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#SESAAU2019

Sizing of district heating systems based on smart meter data

Understanding aggregated domestic energy demand and demand diversity in Great Britain

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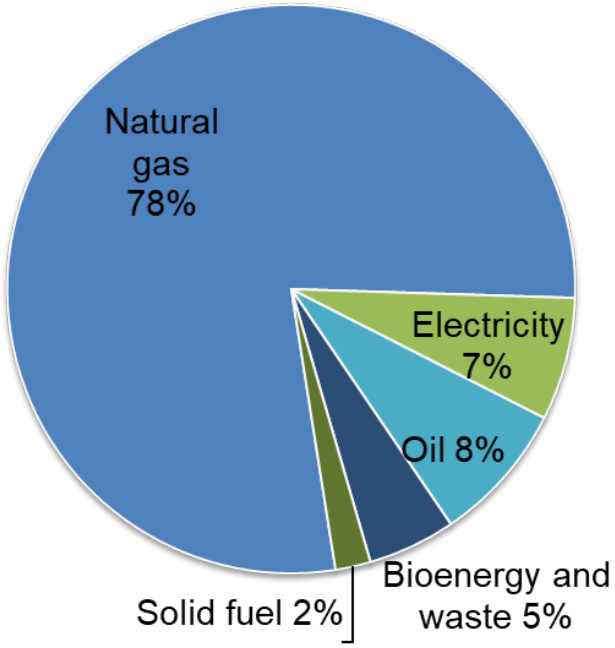
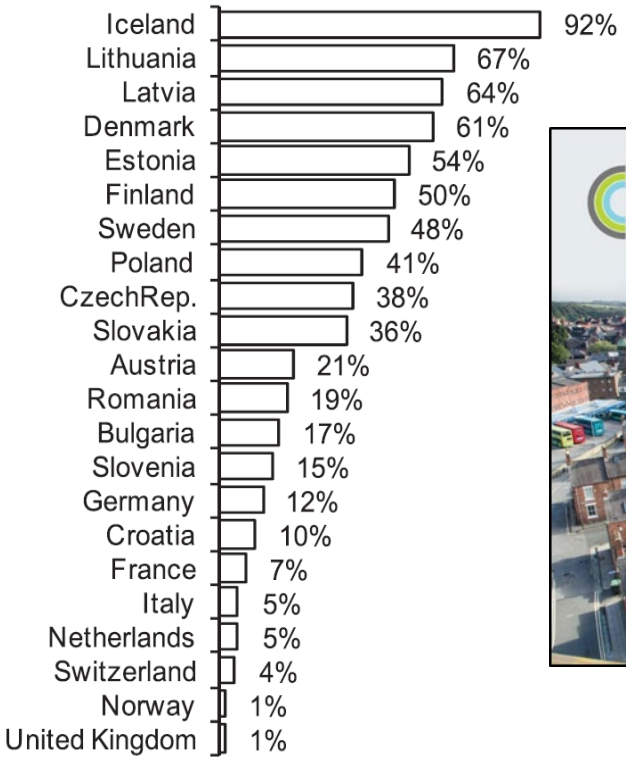
Outline

1. Domestic heat demand and district heating in the UK
2. Appropriate sizing of district heating systems
3. Analysis of energy demand and diversity from smart meter data
4. Results
5. Conclusions

1. Domestic heat demand and district heating in the UK



Fuel consumption for domestic heating in the UK



District heating market shares (source: Sayegh et al., 2016)

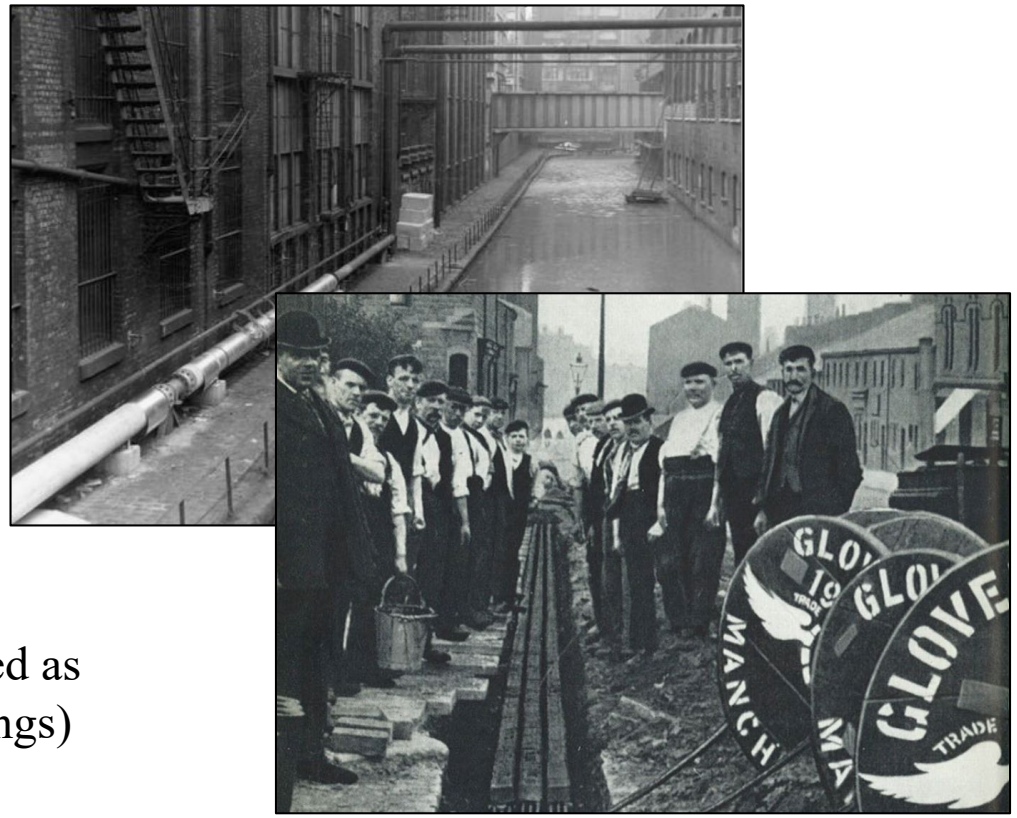
1. Domestic heat demand and district heating in the UK

District heating is not a new concept in the UK

But it is considered as an expensive and risky technology/business

Approximately 2000 networks

Three quarters of them are considered as small schemes (less than 100 dwellings)



First generation district heating in Manchester (source: Urbed archive)

2. Appropriate sizing of district heating systems

Undersizing:

- Insufficient capacities
- Interruptions of service

Oversizing:

- Ensures supply security
- Prepares for severe weather
- Reduces efficiency
- Increases capital and running costs

Common practice tends to become **defensive** and domestic heating systems are typically **oversized**.

Empirical quantifications of energy consumption and peak demand to avoid under or oversizing thorough:

Empirical energy demand load profiles
&
Energy demand **diversity** analysis

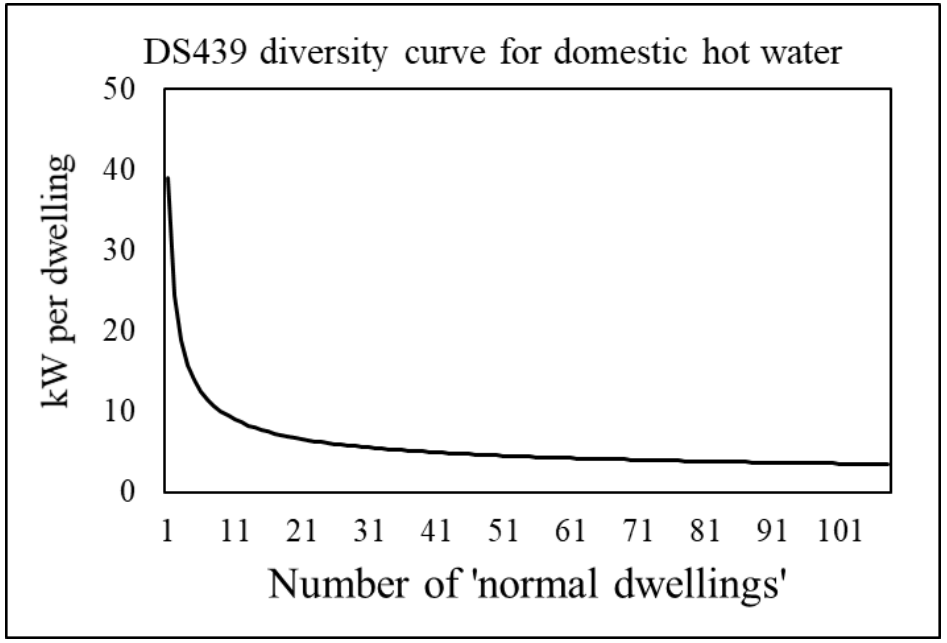
3. Energy demand and demand diversity from smart meter data analysis

What is energy Demand Diversity and After Diversity Maximum Demand?

Demand Diversity:

$$Diversity\ fator\ = \frac{\sum I\,ndividual\ maximum\ demand}{maximum\ demand\ of\ the\ aggregated\ system}$$

$$Coincident\ factor = \frac{1}{Diversity\ factor}$$

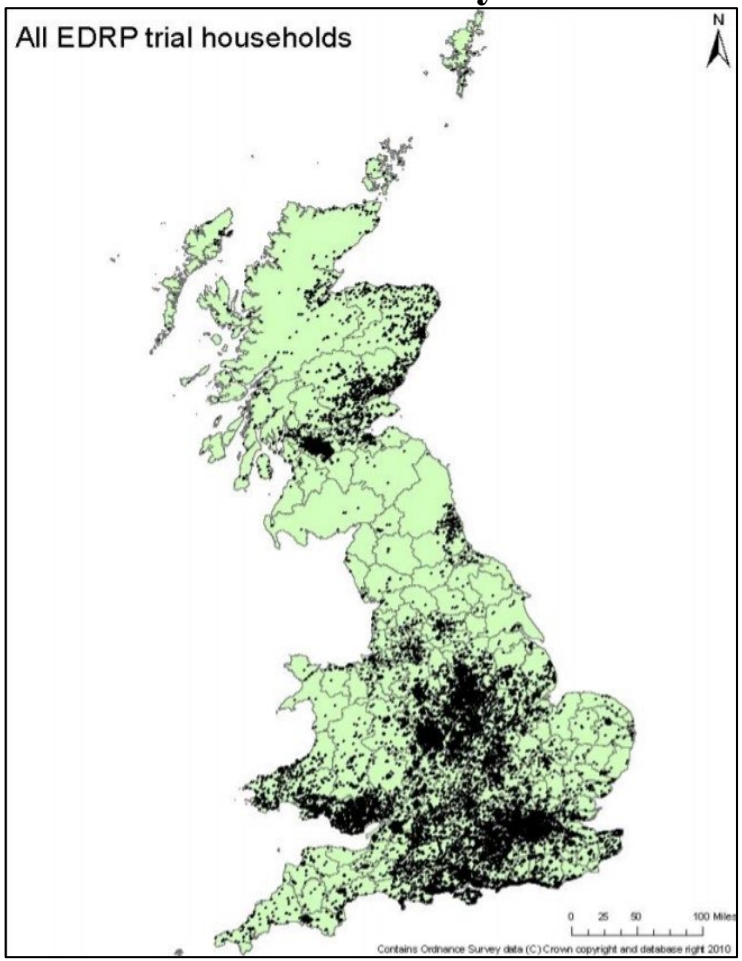


After Diversity Maximum Demand:

$$ADMD = \lim_{N\to\infty} \frac{1}{N} \sum_{i=1}^{N} MD_i$$

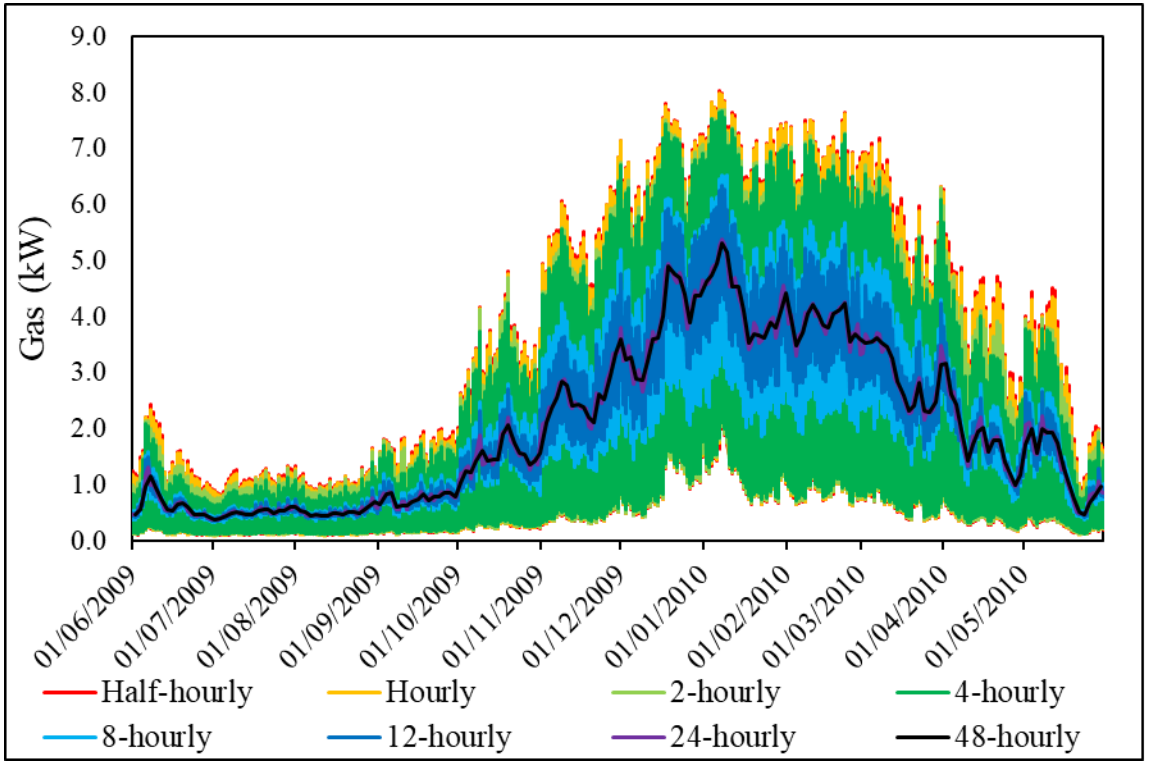
3. Energy demand and demand diversity from smart meter data analysis

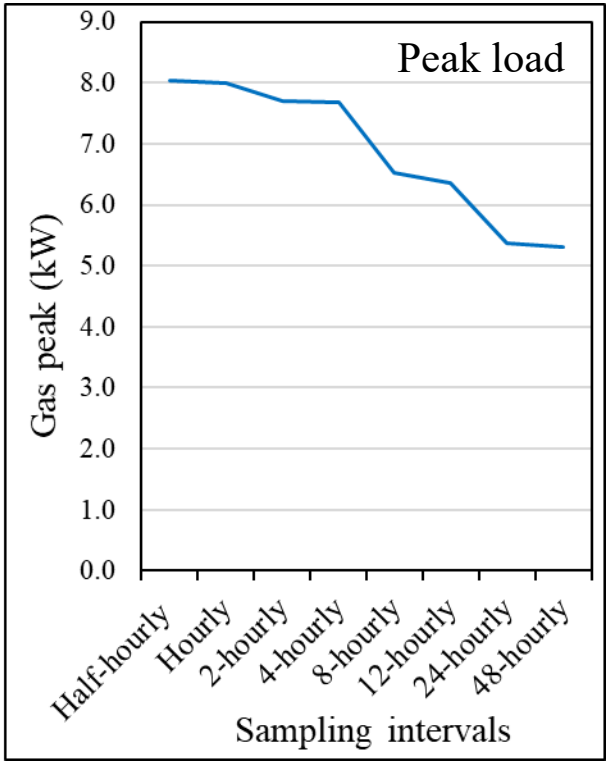
- Energy consumption data collected from **the largest smart meter field trial** in the UK
  - Half-hourly electricity and gas consumption data from 18,380 households
  - Data collected between January 2008 to September 2010
- Including **two particularly cold winters**, and one of them is the **coldest winter** in the past four decades



Source: Office of Gas and Electricity Markets (Ofegm)

4. Results: load profiles and aggregated peak demand based on different temporal sampling frequencies





(Sample: 8466 households)

Half-hourly peak demand: 8 kW per household.

Half-hourly to hourly: **0.4% reduction**

Half-hourly to daily: **33% reduction**

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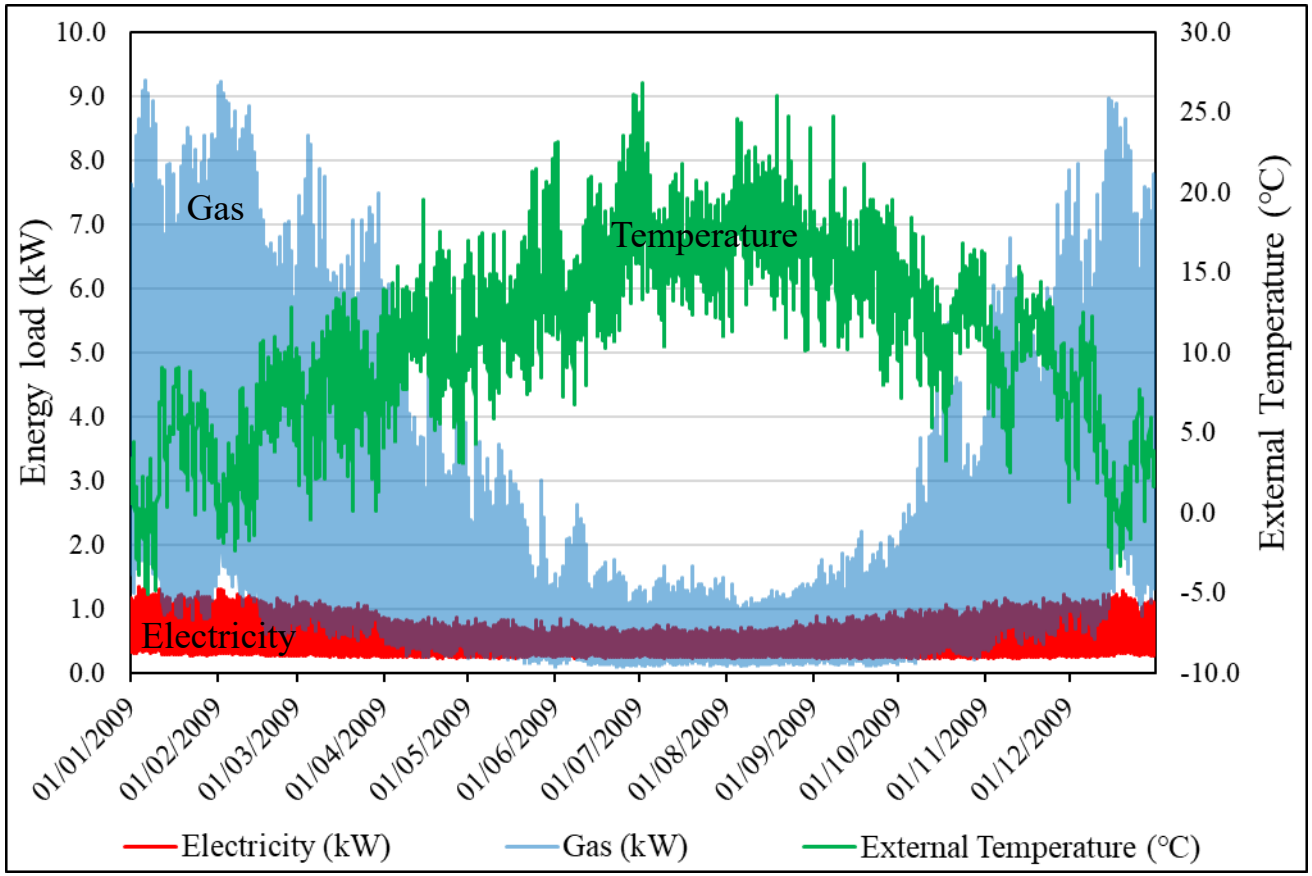
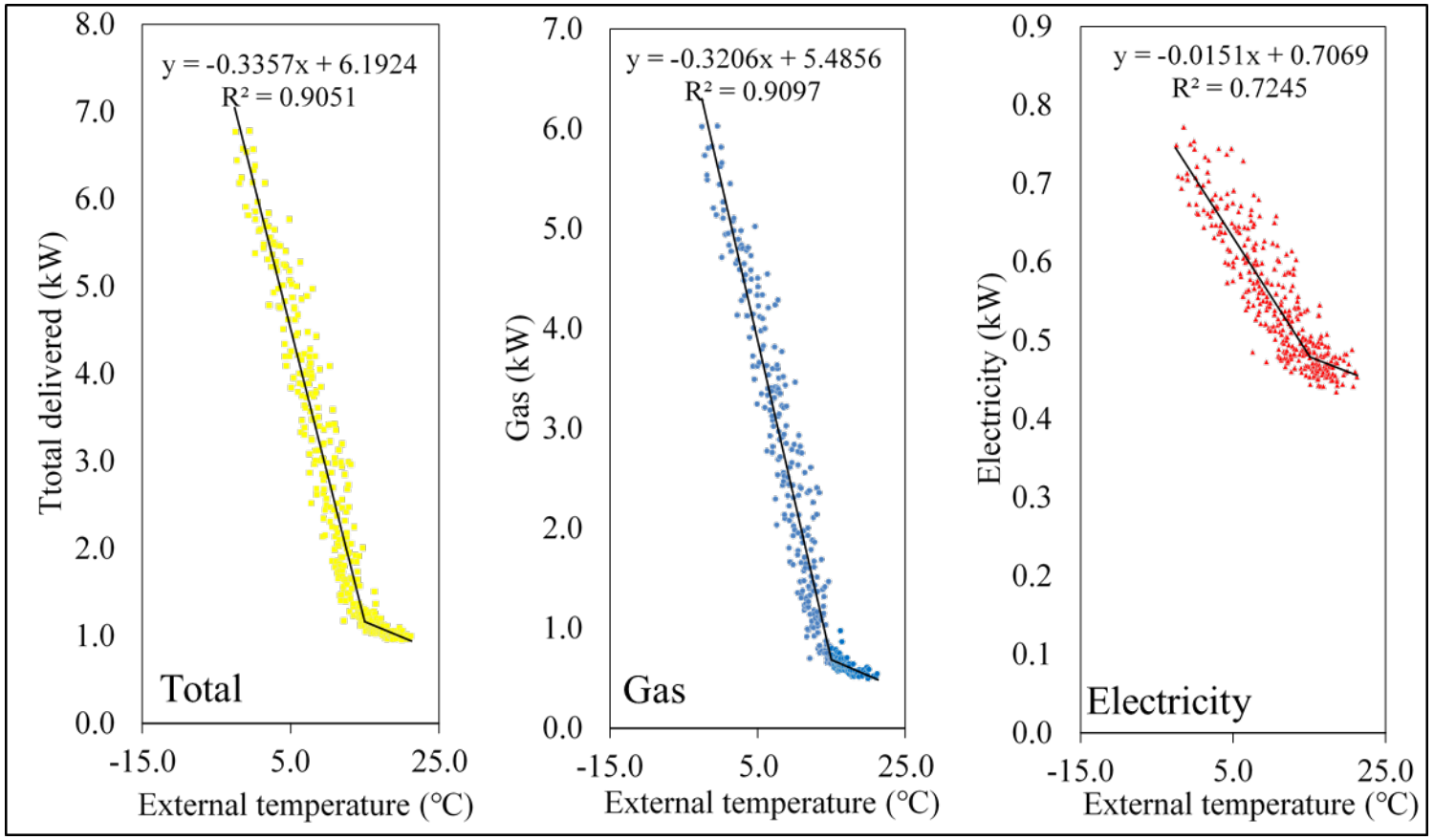
4. Results: Hourly electricity and gas load profiles versus external temperature in 2009



- Annual gas consumption was **four times** higher than electricity consumption.
- Peak hourly gas demand was **seven times** higher than peak hourly electricity demand.

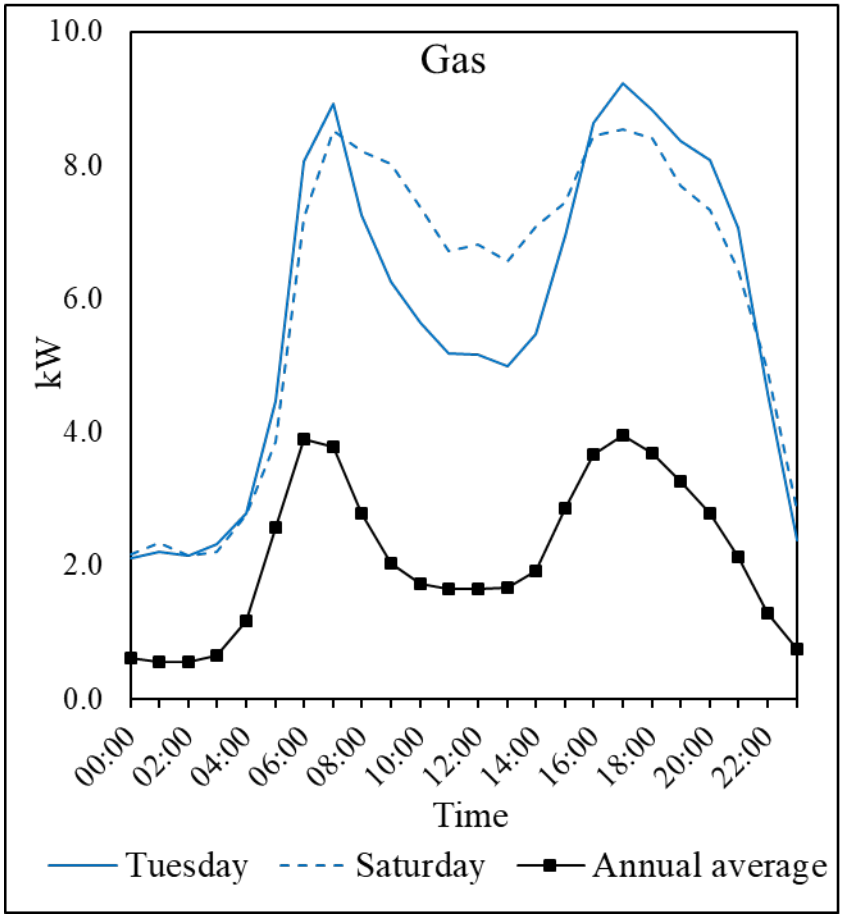
4. Results: Daily delivered electricity and gas loads in response to external temperature

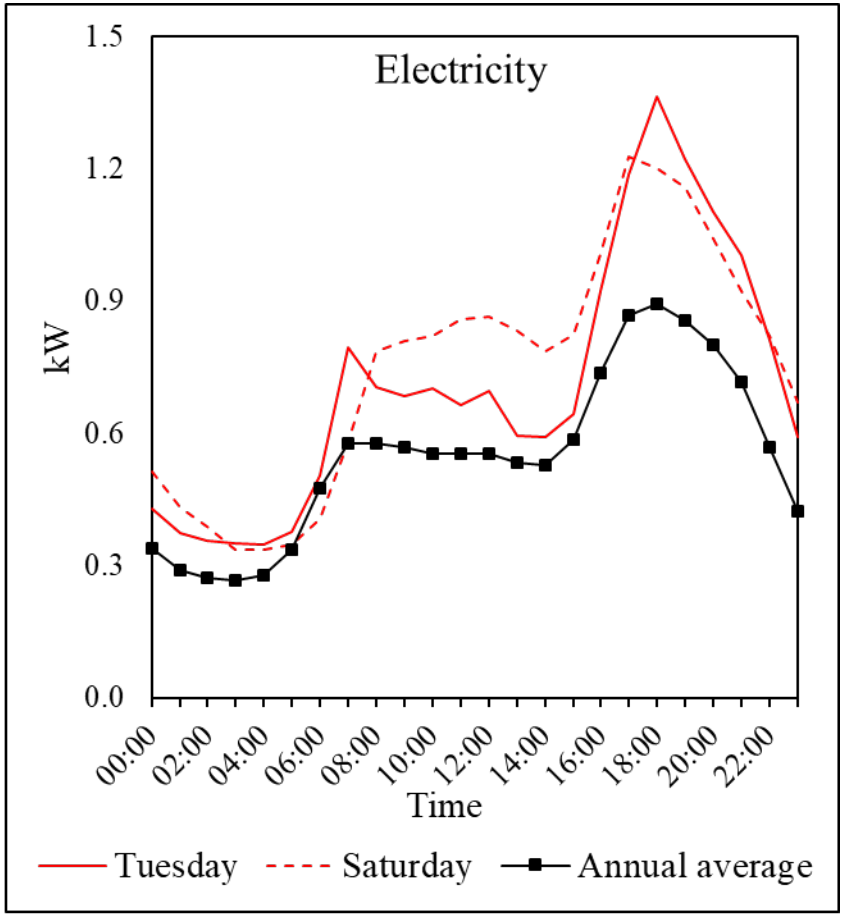


Electricity:
15 W/°C

Gas:
320 W/°C

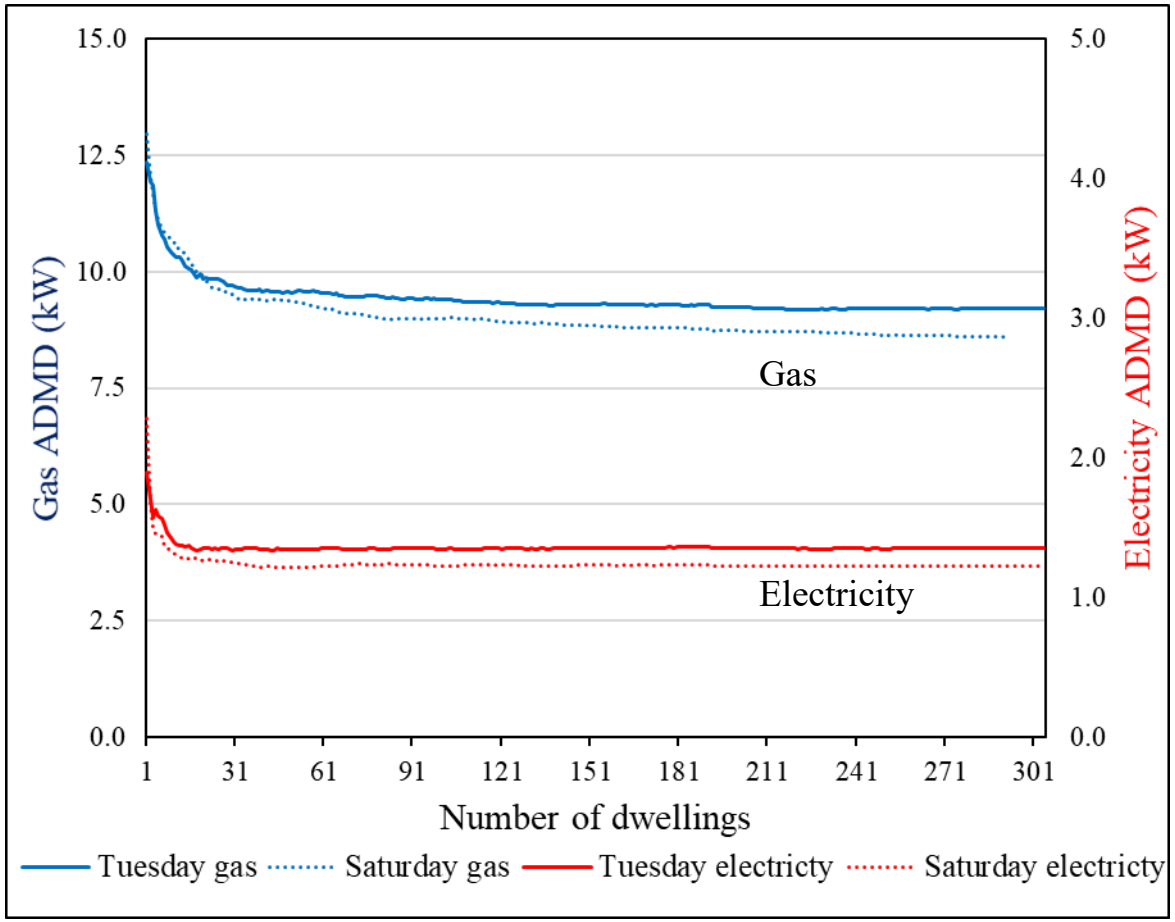
4. Results: 24-hour load profiles on the two coldest day of 2009.





Tuesday 6th January and Saturday 10th January 2009

4. Results: After diversity maximum demand on the two coldest days of 2009



Tuesday 6th January and Saturday 10th January 2009

$$ADMD = \lim_{N\to\infty} \frac{1}{N} \sum_{i=1}^{N} MD_i$$

On the coldest day (Tuesday 6th Jan)

For one dwelling:

- Peak gas: 12.4 kW
- Peak electricity: 1.9 kW

For 100 dwellings:

- Peak gas: 9.4 kW per dwelling (24% drop)
- Peak electricity: 1.35 kW per dwelling (29% drop)

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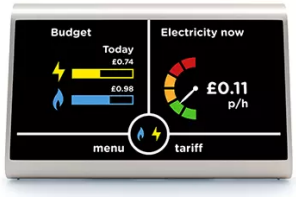
5. Conclusions

- The sizing of district heating systems needs **quantitative** and **empirical** bases.
- High temporal resolution **smart meter data** from individual dwellings can offer better **understanding** and **management** of energy demand.
- **Demand diversity effect** may reduce aggregated peak demand and contribute to **economies of scales** in district heating.
- Studying **peak demand** under **extreme weather conditions** offers insights that can improve district heating design, construction and operation.



Thank you!

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