UCL INSTITUTE FOR ENVIRONMENTAL DESIGN & ENGINEERING, THE BARTLETT

Indoor Air Quality during Lockdown:

A Monitoring-based Simulation-assisted Study in London

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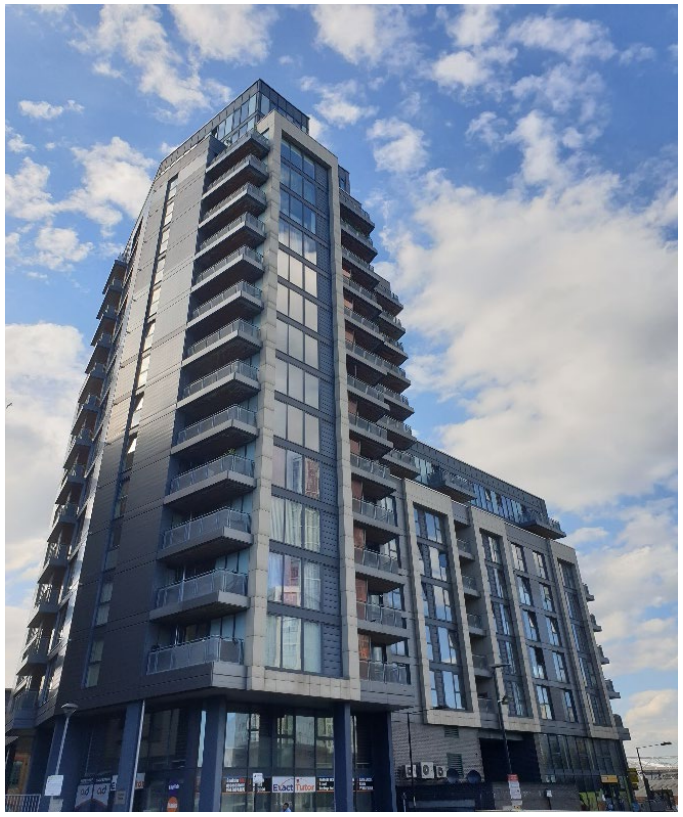
Project aims

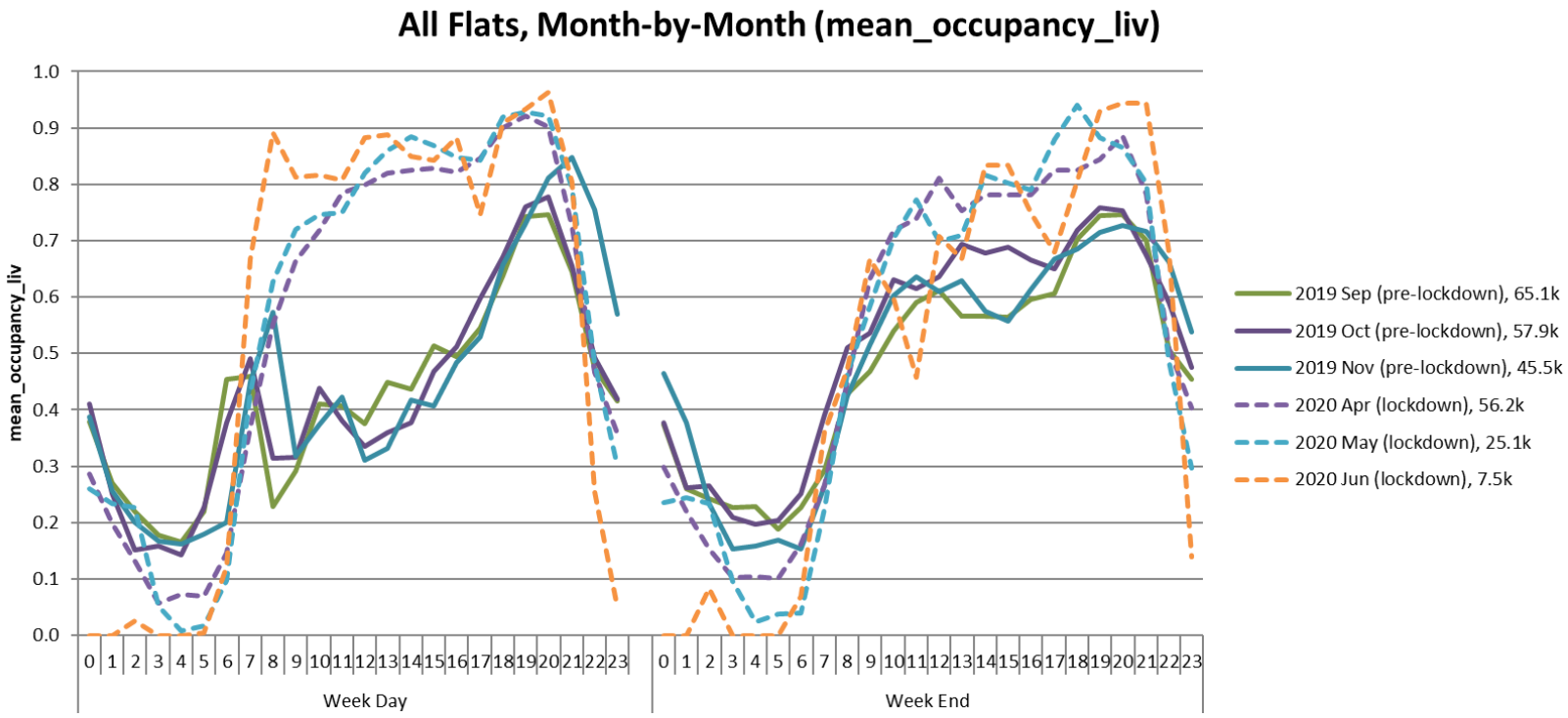
- Analyse occupant behaviour and IAQ before and during lockdown
- Understand the implications of the lockdown for the development of occupant window operation models
- Explore the potential of alternative ventilation strategies to enhance IAQ.

Background

- The COVID-19 lockdown in the U.K. resulted in extraordinary patterns of home occupancy, whose implications on indoor air quality (IAQ) are unknown.
- Previously installed IAQ and window operation monitoring devices in 8 apartments in East London, and one year of prior continuous data.
- The dataset covered indoor and outdoor air temperature, relative humidity, CO_2, $PM_{2.5}$ and PM_{10}, occupancy, and window state.
- The pre-lockdown dates, used as a comparator to lockdown, were August-October 2019.

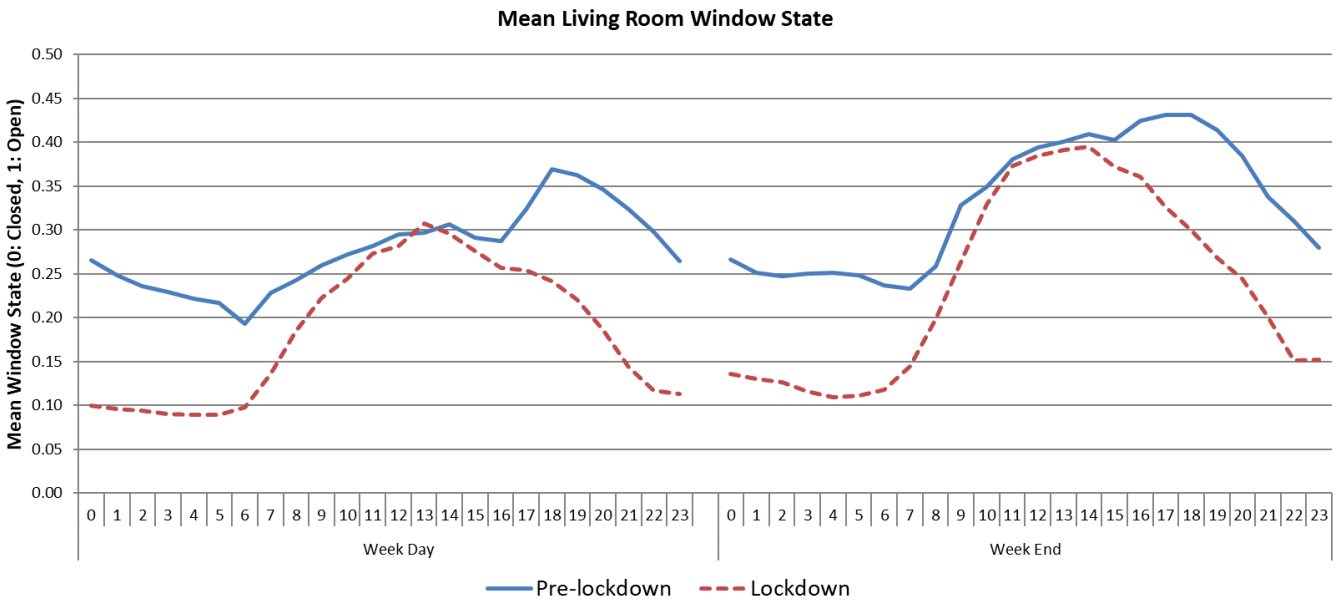


Observations: Occupancy



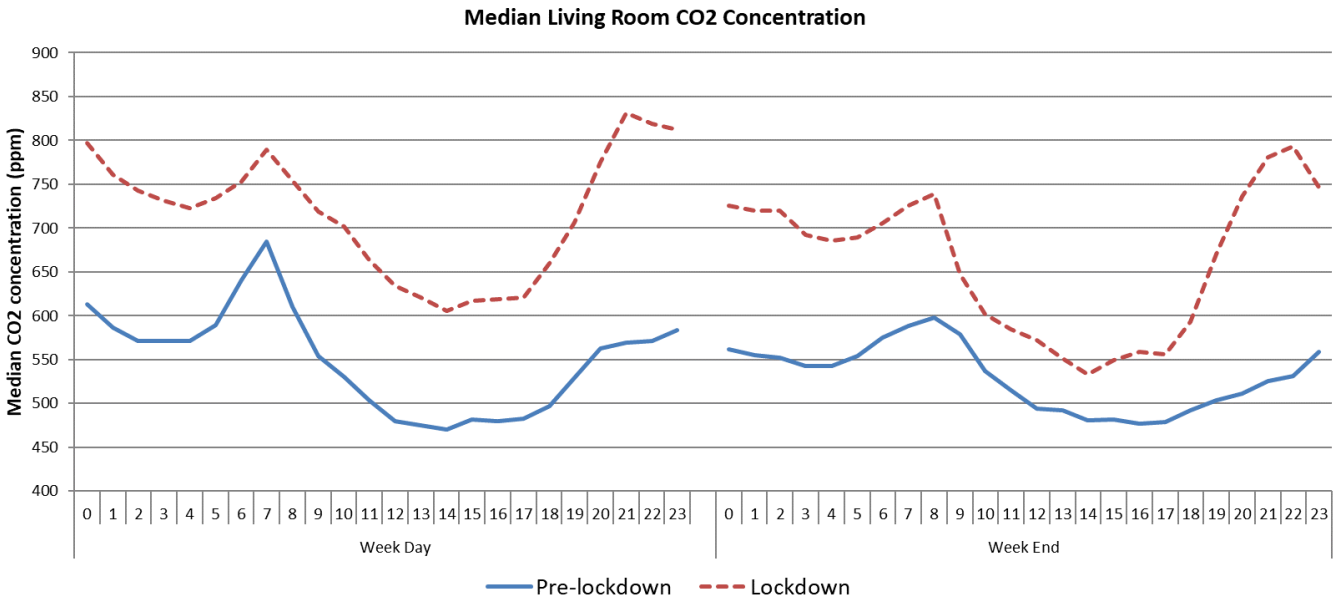
Observations: Window operation

Windows in the living rooms of flats were open for less of the day during lockdown (mid-March to mid-June 2020)



Observations: CO_2

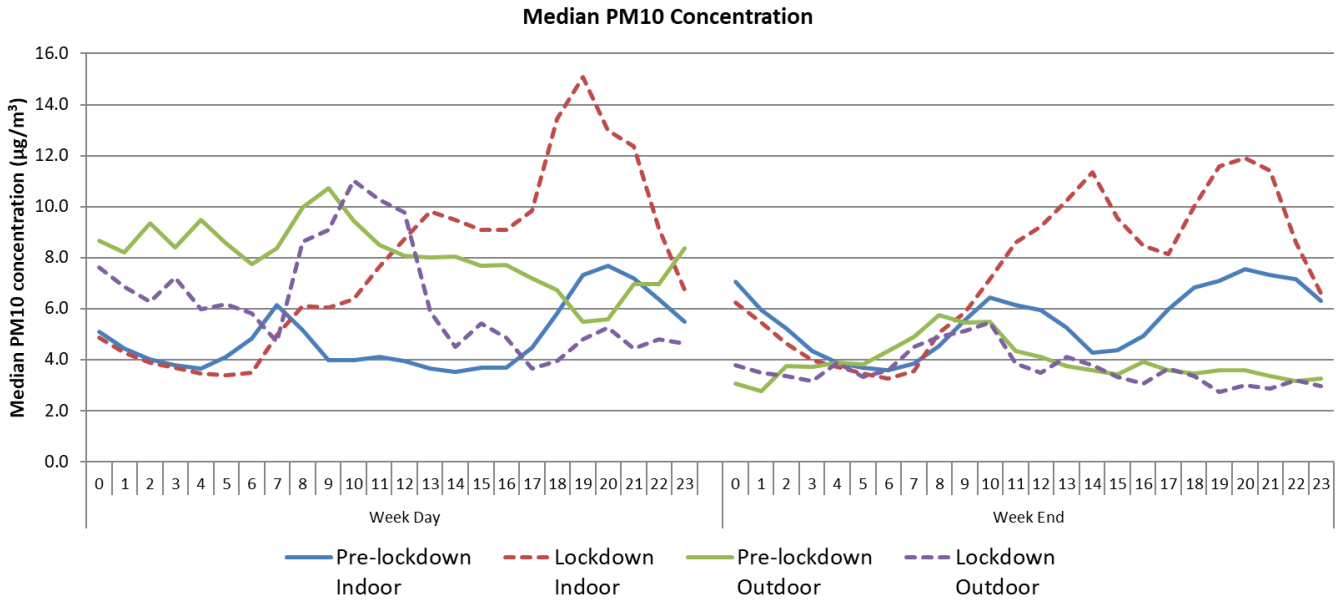
CO2 level rose, indicative of higher rates of occupancy during lockdown, as well as reduced use of windows for ventilation.



Observations: $PM_{2.5}$ and PM_{10}

Relative to pre-lockdown:

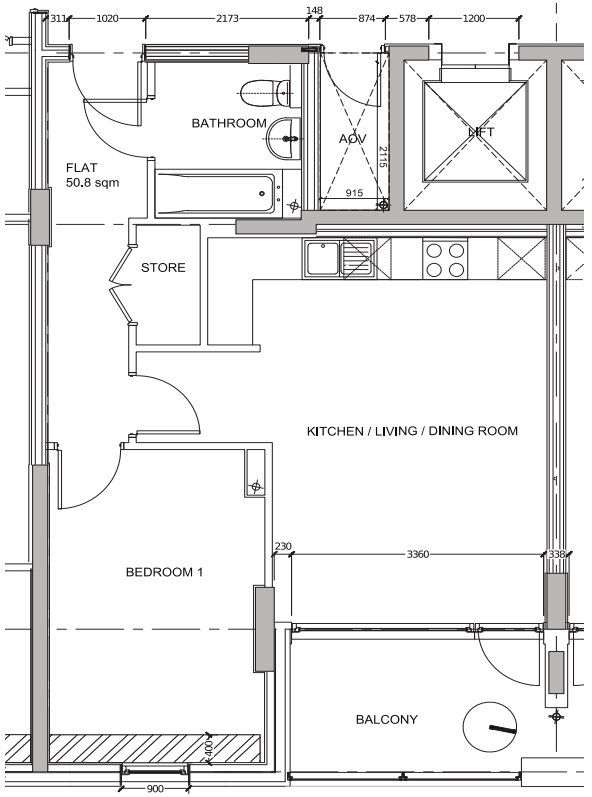
- Outdoor $PM_{2.5}$ and PM_{10} concentrations fell on weekdays during lockdown
- Indoor $PM_{2.5}$ and PM_{10} concentrations rose on weekdays during lockdown
- Trends in the Indoor PM concentrations changed during lockdown



A building model for CO_2 assessment

- A one-bedroom flat with one-sided ventilation through two east-facing windows, modelled in DesignBuilder and EnergyPlus, including an air flow network definition.

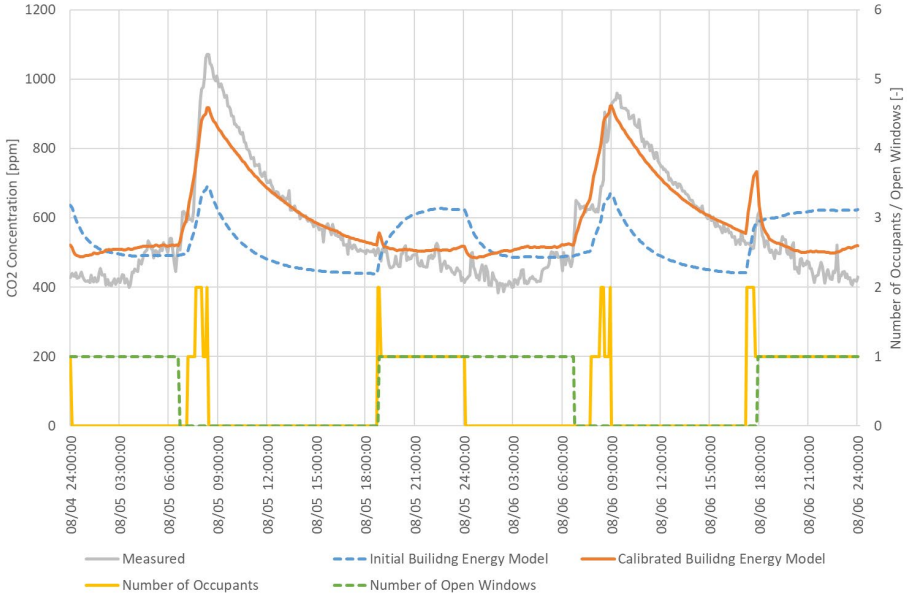
- Monitored data on occupancy, window states and on-site outdoor CO_2 concentration were fed into the EnergyPlus model to reduce the number of unknown parameters in the calibration process.



A building model for CO_2 assessment

- Subsequently, key input parameters governing the air flow model and CO_2 generation were subjected to calibration.

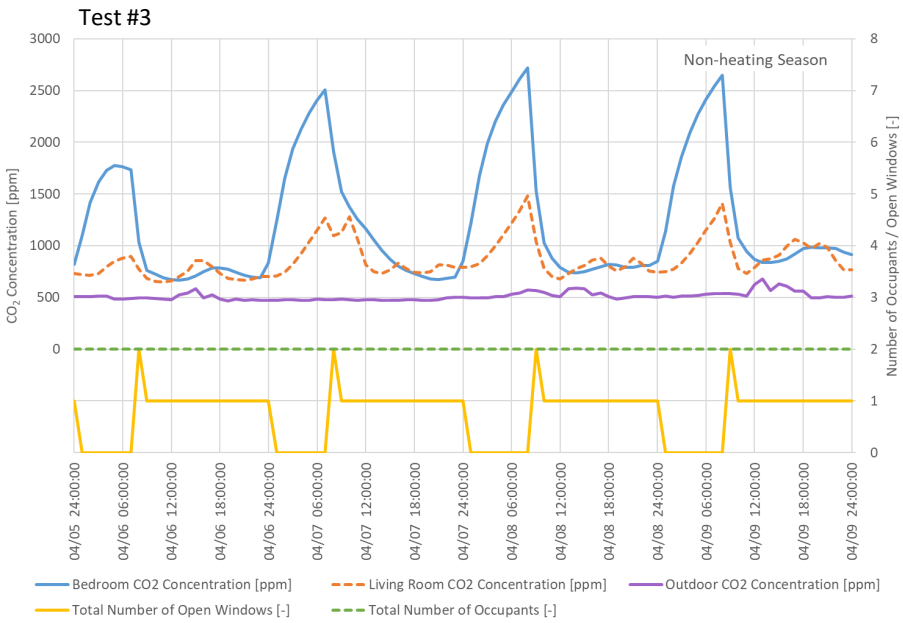
Input parameters	Initial model	Calibrated model
Bedroom closed window air mass flow coeff. [kg/s.m]	0.0001	0.0005
Living room closed window air mass flow coeff. [kg/s.m]	0.0001	0.02
Bedroom window width factor for open state [-]	0.05	1
Living room window width factor for open state [-]	0.05	0.6
Corridor door width factor for open state [-]	0.025	1
Living room occupant activity level [W/person]	99	115
Occupant carbon dioxide generation rate [m^3/s-W]	3.82E-08	6.00E-08



Error metrics	Initial model	Calibrated model
Bedroom MBE [ppm]	-245	60
Living room MBE [ppm]	-86	-42
Bedroom RMSE [ppm]	511	318
Living room RMSE [ppm]	270	189

Ventilation in non-heating season

- Quantifying the positive impact of different ventilation strategies
- Benchmark: Worst-case scenario of no window opening with normal and lockdown occupancy



Test no.	Run period	Occupancy	Window opening pattern	MVHR [l/s.pers]	Bedroom peak CO_2 conc. [ppm]	Living room peak CO_2 conc. [ppm]	Sleeping time above 2500 ppm [%]	Active time above 2500 ppm [%]	Heating Demand [kWh/m²]
1	Apr - May	Normal	No window opening	-	4942	4272	60.5	20.0	-
2	Apr - May	Lockdown	No window opening	-	5195	5038	78.3	65.1	-
3	Apr - May	Lockdown	Bedroom win. open 1 hour in morning, Living room win. open in waking ours	-	2715	1478	1.6	0.0	-

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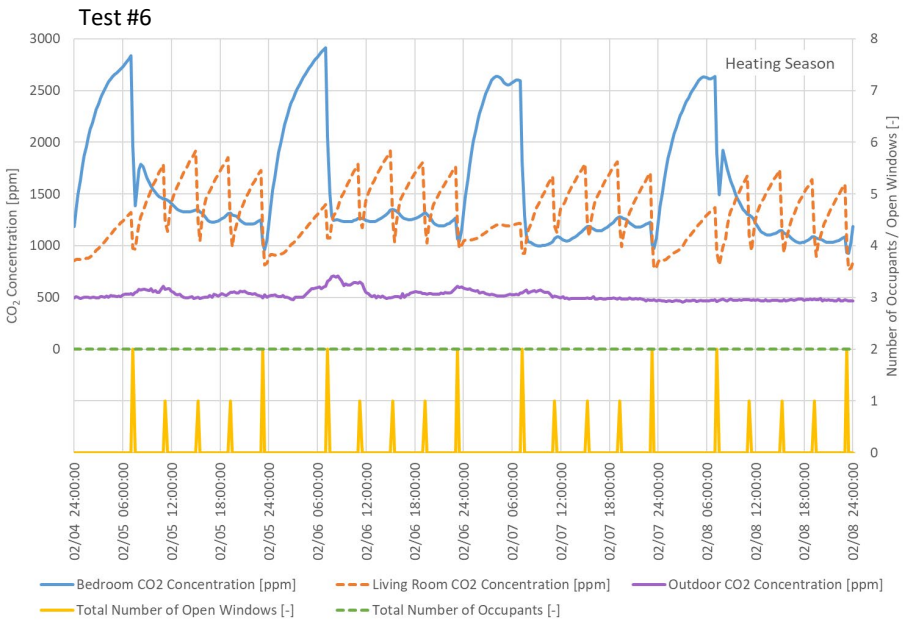

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4	Jan - Feb	Normal	No window opening	-	4540	3552	64.6	32.7	1.96
5	Jan - Feb	Lockdown	No window opening	-	5236	4643	86.4	89.9	0.95
6	Jan - Feb	Lockdown	1 to 2 windows open for 15 minutes every 4 waking hours	-	3090	2024	28.8	0.0	6.55

Ventilation in heating season

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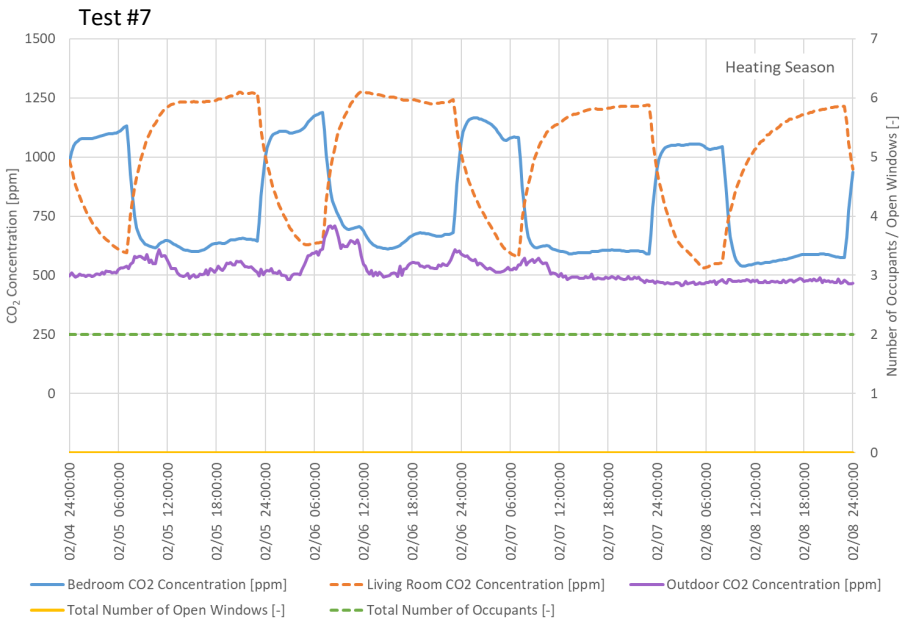

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7	Jan - Feb	Lockdown	No window opening, but MVHR	7.0	1250	1326	0.0	0.0	3.79

Conclusion

- Higher indoor CO_2 and PM_{10} concentrations observed during the lockdown as compared with the pre-lockdown period.
- Outdoor concentrations of $PM_{2.5}$ and PM_{10} were not the drivers of indoor particulate matter concentrations.
- Despite more occupied hours, occupants did not rely more on natural ventilation during lockdown across the studied flats.
- The main environmental driving factor for window operation in both pre-lockdown and lockdown periods was indoor temperature.
- The natural ventilation strategies tested on a flat and the use of MVHR proved to be very effective to maintain acceptable levels of CO_2 concentrations at home.

Thank you!

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The study presented in this presentation is funded by EPSRC IAA (Project number 559487) and CIBSE Support for Research.