Imperial College London

Spatially-resolved systems modelling for cost-effective heat decarbonisation: A case study

Francisca Jalil-Vega[1] and Adam Hawkes[1]

[1]Department of Chemical Engineering, Imperial College London, SW7 2AZ, United Kingdom

RESEARCH OBJECTIVES

- Formulate and implement a spatially-resolved model that allocates primary energy supply, infrastructure, end-use technologies for studying cost effective heat decarbonisation pathways.
- Apply this model for a case study in the City of Bristol.

METHODOLOGY

City of Bristol Divided into Middle Layer Super Output Areas (MSOA) [1] .

INPUTS

- Commercial/ domestic heat/ electricity demand per MSOA
- Electricity, gas, carbon prices
- Gas/electricity emission factors
- Heat supply technologies technoeconomic parameters
- Electricity, gas, heat network costs
- Road lengths per MSOA

MODEL

- Mixed integer linear programme model
- Investment/ decommissioning decisions from 2015 to 2050, every 5 year periods
- 16 time slices for demand seasonal variation

$$\min COSTS = + CAPITAL + OPERATION + CARBON + ELECTRICITY + FUEL - SOLD\ ELECTRICITY$$

OUTPUTS

- Location and capacity of individual and district heat supply technologies
- Networks within and between zones
- Operation of technologies
- Total costs
- CO_2 emissions

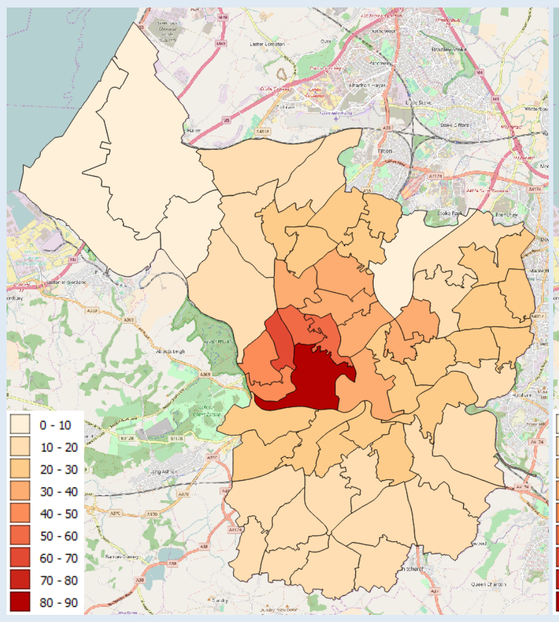


Figure 1: Heat density based on input subnational gas consumption per MSOA [2] [kWh/m^2]

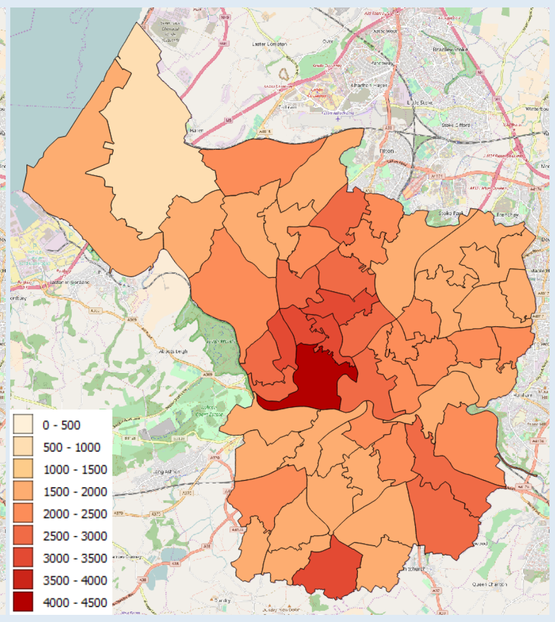


Figure 2: Linear heat density based on input subnational gas consumption per MSOA [2] [kWh/m]

Case 1

- Allows for only for high temperature heat networks:
- High-temperature network :

  Supply/Return: 80/50°C

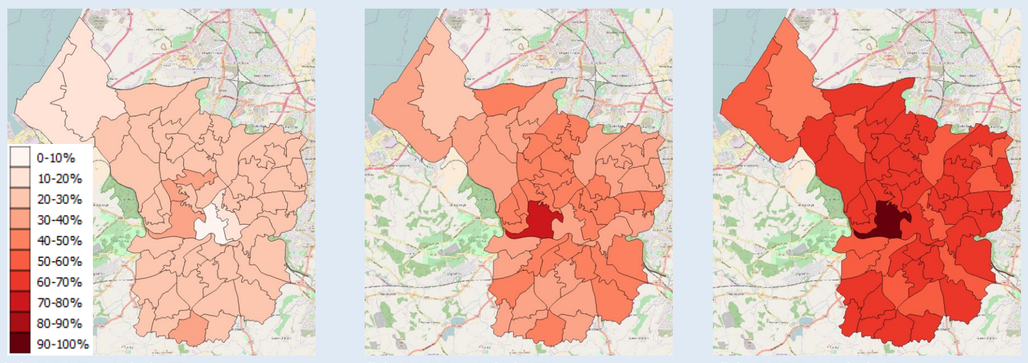
Case 2

- Allows for high and medium temperature heat networks
- Mid-temperature heat network:

  Supply/Return: 70/40°C

RESULTS

Case 1



(a) **2015** - High Temperature (b) **2030** - High Temperature (b) **2050** - High Temperature

Figure 3: High temperature heat network penetration

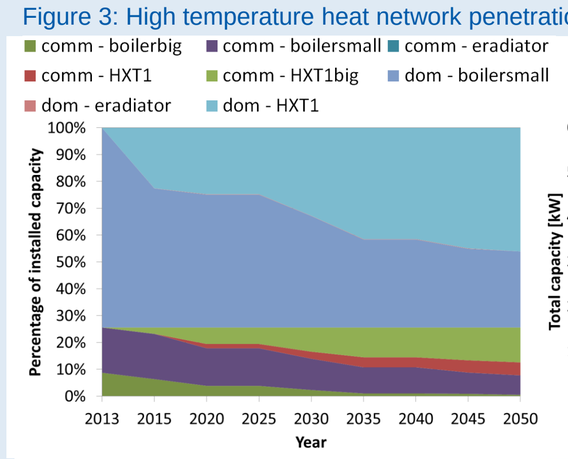


Figure 4: Individual heat supply installed capacity

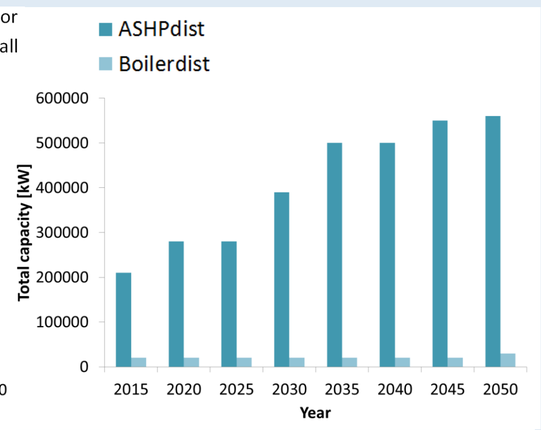
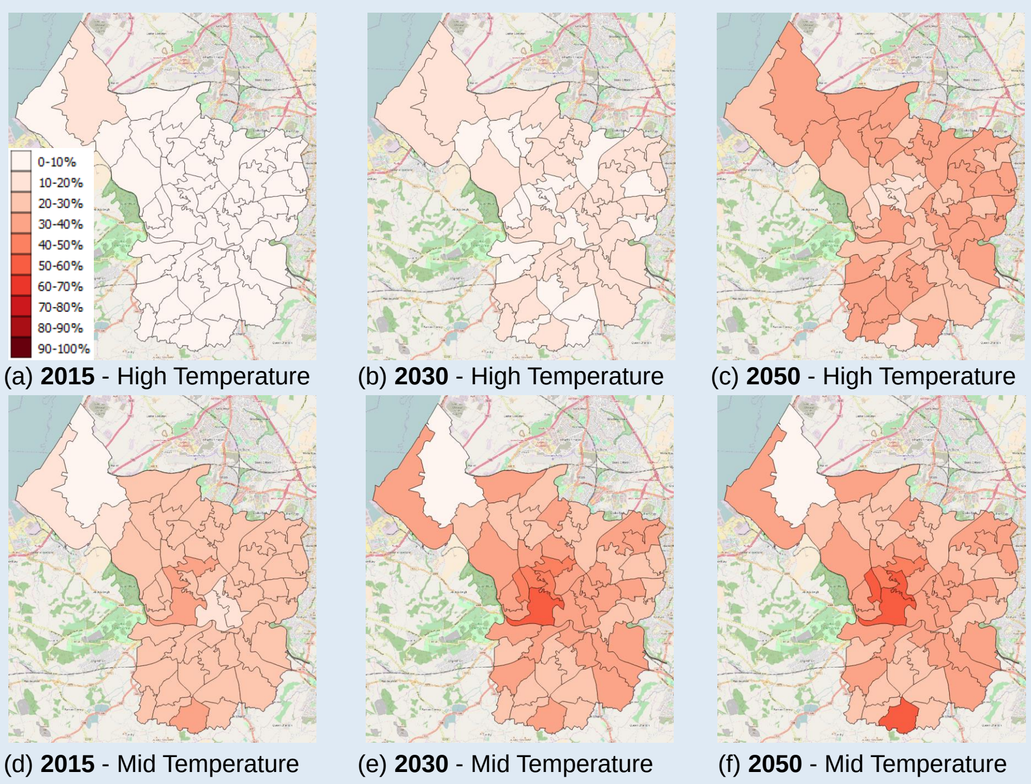


Figure 5:District heat supply installed capacity

Case 2



(a) **2015** - High Temperature (b) **2030** - High Temperature (c) **2050** - High Temperature

(d) **2015** - Mid Temperature (e) **2030** - Mid Temperature (f) **2050** - Mid Temperature

Figure 6: High and Mid temperature heat network penetration

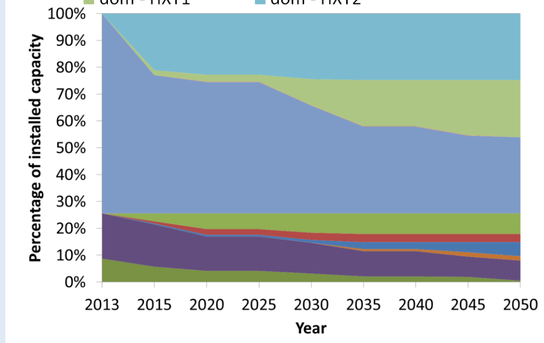


Figure 7: Individual heat supply installed capacity

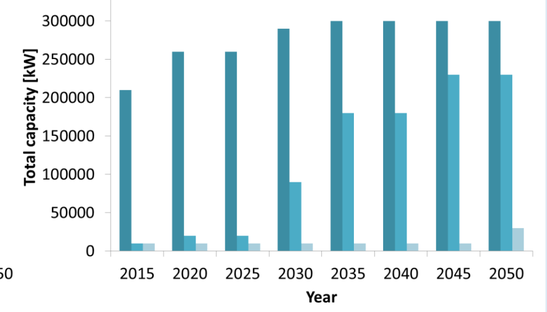


Figure 8: District heat supply installed capacity

CONCLUSIONS

- Results are highly dependant on case-specific demand topology and on tehcnoeconomic assumptions, which are uncertain.
- For these case-specific technoeconomic assumptions, medium temperature heat networks are more cost effective in higher linear heat density zones, and when available achieve a higher overall heat network uptake.
- Importance of considering infrastructure and technology trade-offs in a spatially-resolved manner for achieving cost-efficient heat decarbonisation.

AKNOWLEDGEMENTS

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