottingham, UK

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AALBORG UNIVERSITY
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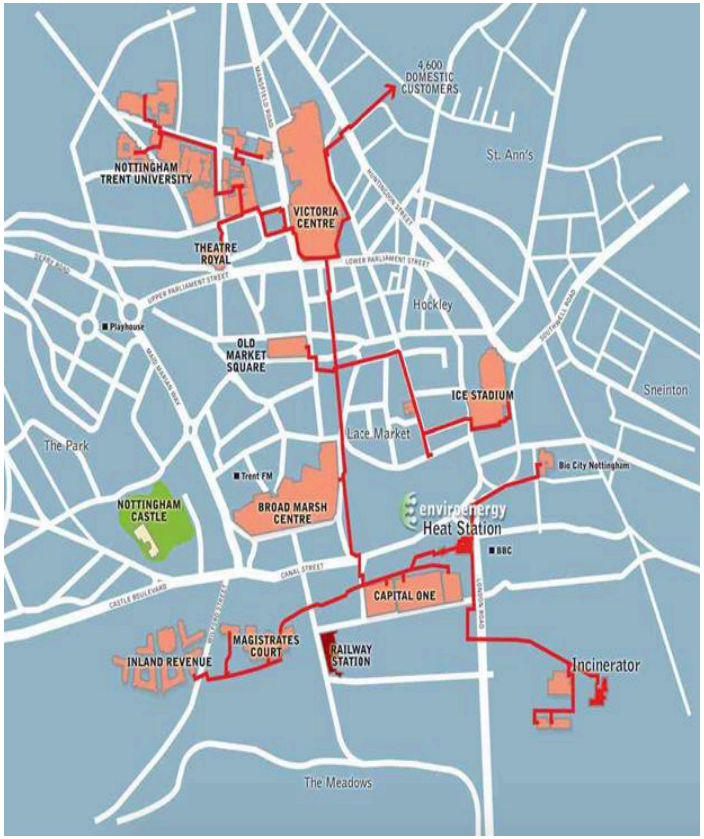
Outline

- Background
- Demonstration Site
- Research Aims
- Scenarios
- Method
- Results
- Conclusion

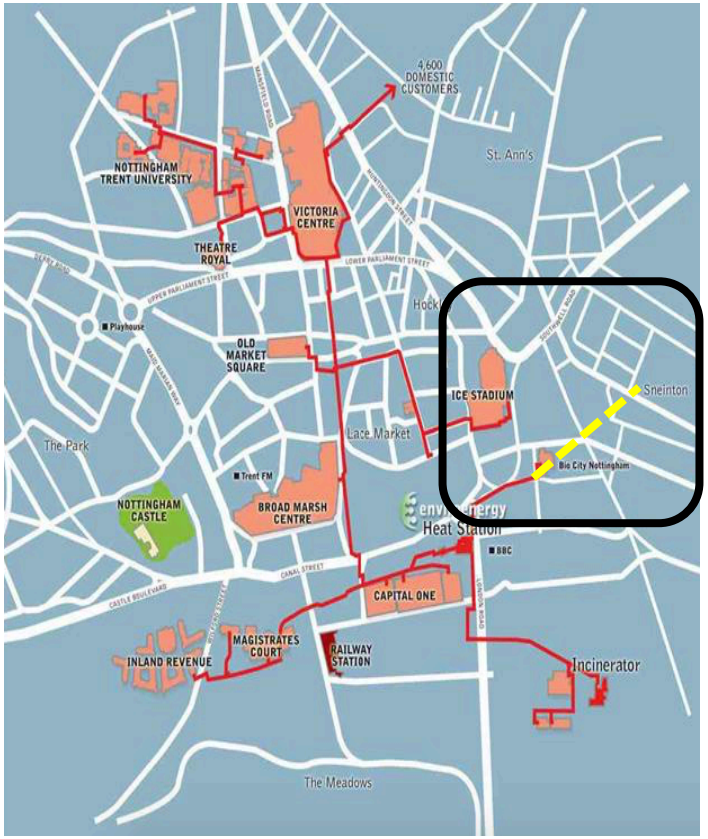
District Heating System in Nottingham

- 4900 homes and commercial buildings
- 68 km of insulated pipework
- Heat is coming from Eastcroft Energy From Waste incineration plant
- 144,000 MWh annual heat demand
- Network supply temperature is between 85-120°C
- Network return temperature is around 70°C



District Heating intervention in Nottingham

High return temperature shows sufficient capacity for a LTDH intervention to the nearby areas rather than extending high temperature network.



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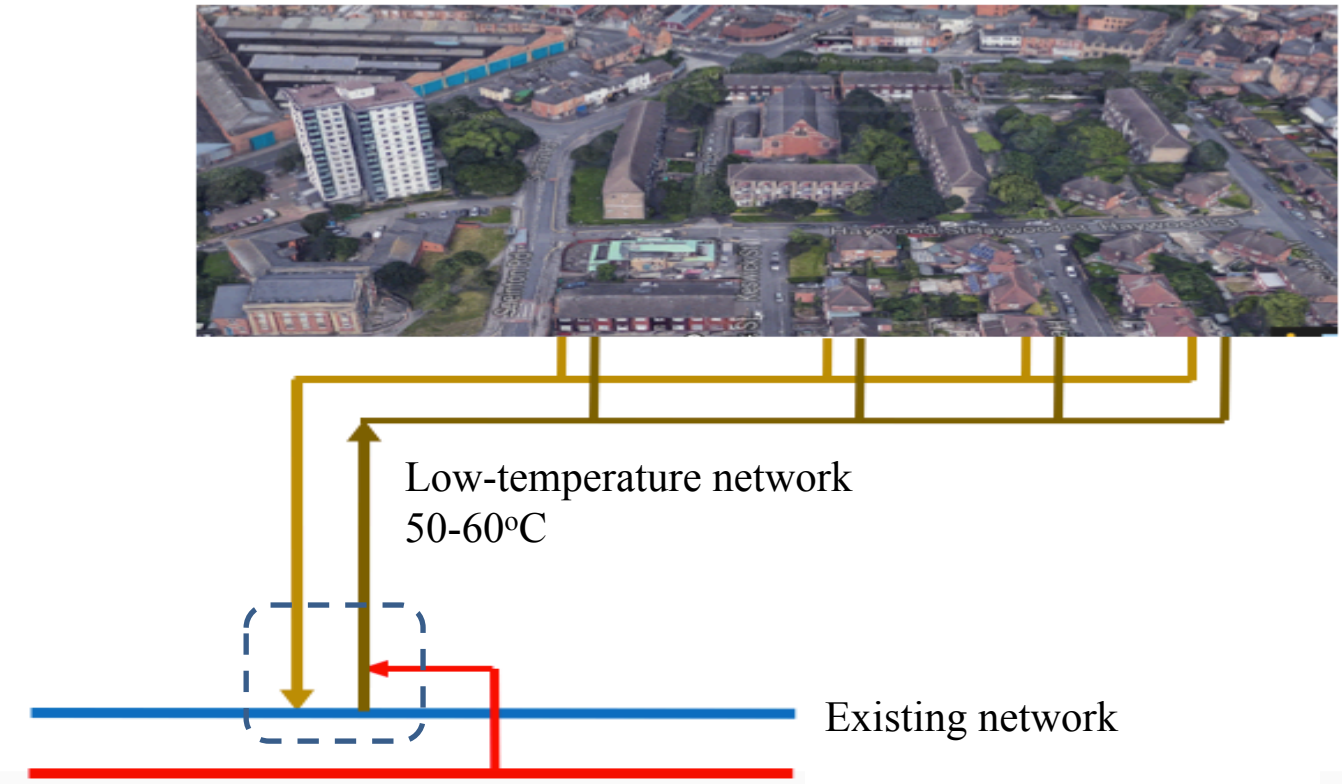
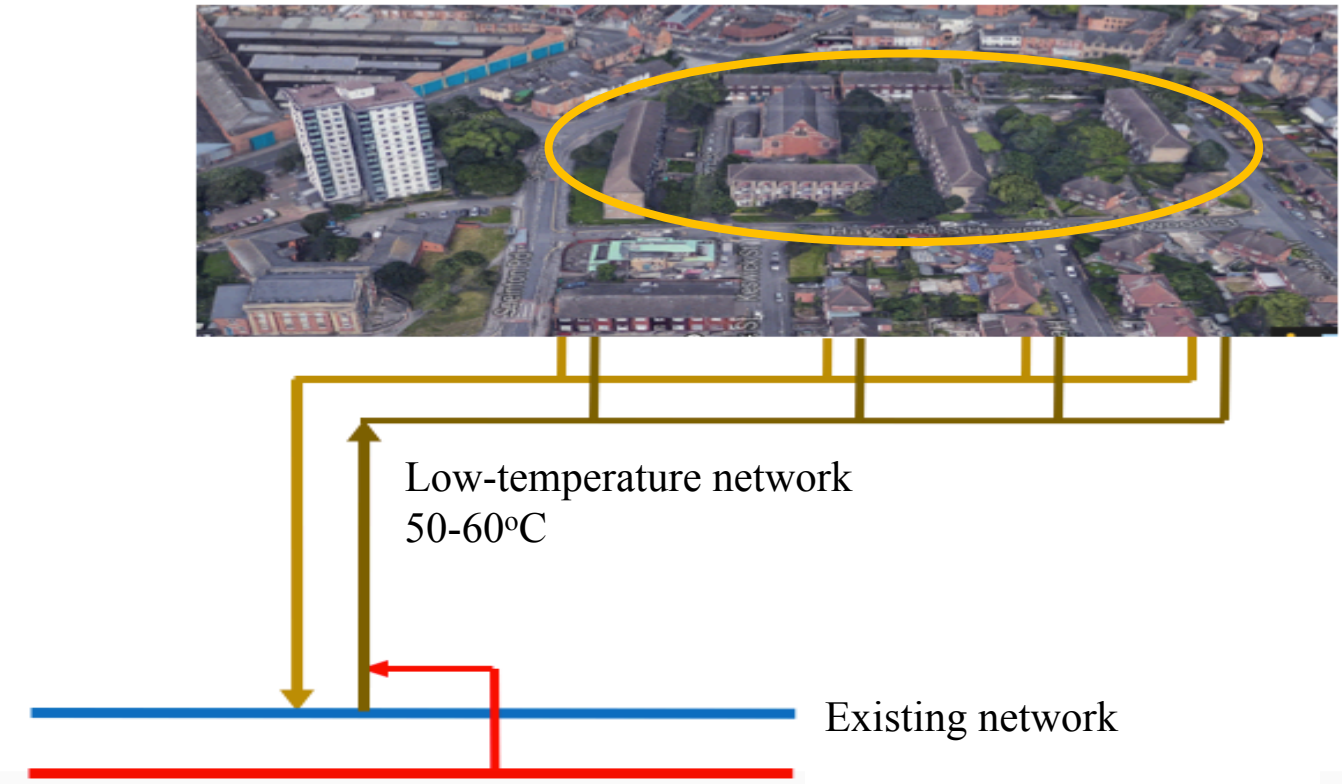
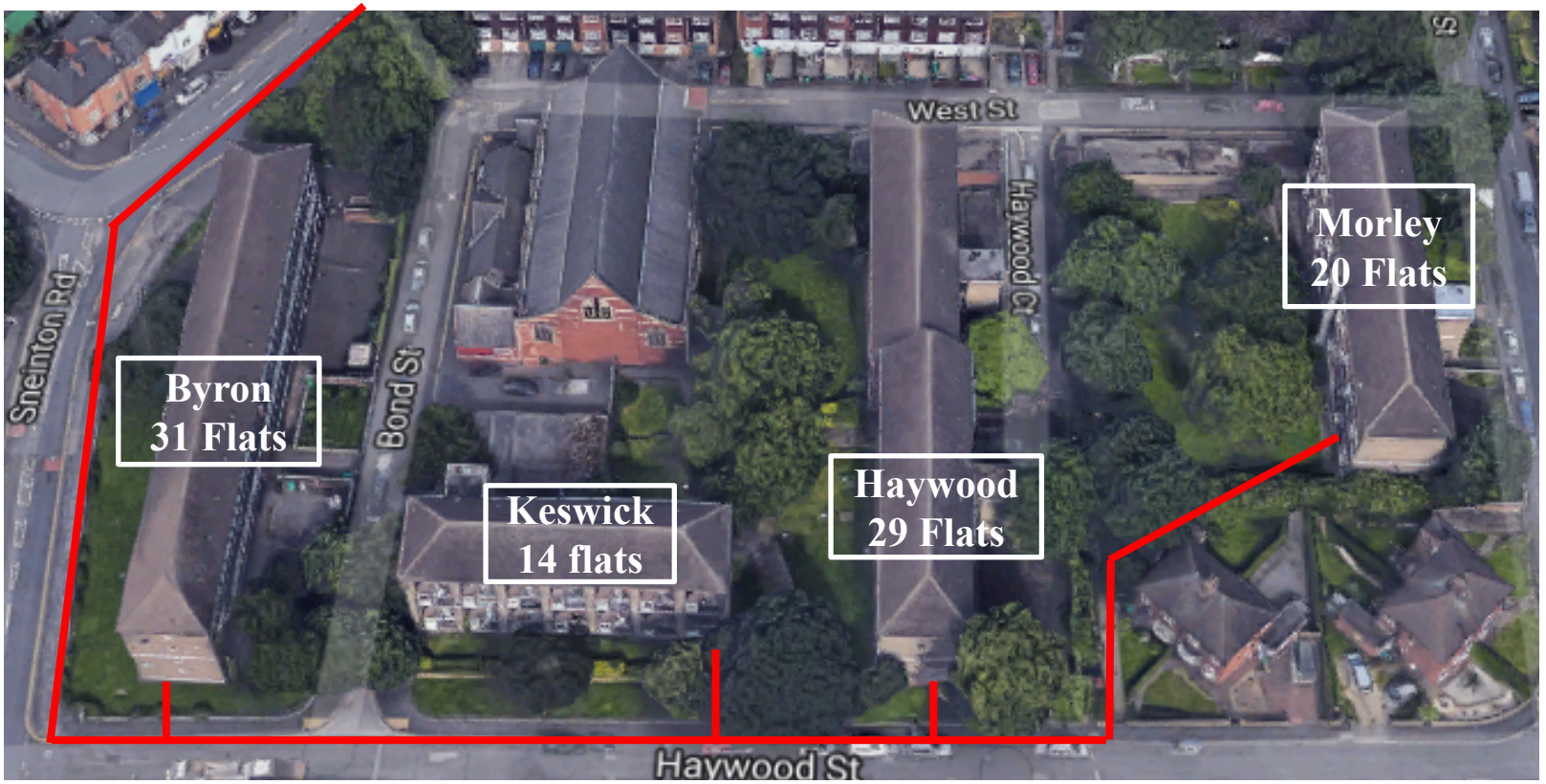
District Heating intervention in Nottingham



District Heating intervention in Nottingham



LTDH Demonstration Site



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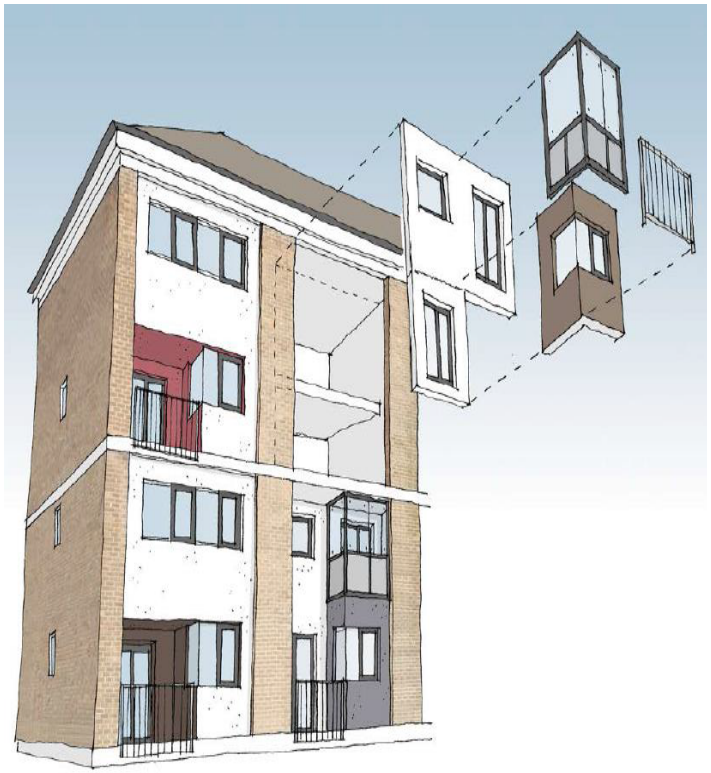
Buildings Retrofit

Morley Court

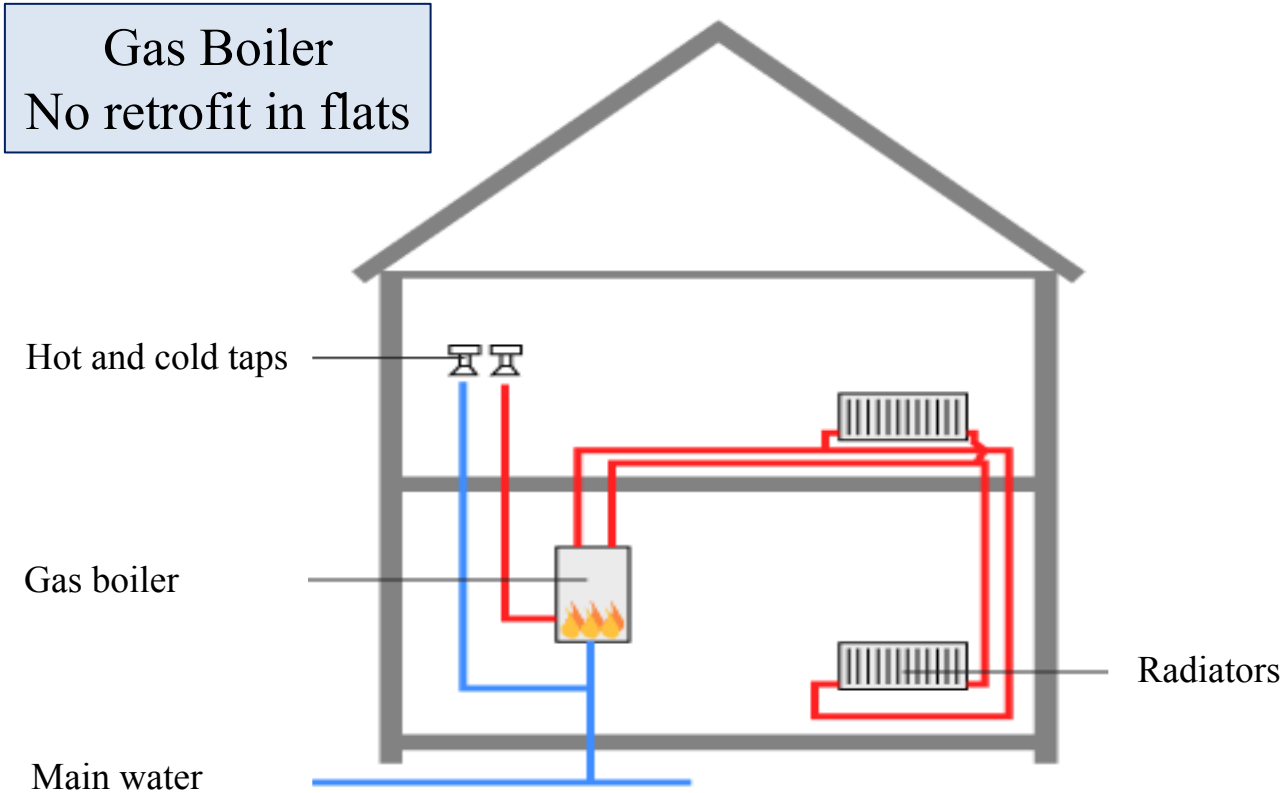


Research Aim

A techno-economic analysis of low-temperature district heating intervention incorporated with buildings retrofit to evaluate its competiveness compare to existing heating systems in the demonstration site through studying 4 scenarios

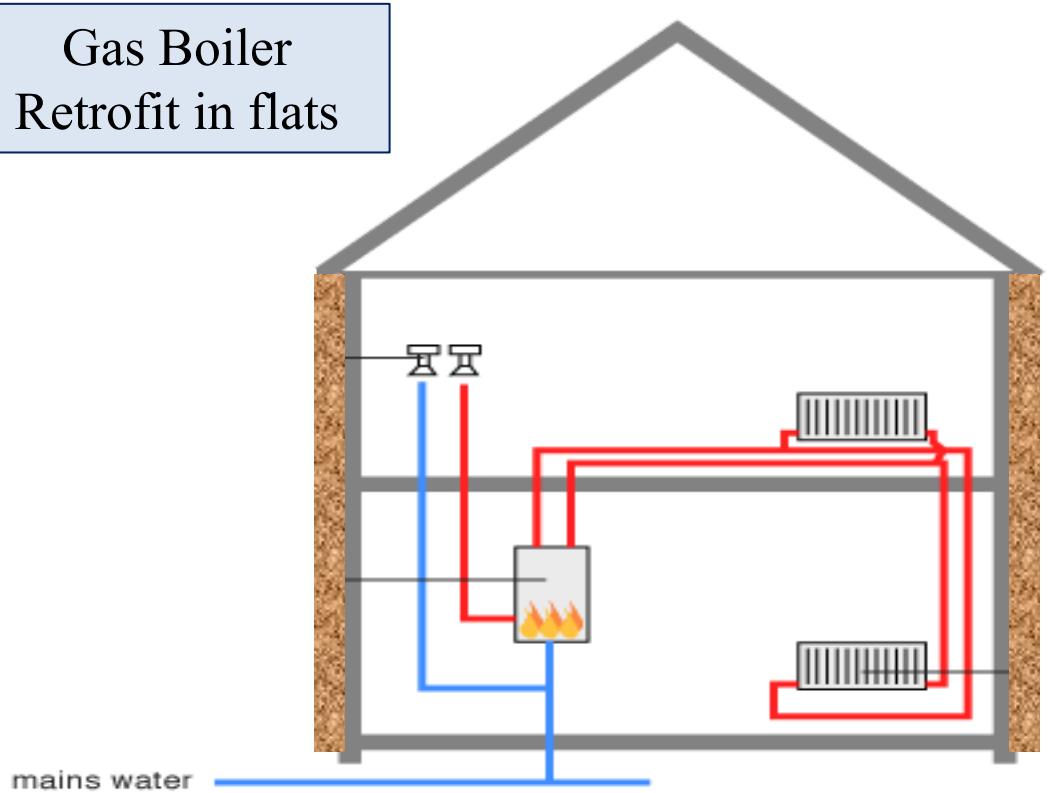
Scenario 1

Gas Boiler
No retrofit in flats



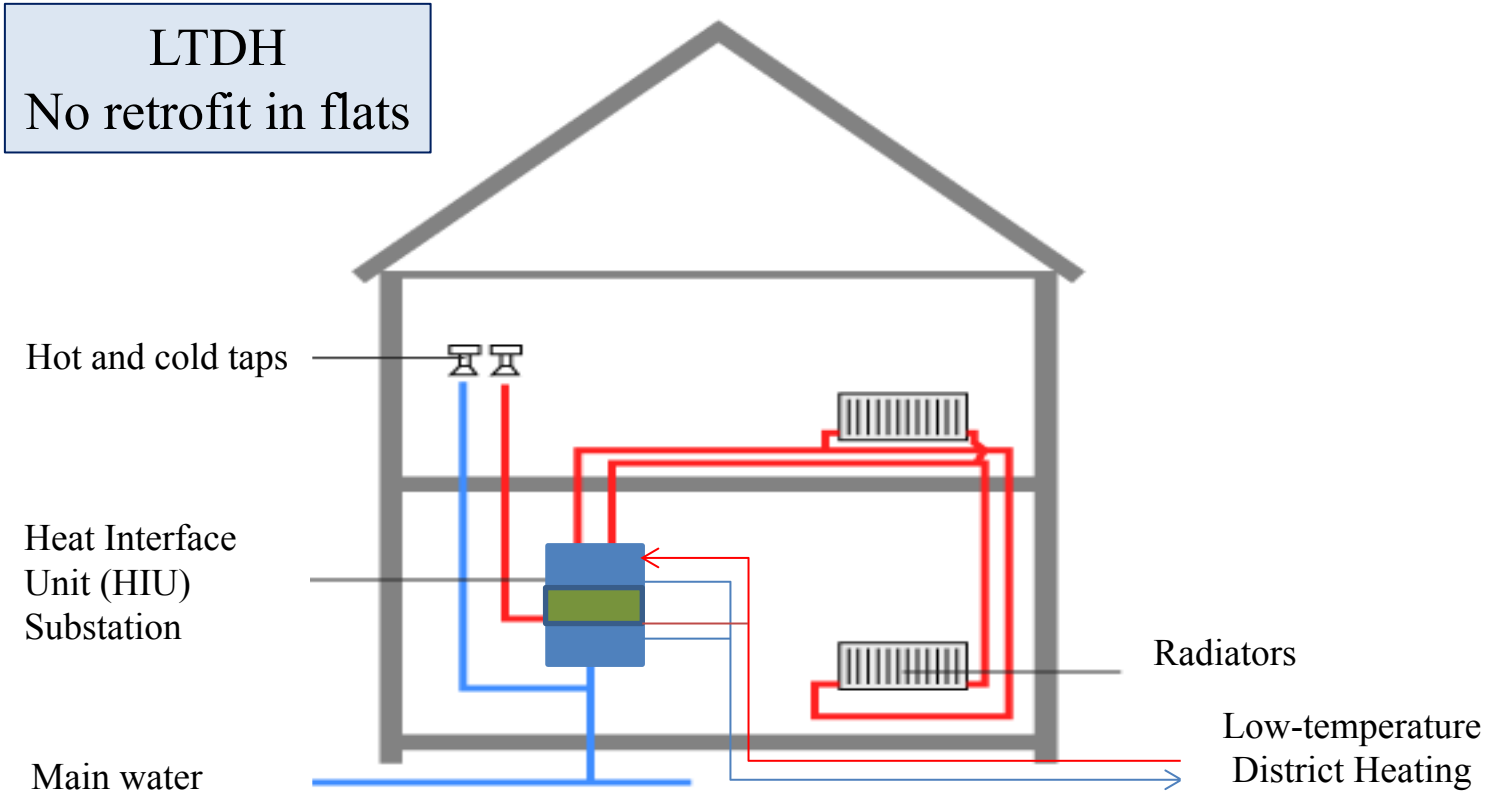
Scenario 2

Gas Boiler
Retrofit in flats



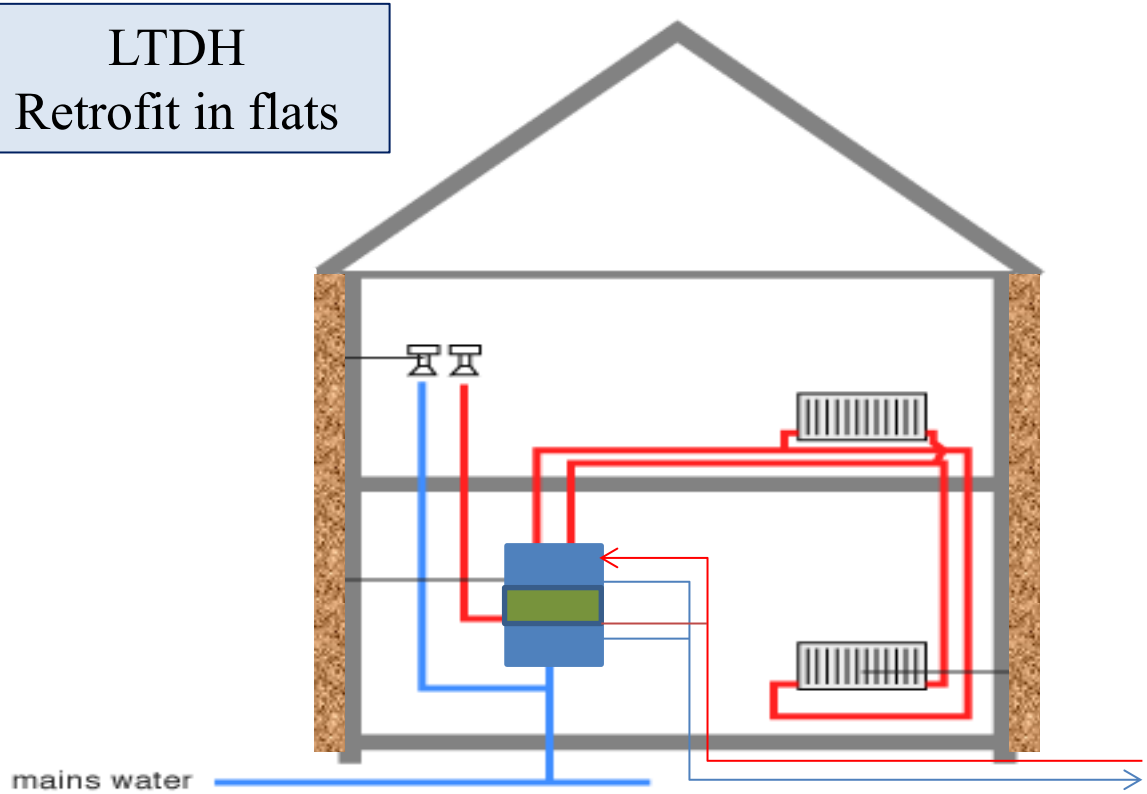
Scenario 3

LTDH
No retrofit in flats



Scenario 4

LTDH
Retrofit in flats



Building energy performance

Simulation of hourly heat demand profile

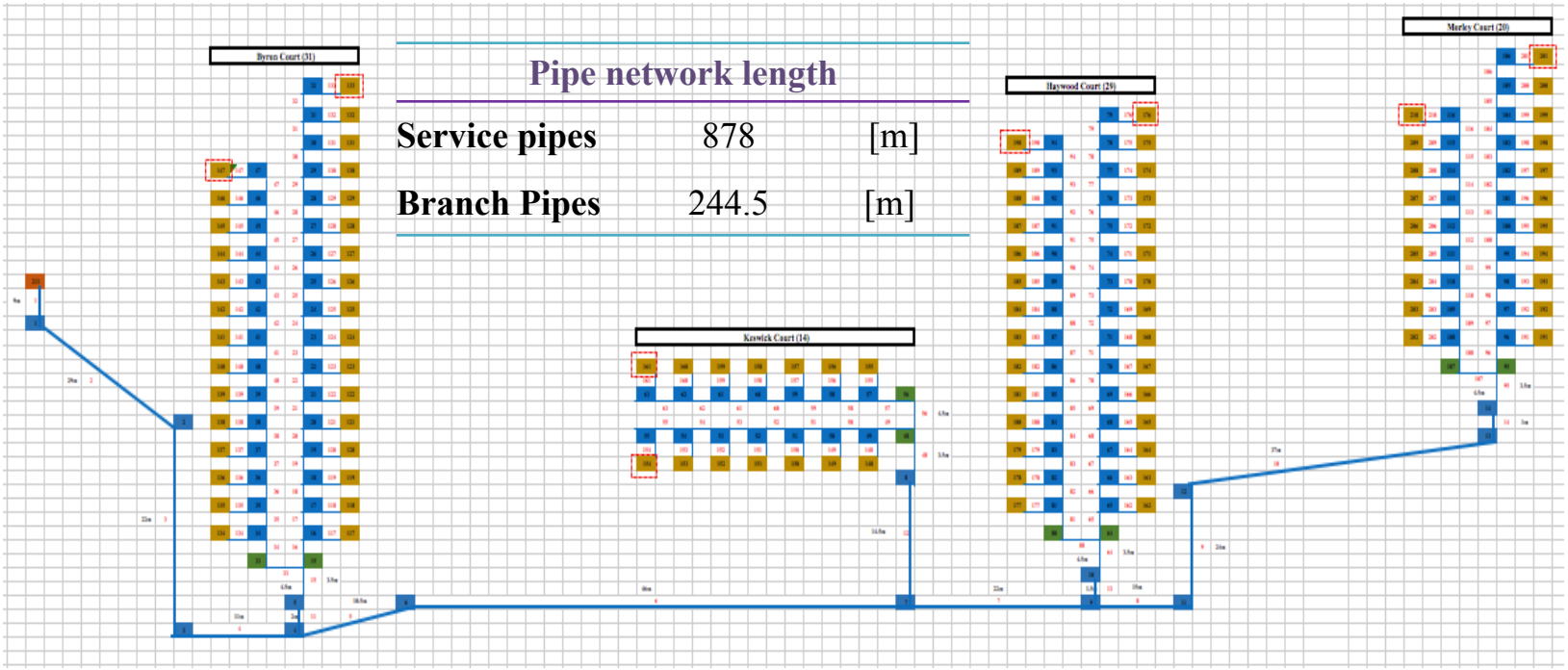
- Weather data: Nottingham 2016
- Peak heat load and hourly space heating demand profile: Design Builder Simulation Software

Peak load	Before Retrofit [kW/Flat]	After Retrofit
Byron Court	5.18	3.24
Keswick Court	5.35	3.30
Haywood Court	5.04	3.21
Morley Court	5.35	3.30

- Domestic hot water demand is modelled applying the BRE (Building Research Establishment) domestic energy model

District Heating Network Hydraulic Design

Network layout (including both branch pipes and service pipes to the properties)



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District Heating Network Hydraulic Design

Network design criteria:

- The design supply temperature: 60°C
- The design return temperature: 30°C
- Max flow velocity: 2 m/s
- Max pressure drop: 8 bar
- Optimal maximum allowed pressure drop (for the longest route in the network)
- Simultaneity factor is applied for both SH and DHW demand

	Before Retrofit	After Retrofit
Pipe dimension range	DN75-DN20	DN63-DN20

District Heating Network Simulation

LTDH network one year operation is simulated in a thermal-dynamic modelling tool[*] based in hourly time interval.

Number of connected Consumers	94	[-]
Pipe types	PEXFlextra series 2	[-]
Pipe network length	1122 m	[m]
Number of bypasses	8	[-]
Bypass set point temperature	50	[°C]
Supply Temperature to the network	60	[°C]
Return temperature from consumers	30	[°C]
Soil temperature	8	[°C]

*A thermal-dynamic modelling tool developed in Matlab programming language.

Results

LTDH implementation for non retrofitted and retrofitted buildings

Energy Performance		Before Retrofit	After Retrofit
Total Annual heat loss	[MWh]	87.90	86.14
Total annual consumers heat demand	[MWh]	1372.01	810.76
Total annual heat production	[MWh]	1460.68	897.81
Share of heat loss	[%]	6.02	9.59

Results

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Economic		Before Retrofit	After Retrofit
Retrofit cost	[M€]	0	0.386
Pipe network installation cost	[M€]	0.967	0.954
The network annual operating cost	[M€/year]	0.111	0.076

The DH price is 61.9 [€/MWh]

Including annual heat cost and network annual maintenance cost

Results

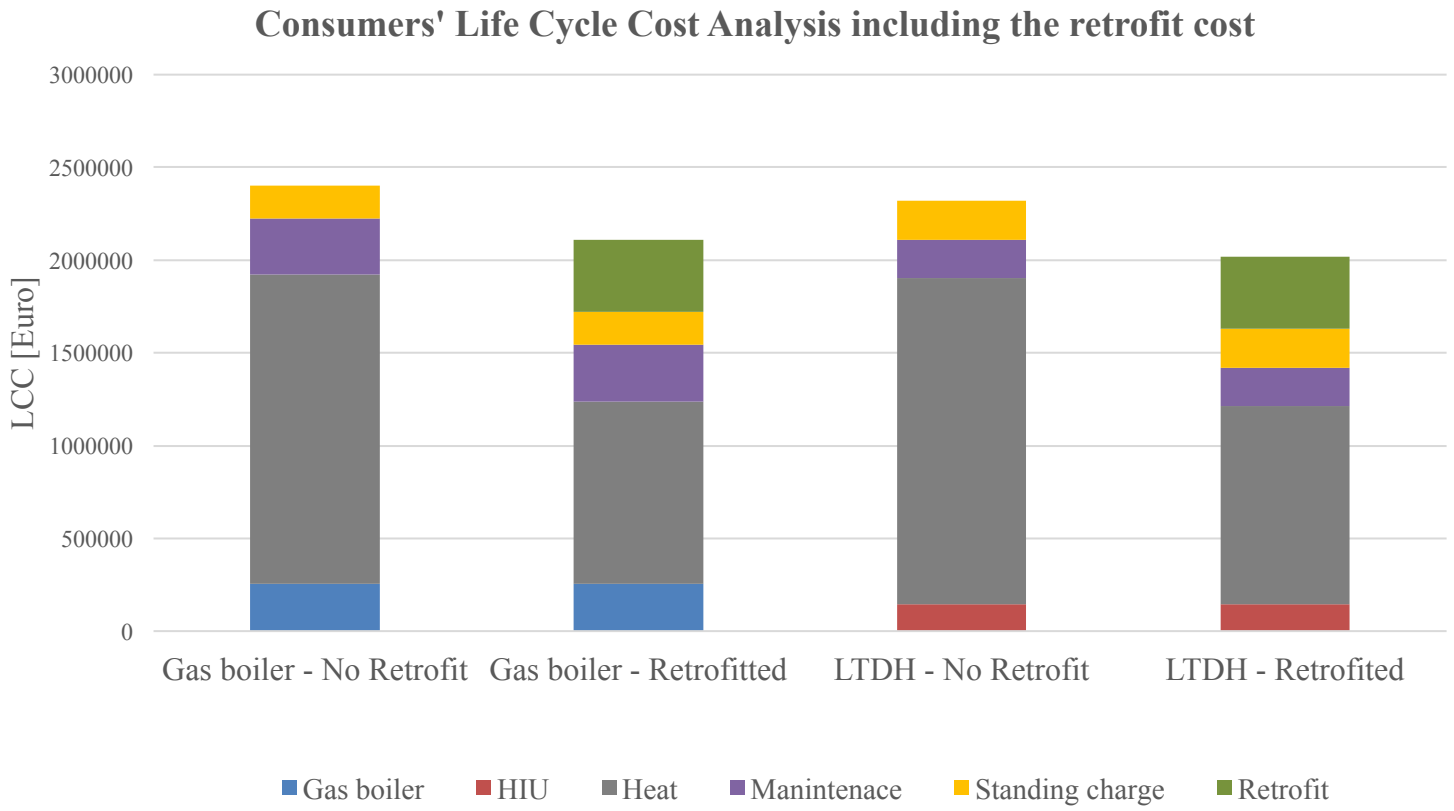
Economic analysis of the four defined scenarios from the consumers perspective

The DH price is 61.9 [€/MWh] and gas price is 53.3 [€/MWh]

Scenarios		Gas Boiler No retrofit	Gas boiler Retrofitted	LTDH No retrofit	LTDH Retrofitted
Gas boiler capital cost	[€]	255434	255434	0.00	0.00
HIU Capital cost & meters	[€]	0.00	0.00	143043	143043
Heat consumption	[€/year]	83993	49634	88882	54054
Maintenance cost	[€/year]	15326	15326	10217	10217
Standing Charge	[€/year]	8965	8965	10778	10778
Life Cycle Cost	[M€]	2.66	1.98	2.46	1.77
Life Cycle Cost + Retrofit cost	[M€]	2.66	2.36	2.46	2.16

Life cycle cost analysis: 30 years life cycleInterest rate = 3% Inflation rate = 6 %

Results


Consumers' Life Cycle Cost Analysis including the retrofit cost
LCC [Euro]
3000000
2500000
2000000
1500000
1000000
500000
0
Gas boiler - No Retrofit
Gas boiler - Retrofitted
LTDH - No Retrofit
LTDH - Retrofited
Gas boiler
HIU
Heat
Manintenace
Standing charge
Retrofit

Conclusion

- Low temperature district heating together with implementing some retrofit measures in the building is the best scenario from economic perspective.
- It is vital to include all the associated costs when evaluating the district heating interventions against its rivals.
- There are different district heating schemes in UK with different prices varies between 43-163 [€/MWh], therefore the feasibility of this kind of intervention needs to be studied for different schemes.

Next Steps

- Looking into the cost of the DH production from the heat providers point of view
- Research the replication of this intervention for other areas in Nottingham

Thank You

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