The urban heat island and its influence on building energy consumption in England and South Korea

G Levermore\textsuperscript{2}, K Lee\textsuperscript{1} J Parkinson\textsuperscript{2}
Radiation shield
Measurement station on lighting column
Manchester and Greater Manchester
United Kingdom

• Manchester, population 514,417 in 2013, is in the United Kingdom's 2nd most populated urban area, with a population of 2.55 million in Greater Manchester.

• Manchester expanded at an astonishing rate in the 19th century due to the development of textile manufacturing. Manchester became the world's first industrialised city.

• The Greater Manchester economy is the 3rd largest in the United Kingdom and is the third-most visited city in the UK by foreign visitors, after London and Edinburgh.
Manchester (53°28’N 2°14’W)

• Manchester has a temperate Oceanic climate, like much of the British Isles, mild summers and cool winters.
• Relatively high humidity levels and soft water, important for the textile industry.
• Monthly mean temperatures: January 4.4 °C, July 16.2 °C
• Light precipitation throughout the year. Average annual rainfall is 806.6 millimetres (UK average of 1,125.0 millimetres.)
Stations positioned radially from the cite centre
The urban heat island effect in Greater Manchester reduces with distance from the city centre
The reason for the reduced UHII on the northern transect: Heaton Park
The future in Manchester
Green roof in Manchester, UK
The roof before it became green
The Urban Heat Island Effect in Greater Manchester reduces as the wind speed increases.

UHI intensity against wind speed in clear nights from Feb to Apr 2010

\[ y = -0.0099x^4 + 0.0185x^3 - 0.0604x^2 - 0.839x + 6.1183 \]

\[ R^2 = 0.5791 \]

UHI intensity against wind speed in clear nights from May to Aug 2010

\[ y = -0.0016x^3 + 0.0728x^2 - 1.1089x + 7.3855 \]

\[ R^2 = 0.5515 \]
Can reduce the UHI with wider streets to allow more ventilation
Ulsan, South Korea

- Ulsan is South Korea's 7th largest city, population of over 1.1 million.
- Ulsan is the industrial powerhouse of South Korea, with the world's largest automobile assembly plant (Hyundai Motor Company), the world's largest shipyard (Hyundai Heavy Industries) and the world's second largest oil refinery, owned by SK Energy.
- In 2012, Ulsan had the highest GDP per capita ($79,623), in South Korea.
Ulsan (35°33’N 129°19’E)

• Ulsan has a monsoon-influenced humid subtropical climate
• Cold but dry winters, and hot, humid summers.
• Monthly means 2.0 °C in January to 25.9 °C in August, with diurnal temperature ranges generally low.
• Precipitation is relatively low in the winter months, but is made up by the high rainfall falling from April to September.
Kwanho Lee work on Ulsan, South Korea
Ulsan Met-office, 2.5 km, 35m (151)
Dry Air Temperature, Summer

Day, Manchester 2010

Night, Manchester 2010

Day, Ulsan 2012

Night, Ulsan 2012
Short Wave Solar Radiation

Day, Manchester
2010 Summer

Day Manchester
2010 Winter

Day, Ulsan
2012 Summer

Day Ulsan
2012 Winter
Correction factors for Ulsan and Manchester
Office simulation (IES) with and without UHI (K Lee)

## Building envelope parameters

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<tr>
<th>Component</th>
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Cooling load for Manchester on June 2010
Cooling load for Manchester on June 2010
Compare to Ulsan Centre and Rural Area

![Graph comparing cooling load (kwh/m²) by month between Samdong and Ulsan Centre.](image)
Manchester heating and cooling loads with and without UHI

![Graph showing heating and cooling loads for Manchester and Woodford with and without UHI over the months. The graph compares the load variations month by month, highlighting the impact of urban heat island effect.](image-url)
Conclusion

- The UHI does have a significant effect on the heating and cooling loads for Manchester and an even greater effect on the loads for Ulsan.