UCL Institute for Environmental Design and Engineering

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The benefits of a holistic approach to building performance data

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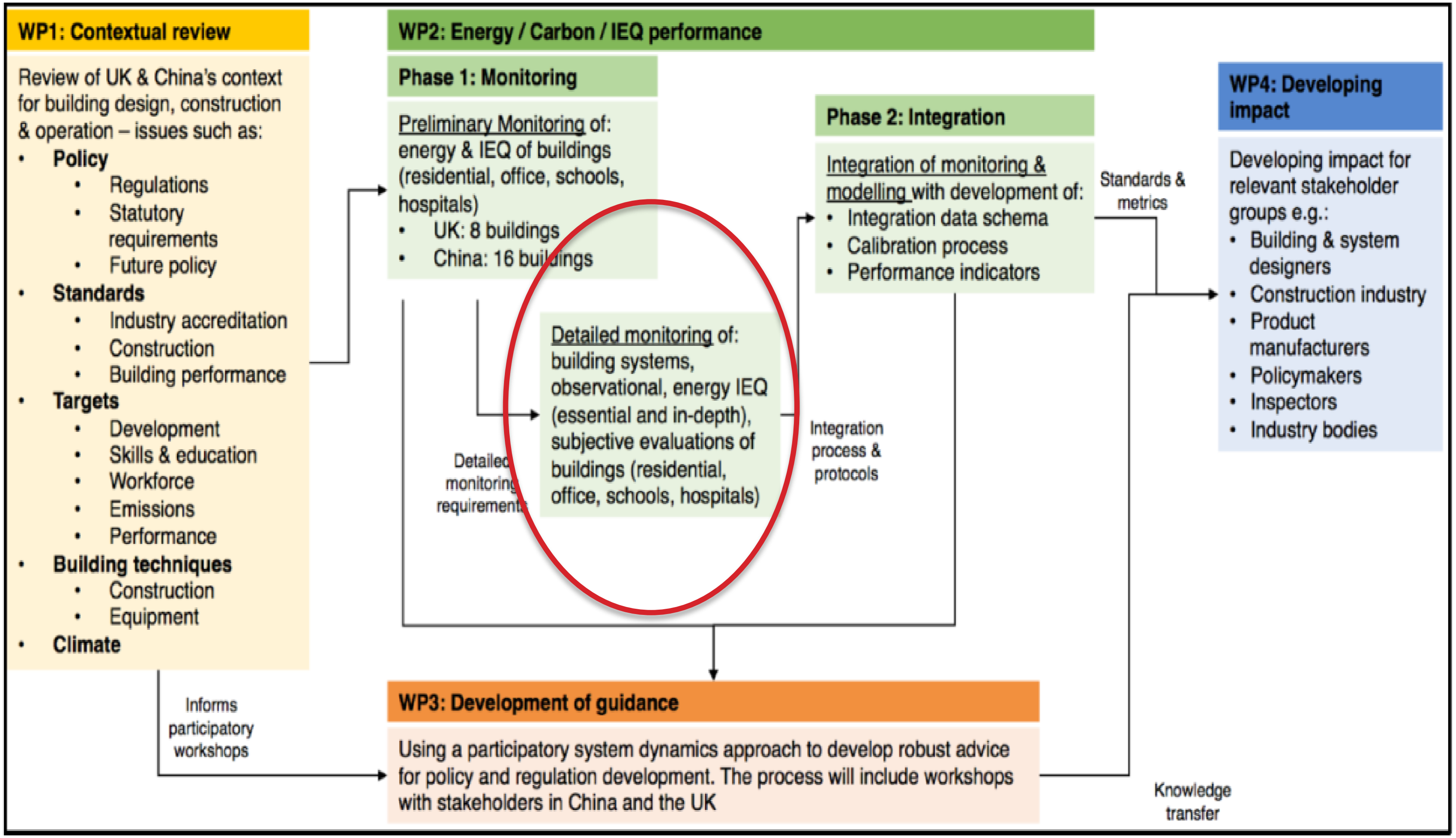
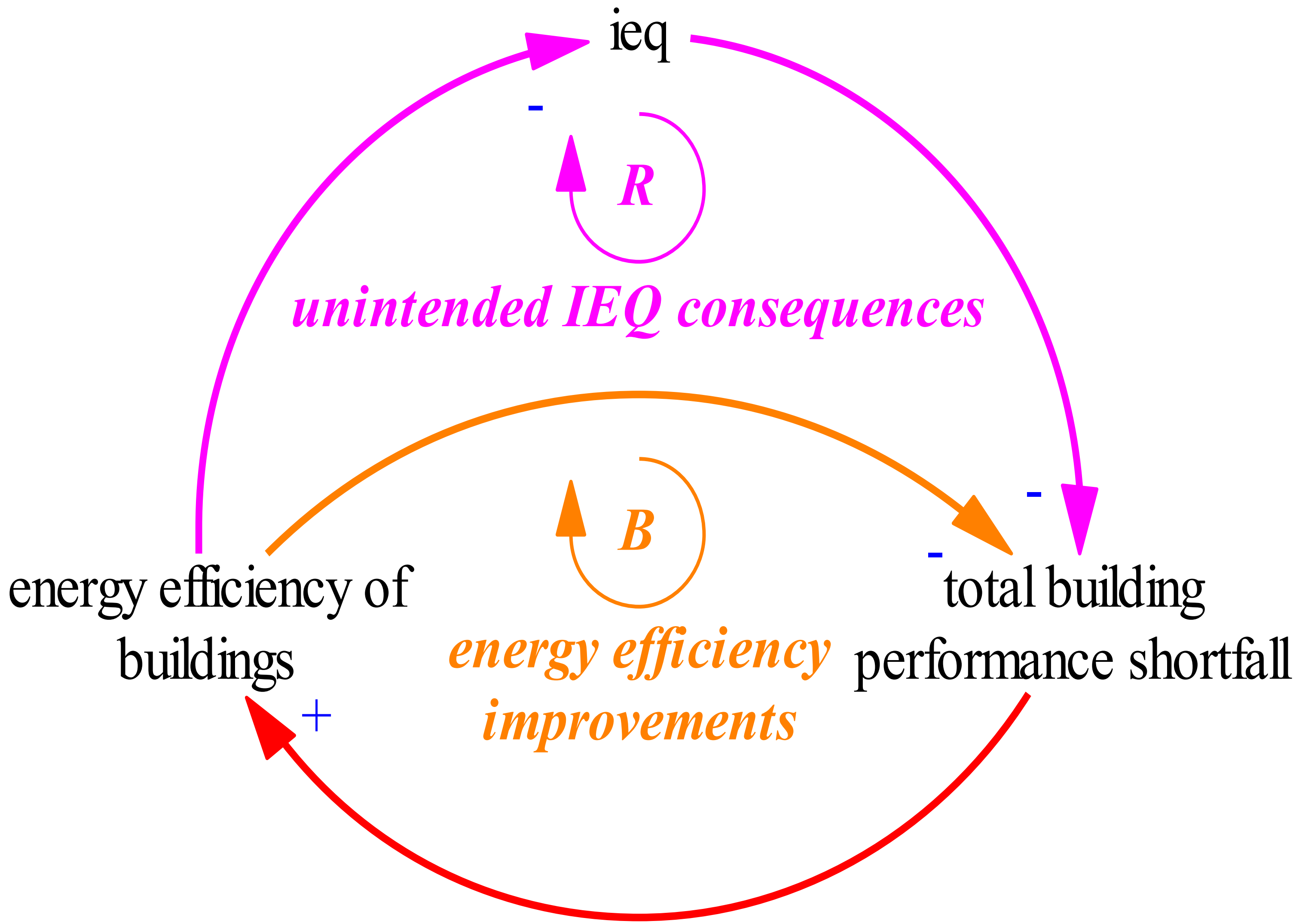
Outline

- Introduction to TOP project
- Overview of the case studies
- Available data
- Building diagnostics and improvement opportunities
- Relevance to Level(s)

Total Performance of Low Carbon Buildings in China and the UK (TOP)



Unintended consequences of energy efficiency policies



TOP case studies in the UK

- TOP focus is large scale building projects
- Where modest improvements in building procurement & management could bring significant environmental benefits
- Offices, educational buildings, and hospitals account for around 65% of the UK non-domestic building stock & 32% of its carbon emissions
- Apartment blocks account for 12% of the UK residential floor area
- Eight case studies are covered in the UK (two from each sector)

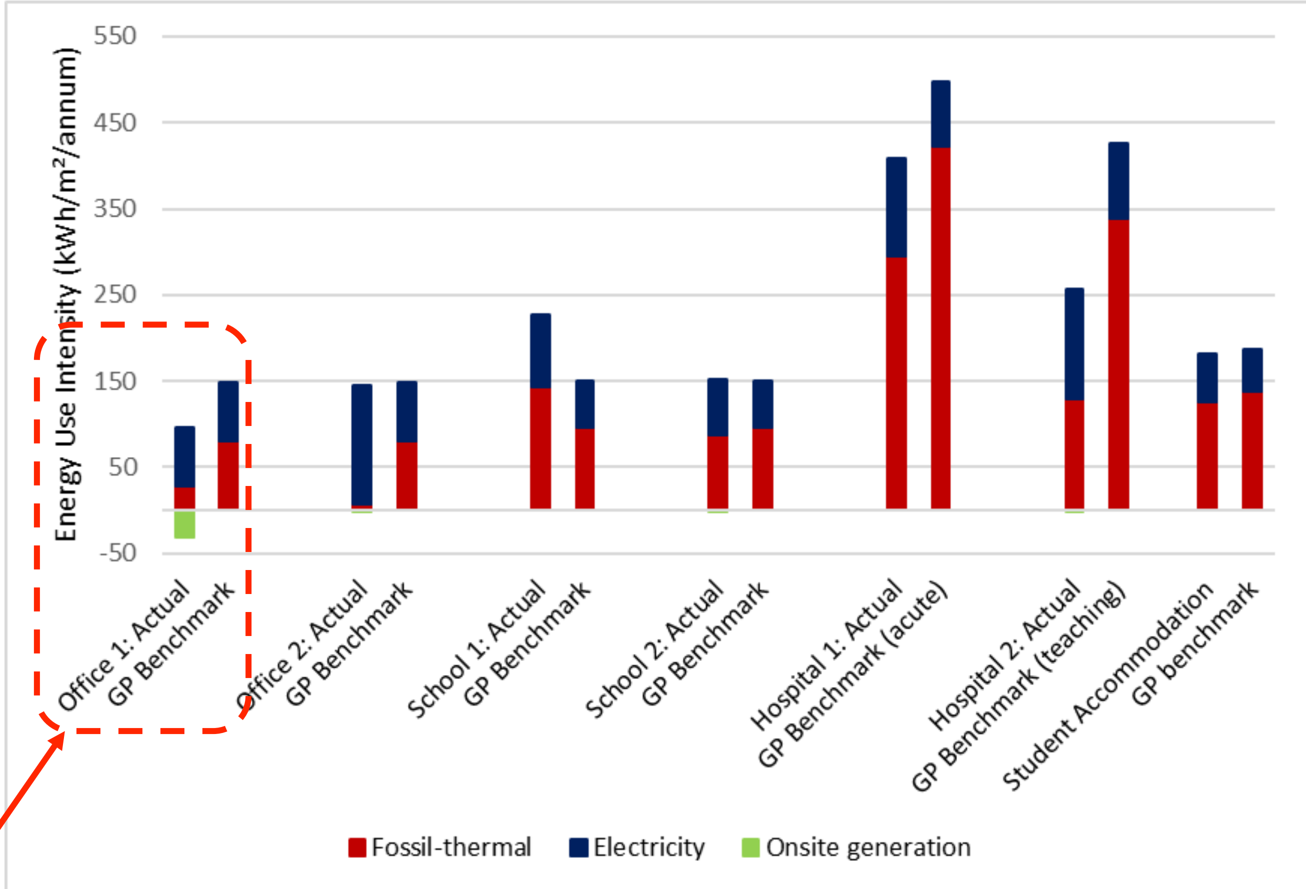
Offices

Schools

Hospitals

Apartment blocks

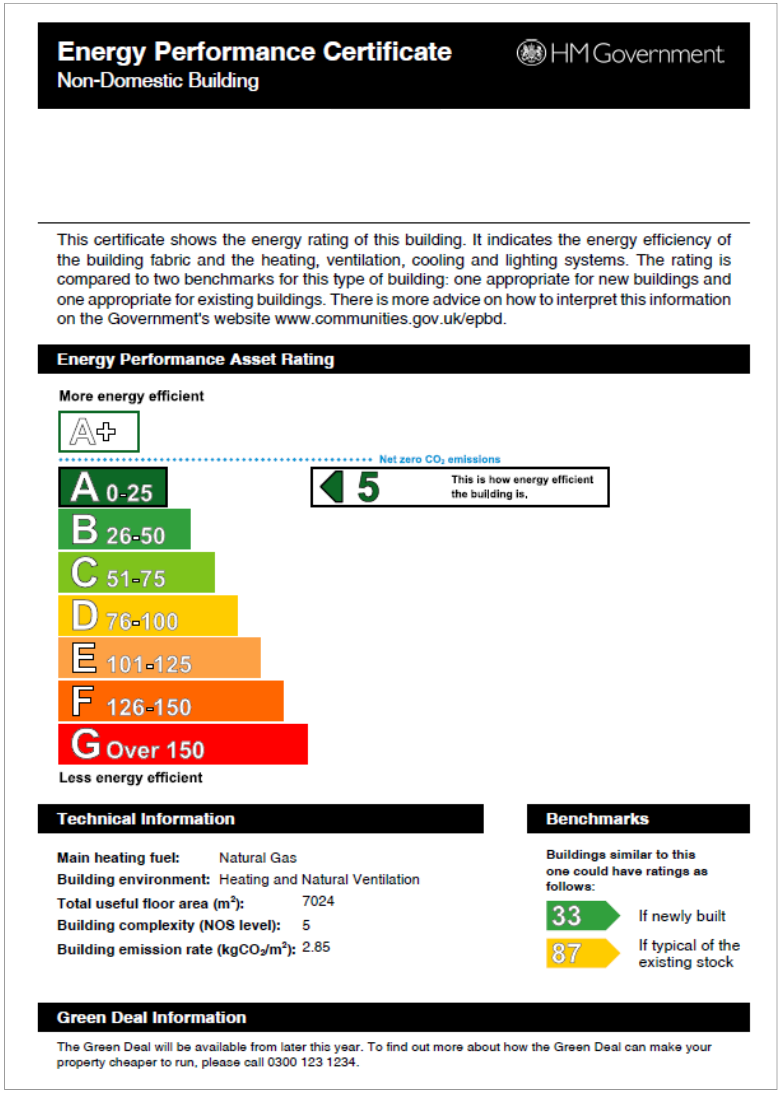
Energy performance of the non-domestic cases against Good Practice (GP) benchmarks



GP benchmarks: 25% of DEC dataset, ECG72 benchmarks for hospitals

Ambitious ‘energy budgets’ set out by designers; the building is subject to **Soft Landings & performance contracting**

Can performance contracting close the gap?



Energy Performance Certificate
Non-Domestic Building

HM Government

This certificate shows the energy rating of this building. It indicates the energy efficiency of the building fabric and the heating, ventilation, cooling and lighting systems. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings. There is more advice on how to interpret this information on the Government's website www.communities.gov.uk/epbd.

Energy Performance Asset Rating

Technical Information

Main heating fuel: Natural Gas
Building environment: Heating and Natural Ventilation
Total useful floor area (m^2): 7024
Building complexity (NOS level): 5
Building emission rate ($kgCO_2/m^2$): 2.85

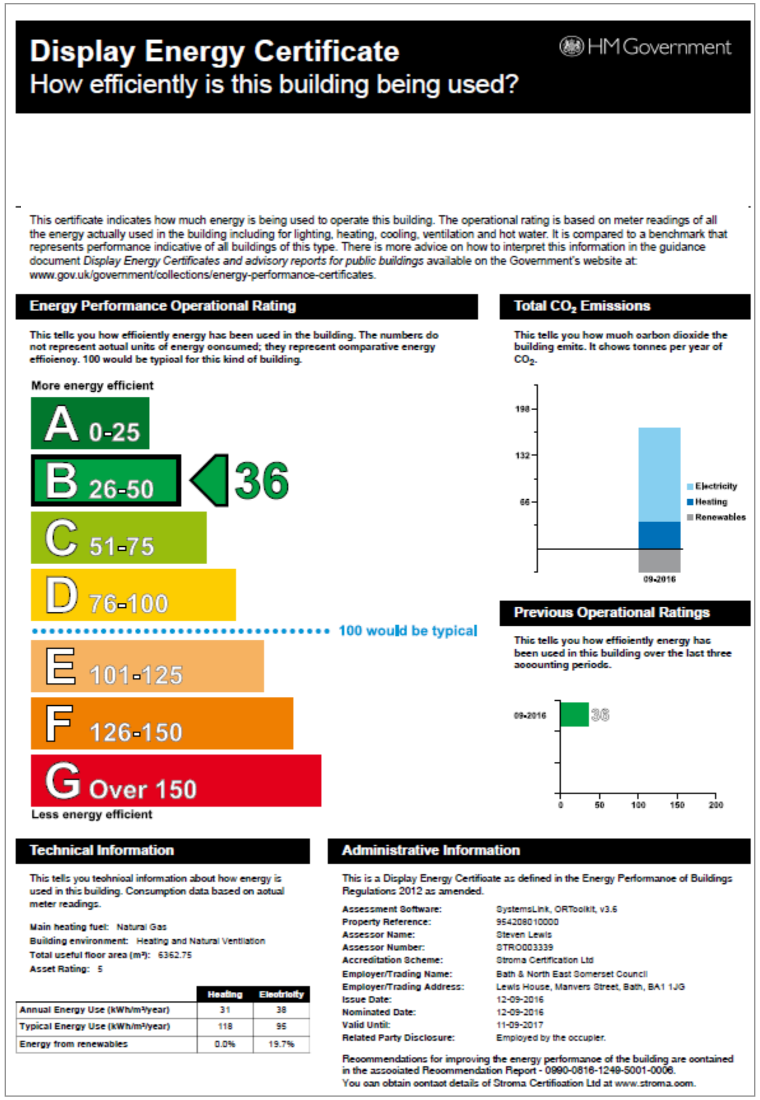
Benchmarks

Buildings similar to this one could have ratings as follows:

33 If newly built
87 If typical of the existing stock

Green Deal Information

The Green Deal will be available from later this year. To find out more about how the Green Deal can make your property cheaper to run, please call 0300 123 1234.



Display Energy Certificate
How efficiently is this building being used?

HM Government

This certificate indicates how much energy is being used to operate this building. The operational rating is based on meter readings of all the energy actually used in the building including for lighting, heating, cooling, ventilation and hot water. It is compared to a benchmark that represents performance indicative of all buildings of this type. There is more advice on how to interpret this information in the guidance document *Display Energy Certificates and advisory reports for public buildings* available on the Government's website at: www.gov.uk/government/collections/energy-performance-certificates.

Energy Performance Operational Rating

This tells you how efficiently energy has been used in the building. The numbers do not represent actual units of energy consumed; they represent comparative energy efficiency. 100 would be typical for this kind of building.

Total CO_2 Emissions

This tells you how much carbon dioxide the building emits. It shows tonnes per year of CO_2.

Previous Operational Ratings

This tells you how efficiently energy has been used in this building over the last three accounting periods.

Technical Information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings.

Main heating fuel: Natural Gas
Building environment: Heating and Natural Ventilation
Total useful floor area (m^2): 6362.75
Asset Rating: 5

	Heating	Electricity
Annual Energy Use ($kWh/m^2/year$)	31	38
Typical Energy Use ($kWh/m^2/year$)	118	95
Energy from renewables	0.0%	19.7%

Administrative Information

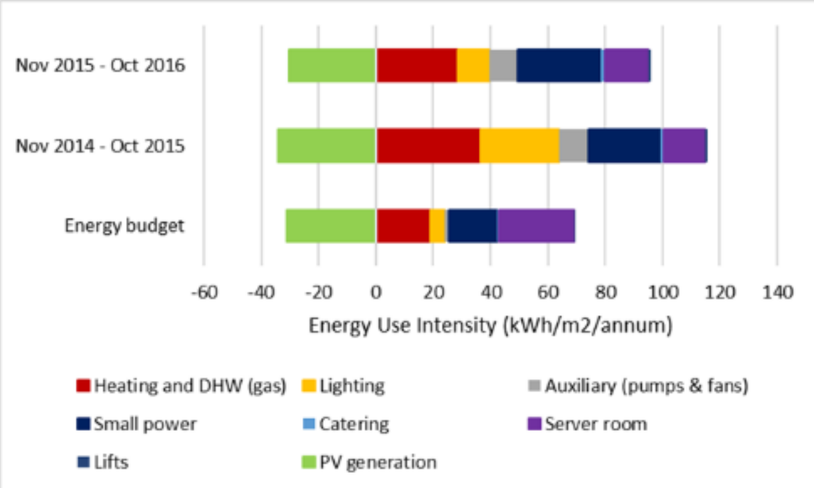
This is a Display Energy Certificate as defined in the Energy Performance of Buildings Regulations 2012 as amended.

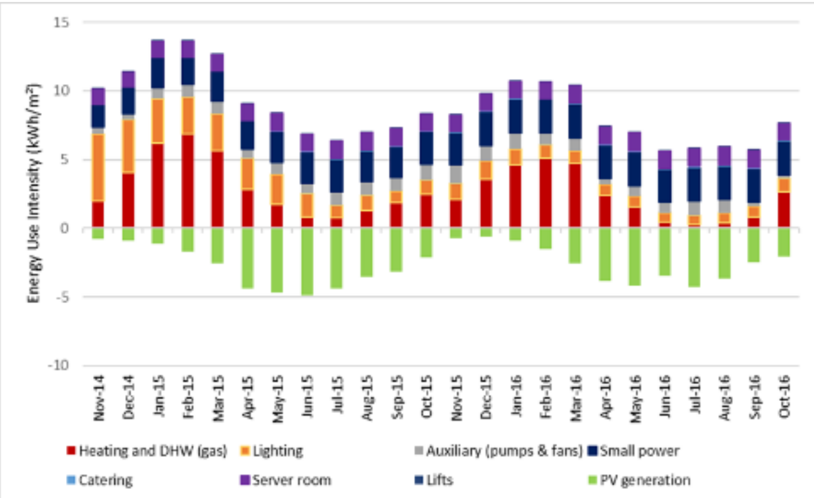
Assessment Software:	SystemsLink, ORToolkit, v3.6
Property Reference:	954208010000
Assessor Name:	Steven Lewis
Assessor Number:	STRO003339
Accreditation Scheme:	Stroma Certification Ltd
Employer/Trading Name:	Bath & North East Somerset Council
Employer/Trading Address:	Lewis House, Manvers Street, Bath, BA1 1JG
Issue Date:	12-09-2016
Nominated Date:	12-09-2016
Valid Until:	11-09-2017
Related Party Disclosure:	Employed by the occupier.

Recommendations for improving the energy performance of the building are contained in the associated Recommendation Report - 0990-0816-1249-5001-0006.
You can obtain contact details of Stroma Certification Ltd at www.stroma.com.

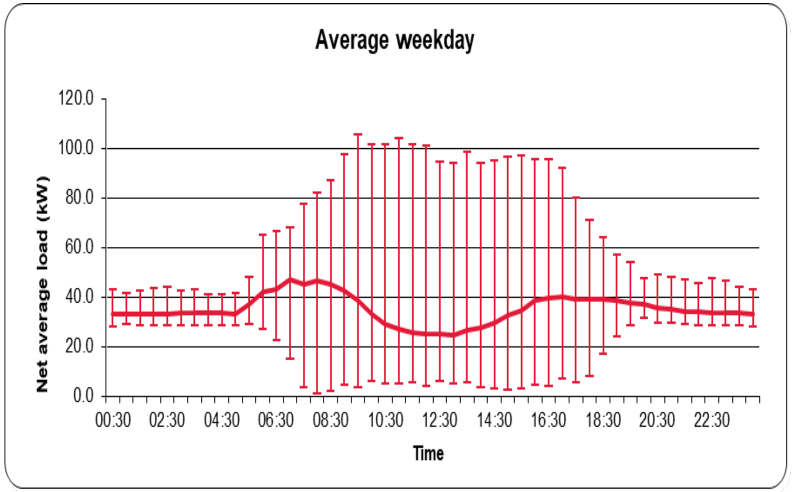
The target was to achieve DEC-A rating by the second year of operation

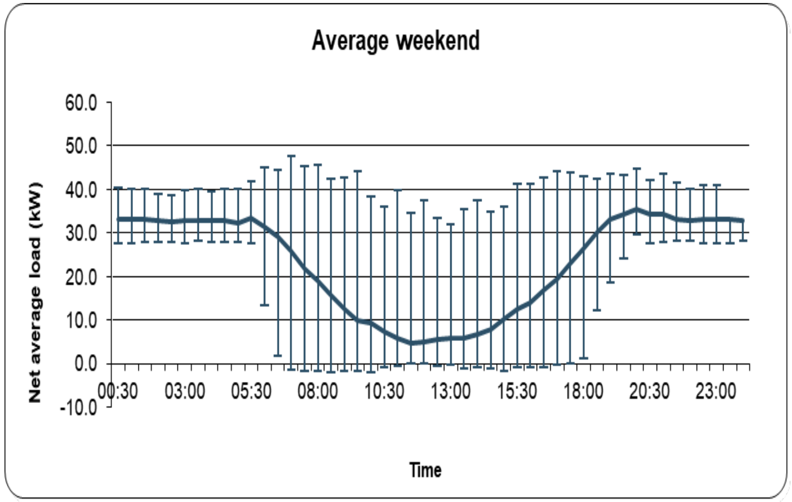
Energy performance: Office 1



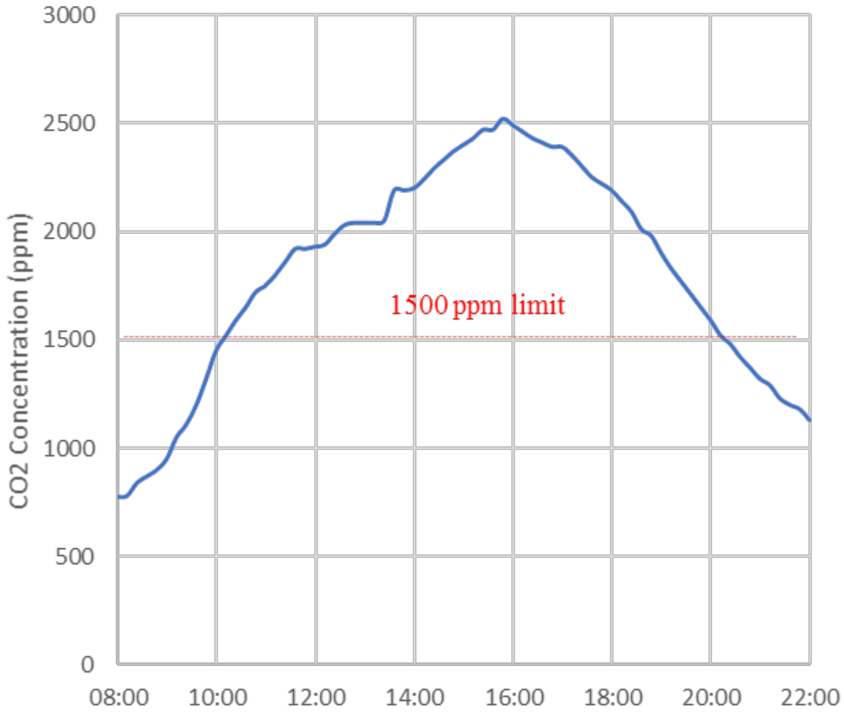


Net electrical demand: Office 1

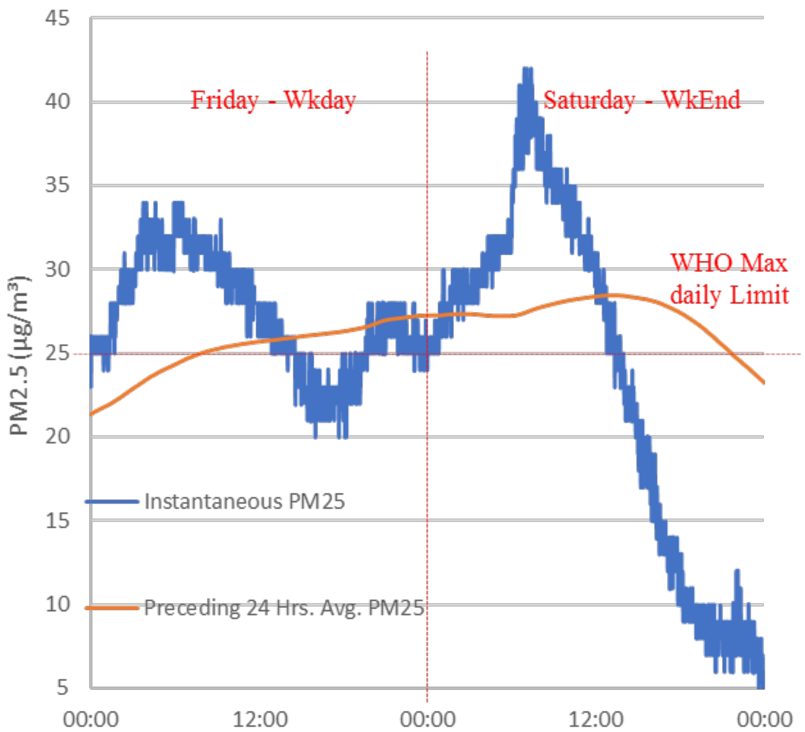




IEQ Performance: Air Quality

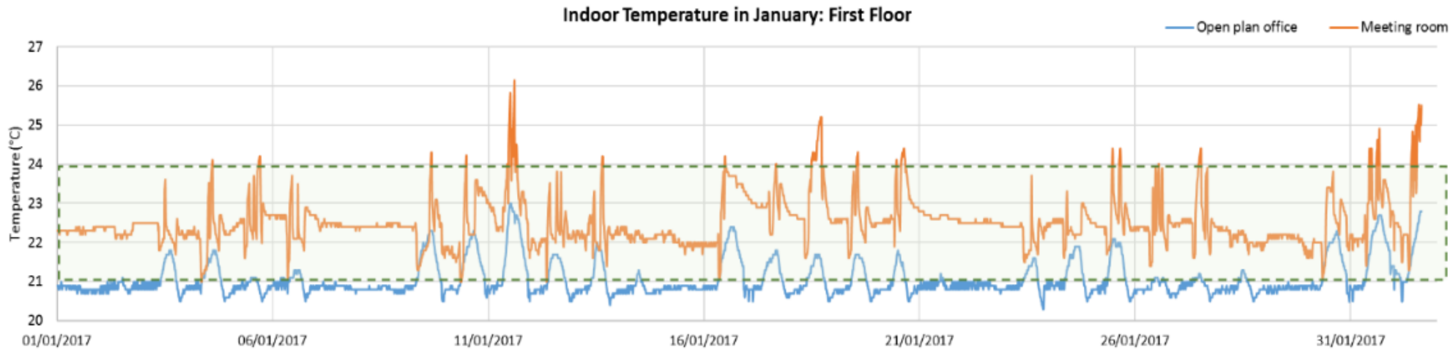


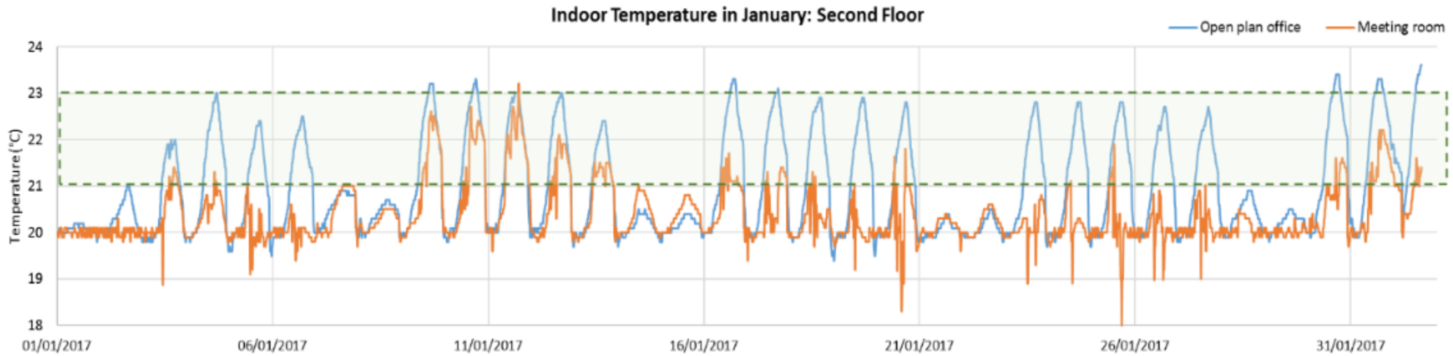
- *Indoor CO_2 concentration (reproduced from BMS data)*

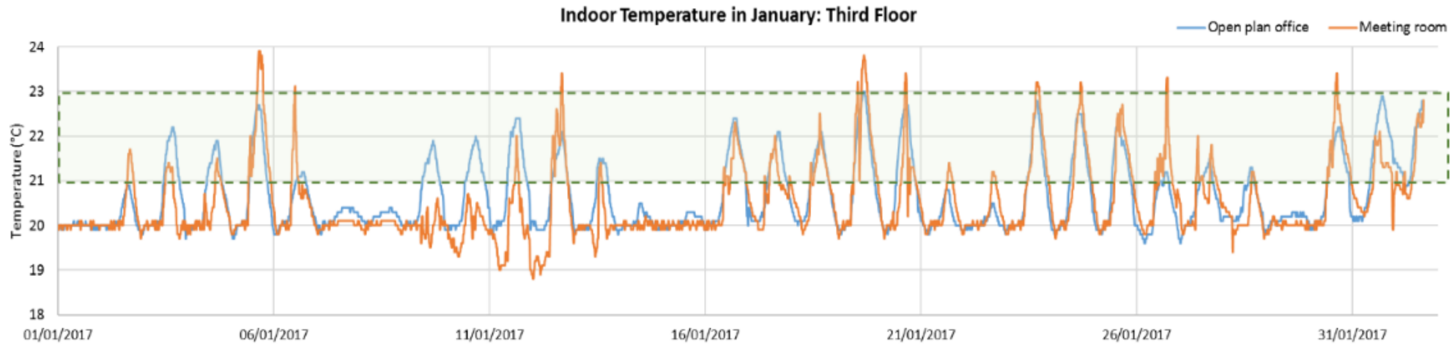


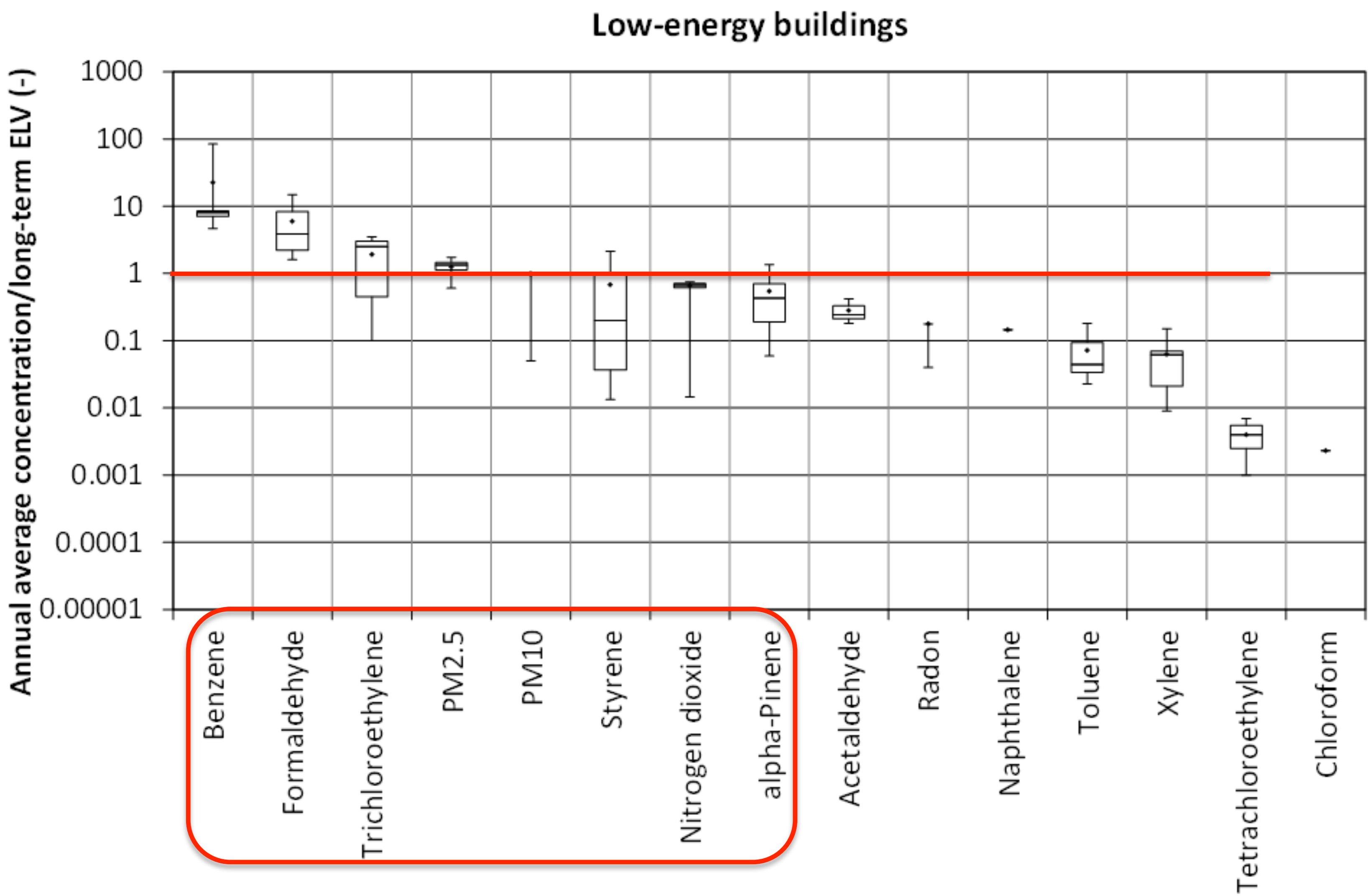
- *Indoor $PM_{2.5}$ concentration*

Out of range values: thermal comfort



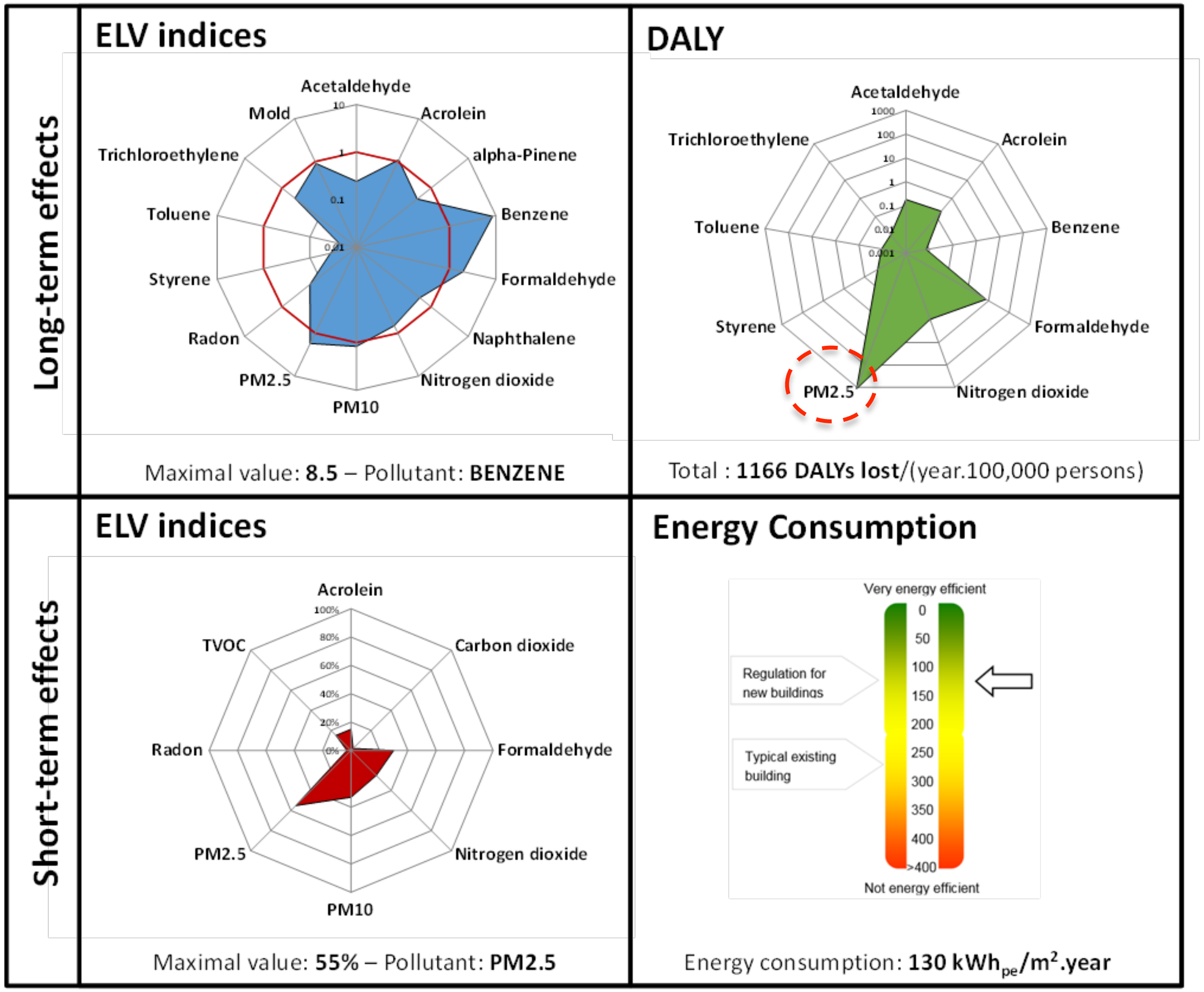






Source: Abadie et al., 2016. IEA EBC Annex 68 – Indoor Air Quality Design and Control in Low-energy Residential Buildings, SUBTASK 1: Defining the metrics

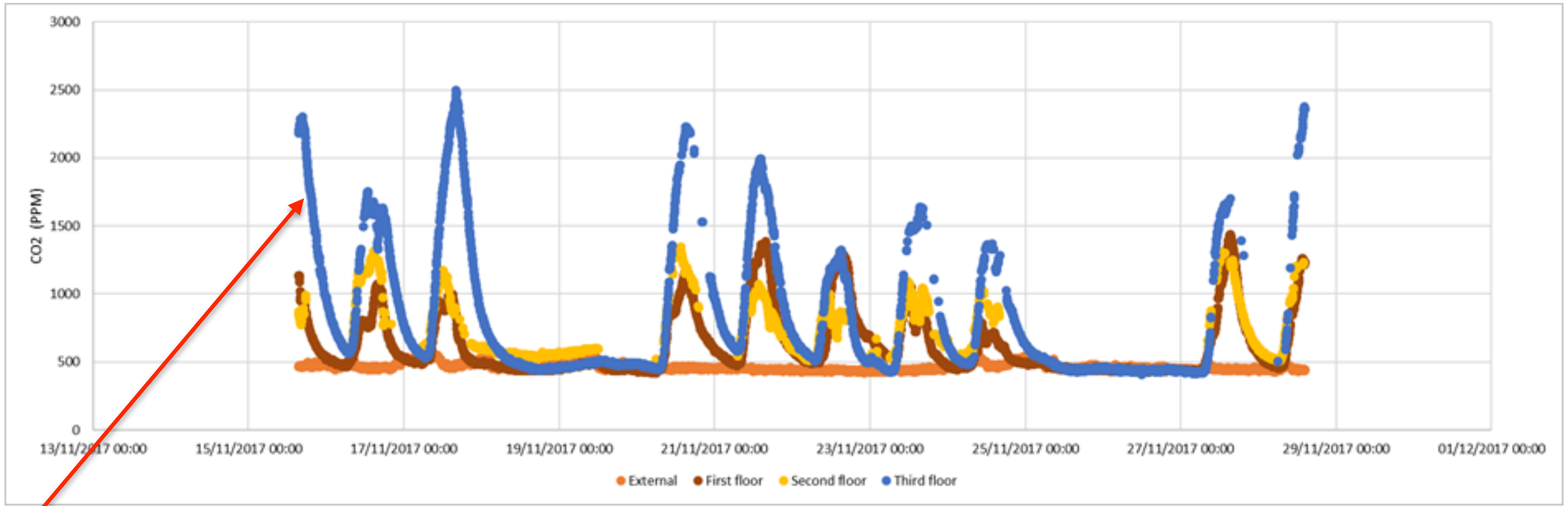
Towards 'total' performance: Energy + IAQ



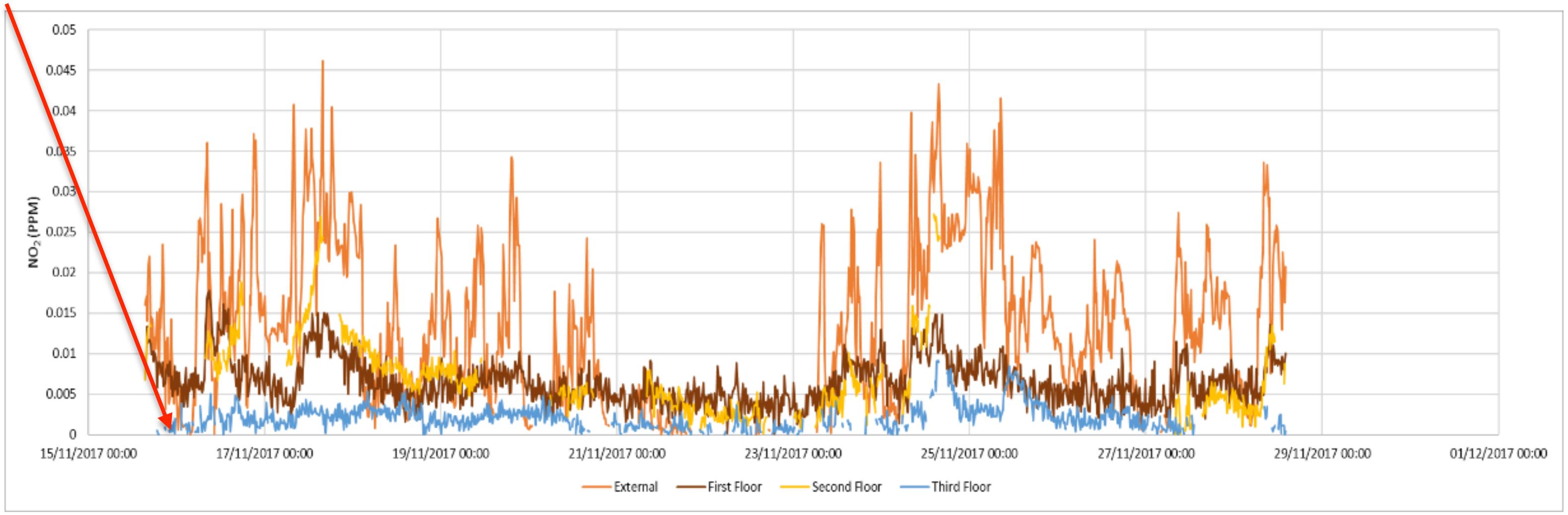
Source: Abadie et al., 2016. IEA EBC Annex 68 – Indoor Air Quality Design and Control in Low-energy Residential Buildings, SUBTASK 1: Defining the metrics

TOP Case Study (Office 1): Natural ventilation strategy

Monitoring of indoor/outdoor air quality



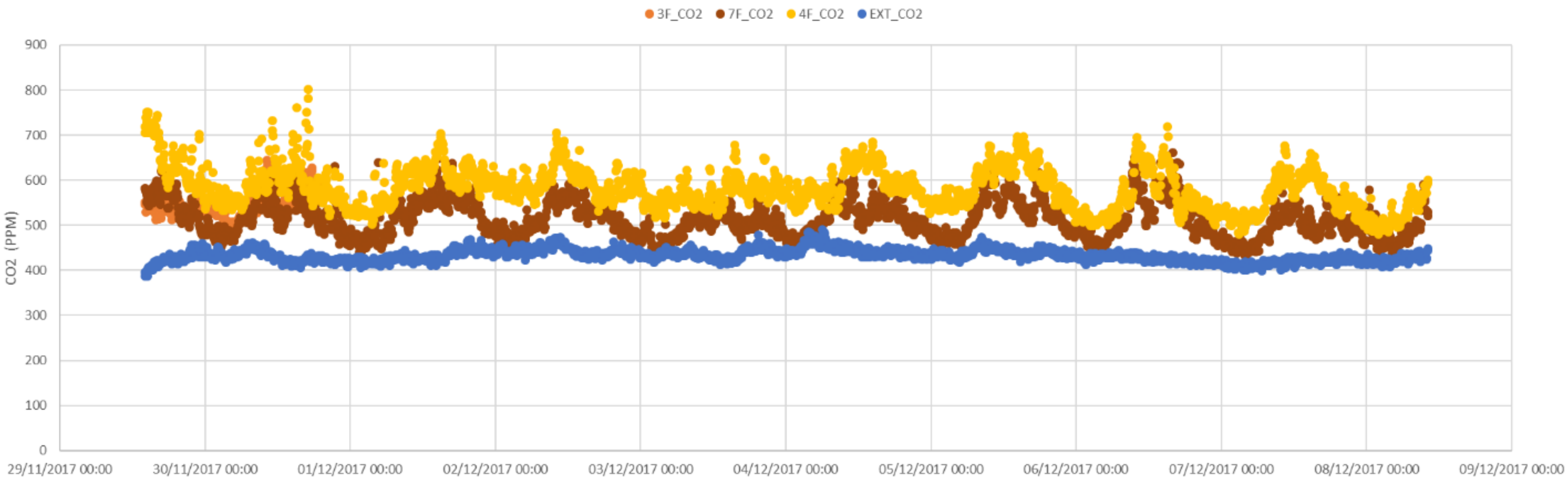
Trade-offs between CO_2 levels (ventilation rate) and NO_2/PM2.5



TOP Case Study (Hospital 1)

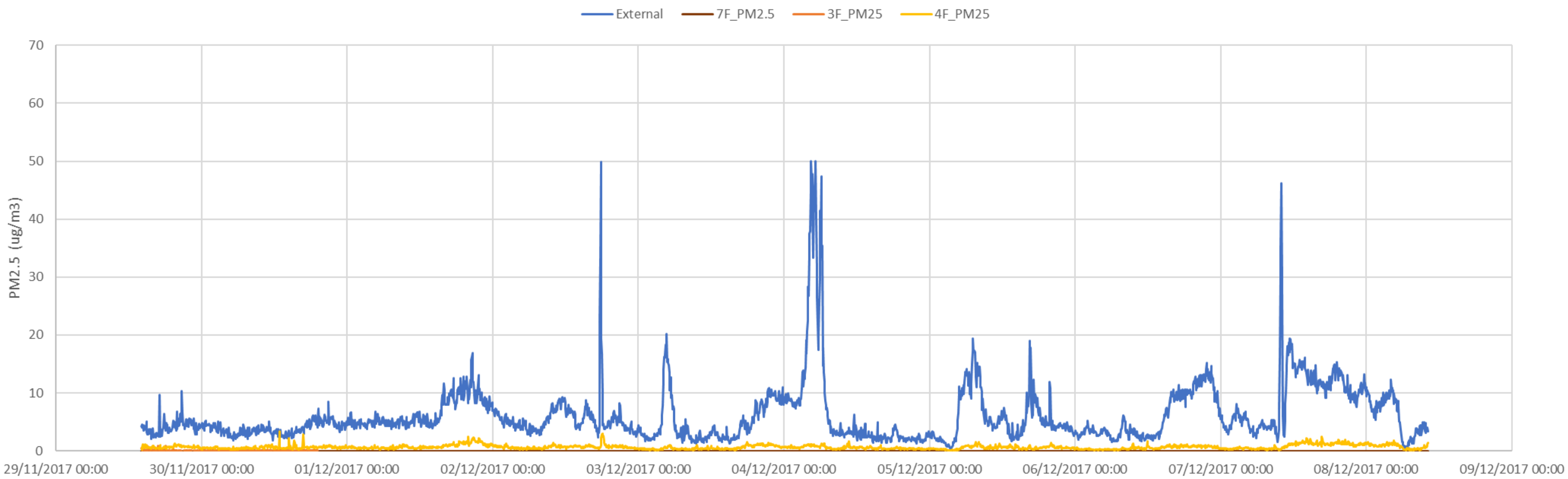
- Hospital in Bristol City Centre
- Inpatient services for surgery and medicine (two operating theatres)
- Full mechanical ventilation (10-12 ACH)
- Sealed envelope

Monitoring of indoor/outdoor air quality: CO_2



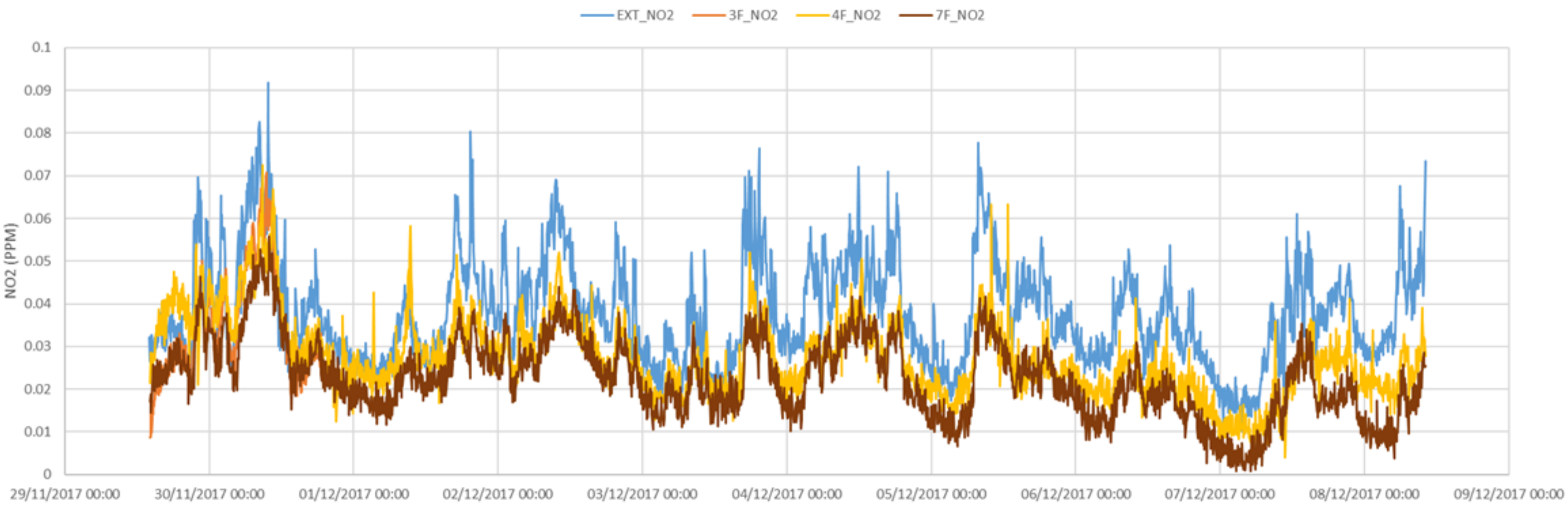
CO_2 concentration levels are usually lower than 750 ppm.
(IDA Class 4 Ventilation in BS EN 13779)

Monitoring of indoor/outdoor air quality: PM2.5



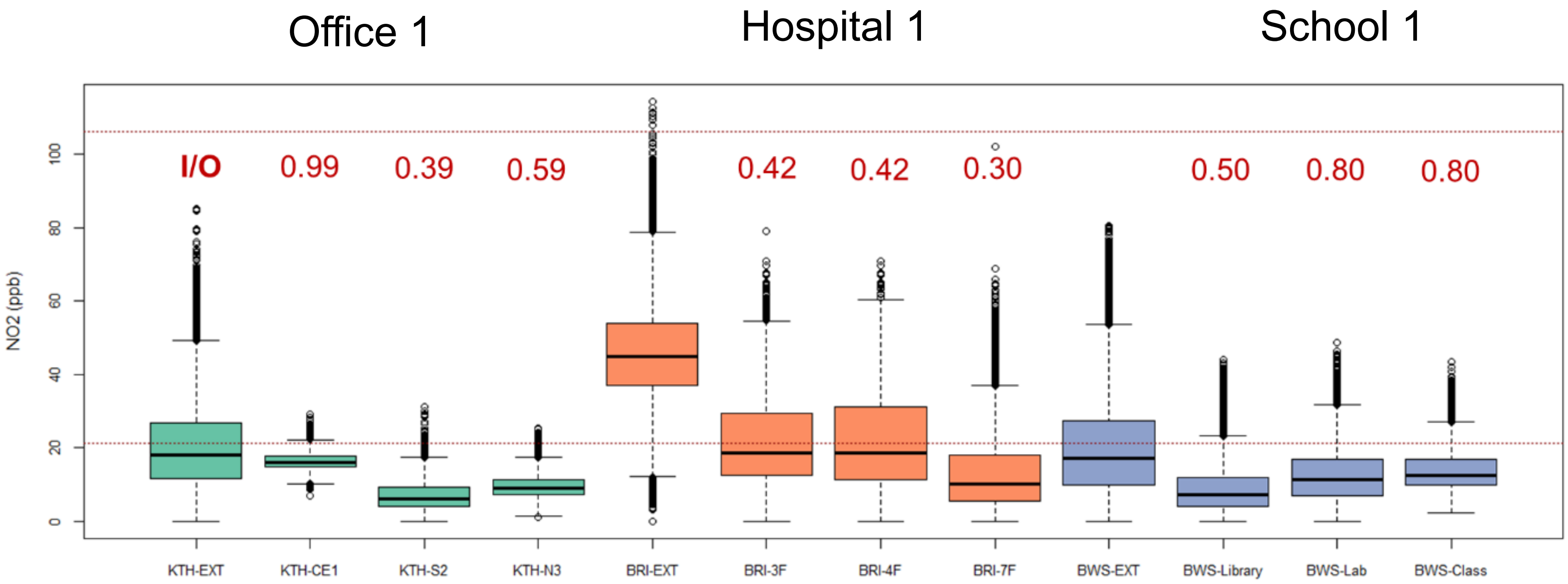
Indoor concentration levels are significantly lower than outdoor.
(F9/HEPA filtration in air handling units)

Monitoring of indoor/outdoor air quality: NO_2



Indoor NO_2 closely follows outdoor NO_2!
(Activated carbon filter or other measures required)

NO_2 concentrations in non-domestic case studies

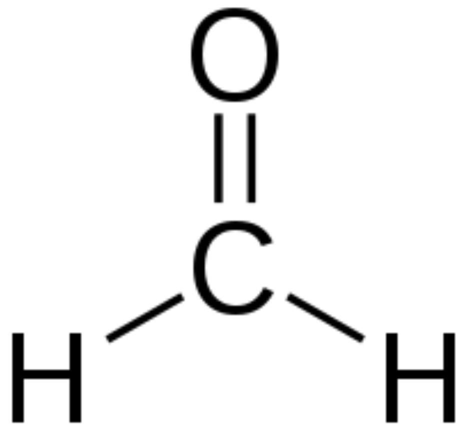


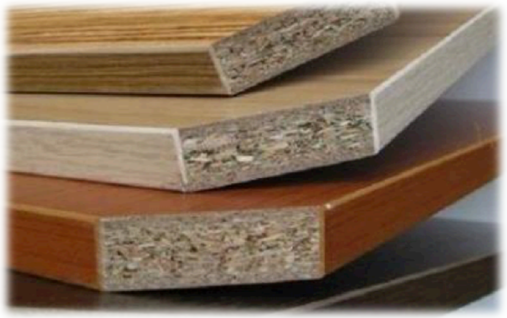
WHO guideline limits:

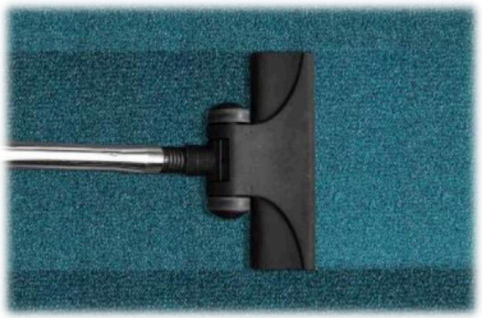
- Annual mean (chronic health effects): 40 µg/m³ (**21 ppb**)
- Hourly mean (acute health effects): 200 µg/m³ (**105 ppb**)

Internal sources of pollution

- Formaldehyde in all apartments 3xs ELV's after 3 and a half years.
- Perceived wisdom of 2 years to off-gas is questionable. Boost ventilation mode on MVHR required to be used?
- No notable formaldehyde in one school possibly due to low-emission material specification for fixtures and fittings.







Passive sampling of VOCs: heating season

VOC concentration (µg/m³) & Air Change rates per Hour for each zone	APT. 3 (Block A, 9th Floor)			APT. 4 (Block B, Ground Floor)			IEA EBC Annex 68 Long Term ELV
	Living room	Kitchen	Sample bedroom	Living room	Kitchen	Sample bedroom	
Benzene	**1.3**	**1.0**	**1.2**	**1.5**	**2.1**	**1.6**	0.2
Formaldehyde	**29.25**	**26.87**	**29.53**	**21.23**	**31.35**	**27.44**	9
Trichloroethylene	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	2
Styrene	1.5	2.2	3.0	0.8	0.7	1.7	30
Naphthalene	**5.4**	**5.4**	**5.0**	0.9	0.9	1.3	2
Toluene	2.7	2.9	3.1	2.2	2.6	2.4	250
Tetrachloroethylene	0.6	<0.6	<0.6	1.5	1.2	1.8	100
ACH (PFT measurements)	0.50	0.52	0.76	1.02	1.14	0.6	n/a

Concentration levels of benzene and formaldehyde are significantly higher than long-term/chronic exposure limit values (ELVs) in both apartments 3 years after completion!

Conclusions

- Energy Performance Contracting & Soft Landings are quite effective in closing the performance gap
- However, IEQ must also be included (Towards EEPC)
- Collated data point to improvement opportunities in control strategies in both naturally & mechanically ventilated buildings
- Standards for VOC source control of construction material should be improved

Relevance to Level(s):

Design targets and operational data for energy, thermal comfort and IAQ available for 4 UK case studies with high granularity + calibrated computer models for scenario analysis: LEVEL 3

One building registered for Level(s) pilot study: the office building subject to EPC & Soft Landings

Available Data for Level(s)

- Active monitoring results for four buildings (weekly blocks in heating season& summer): PM1-10, NO_2, TVOC, CO, CO_2, T, RH
- Passive sampling results (weekly blocks in heating season& summer): concentrations of all critical pollutants identified for low energy dwellings in Subtask 1 of IEA EBC Annex 68
- PFT measurements in apartments (air exchanges in all zones)
- Contextual information: occupancy level & pattern, occupant behaviour (self-reported + site observations)
- Energy performance data
- Occupant satisfaction surveys (thermal comfort & IAQ)
- Design information (energy targets and IEQ standard limiting values)

Towards ‘total’ energy & environmental performance

Source: Evening Standard, 8 May 2017

Any questions?

Contact: esfand.burman@ucl.ac.uk

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