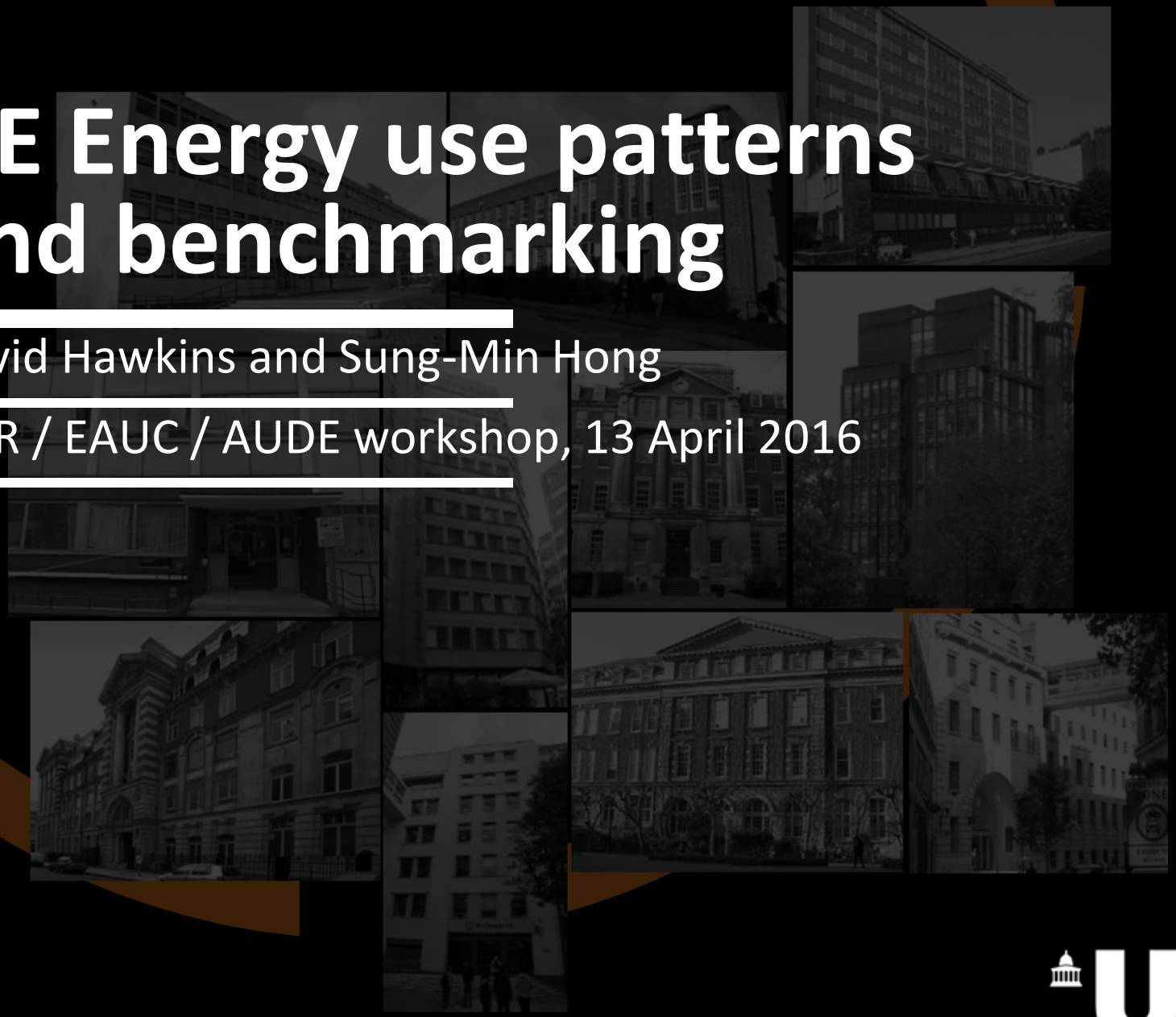
HE Energy use patterns and benchmarking

David Hawkins and Sung-Min Hong

AHR / EAUC / AUDE workshop, 13 April 2016



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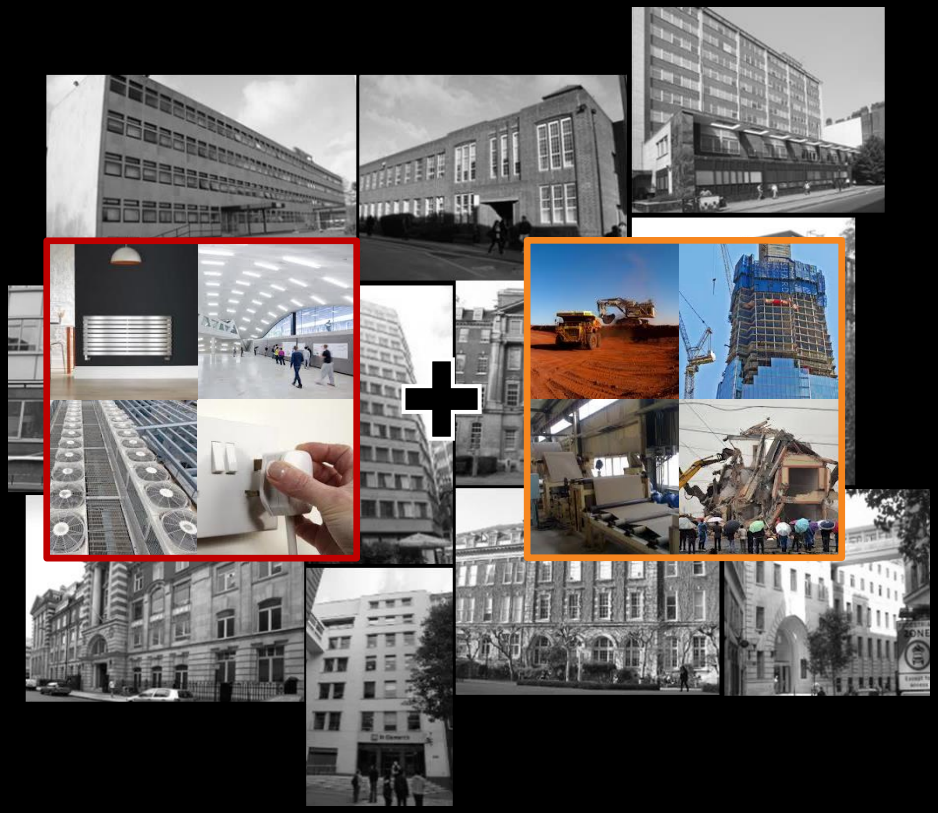
Context

EngD: Life cycle carbon impact of higher education building redevelopment (2015)

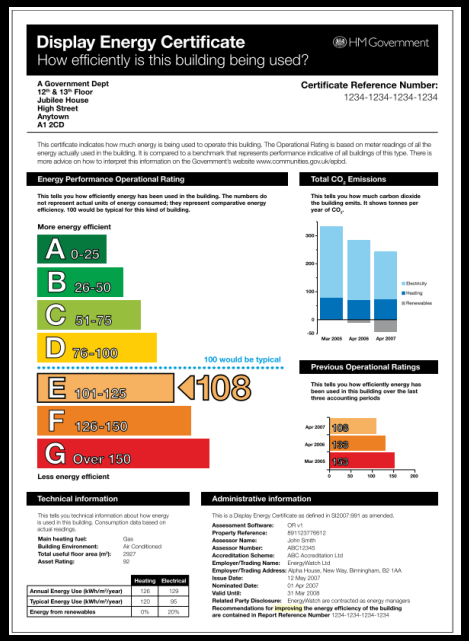


Feilden Clegg Bradley Studios

UCL Engineering Doctorate
Virtual Environments Imaging & Visualisation

EPSRC
Engineering and Physical Sciences Research Council

HE buildings database (1,951)



Display Energy Certificate
How efficiently is this building being used?

HM Government

A Government Dept
12th & 13th Floor
Jubilee House
High Street
Anytown
A1 2CD

Certificate Reference Number:
1234-1234-1234-1234

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. 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 on the Government's website www.communities.gov.uk/epbd.

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.

More energy efficient

A 0-25
B 26-50
C 51-75
D 76-100
100 would be typical
E 101-125 ◀108
F 126-150
G Over 150

Less energy efficient

Total CO_2 Emissions

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

Mar 2005 Apr 2006 Apr 2007
Electricity
Heating
Renewables

Previous Operational Ratings

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

Apr 2007 108
Apr 2006 123
Mar 2005 129

Technical information

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

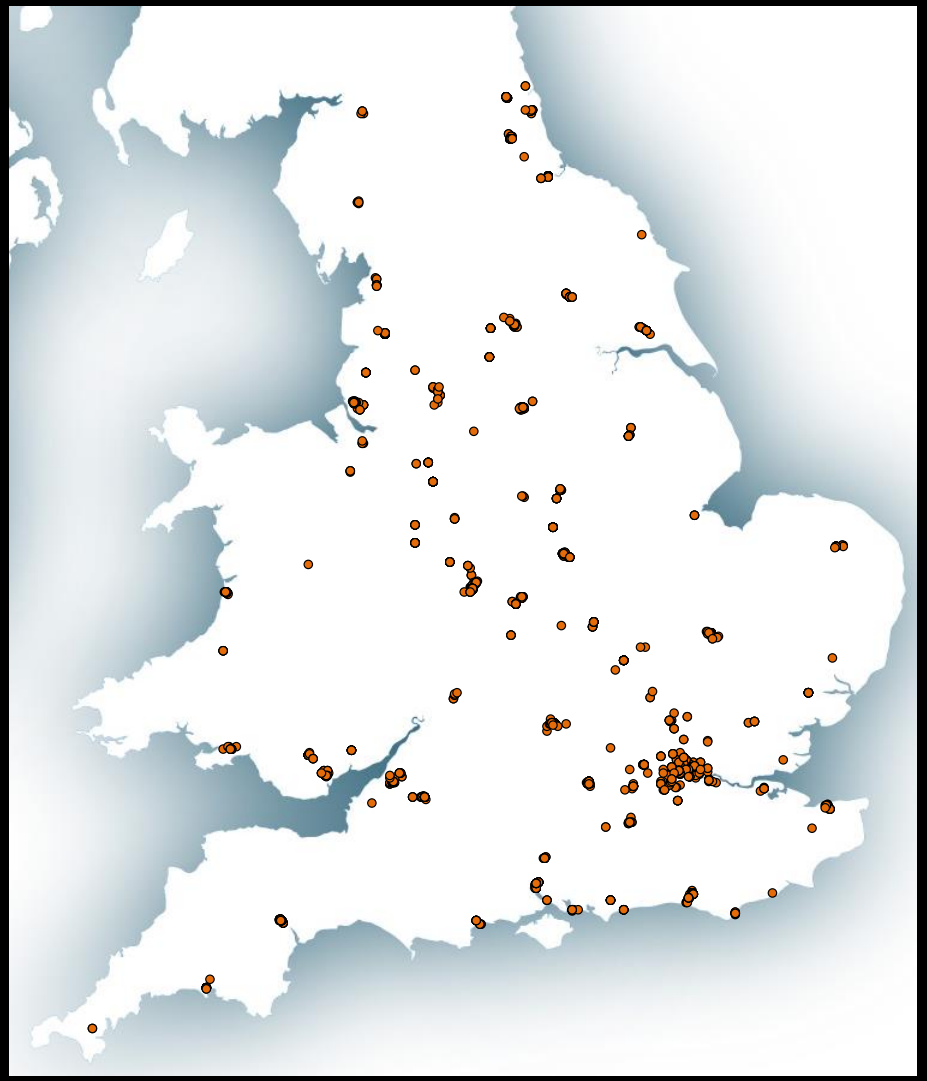
Main heating fuel: Gas
Building Environment: Air Conditioned
Total useful floor area (m²): 2927
Asset Rating: 92

	Heating	Electrical
Annual Energy Use (kWh/m²/year)	126	129
Typical Energy Use (kWh/m²/year)	120	95
Energy from renewables	0%	20%

Administrative information

This is a Display Energy Certificate as defined in SI2007 991 as amended.

Assessment Software: OR v1
Property Reference: 89112377961
Assessor Name: John Smith
Assessor Number: ABC12345
Accreditation Scheme: ABC Accreditation Ltd
Employer/Trading Name: EnergyWatch Ltd
Employer/Trading Address: Alpha House, New Way, Birmingham, B2 1AA
Issue Date: 12 May 2007
Nominated Date: 01 Apr 2007
Valid Until: 31 Mar 2008
Related Party Disclosure: EnergyWatch are contracted as energy managers
Recommendations for improving the energy efficiency of the building are contained in Report Reference Number 1234-1234-1234-1234



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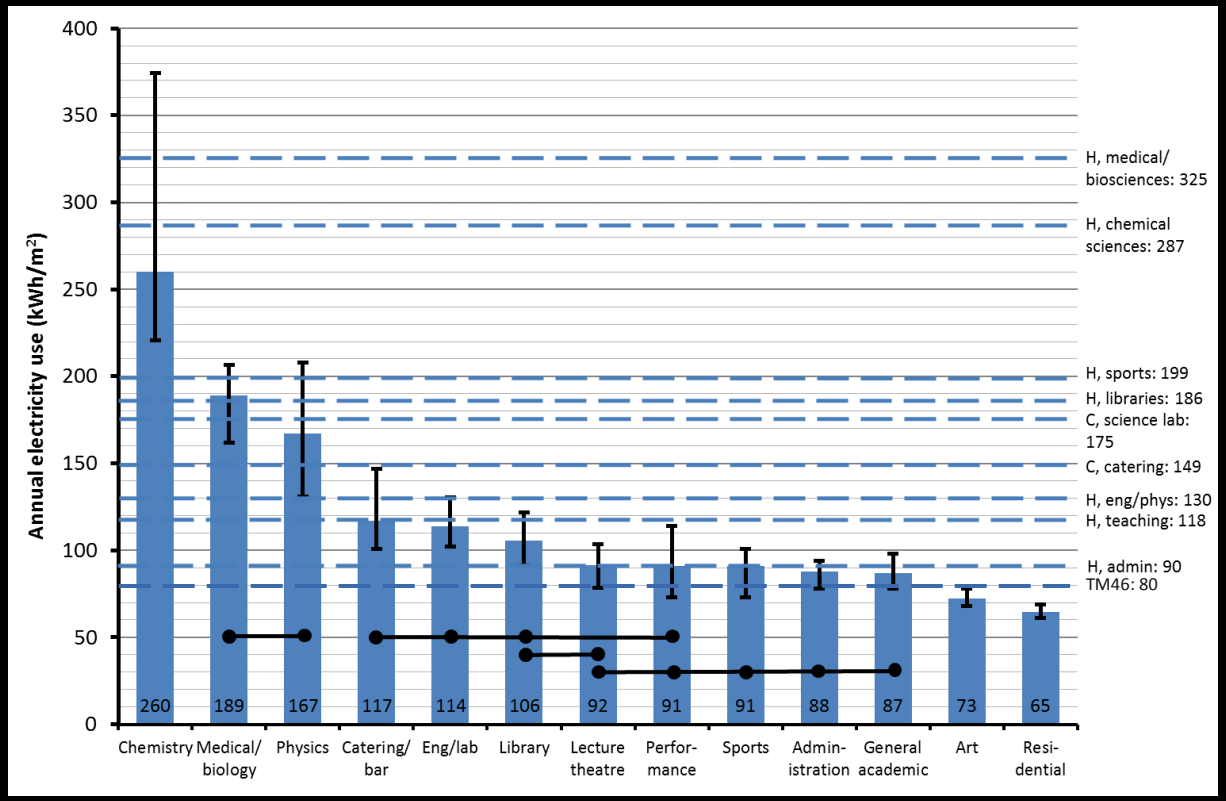
Electricity use by activity



Median values with 95% confidence intervals. Benchmarks: H = HEEPI; C = CIBSE Guide F; TM46 = CIBSE TM46 "University campus"

Horizontal bars link statistically similar classes

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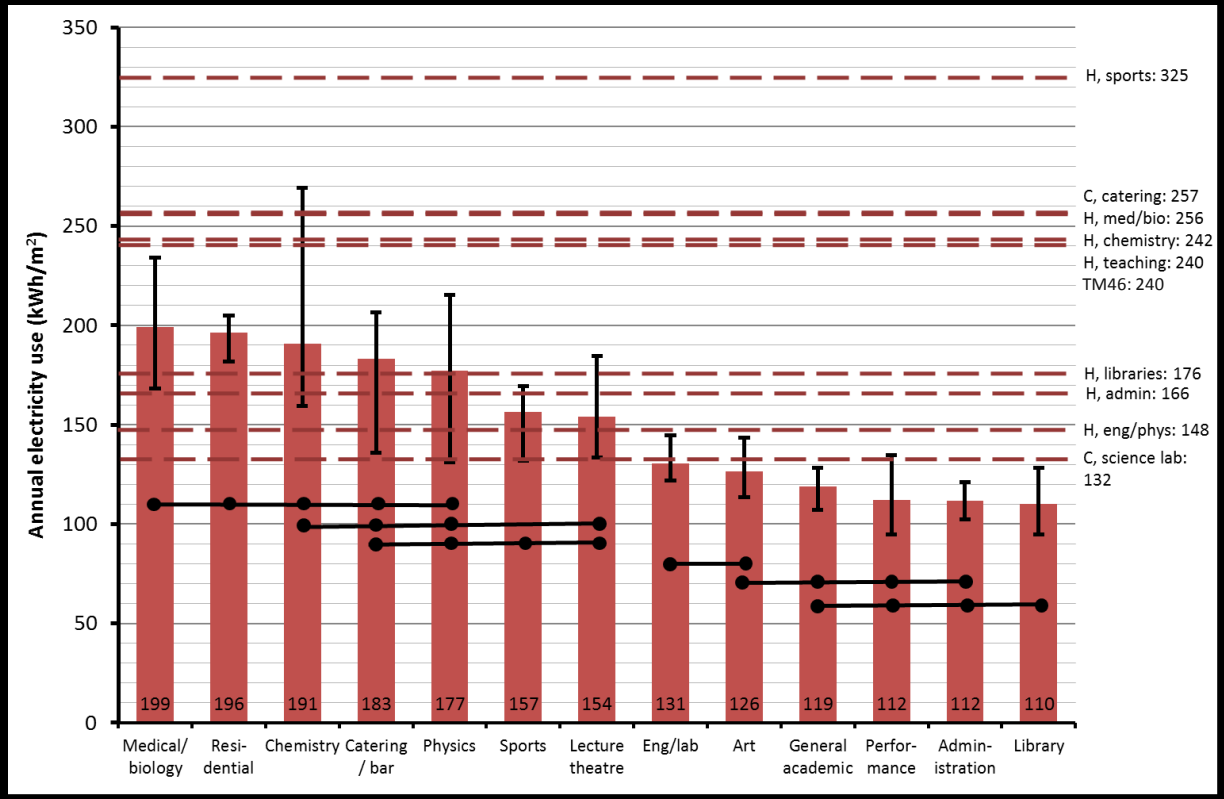
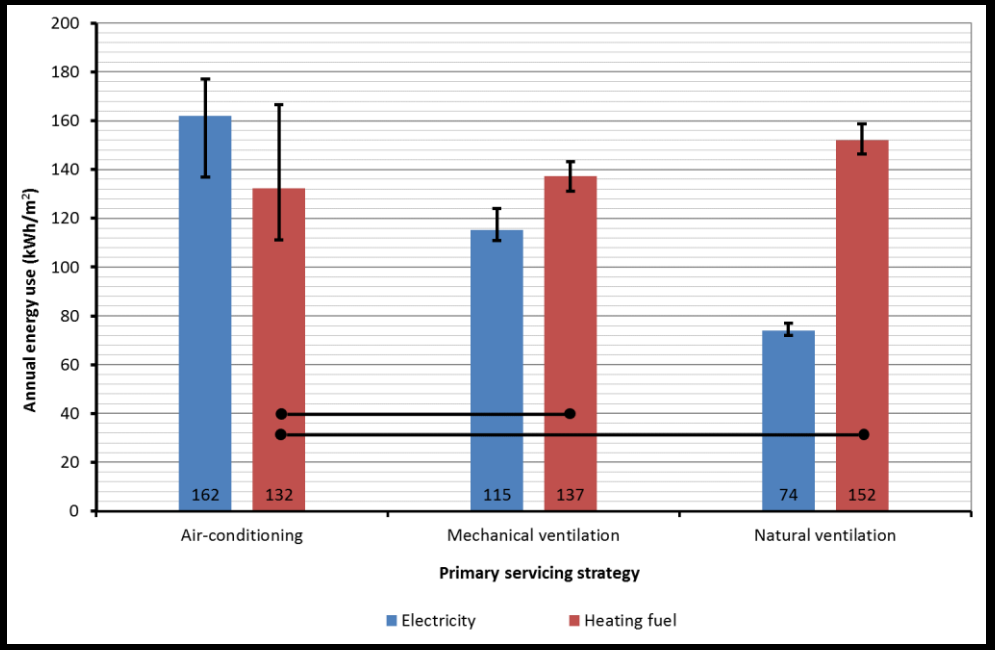
Heating fuel use by activity



Median values with 95% confidence intervals. Benchmarks: H = HEEPI; C = CIBSE Guide F; TM46 = CIBSE TM46 "University campus"

Horizontal bars link statistically similar classes

Energy by servicing strategy



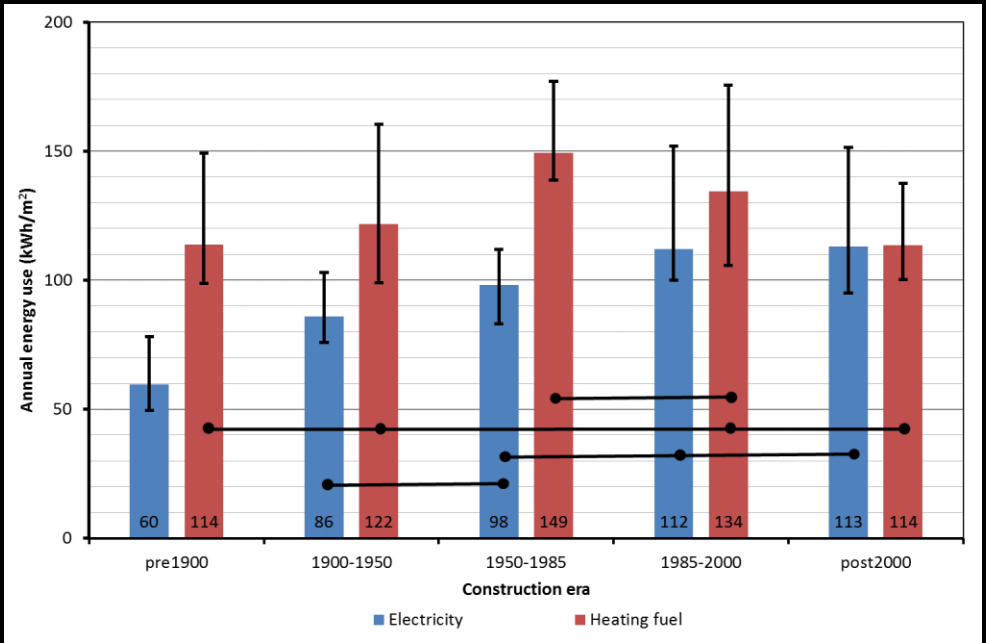
Median values with 95% confidence intervals

Horizontal bars link statistically similar classes

	Mech vent/AC higher	Nat vent higher
Electricity	- Art - General academic - Engineering - Performance - Med./biology - Admin. - Libraries - Sports	
Heating fuel	- Med/biology	- Residential - Physics

By activity (statistically significant differences only)

Energy by construction era



Median values with 95% confidence intervals

Horizontal bars link statistically similar classes

	Pre-1985 higher	Post-1985 higher
Electricity		- Physics - Admin - Lecture theatres
Heating fuel	- Residential - General academic - Engineering - Performance - Libraries	- Catering/bar

By activity (statistically significant differences only)

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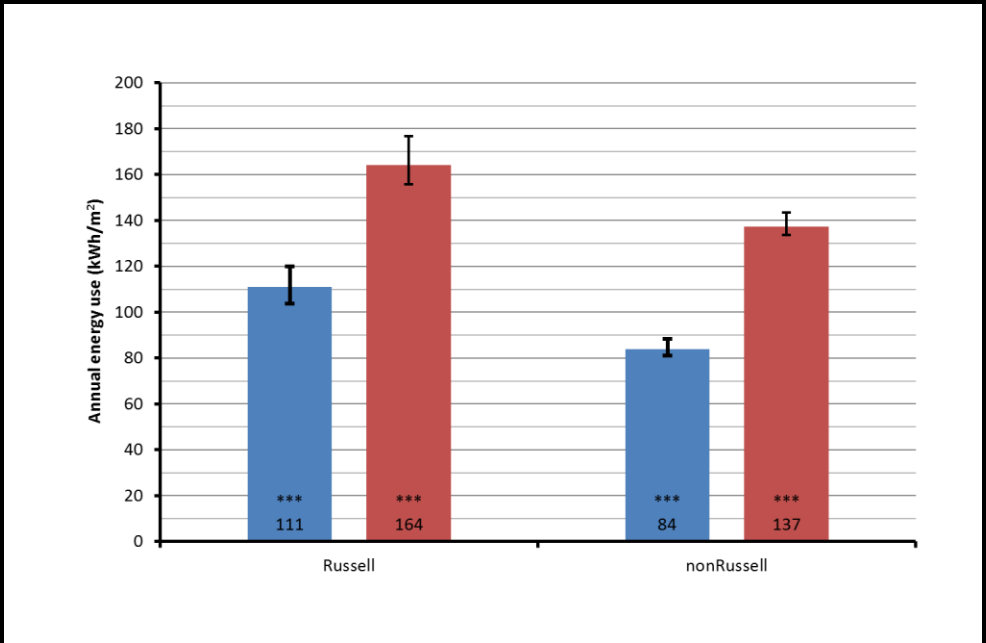
Energy by Russell Group



Median values with 95% confidence intervals

Horizontal bars link statistically similar classes

	Russell higher	Non-Russell higher
Electricity	- Residential - Art - General academic - Engineering - Med./biology - Physics	
Heating fuel	- Residential - Engineering - Med./biology	- Admin

By activity (statistically significant differences only)

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Carbon reduction targets

Total % reduction in carbon emissions by target (all buildings in database)

Activity type	Target: Poor to Typical	Targets: Poor to Typical + Typical to Good practice
ALL	29%	33%
Academic – general	29%	32%
Academic - engineering	32%	35%
Academic – science/lab	33%	37%
Non-academic	31%	33%
Residential	19%	23%

Poor: above median energy use by activity

Typical: median energy use by activity

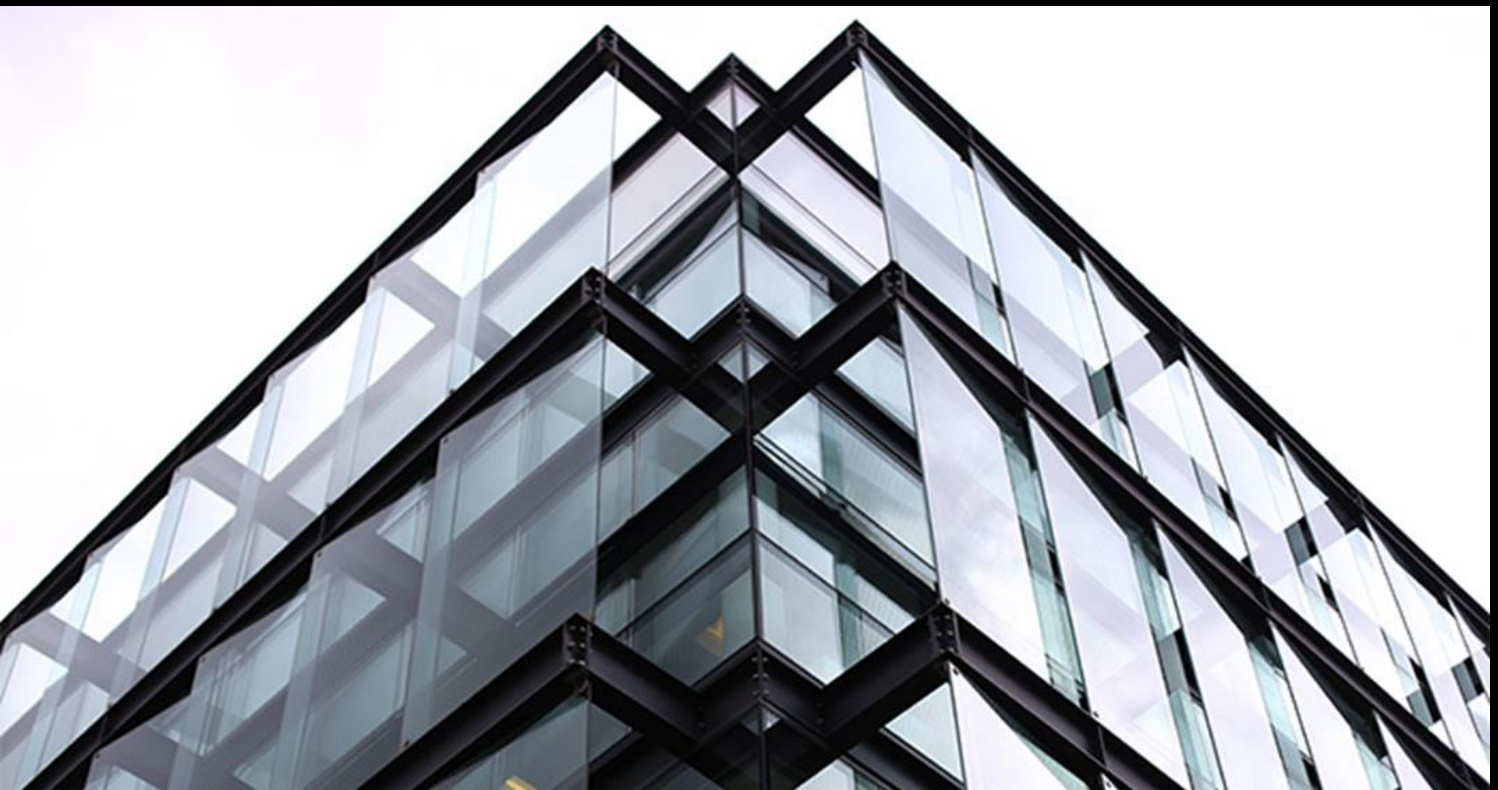
Good practice: lower quartile energy use by activity

Benchmarking the Energy Performance of Non-Domestic Buildings

Dr Sung-Min Hong

CIBSE Research Associate in Energy Benchmarking

University College London



Aims and objectives

- **Revisions** of energy benchmarks in CIBSE Guide F and TM46
  - *Annual cross-sectional and longitudinal analyses of DECs*
- Dynamic and context driven benchmarking system
  - **Develop** dynamic benchmarking methods to provide more meaningful feedback
  - **Establish** generic templates for collecting and managing relevant data
- **Support** policy making and energy management

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Department for Education

Ministry of Justice

GREATER LONDON AUTHORITY

Mayor of London Business Energy Challenge

Julie's Bicycle
SUSTAINING CREATIVITY

Department of Health

UCL

Department for Communities and Local Government

BETTER BUILDINGS PARTNERSHIP

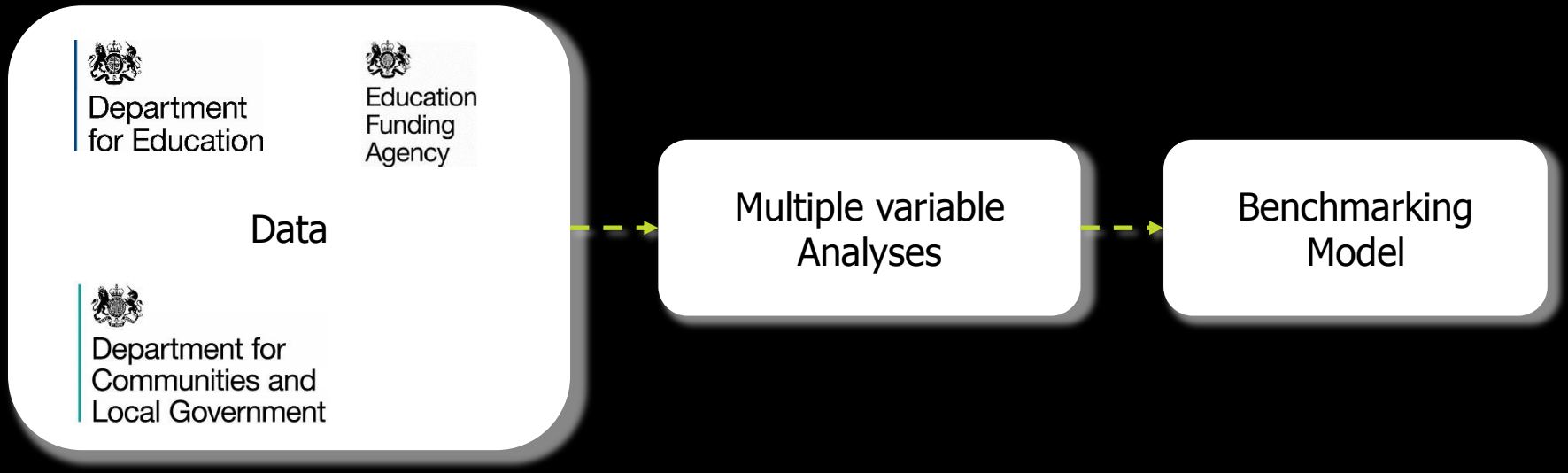
Challenges for benchmarking HE buildings

- Existing benchmarks **out-of-date**
- **Classification** of buildings requires revision
- **Diversity** of activities and building characteristics specific to HE sector **not** taken into account
- Feedback from benchmarking can be **limited**

Contextualised benchmarking approach

Activity type + Weather + Occupancy + ?

A schools example



Energy and intrinsic building characteristics

Identify key determinants of energy use

Calculate contextualised benchmarks

Benchmarking model

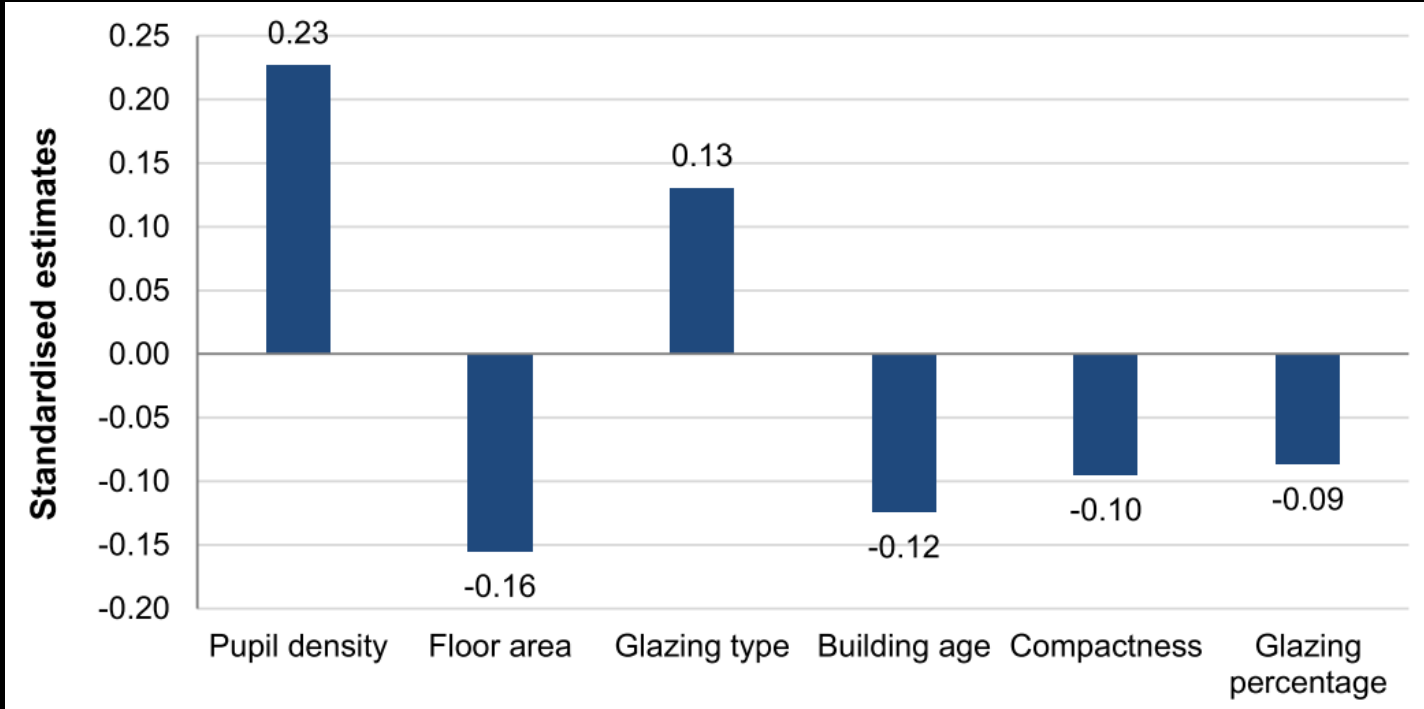
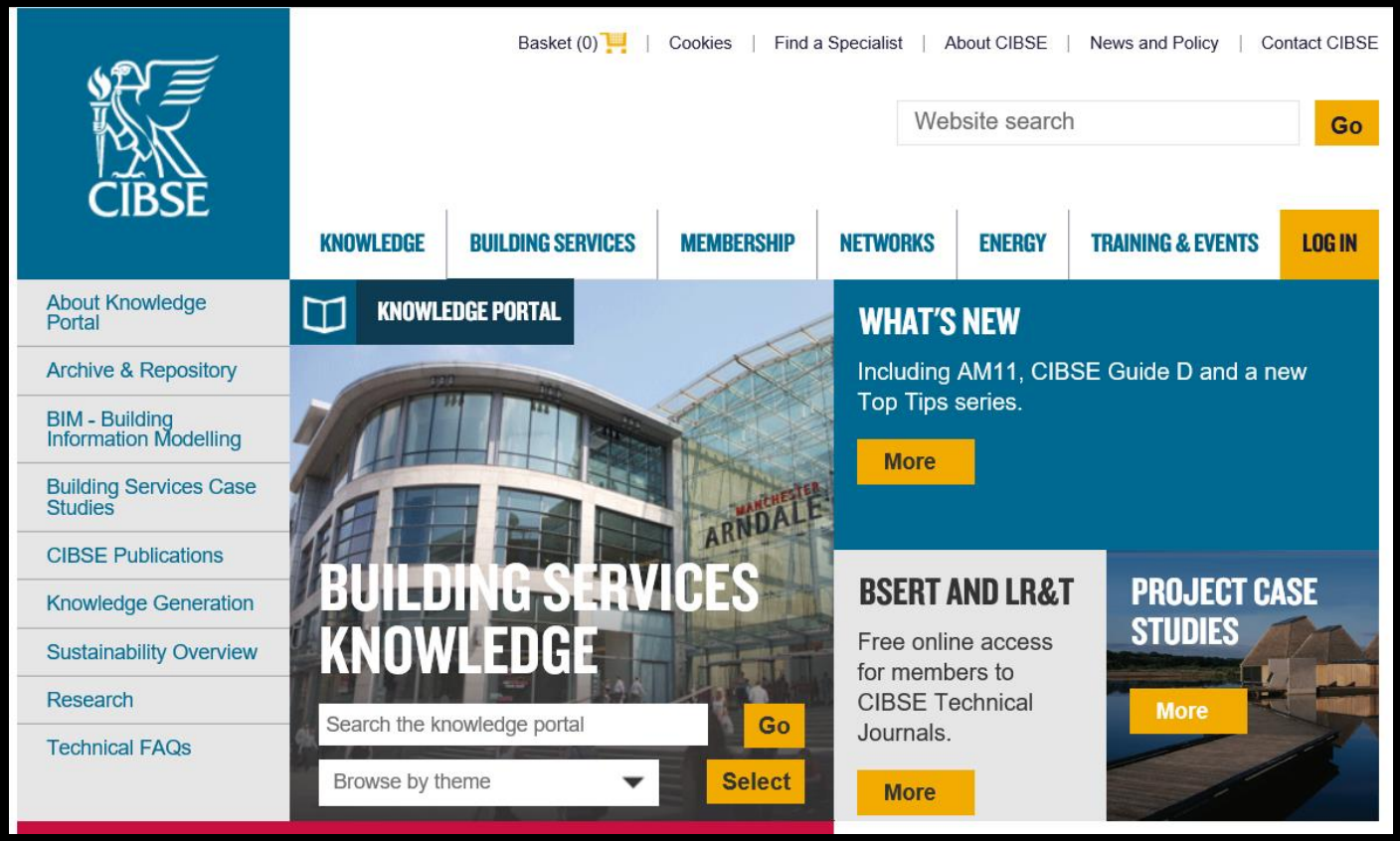


Figure 7.16 Standardised regression coefficients from the final multiple linear regression model for electrical EUI of primary schools

Benchmarking platform

Robust, dynamic, and transparent



Opportunities

- **Existing** knowledge on higher education buildings
- More and more **empirical data** becoming available across the sector
- Possibilities of developing a **sector specific** benchmarking method and a platform
- **Dedicated** resources available at UCL
- **All data** to be **stored** and **managed** by UCL

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Case studies

Law school, late 1950s
Lecture theatres, seminar rooms, offices
GFA: 5,000m^2

Chemistry building, 1968
Teaching/research laboratories, IT clusters
GFA: 12,551m^2

Medical school, 1907
Teaching/research laboratories
GFA: 8,462m^2

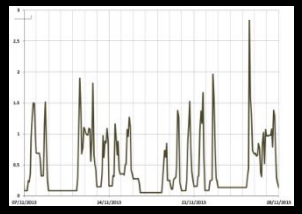
Administration building, 1960
Academic/administrative office,
teaching/seminar spaces
GFA: 13,903m^2

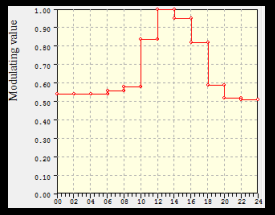
Art and design building, 1962
Studios, workshops, galleries
GFA: 14,578m^2

Data collection

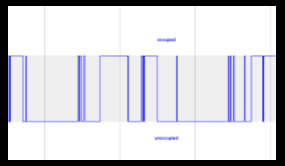
Energy simulation profiles

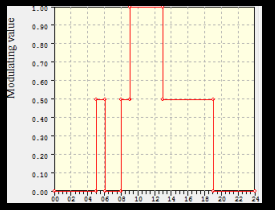
Electricity (small power/ lighting)



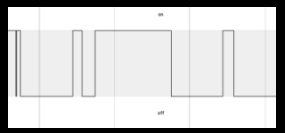


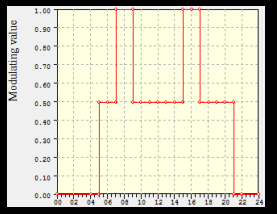
Occupancy



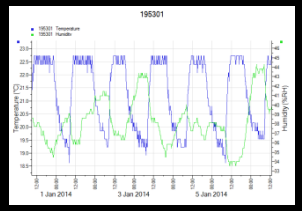


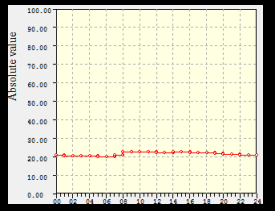
Lighting





Temperature





Building meter data and bills for energy use calibration (heating fuel simulated as gas)

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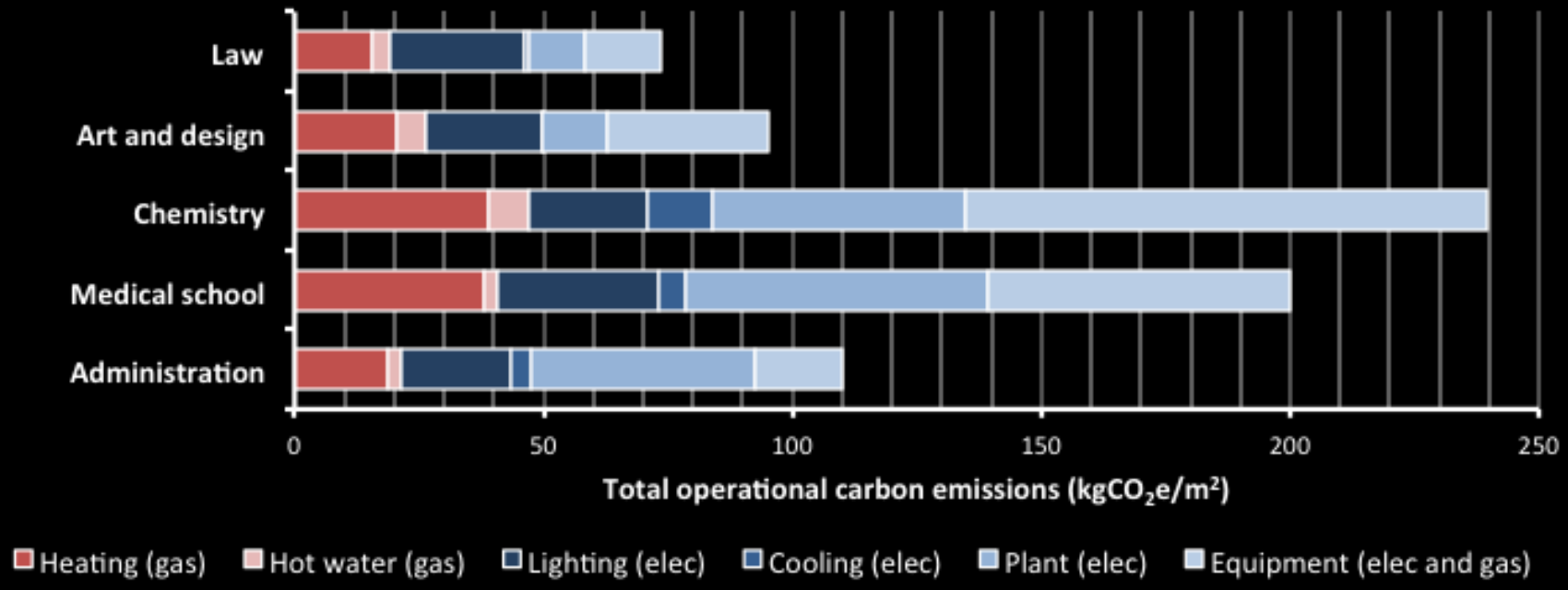
Baselines

Annual carbon emissions



Baselines

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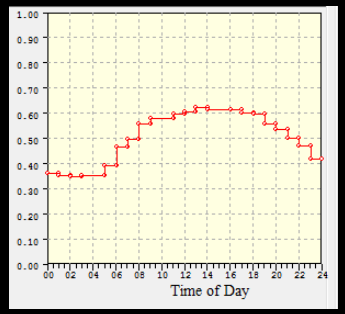
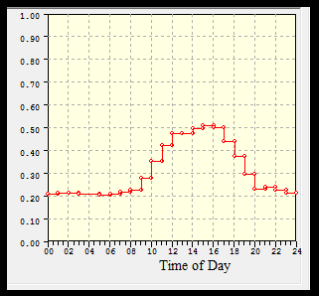
Circulation lighting, weekdays, peak 16W/m²



Office equipment, weekdays, peak 11W/m²

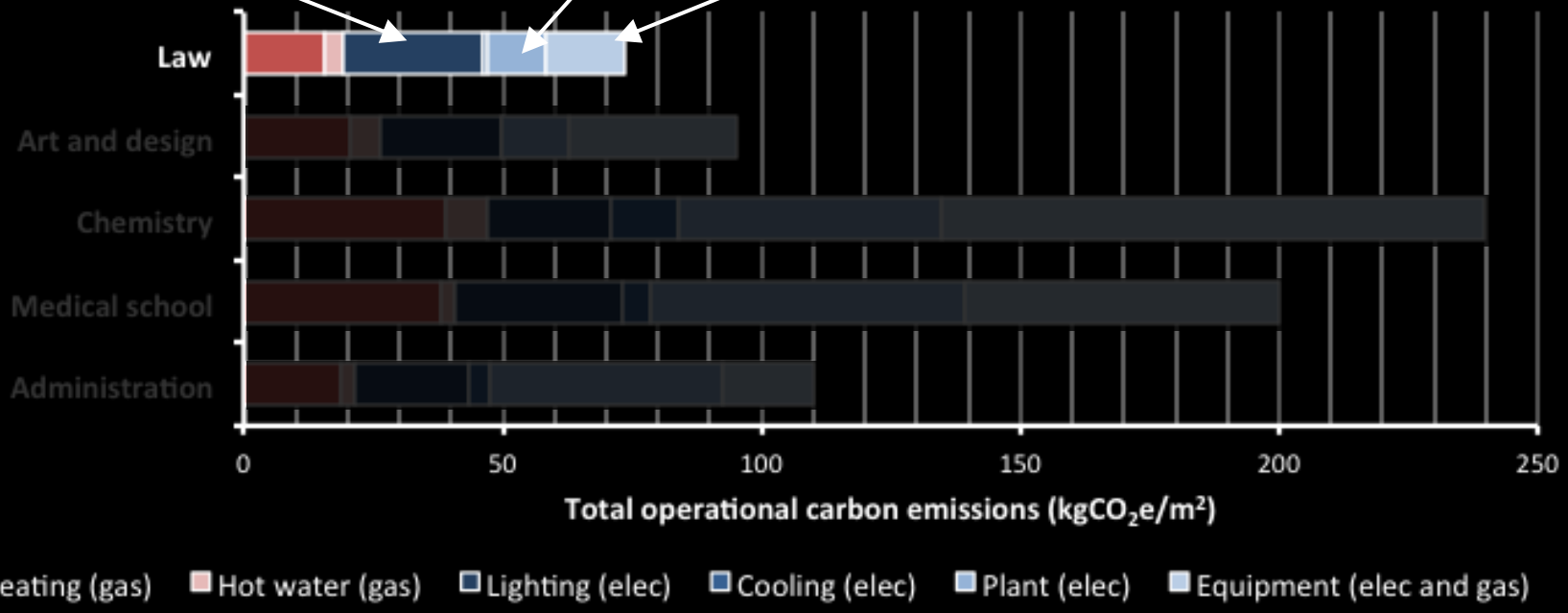


Large lighting component: high overnight use

Small plant/cooling components: mostly naturally-ventilated

Office equipment, low out-of-hours use

Annual carbon emissions



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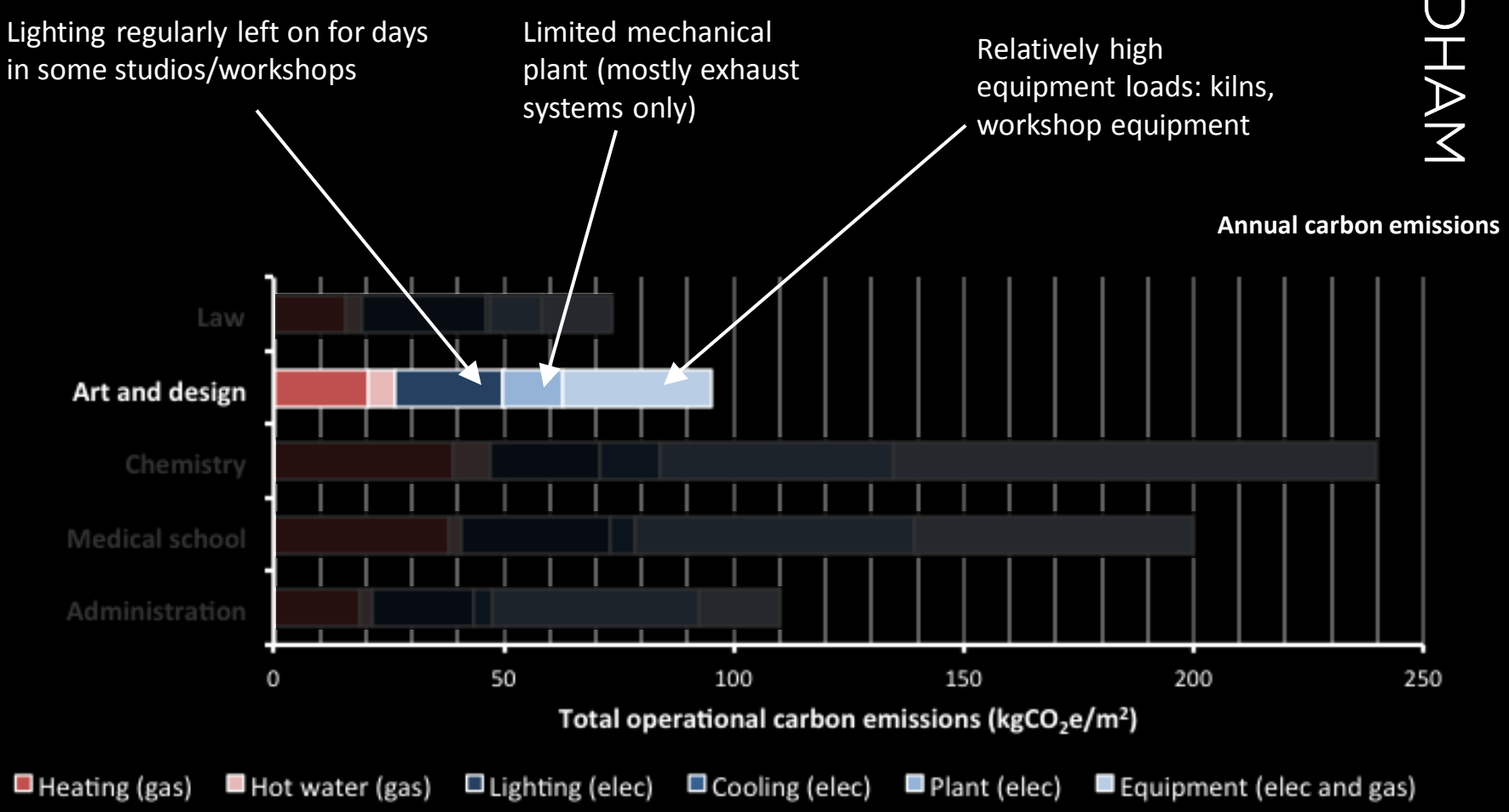
Baselines



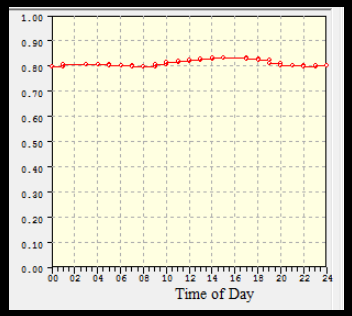
Baselines

Appreciable equipment/ space cooling loads

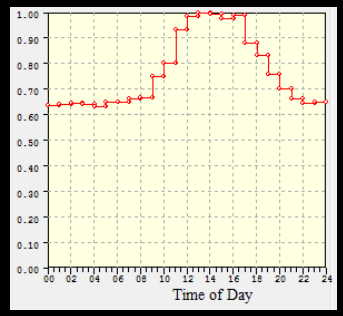
High fan powers / 24-7 operation

High ventilation-related heating loads

High power / 24-7 operation equipment; overnight lab equipment use; servers and IT equipment

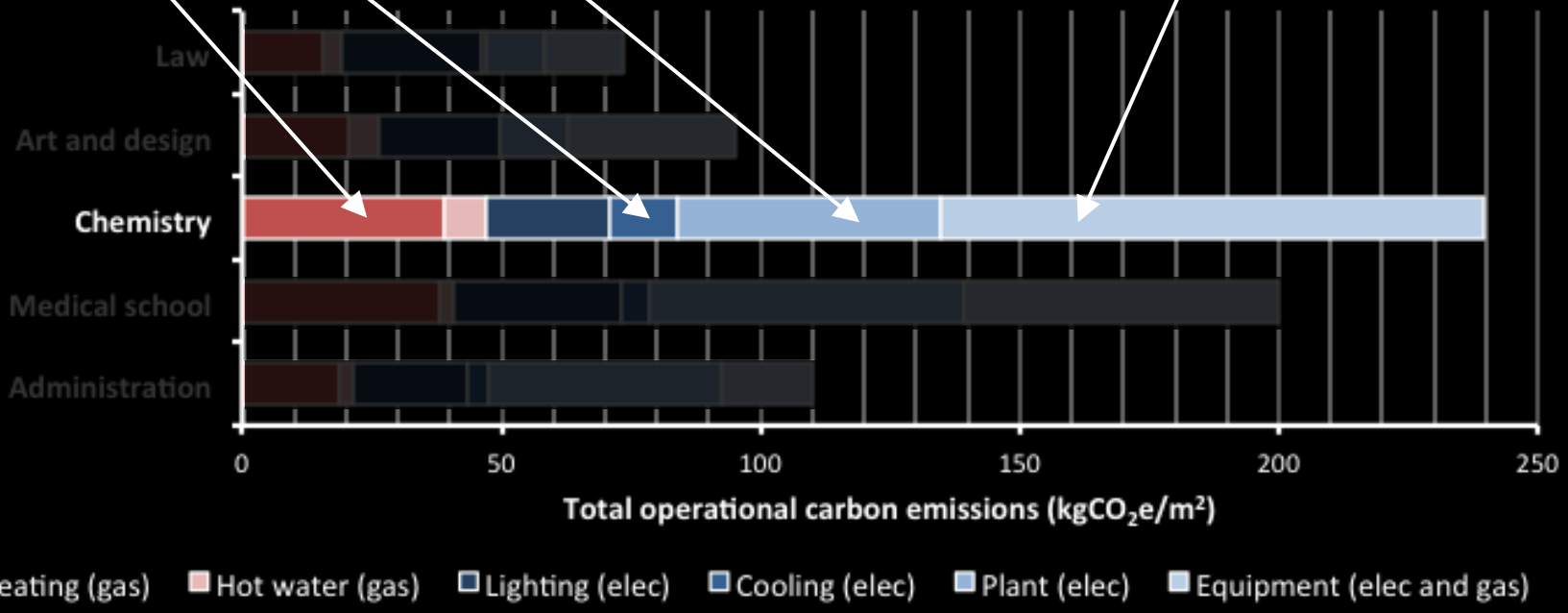


Research lab ventilation



Research lab equipment, weekdays, peak 21W/m²

Annual carbon emissions

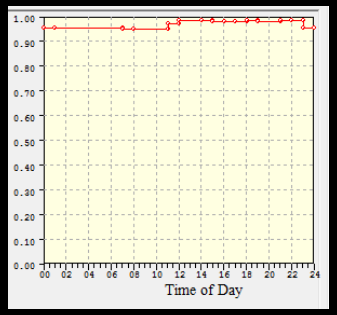


Baselines

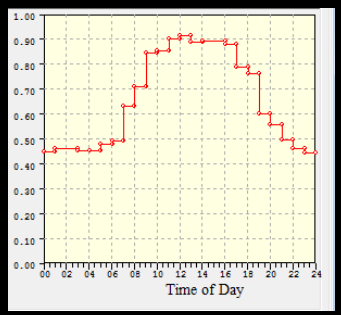
Appreciable lighting contribution: continuous use in some areas

High ventilation-related heating loads

High fan powers / 24-7 operation



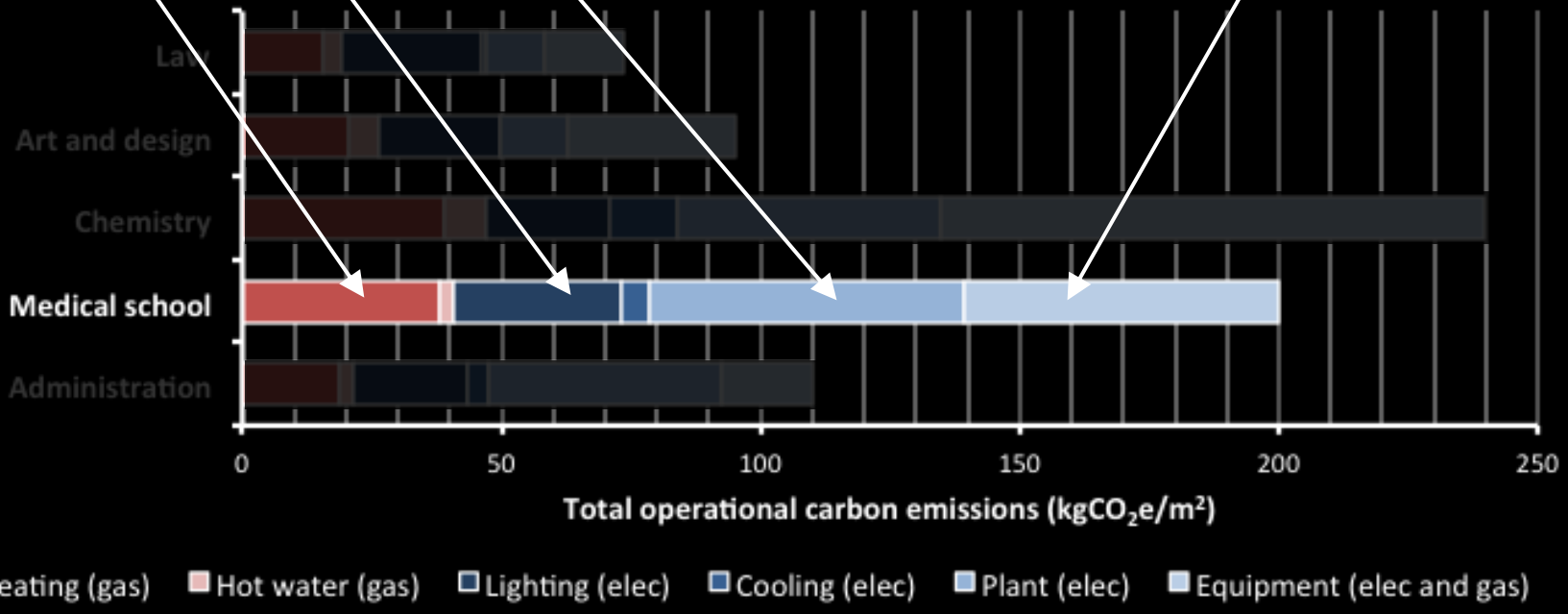
Research lab ventilation



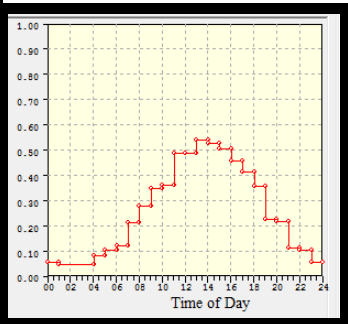
Research lab equipment, weekdays, peak 53W/m²

Lab equipment with overnight use; refrigeration; IT equipment

Annual carbon emissions



Baselines

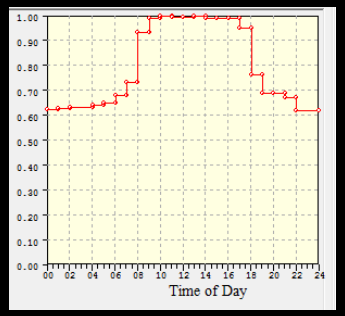


Academic office lighting, weekdays, peak 12W/m²

Lighting load relatively low: PIR-control in cellular offices

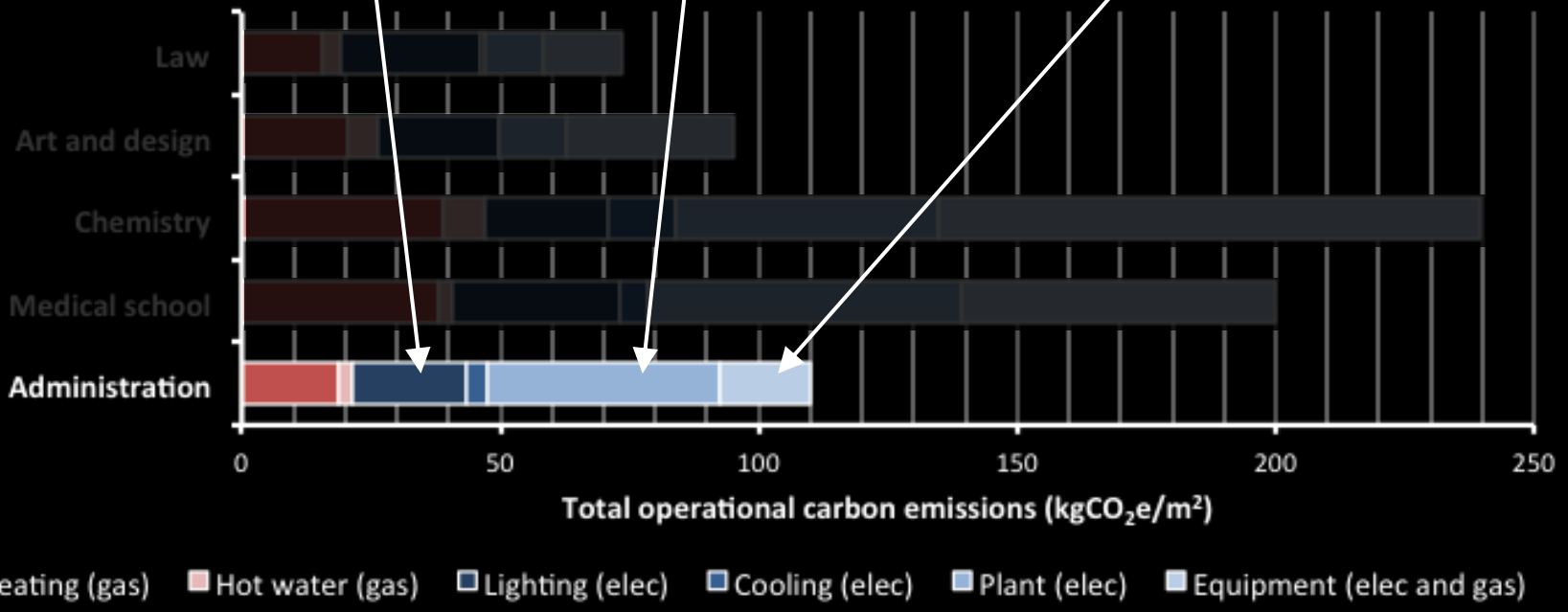
High ventilation component: used throughout

Office ventilation



Office equipment use, relatively low

Annual carbon emissions



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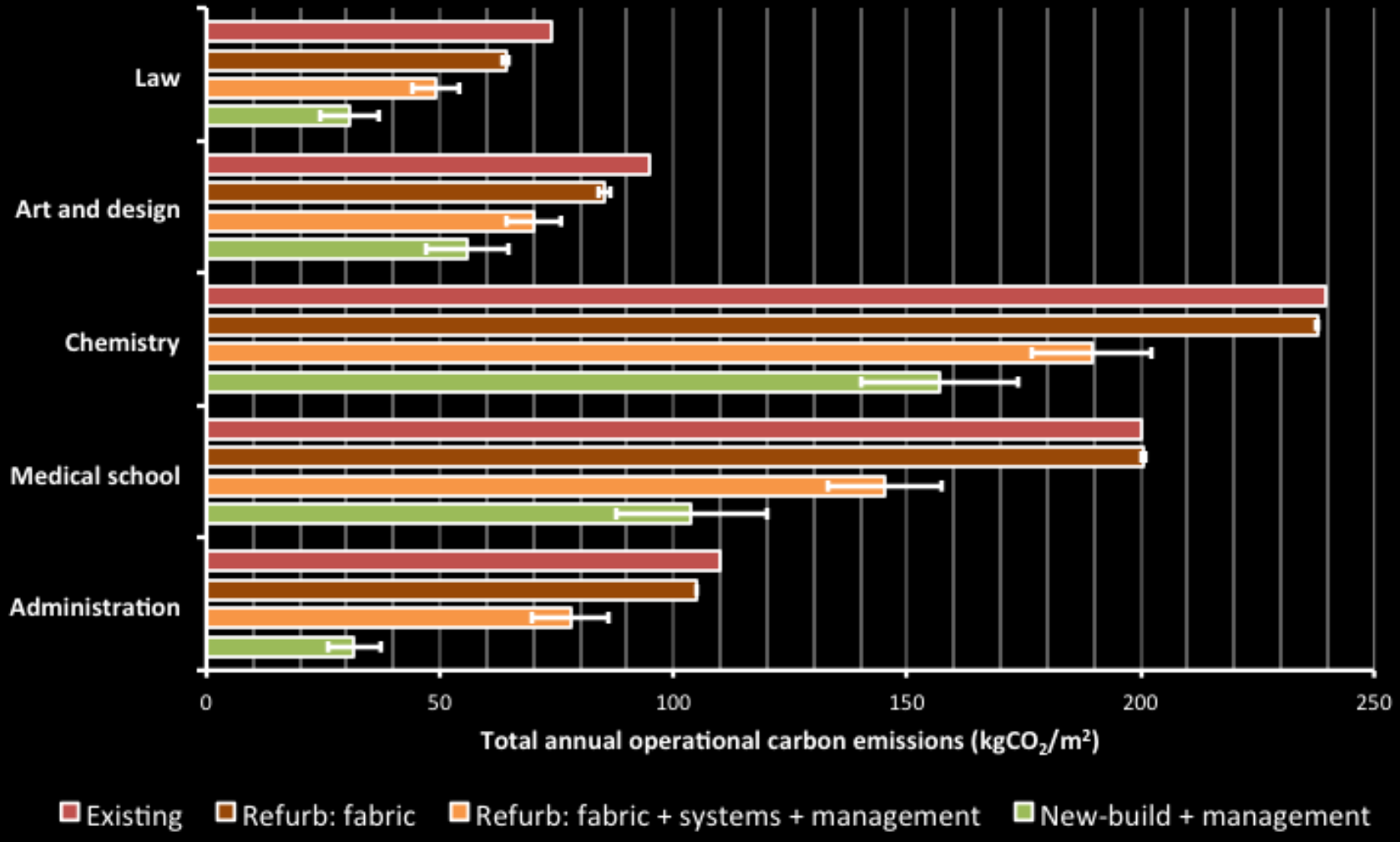
Redevelopment scenarios



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Summary

Evaluate existing carbon performance: related to activity, servicing, age etc.

Set targets to suit existing performance and aspirations

Assess baseline end uses: desktop methods, monitoring

Identify reduction opportunities

Risk factors: low-intensity buildings – fabric, lighting; high-intensity – building systems, equipment


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