Information paper – 9

Design energy rating data

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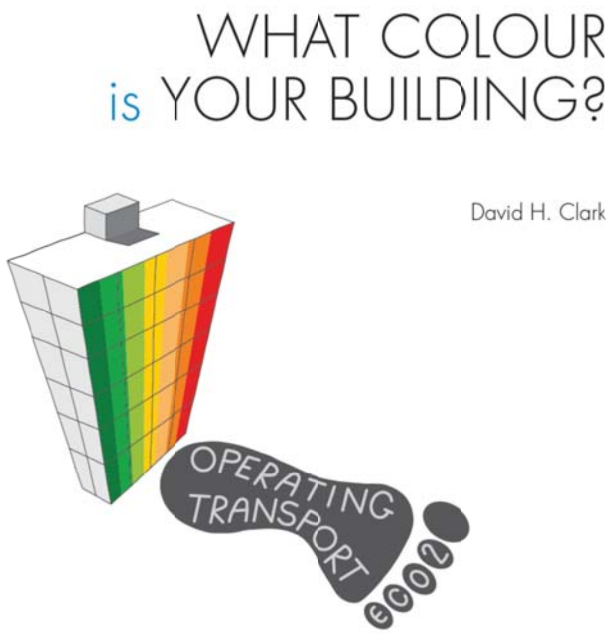
A paper referenced in the book:



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This information paper is one of a series of papers written during the preparation of the book **What Colour is Your Building?** (www.whatcolourisyourbuilding.com). The papers do not form part of the book and have not been peer reviewed. They provide further technical detail, analysis and information to support statements made in the book. All of the papers can be downloaded from www.wholecarbonfootprint.com.

Design energy rating data

This information paper provides data to illustrate the difference between design energy ratings and modelling, and actual energy consumption – the 'performance gap.'

1. DESIGN ENERGY RATINGS AND BUILDING REGULATIONS

Many building regulations, such as the UK's Part L 2010 and the Building Code of Australia, compare the design of a building against a reference building. The reference building is based on the same geometry as the building design and establishes an energy benchmark that the design has to match or improve on.

In the UK, energy modelling of buildings is typically limited to calculating the 'regulated' energy performance only. Details of the building geometry, fabric and (most of) the building services are entered into the software and two values are calculated: the Target Emission Rate (TER) of a notional (reference) building and the Building Emission Rate (BER) of the designed building. If the BER is less than the TER then the building passes the energy efficiency criteria in the Building Regulations. The same energy model is used to calculate the Energy Performance Certificate (EPC) and the BREEAM energy points, although different formula are used by each.

Under Part L 2010 regulations, the TER for a typical office building would be around 25 $kgCO_2/m^2$. This is orders of magnitude less than the actual performance of most office buildings. Even the greenest buildings in Figure 2.8 in Chapter 2 of the book have 40 $kgCO_2e/m^2$. Some key reasons for the differences (the 'performance gap') include:

- Unregulated energy consuming items such as servers, computers, printers, appliances, lifts, external lighting and car park ventilation are not included in the model.
- The models are based on quality (efficiency) and not quantity. For example, lighting is based on the efficiency of the fitting not how many are installed, so you can provide twice as many light fittings as you actually need without affecting the score – but they will have twice the energy consumption in reality.
- The hours of operation may be longer than the fixed assumptions in the model.
- Building controls do not operate as perfectly as the software assumes.
- Systems may not be performing to their optimum (factory) efficiency due to maintenance and management practices.
- The behaviour of people in buildings are not taken into consideration.

The TER is often the value quoted in case studies of buildings, but rarely has any correlation with actual performance. It is unfortunate that the EPC rating scale (based on theory) and DEC rating scale (based on reality) look almost identical, which invariably leads to confusion in the property industry.

2. PART L VERSUS OPERATIONAL ENERGY BENCHMARKS

The ECON 19 energy breakdowns in Fig 6.1 in Chapter 6 of the book are based on data in Table C.2 in Appendix C for Type 3 air conditioned office with humidification excluded.[1] The fan energy benchmarks are taken from Table 4 in ECON 19, and the pump/control benchmarks are split 50% to cooling and 50% to heating. Small power is based on combining the office equipment, catering and computer room benchmarks.

The Part L 2010 Target Emission Rate (TER) breakdown is based on a typical10,000m^2 new air conditioned office building in London, modelled in SBEM v4.1d. The same building modelled in TAS and IES software gives slightly different results for the TER, and even bigger differences for the Building Emission Rate (BER) – depending on which software is used the building either passes by 10% or fails by 5%. This further highlights the problems with using modelling as a reliable method of benchmarking building performance in real buildings.

Table 1 shows the ECON 19 and Part L data used to produce Figure 6.1 in Chapter 6. The Part L values are much lower than operational best practice benchmarks, particularly for heating.

	ECON 19 - typical			ECON 19 - best practice			Part L 2010 (TER)		
	kWh/m^2	kgCO_2e/m^2		kWh/m^2	kgCO_2e/m^2		kWh/m^2	kgCO_2e/m^2	
Lighting	49	30	*20%*	24	15	*18%*	16	10	*36%*
Equipment - small power	50	30	*21%*	38	23	*28%*	-	-	-
Equipment - other	7	4	*3%*	6	4	*5%*	-	-	-
Air (ventilation fans)	38	23	*16%*	20	12	*14%*	10	6	22%
Cooling	36	22	*15%*	16	10	*12%*	10	6	22%
Heating	168	37	*25%*	91	20	*24%*	16	6	20%
Total	**347**	**146**		**195**	**83**		**52**	**28**	

Notes on typical Part L 2010 breakdown:

1. The allowance for equipment in the National Calculation Methodology is around 35 kWh/m^2 which equates to 21 kgCO_2e/m^2 but this is excluded from the Part L 2010 compliance check and EPC rating.
2. The software is a black box and doesn't give an energy breakdown of the 16 kWh/m^2 for auxiliary uses (fans and pumps). In the table, the assumed breakdown is 10 kWh/m^2 for fans, 3 kWh/m^2 for cooling pumps and 3 kWh/m^2 for heating pumps. The pump values have been added to the cooling and heating totals.
3. The heating total is based on gas boilers for space heating (10 kWh/m^2) , electric DHW (3 kWh/m^2) and heating pumps (3 kWh/m^2).

Table 1 Typical energy breakdown for operational energy and Part L in an air conditioned office building.

3. CARBONBUZZ: DESIGN VERSUS OPERATIONAL

In 2008, the CarbonBuzz website was established by RIBA and CIBSE to collect anonymous building energy consumption data to highlight the performance gap between design figures and actual readings.[2]

The data from Carbon Buzz was accessed by the author on 2 June 2012. Since that time the website has been expanded and enhanced, and was re-launched in June 2013. The 36 office case studies listed on the site were reviewed and 12 were found not to have design data entered and seven had unreliable data (multiple entries of the same building or missing gas or electricity consumption figures). This left 17 case studies, the data for which is shown in Table 2.

ID no	Design ($kgCO_2/m^2$)	Actual ($kgCO_2/m^2$)	kWh/m^2								BREEAM
			Design elec	Design fuel	Actual elec	Actual fuel	Design elec reg	Design elec unreg	Actual elec reg	Actual elec unreg	
1	38	190.3			341	14					Excellent
2	57	182.9			292	115					Good
3	88.5	130.7	143	50.6	221	40.7					Very Good
4	35.6	114.2	45	55.7	188	55.7			65	123	Excellent
5	63.6	113.7									Excellent
6	**32.8**	**110**	**56.9**	**8**	**174.2**	**72.9**	**16.5**	**20.2**	**99.8**	**50.8**	
7	**82.9**	**107.1**	**144**	**19**	**164**	**87**	**13**	**131**	**30**	**134**	
8	**96.3**	**94.2**	**175**	**0**	**171.3**	**0**	**134**	**41**	**106.4**	**64.9**	
9	**36.1**	**93.5**	**61**	**13**	**140**	**87**	**48**		**63**	**41**	
10	**48.1**	**85.8**	**86.9**	**35.8**	**127.9**	**114.2**	**21.3**	**65.6**	**30.5**	**97.4**	**Excellent**
11	**45.3**	**75.4**	**77**	**32**	**135**	**26**	**30**		**56**	**0**	
12	42.4	73	69	23	96.7	173.7			20.7	4.4	
13	14.3	67.5	26		91	90					Very Good
14	**33**	**55**	**60**	**0**	**100**	**0**	**60**		**50**	**50**	**Very Good**
15	35.6	46.6	45	55.7	65	55.7					Excellent
16	**14.3**	**41.5**	**9**	**48**	**48.3**	**77**	**9**		**26.5**	**21.8**	
17	33.9	22.8	51	75	25.3	57.2				`	Excellent

Renewable energy contributions are: **9** (2 kWh/m^2 of SHW), **10** (12 kWh/m^2 of PV), **11** (5 kWh/m^2 of PV and 6 kWh/m^2 of SHW), **12** (70.8 kWh/m^2 of biomass + 0.3 kWh/m^2 of SHW) and **17** (11.5 kWh/m^2 of biomass).

Table 2 Design and Actual data for office buildings from Carbon Buzz website (accessed 2 Jun 2012)

Figure 2 shows the design versus actual CO_2 emissions and in all but two cases (8 and 17), design predictions (which include estimates for both regulated and unregulated) are lower than the actual measured data in office buildings. Across the 17 buildings, the design CO_2 emissions were on average of 57% of the value of the actual metered consumption.

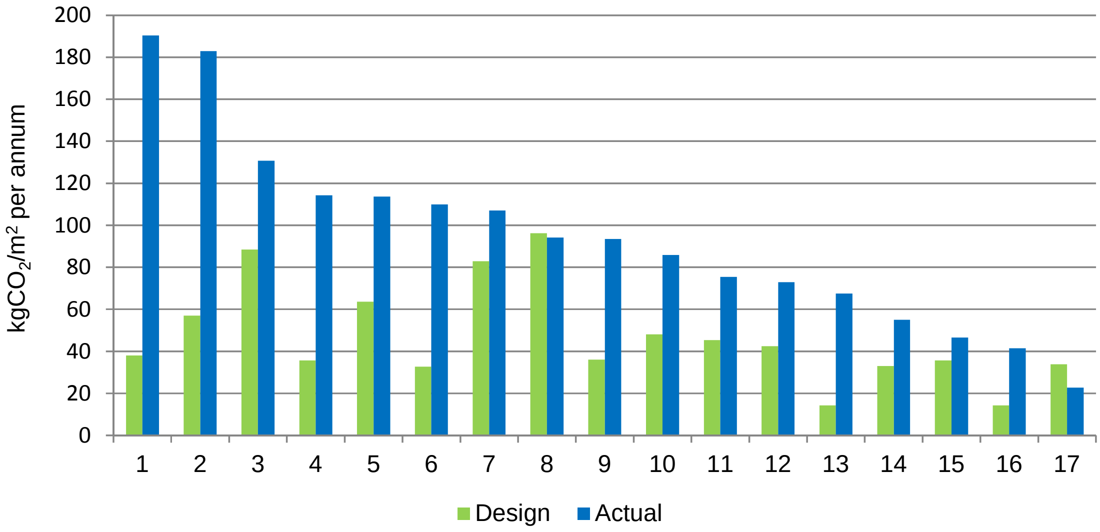

Fig 2 **Design CO_2 emissions compared to actual measured CO_2 emissions for 17 office building (source: CarbonBuzz website)**

For some buildings (shown in bold in Table 1) the electrical energy consumption was split into regulated (EPC / Part L) and unregulated energy. Fig 2.9 in Chapter 2 was based on data for these buildings, assuming EPC emission factors of 0.184 $kgCO_2/kWh$ for heat and 0.541 $kgCO_2/kWh$ for electricity.

4. BETTER BUILDINGS PARTNERSHIP

The objective of the report *A Tale of Two Buildings: Are EPCs a true indicator of energy efficiency?* published by Jones Lang LaSalle and the Better Building Partnership in 2012, was to demonstrate how Energy Performance Certificates (EPCs) alone are not sufficient to deliver the Government's targets to 'de-carbonise' the UK's built environment.

The report shows two London buildings, Ropemaker Place, a new building with a B rated EPC, and 10 Exchange Square with an E rated EPC. One would expect that Ropemaker Place would be the more efficient, however 10 Exchange Square has 66% lower actual energy consumption.

The key purpose of the report was to '*highlight the shortcomings of relying on EPCs alone, showing that actual energy performance, as opposed to theoretical, should be the real focus for commercial property owners and occupiers – an area that is currently neglected by Government policy.'*

The report also looked at how successfully the commercial property industry in London is tackling the issue of reducing actual energy consumption, and provides recommendations and guidance for owners and occupiers on what to do next.

Figure 3 shows a draft analysis of preliminary DEC ratings for 123 commercial London buildings in the JLL / BBP dataset using energy consumption in 2009/10.[3] The preliminary ratings were not adjusted for hours of operation or allowable seperables.

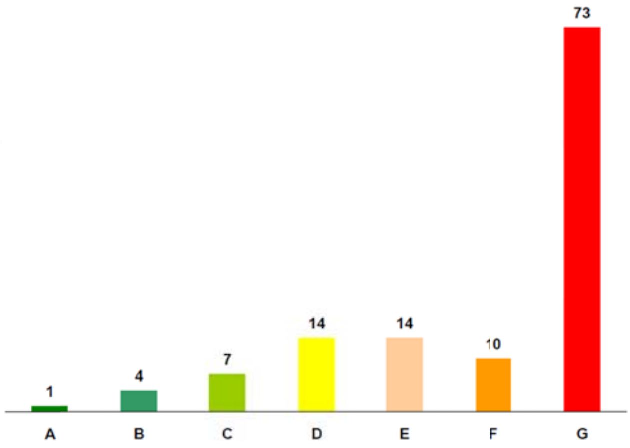

Fig 3 **Number of buildings by DEC rating in 2009-10 (source: BBP / JLL)**

5. THE UK GOVERNMENT VIEW IN 2013

In 2013 the UK government was of the opinion that EPCs are a robust and useful tool to reduce energy consumption in buildings and that DECs only tell a new occupier of a building how efficient the previous occupant was.[4] The government also believes that building owners would voluntarily choose to undertake and publically disclose DEC ratings, despite overwhelming evidence to the contrary.

Notes

All websites were accessed on 15 June 2013 unless noted otherwise.

1. *Energy Consumption Guide 19: Energy use in offices*, UK Government, 2003.

2. www.carbonbuzz.org

3. The DEC data was supplied to the author by BBP and Jones Lang LaSalle in November 2012.

4. Letter to UK-GBC from Don Foster MP, 10 January 2013. www.ukgbc.org/document/letter-don-foster-jan-2012-epbd2. In Australia, the Commercial Building Disclosure takes an opposing view, and requires landlords to provide a NABERS Base Building rating (effectively a landlord DEC) on the sale or lease of office buildings greater than 2,500m^2.