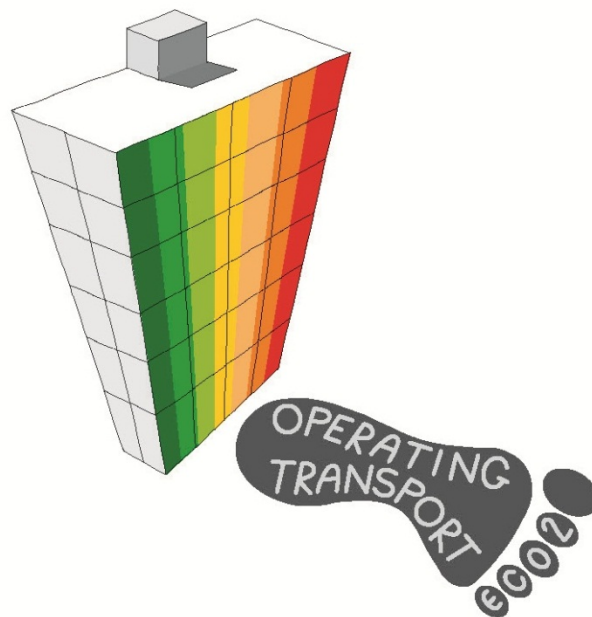


WHAT COLOUR *is* YOUR BUILDING?

Measuring and reducing the energy
and carbon footprint of buildings

David H. Clark



Appendix M Building X and Hotel Y

www.whatcolourisyourbuilding.com

Appendix M: Building X and Hotel Y

Nothing's more dangerous than a heckler with statistics.

Rich Hall, American comedian, writer and musician.

Contents

This appendix provides energy data for the hypothetical office (Building X) and hotel (Hotel Y) buildings used in Chapter 7 (Renewable energy).

- M1. Introduction
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- M4. Summary

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M1. INTRODUCTION

Two hypothetical buildings, both located in London, are used in Chapter 7 as guinea pigs to test and illustrate potential carbon savings from renewable energy systems:

- Building X is a generic air conditioned commercial office building.
- Hotel Y is a typical hotel (without a swimming pool).

The buildings have the same floor area, are both 10 storeys tall, and obtain their energy from grid electricity and natural gas. While this book is primarily concerned with the carbon footprint of office buildings, it was necessary to introduce a building type with a higher demand for heating to allow the contribution of heating-based renewable energy systems to be put into perspective. There are many buildings which perform better than Building X and Hotel Y, and there are many that are significantly worse. Every real building is unique by virtue of its location, construction, equipment, maintenance, control and the people inside.

Table M.1 shows the emission factors and tariffs used in the cost comparison of systems.

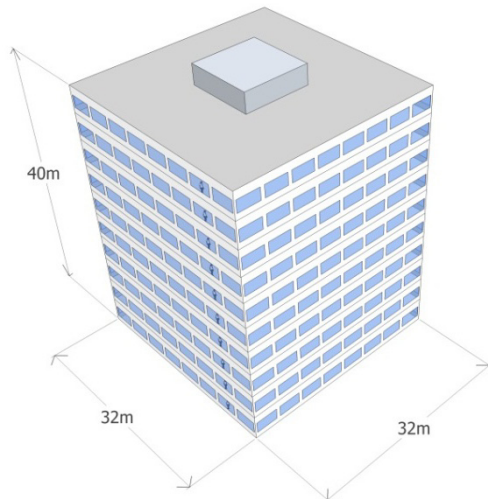
	CO ₂ e emissions (kgCO ₂ e / kWh)	Primary energy (kWh _{primary} / kWh)	Energy cost (£ / kWh)
Electricity	0.6	2.7	£0.10
Gas	0.2	1.1	£0.035

Table M.1 CO₂e emission factors and energy tariffs

M2. BUILDING X

M2.1 Overview

Building X is a generic air conditioned commercial office building located in central London. Figure M.1 shows the layout and occupancy.



Gross Internal Area (GIA):	10,000 m ²
Net Lettable Area (NLA):	8,000 m ²
Treated Floor Area (TFA):	9,000 m ²
No. of floors:	10
Floor to floor height:	4 m
No. of occupants:	665
Occupancy density:	1 per 12 m ² NLA

Fig M.1 Layout & occupancy of Building X

M2.2 Annual energy consumption

The typical energy consumption of office buildings in the UK was discussed in Chapter 2 and a benchmark of 100 kgCO₂e/m² was proposed. The energy breakdown for Building X is summarised in Table M.2 and Figure M.2. It is not a great building, but it is certainly not the worst performing building on the planet either, so it will suffice as being representative of a ‘typical’ city centre office building in the UK.

Use	Energy consumption (kWh/m ² GIA)	CO ₂ e emissions (kgCO ₂ e/m ² GIA)	Energy Costs (£/m ² GIA)
Lighting	35	21	
Equipment	50	30	
Fans, pumps and controls	40	24	
Cooling	20	12	
Lifts	5	3	
Total electricity	150	90	£15.00
Heating	70	14	
Domestic hot water	5	1	
Total gas	75	15	£2.63
TOTAL	225	105	£17.63

Table M.2 Energy breakdown for Building X

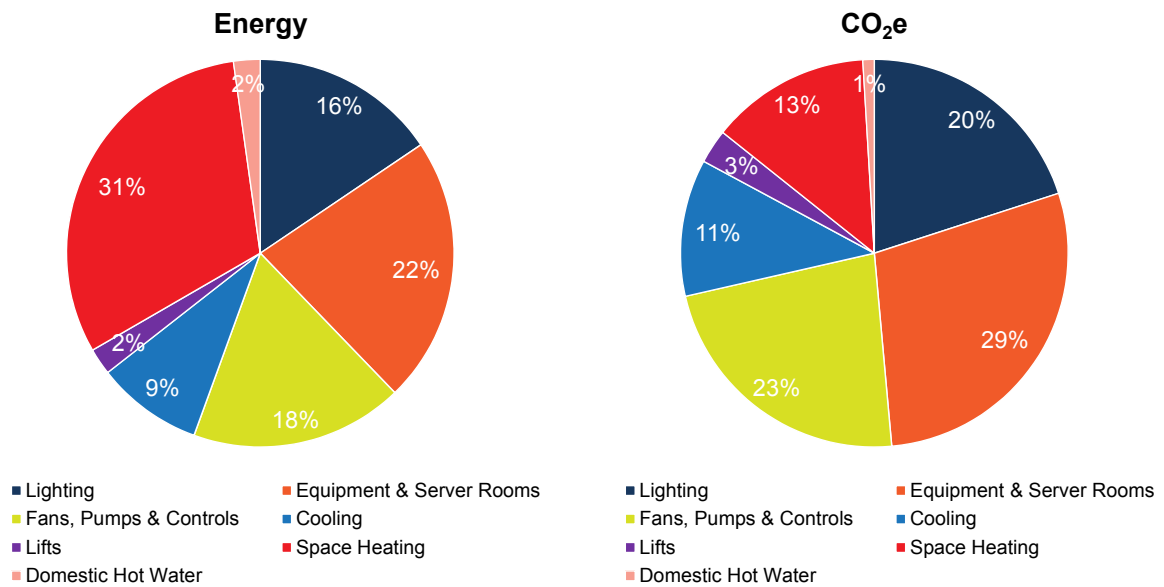


Fig M.2 Energy and carbon breakdown by end use in Building X

M2.3 Landlord and tenant energy split

Building X has a conventional landlord/tenant arrangement – the base building services (air conditioning, lifts, domestic hot water and common area light and power) are provided by the landlord. The building is multi-tenanted and each tenants’ energy consumption from light and small power (including any package cooling to the server rooms) is separately metered by floor. The landlord’s common areas (foyer, lift lobby, stairs and so on) account for around 5% of the building’s total light and power consumption. The metered energy split for the building is shown in Table M.3.

Metered energy supply	Energy consumption (kWh/m ² GIA)	CO ₂ e emissions (kgCO ₂ e/m ² GIA)
Landlord - electricity	70	42
Landlord - gas	75	15
Tenants - electricity	80	48
Total	225	105

Table M.3 Landlord – Tenant energy split in Building X

M2.4 Seasonal energy profiles

Heating and cooling energy consumption varies seasonally while most of the other items do not vary significantly throughout the year. Lighting could be a little higher in winter than summer, but only if the lights are switched off around the perimeter during daylight hours – in Building X this doesn’t happen much.

The seasonal heating gas energy consumption for Building X is shown in Table M.4.

	Annual	Spring	Summer	Autumn	Winter
	kWh/m ²				
Heating profile	100%	24%	0%	20%	56%
Gas for heating	70	17	0	14	39

Table M.4 Seasonal heating gas energy consumption for Building X

The gas boiler providing the heating and domestic hot water has an energy efficiency of 90%. The heat energy requirement in kWh_{heat}/m² is shown in Table M.5 and is used when comparing alternatives to gas boilers to provide heat.

	Annual	Spring	Summer	Autumn	Winter
	kWh _{heat} /m ²				
Heating	63.0	15.1	0.0	12.6	35.3
Domestic hot water	4.5	1.1	1.1	1.1	1.1
Total	67.5	16.2	1.1	13.7	36.4

Table M.5 Annual and seasonal heat energy breakdown for space heating and DHW in Building X

The cooling energy profile will be the opposite to the heating, although its variation is less pronounced – refer to Table M.6. A lot of the cooling energy is used to remove the constant heat gains due to equipment, people and lighting inside the building all year round. It is not unusual for cooling to be required for internal zones in the winter while heating is being provided around the perimeter due to heat losses through the facade.

	Annual	Spring	Summer	Autumn	Winter
	kWh/m ²				
Cooling profile	100%	20%	50%	20%	10%
Electricity for cooling	20	4	10	4	2

Table M.6 Annual and seasonal electricity breakdown for cooling in Building X

Figure M.3 shows the energy consumption in Building X by season.

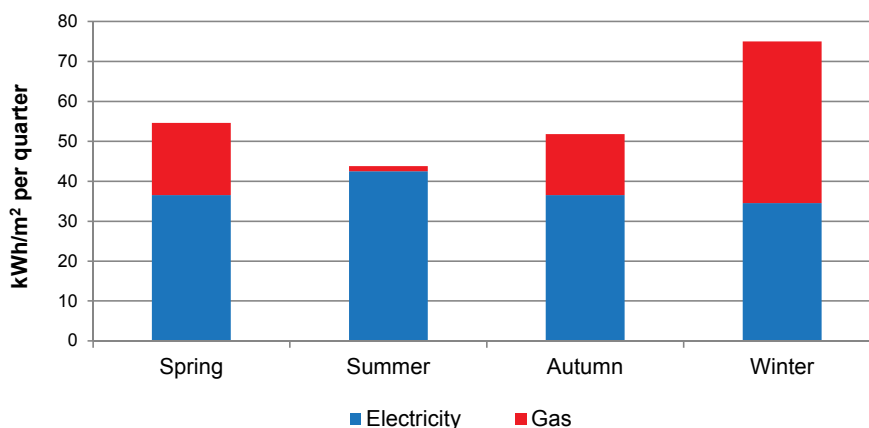
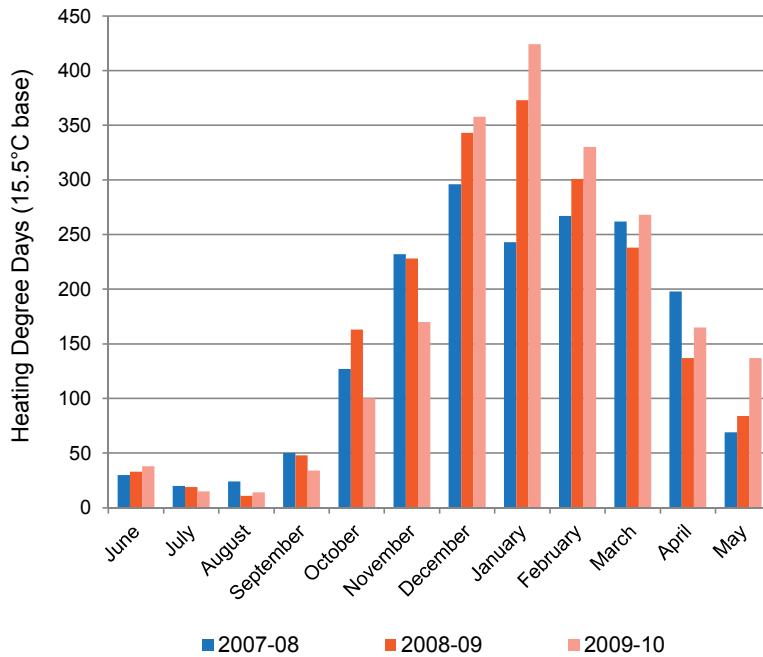


Fig M.3 Seasonal energy consumption summary for Building X

IS THE ASSUMED SEASONAL HEATING PROFILE REASONABLE?

To test whether Table M.5 is reasonable, the monthly Heating Degree Days (HDD) for London between June 2007 and May 2010 are shown in Figure M.4.¹ The table summarises the HDDs by season over the three years. This correlates reasonably well with the profiles in Table M.5.



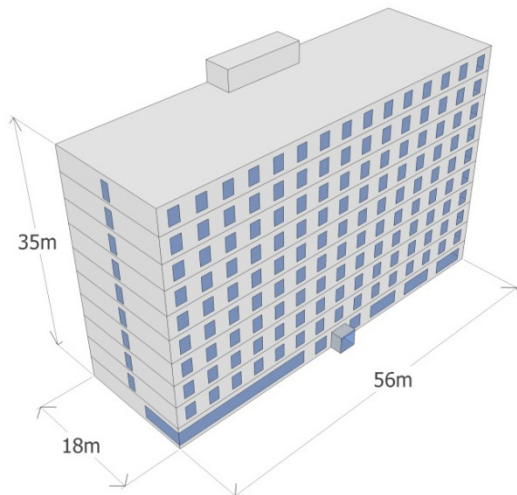
	Total	Spring	Summer	Autumn	Winter
2007/08	1818	529	74	409	806
2008/09	1978	459	63	439	1017
2009/10	2053	570	67	304	1112
Average	1950	519	68	384	978
		27%	3%	20%	50%
Building X split		24%	0%	20%	56%

Fig M.4 Heating degree days in London (2007 to 2010)

M3. HOTEL Y

M3.1 Overview

Building Y is a 4 star air conditioned hotel building located in central London. Fig M.5 shows the key features of the building. The hotel does not have a swimming pool.



Gross Internal Area (GIA): 10,000 m²
 No. of floors: 10
 No. of bedrooms: 175

Fig M.5 Layout & occupancy of Hotel Y

M3.2 Annual energy consumption

The energy breakdown for Hotel Y is summarised in Table M.7 and Figure M.6. This excludes energy consumption due to catering. The CO₂e emissions are, by a happy coincidence, made possible by using hypothetical buildings, exactly the same as for Building X.

Use	Energy consumption (kWh/m ² GIA)	CO ₂ e emissions (kgCO ₂ e/m ² GIA)	Energy costs (£/m ² GIA)
Lighting	30	18	
Equipment	20	12	
Fans, pumps and controls	20	12	
Cooling	20	12	
Lifts	10	6	
Total electricity	100	60	£10.00
Heating	150	30	
Domestic hot water	75	15	
Total gas	225	45	£7.88
TOTAL	325	105	£17.88

Table M.7 Energy breakdown for Hotel Y

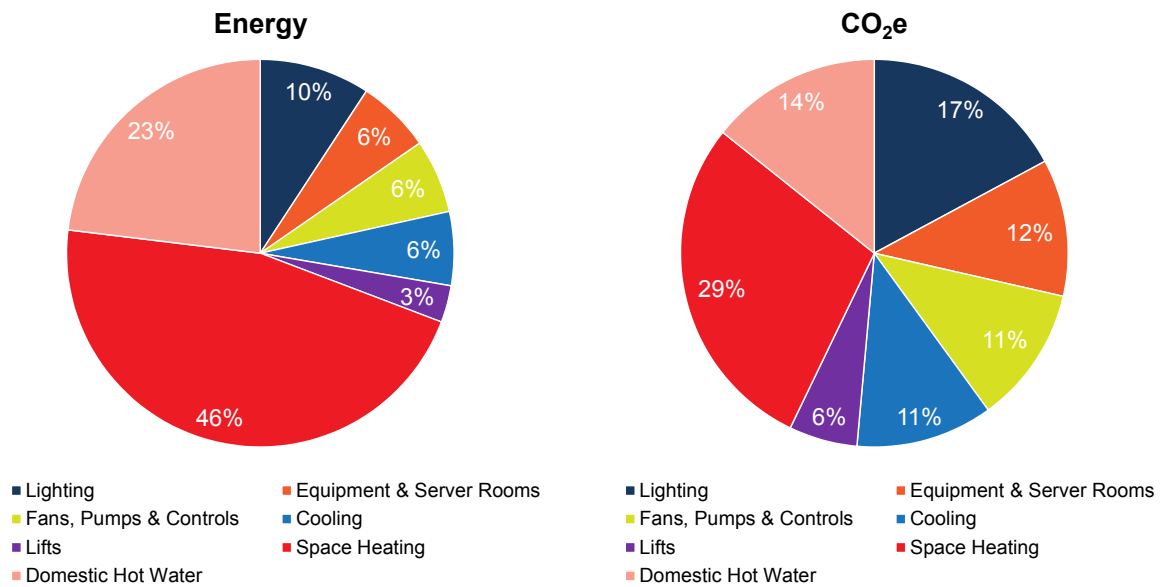


Fig M.6 Energy and carbon breakdown by end use in Hotel Y

The energy consumption benchmarks from *ECON 036: Energy Efficiency in Hotels - A Guide for Owners and Managers* for good performance of a luxury hotel are 150 to 300 kWh/m² for gas and 50 to 90 kWh/m² for electricity (without air conditioning). These are summarised in Appendix C. The electricity benchmark increases by about 50% for air conditioned hotels to between 75 and 135 kWh/m². Hotel Y’s gas and electricity consumption sits roughly midway in each range.

M3.3 Seasonal Energy Profiles

The seasonal space heating gas energy consumption for Hotel Y is shown in Table M.8.

	Annual	Spring	Summer	Autumn	Winter
	kWh/m ²				
Heating profile	100%	20%	0%	20%	60%
Gas for heating	150	30	0	30	90

Table M.8 Seasonal heating gas energy consumption for Hotel Y

The gas boiler providing the heating and domestic hot water has an energy efficiency of 90%. The heat energy requirement in kWh_{heat}/m² is shown in Table M.9 and is used when comparing alternatives to gas boilers to provide heat.

	Annual	Spring	Summer	Autumn	Winter
	kWh _{heat} /m ²				
Heating	135.0	27.0	0.0	27.0	81.0
Domestic hot water	67.5	16.9	16.9	16.9	16.9
Total	202.5	43.9	16.9	43.9	97.9

Table M.9 Annual and seasonal heat energy breakdown for space heating and DHW in Hotel Y

The cooling energy profile is shown in Table M.10.

	Annual	Spring	Summer	Autumn	Winter
	kWh/m ²				
Cooling profile	100%	20%	60%	20%	0%
Electricity for cooling	20	4	12	4	0

Table M.10 Annual and seasonal electricity breakdown for cooling in Hotel Y

Figure M.7 shows the energy consumption in Hotel Y by season.

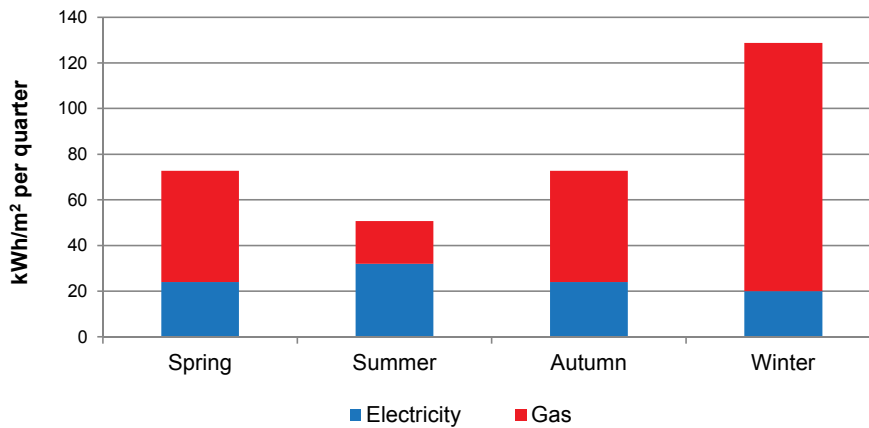


Fig M.7 Seasonal energy consumption summary for Hotel Y

M4. Summary

Figure M.8 shows the annual energy consumption and Figure M.9 shows the annual CO₂e emissions of the two buildings.

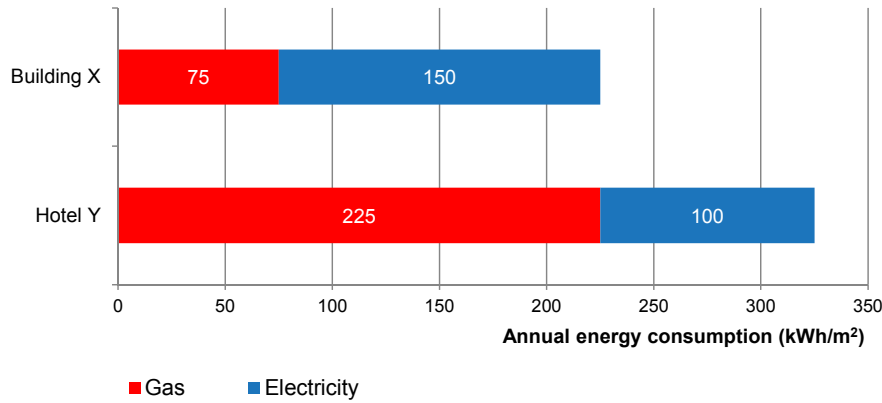


Fig M.8 Annual energy consumption for Building X and Hotel Y

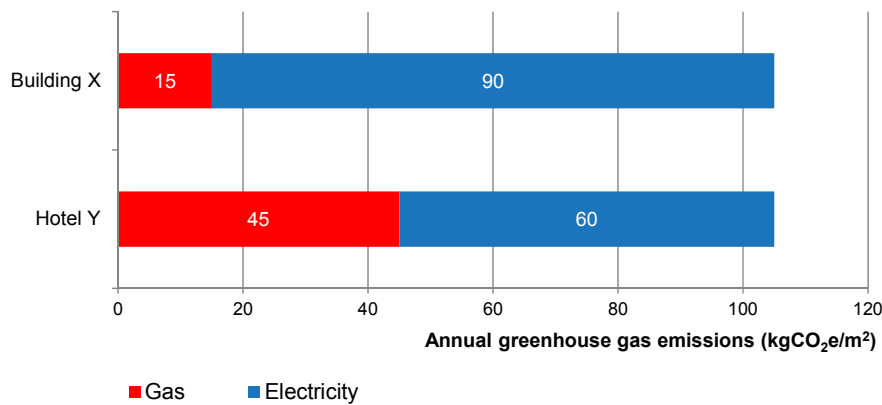


Fig M.9 Annual CO₂e emissions for Building X and Hotel Y

The performances of Building X and Hotel Y (using various energy ratings) are shown in Table M.11. For further details on the rating tools, refer to Appendix C. In the UK the hotel would be considered reasonably efficient (almost a C rating), while in the US (in Seattle) it is better than average, but not an ‘Energy Star.’

	DEC	NABERS Whole Building	Energy Star	Primary energy (kWh/m²)
Building X	F (score = 129)	3 stars	86 (an ‘Energy Star’)	488
Hotel Y	D (score = 76)	3 stars	65	518

Table M.11 Indicative energy ratings for Building X and Hotel Y

Notes

All websites were accessed on 6 November 2012 unless noted otherwise. Information papers referenced are available to download from www.wholecarbonfootprint.com.

1. Heating Degree Days taken from www.degree-days.net (using temperature data from www.wunderground.com) for Heathrow Airport, United Kingdom (0.45W,51.48N). The Celsius-based heating degree days are for a base temperature of 15.5C. For further explanation of degree days, refer to [Information Paper 16 – Heating degree days](#).