The Bartlett School of Graduate Studies

UCL

Indoor Air Quality as Affected by the Urban Environment

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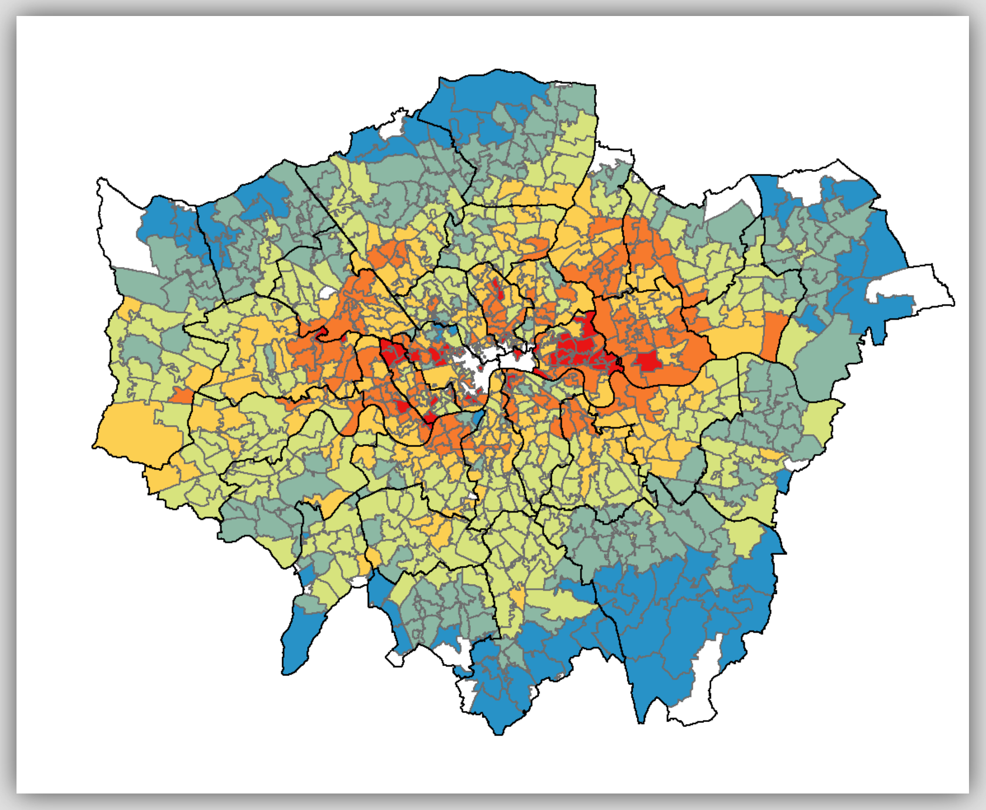


June 11th, 2014

UK HOUSING STOCK

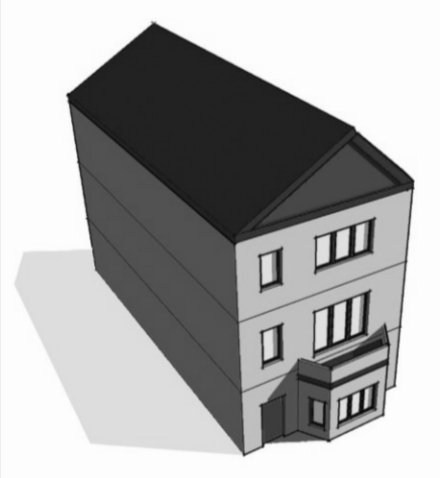
- An estimated 23.1 million dwellings in England
- People in the UK spend around 90% of their time indoors
- Around 60% of that time is spent in their homes
- Therefore, dwellings are an important modifier for population exposure to the external environment (weather, pollution, etc).

Current Projects

- AWESOME - Air pollution and WEather-related health impacts: methodological study based on Spatio-temporally disaggregated multi-pollutant models for present-day and future

BUILDING SIMULATION

1. Building Characteristics
2. Occupancy Behaviour
3. External Conditions
4. Pollutant Characteristics



Dynamic Thermal Simulation (EnergyPlus)

Indoor/Outdoor Pollutant Ratios
Absolute Indoor Concentrations

OUTLINE

Initial Research

- Existing building stock information
- Outdoor pollution levels
- Comparison of results between archetypes
- Mapped results
- Preliminary results for indoor sources

AWESOME Project

- Development of nationally representative housing stock
- Indoor/Outdoor ratios for pollution
- Pollution from indoor sources
- Overheating risk

INITIAL RESEARCH GREATER LONDON AUTHORITY

Develop a building stock model suitable to estimate indoor levels of pollution from outdoor sources

GIS Sources
- OS Address Layer 2
- The Geoinformation Group (Cities Revealed) Building Class Database

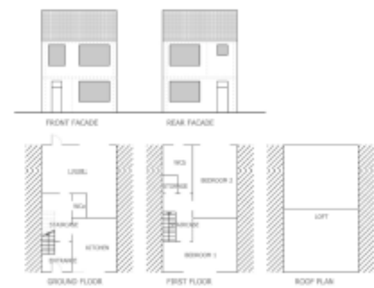
English Housing Survey (EHS)
- Regular survey of around 17,000 dwellings in England
- Includes interview of occupants
- Representative subset have home surveyed by qualified surveyor, physical characteristics noted.

Standard Assessment Procedure (SAP)
- Methodology for estimating the permeability of buildings based on characteristics derived from the EHS.

INITIAL RESEARCH LONDON ARCHETYPES

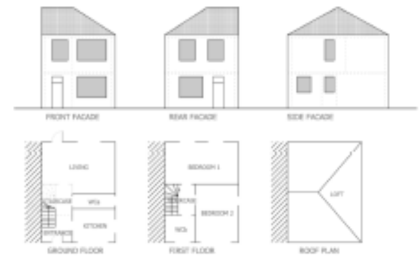
Code: H1
Structure: Terrace with large T
Age: 1902 - 1913
Frequency: 15.4%

Building Fabrics:
Cavity Masonry 16% (16%)
Solid Masonry 84% (2%)



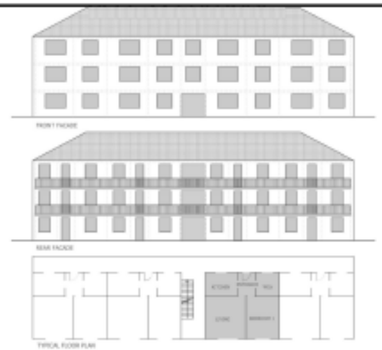
Code: H2
Structure: Simple Terrace
Age: 1914 - 1945
Frequency: 14.5%

Building Fabrics:
Cavity Masonry 56% (45%)
Solid Masonry 42% (4%)
Concrete 2% (39%)



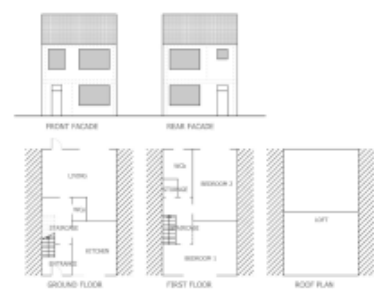
Code: H3
Structure: Large Semi detached
Age: 1914 - 1945
Frequency: 8.8%

Building Fabrics:
Cavity Masonry 67% (36%)
Solid Masonry 31% (4%)



Code: H4
Structure: Purpose Built
Age: 1960 - 1979
Frequency: 5.7%

Building Fabrics:
Cavity Masonry 66% (37%)
Solid Masonry 5% (19%)
Concrete 28% (12%)



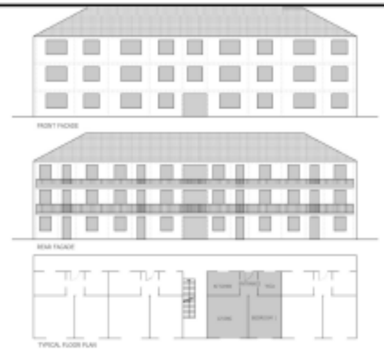
Code: H5
Structure: Simple Terrace
Age: 1902 - 1913
Frequency: 5.5%

Building Fabrics:
Cavity Masonry 16% (16%)
Solid Masonry 84% (2%)

Code: H6
Structure: Purpose Built
Age: 1946 - 1959
Frequency: 4.7%

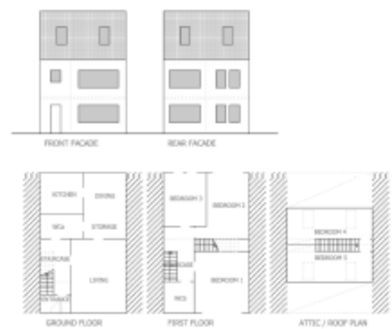
Building Fabrics:
Cavity Masonry 59% (34%)
Solid Masonry 15% (9%)
Concrete 26% (14%)

INITIAL RESEARCH LONDON ARCHETYPES



Code: H7
Structure: Purpose Built
Age: 1980 - 2008
Frequency: 3.6%

Building Fabrics:
Cavity Masonry 89% (54%)
Solid Masonry 2% (69%)
Concrete 6% (42%)

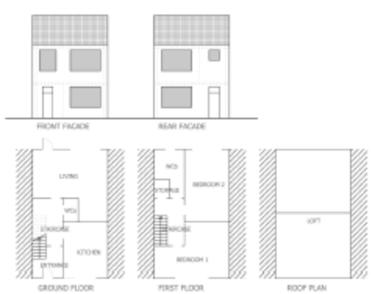


Code: H8
Structure: Terrace with Attic
Age: 1902 - 1913
Frequency: 2.9%

Building Fabrics:
Cavity Masonry 16% (16%)
Solid Masonry 84% (2%)

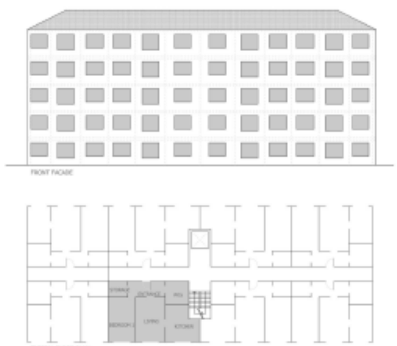
Code: H9
Structure: Bungalow
Age: 1914 - 1945
Frequency: 2.4%

Building Fabrics:
Cavity Masonry 62% (34%)
Solid Masonry 35% (7%)



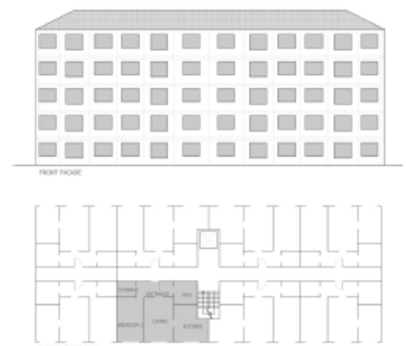
Code: H10
Structure: Simple Terrace
Age: 1960 - 1979
Frequency: 2.4%

Building Fabrics:
Cavity Masonry 79% (41%)
Solid Masonry 7% (22%)
Concrete 9% (14%)
Timber Frame 5% (21%)



Code: H11
Structure: Purpose Built
Age: 1960 - 1979
Frequency: 2.3%

Building Fabrics:
Cavity Masonry 66% (37%)
Solid Masonry 5% (19%)
Concrete 28% (12%)



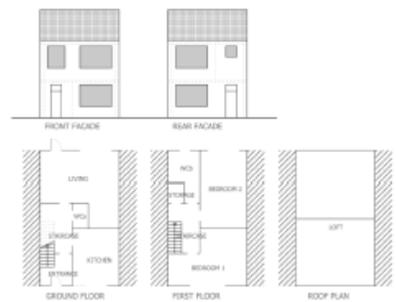
Code: H12
Structure: Purpose Built
Age: 1914 - 1945
Frequency: 2.1%

Building Fabrics:
Cavity Masonry 29% (22%)
Solid Masonry 67% (2%)
Concrete 3% (0%)

INITIAL RESEARCH LONDON ARCHETYPES

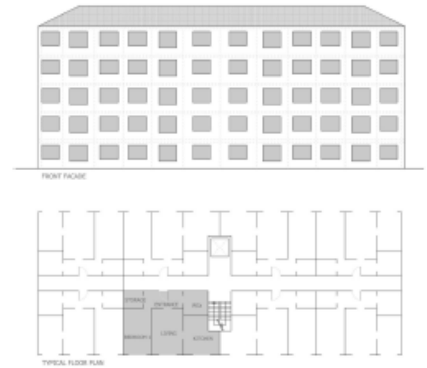
Code: H13
Structure: Terrace with Shops Below
Age: 1980 - 2008
Frequency: 2.1%

Building Fabrics:
Cavity Masonry 89% (54%)
Solid Masonry 2% (69%)
Concrete 6% (42%)
Timber Frame 2% (64%)



Code: H14
Structure: Step Linked Terrace
Age: 1946 - 1959
Frequency: 1.9%

Building Fabrics:
Cavity Masonry 82% (49%)
Solid Masonry 7% (15%)
Concrete 10% (25%)



Code: H15
Structure: Purpose Built
Age: 1946 - 1959
Frequency: 1.8%

Building Fabrics:
Cavity Masonry 59% (34%)
Solid Masonry 15% (9%)
Concrete 26% (14%)

INITIAL RESEARCH OUTDOOR LEVELS OF POLLUTION

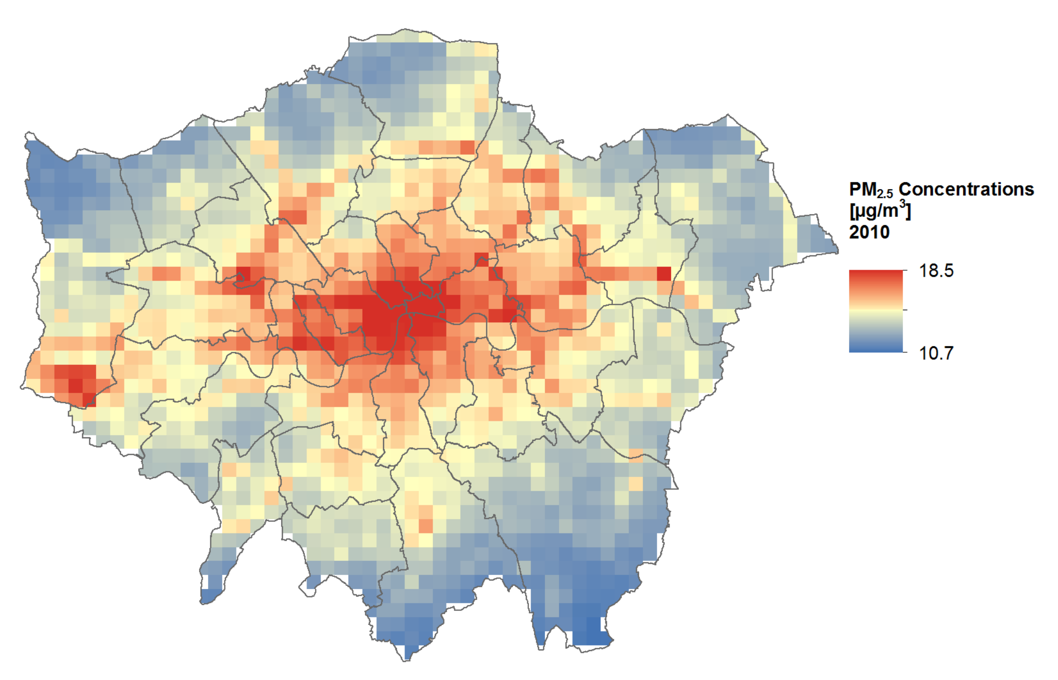
$PM_{2.5}$ chosen as pollutant to model

In London, $PM_{2.5}$ causes mortality equivalent of 4,267 deaths (2008) (Miller, 2010).

Modelled with spatial variation in background levels from DEFRA (2010) and temporal (time of day-month) from London Air (2014).

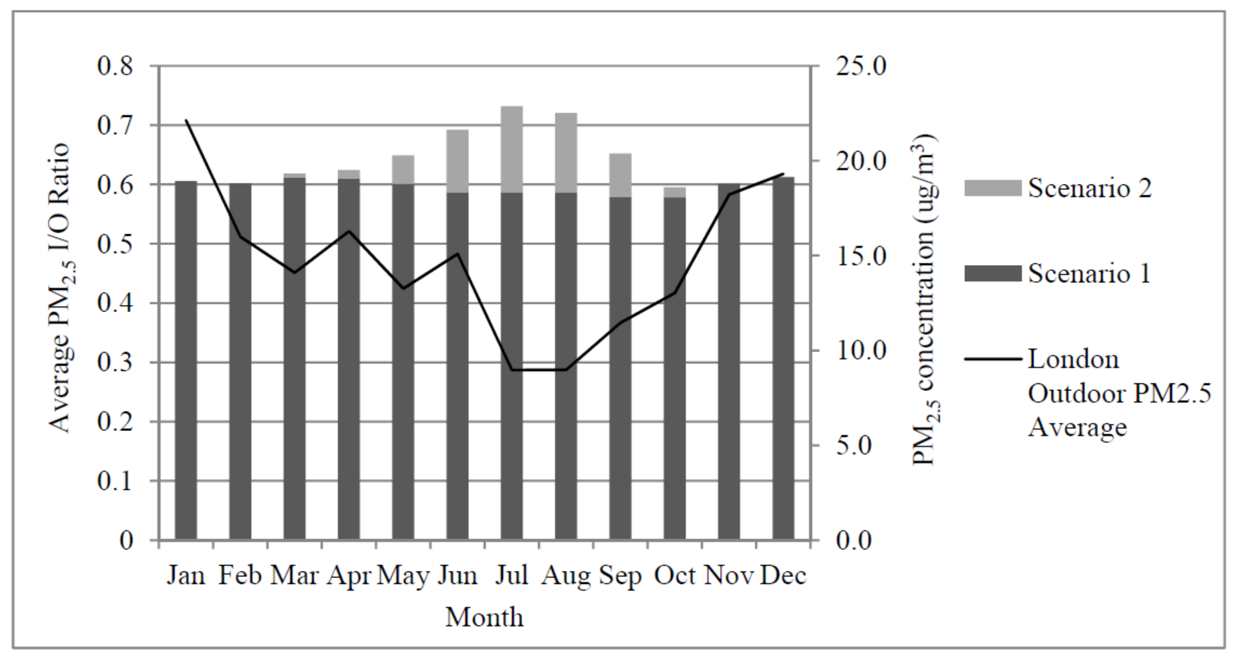
Penetration factor of 0.8 when windows closed, 1.0 when open.

Deposition rate $0.18h^{-1}$



INITIAL RESEARCH: OUTCOMES

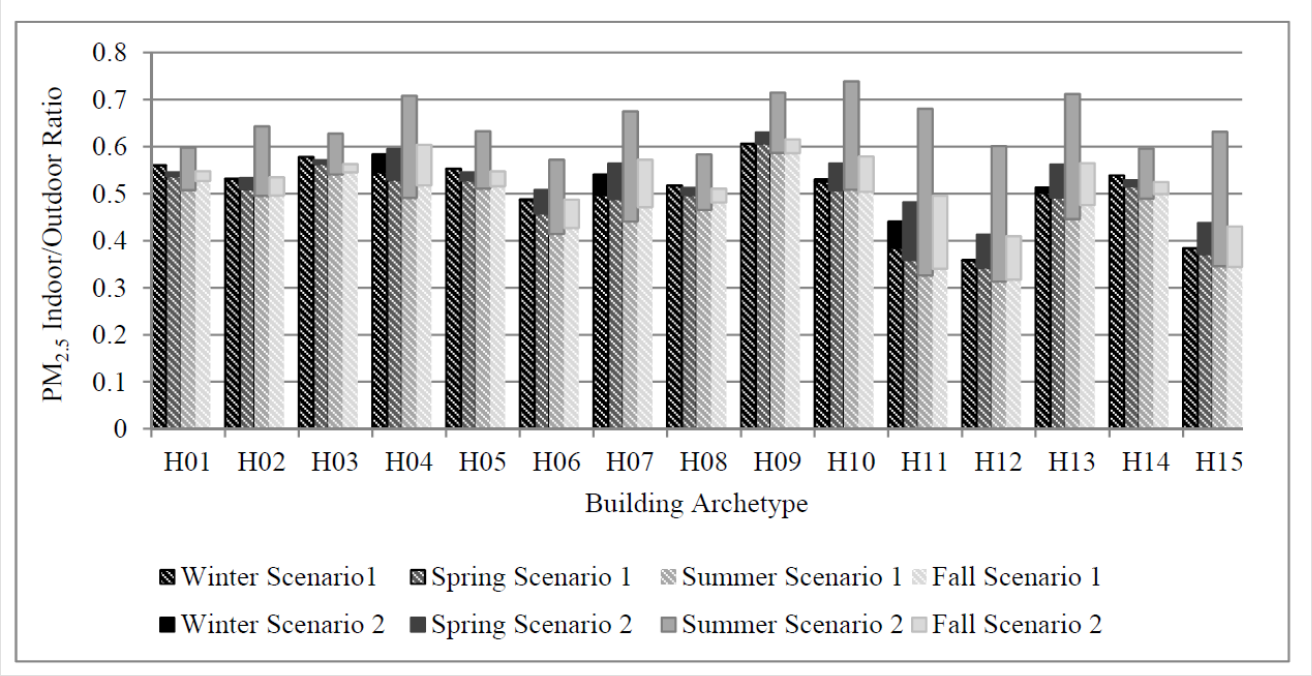
Example: I/O Ratios and average outdoor levels for bungalows over a year.



Key findings

- The I/O Ratio increases in summer if the windows are allowed to open when indoor temperature rise above thresholds.
- While I/O Ratios rise, the outdoor PM levels tend to fall during the summer.

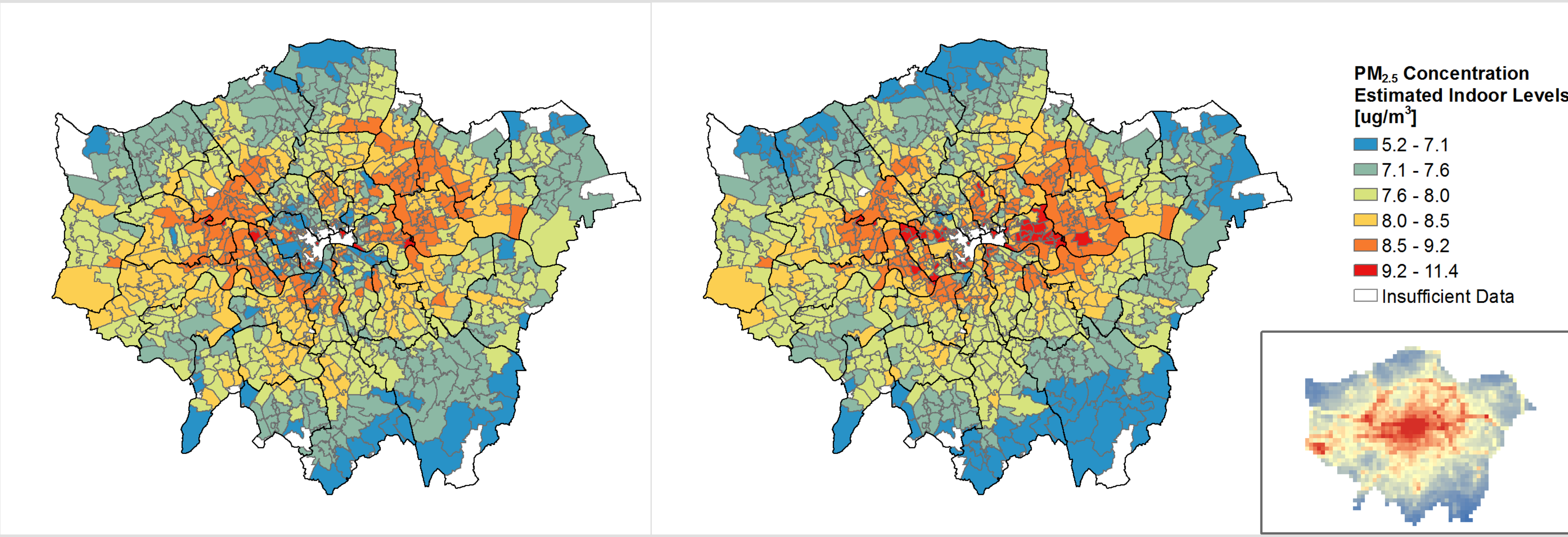
INITIAL RESEARCH: OUTCOMES



Key findings

There an almost two-fold difference in I/O ratios between archetypes, indicating that buildings may have a large impact of population exposure to outdoor $PM_{2.5}$.

INITIAL RESEARCH: OUTCOMES



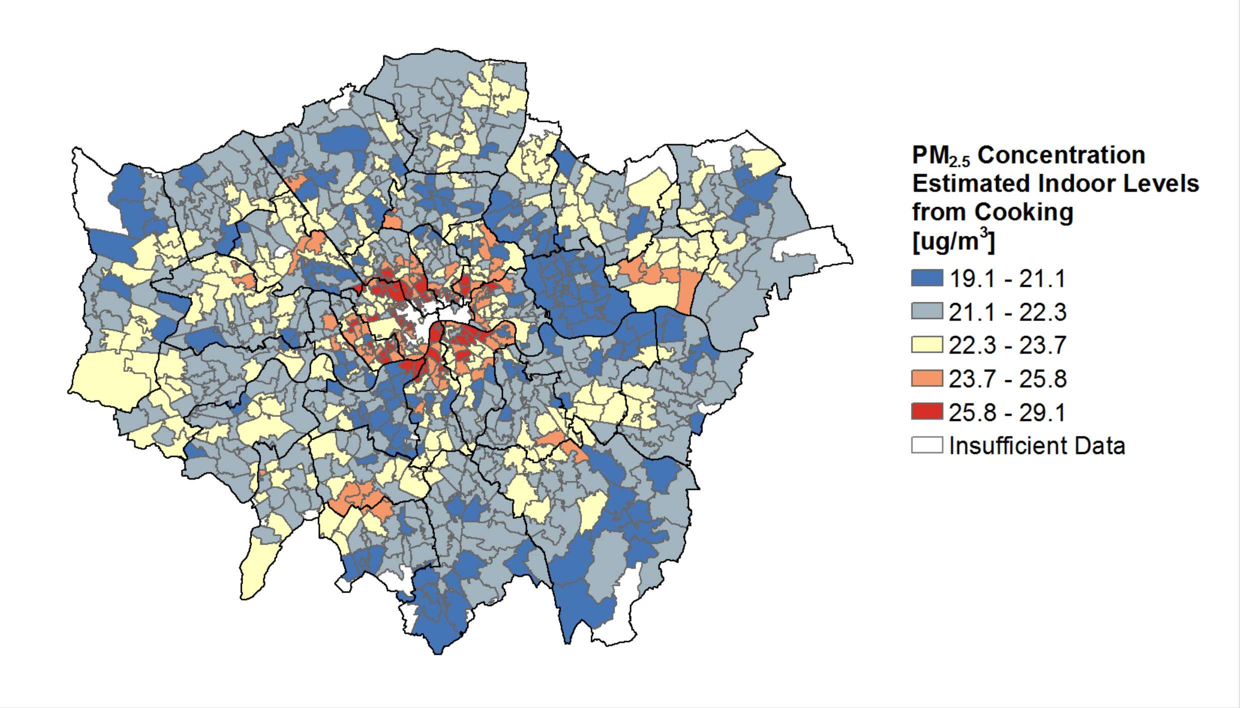
No Window Opening

Window Opening

Key findings

Modern flats have lower infiltration rates, meaning lower amounts of outdoor $PM_{2.5}$ indoors
High density of flats in Central London may reduce exposure

INITIAL RESEARCH: INDOOR SOURCES - COOKING



Key findings

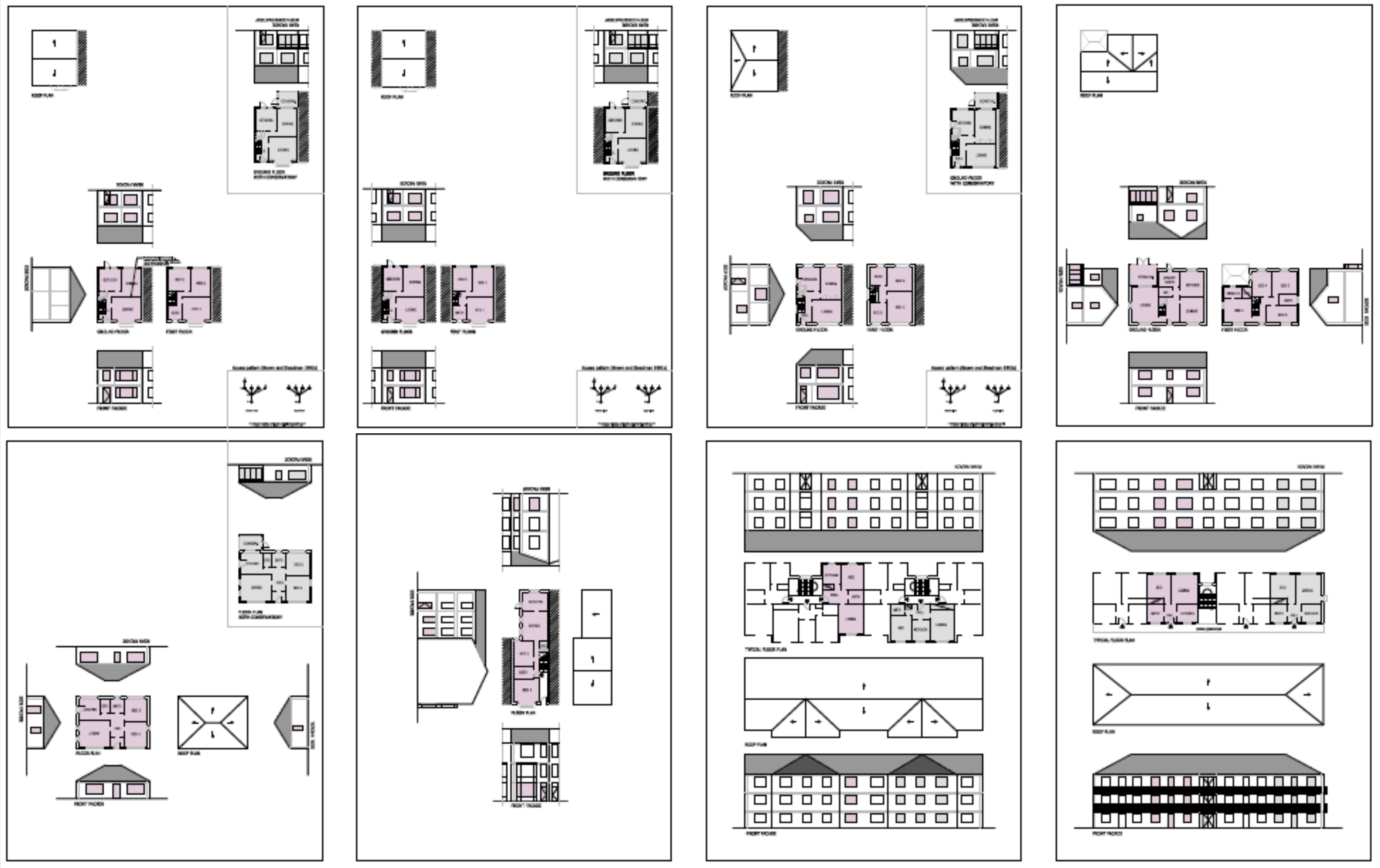
Trends when indoor sources are modelled are the opposite of what is observed with outdoor sources.

AWESOME: NATIONAL OVERHEATING AND IAQ

Develop a national building stock model suitable to estimate indoor levels of pollution from indoor and outdoor sources

English Housing Survey (EHS)	• Regular survey of around 17,000 dwellings in England • Includes interview of occupants • Representative subset have home surveyed by qualified surveyor, physical characteristics noted.
Homes Energy Efficiency Database	• Continuously updated database of individual dwellings in UK from survey and installations data. • Contains at least one piece of information from ~50% of UK dwellings • Physical characteristics only (e.g. Wall type, window type)
Standard Assessment Procedure (SAP)	• Methodology for estimating the permeability of buildings based on characteristics derived from the EHS.

AWESOME UK ARCHETYPES



FUTURE WORK

- Adjust national I/O ratios by local levels of pollution to calculate absolute indoor pollution from outdoor sources.
- Metamodel to scale overheating results by more local temperatures.
- Match indoor pollution levels (indoor and outdoor sources) and overheating data with postcode health data, socioeconomic data.

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Questions?

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