Building Performance Evaluation

Adrian Leaman

Usable Buildings Trust | Building Use Studies

Presentation to LMU, Wednesday March 14, 2012

Consider this ...

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“A digital universe … consists of two species of bits: differences in space and differences in time. Digital computers translate between these two forms of information - structure and sequence - according to definite rules. Bits that are embodied as structure (varying in space, invariant across time) we perceive as memory, and bits that are embodied as sequence (varying in time, invariant across space) we perceive as code. Gates are the intersections where bits span both worlds at the moment of transition from one instant to the next.”

George Dyson. *Turing’s Cathedral*, Allen Lane, 2012. p3.

Structure, sequence, ‘gates’.

Q: How do you know you've succeeded?

A: It's a very strange thing for a designer to say, but one of the things that really irritates me in products is when I'm aware of designers wagging their tails in my face. Our goal is simple objects that you can't imagine any other way. Simplicity is not the absence of clutter. Get it right, and you become closer and more focused on the object. For instance, the iPhoto app we created for the new iPad, it completely consumes you and you forget you are using an iPad.

Sir Jonathan Ive, Interview, The Independent, 13 March 2012

“Designers wagging their tails in my face.”

“Our goal is simple objects that you cannot imagine any other way.”

“It completely consumes you and you forget …”

Things that we have discovered the hard way …

Major capital investment is needed to improve building performance.

In fact relatively minor changes to control, management, space and equipment can often have large effects.

Where capital investment is required, start with the fabric. Yes, for new construction.

However, in existing buildings the engineering services, equipment and controls are usually more important, unless there are major shortcomings with the fabric.

Building performance is a matter for the construction industry.

No, it is much broader than that. Building use needs to be well represented. Designers and builders have normally walked away at handover.

Cue: Usable Buildings Trust

Innovative technologies are the key to better performance.

No, often the innovations required are to bring people, processes and products together in subtly different ways for markedly better results, and with only minor technical changes, e.g. for better usability.

Cue: Soft Landings.

Modelling can provide all the answers.

No, we need feedback of actual performance.

Cue: Real-world research.

More technology produces better buildings.

Not if the technologies require too much integration, support and maintenance. Simpler buildings often perform better.

Generic catch-alls?

Not normally. Context, constraints and options are the (hidden) briefing keys.

Influences ...

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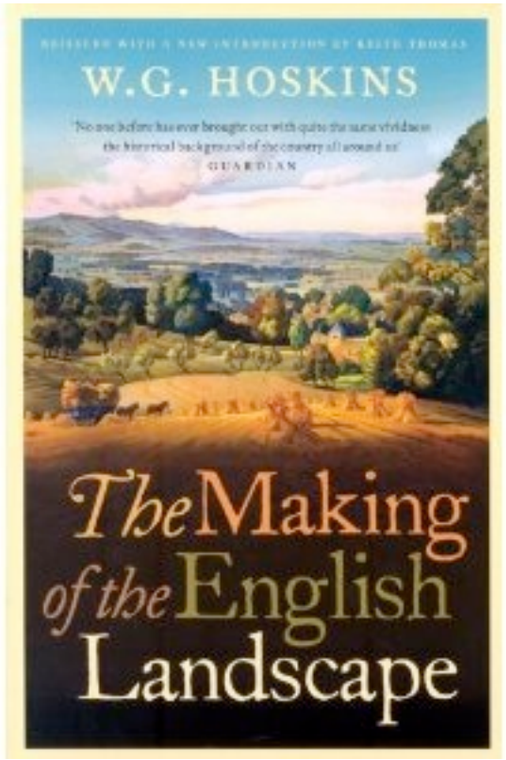
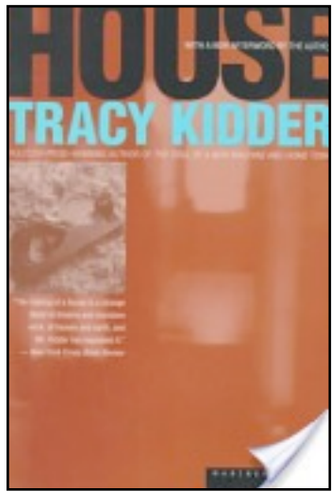
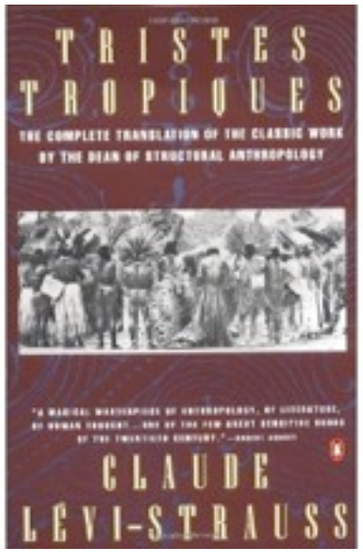


W.G. Hoskins



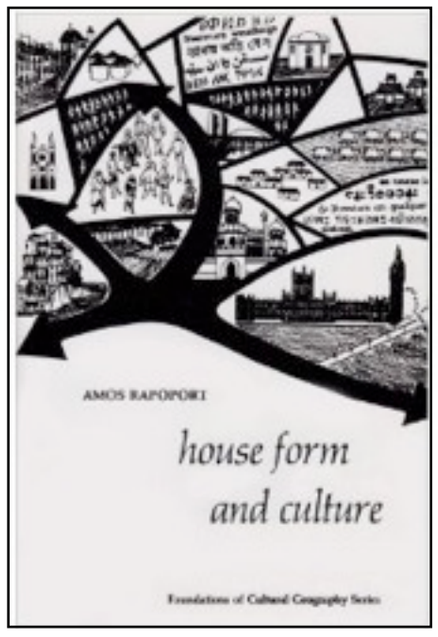
Tracy Kidder

D'Arcy Thompson

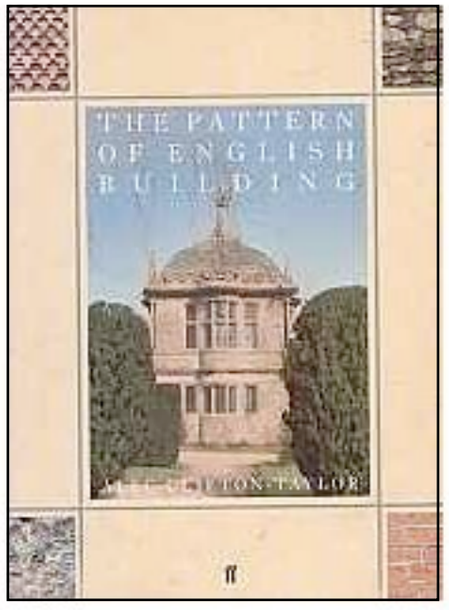


Claude Levi-Strauss

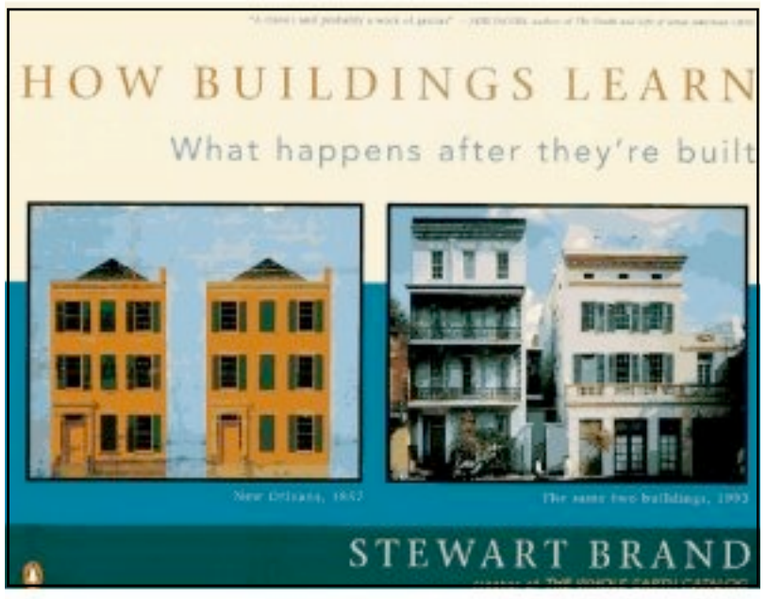
Peter Haggett and geographers like Bill Bunge and David Harvey.



Amos Rapoport



Alec Clifton-Taylor



Stewart Brand

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and especially …

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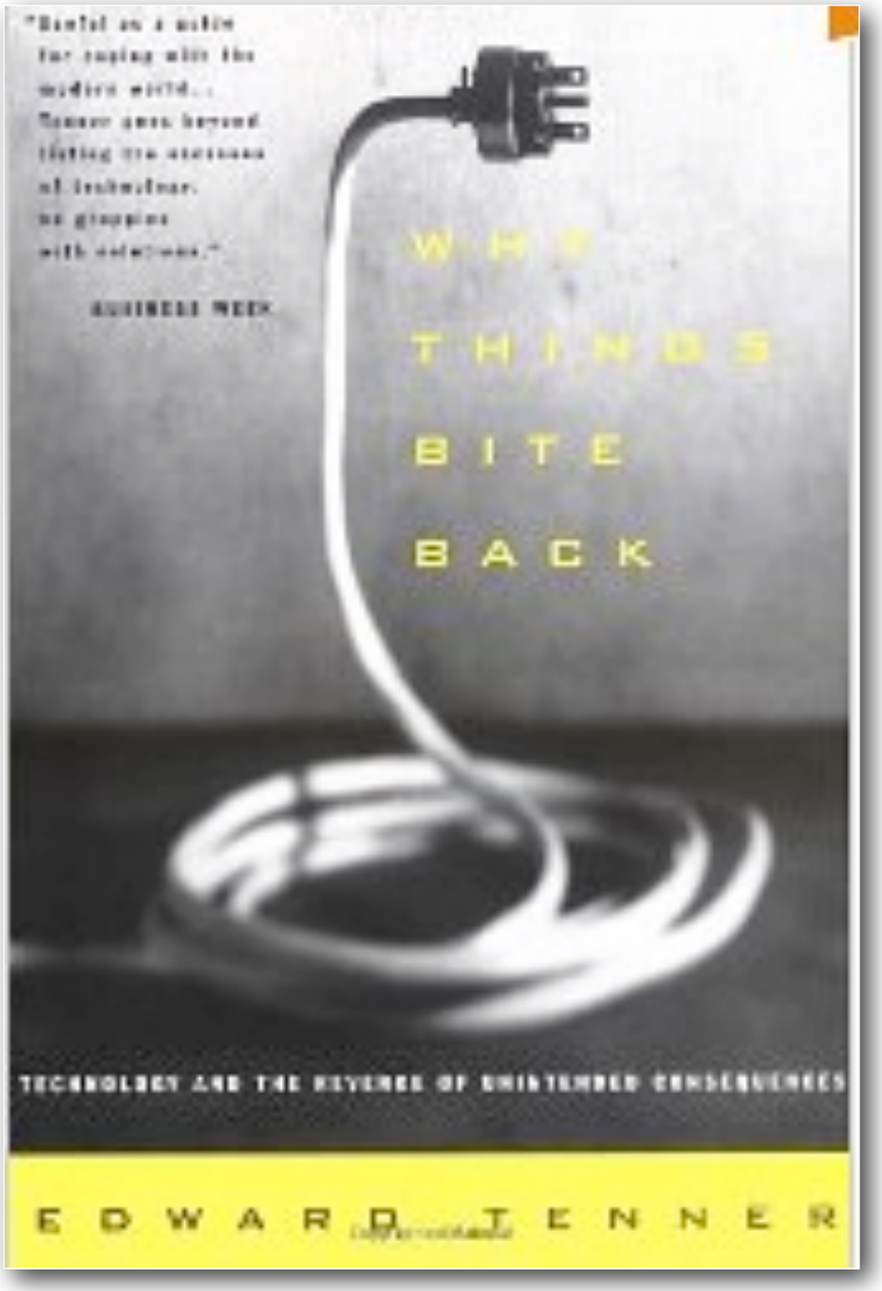

Edward Tenner

Donald Norman

Likes …

House at Grizedale, 1900 C.F.A. Voysey

“Never look at an ugly thing twice. It is fatally easy to get accustomed to corrupting influences.”
C.F.A. Voysey

University of Sunderland School of Computing, BDP, 1995

Kingsmead Primary School, Northwich, Cheshire, White Design, 2004

… and dislikes

St John’s House, Bootle
1971
Occupied 1981
Demolished 2001

Trellick Tower, London,
1966-1972,
Ernő Goldfinger. Grade II* .

Seattle Public Library, Rem Koolhaus

‘Measuring’ building performance

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‘There is nothing more dangerous than a heckler with statistics.’

Rich Hall

Three perspectives

Human needs: Are needs being met?
Environmental performance: How benign?
Costs and resources: Affordable and manageable?

One objective

Better feedback aimed at the most effective people to create better buildings.

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Examples

TEST of TIME

Too many new public and commercial buildings fail to live up to their expectations for energy savings and user comfort, but can the good ones maintain their performance? With support from CIBSE, a team of experts returns to a university building that was found to perform exceptionally well in the late 1990s. **Bill Bordass** and **Adrian Leaman** report on their findings. A separate article on the performance of school buildings generally starts on page 39

A 'PROBE' investigation into the Elizabeth Fry Building at the University of East Anglia in the 1990s found that it had exceptionally good performance in many respects. A recent follow-up visit found that, despite some inevitable 'drift' in its operations, it is still performing better than many brand-new buildings. In the background is the Queen's Building, an earlier building by the same design team

In the early 1990s, the editorial advisory board of *Building Services Journal* (the forerunner of *CIBSE Journal*) had wondered how well the buildings it featured actually performed in practice. In 1994 the *Journal* made a successful bid under the government's Partners in Technology programme to undertake and publish the 'PROBE' (Post-occupancy Review Of Buildings and their Engineering) studies.

Between 1995 and 2002, a total of 20 non-domestic buildings were surveyed, typically two to four years after handover. The process, results and general findings are described in 29 articles in the *Journal*, and in reviews elsewhere.

PROBE number 14 investigated the Elizabeth Fry Building at the University of

Trust in construction

In the atrium, the stairs and wall cladding are made entirely of wood from National Trust estates. A very hard wearing carpet, produced from Herdwick sheep grazed on Trust farmlands, is used in the office areas.

FACTS AND FIGURES

Client
The National Trust/Kier Ventures
Project architect
Feilden Clegg Bradley
Environmental design consultants
Max Fordham LLP

Construction value: £10.4 million (shell and core)

Start on site: January 2004

Occupation: 4 July 2005

Treated floor area: 7350 m²

Occupancy: 470 (350 average)

Airtightness: 5.61 m³/(h.m²)

Like many organisations with a strong environmental conscience, the National Trust was keen to ensure that its new central office building trod upon the earth as lightly as possible. In Trust language, sustainability translated into low energy consumption, low running costs, and an outstanding place to work. The Trust also wanted open-plan offices to encourage good communication between departments, formerly in different buildings.

The Trust also desired a brownfield site. A suitable location was found on a plot of land among former railway engineering sheds in Swindon. The trapezoidal site was a challenge for architect Feilden Clegg Bradley and environmental consultant Max Fordham who designed the shell and core.

The footprint of the Heelis building closely follows the boundaries of the site (Figure 1). The building's design – from its pitched roofs to the use of blue engineering brick – gives an affectionate nod to the nineteenth century sheds.

The building was needed as the Trust wanted to centralise staff from six sites. People came from 1970s smoked-glass office blocks and converted stately homes. They therefore arrived with varying expectations of the new building.

Design description

The Heelis building was developed by Kier Ventures as a pre-let for the National Trust.

In the analysis that follows, it is important to recognise that Kier Ventures used the RIBA Stage D report as the basis of costing and financing the project. Although the design team developed the engineering concepts to get the most effective packages, they were not aware that the developer had already set the budget. Ultimately, this affected the choice of some engineering systems, which are not as tightly specified as they could have been.

The design team settled on a two-storey deep-plan building on a north-south axis, with the longest facade angled due south. The construction is conventional, being of a steel frame on a concrete base, with a pitched roof, in-filled with exposed, 80 mm thick, pre-cast concrete planks to provide thermal mass.

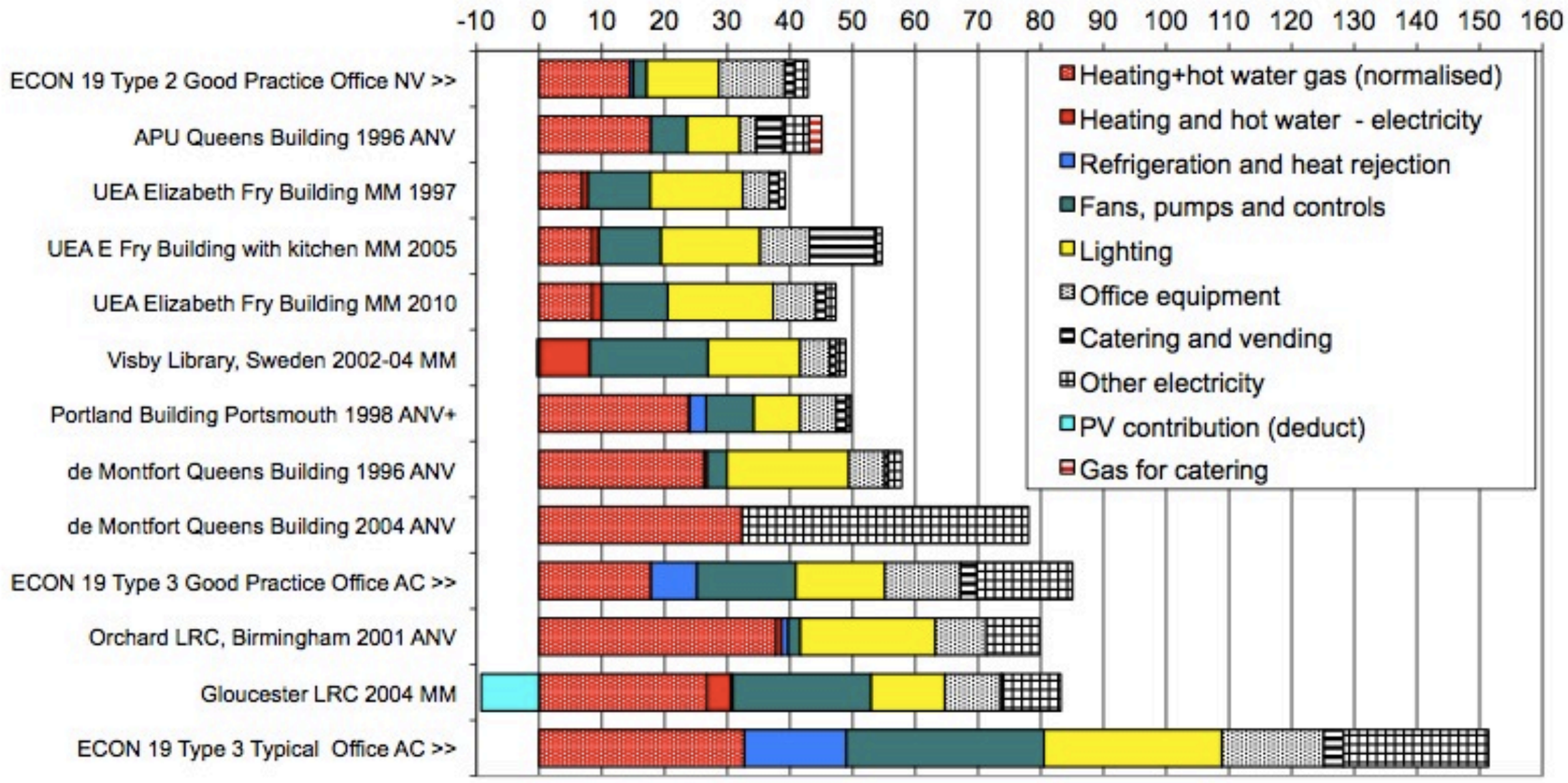
The 30° pitched roofs on the south side provided a suitable orientation for 1554 photovoltaic panels, while the north-facing slopes provided a location for northlights. These are located between prominent motorised extract ventilators (called snouts).

The envelope is a mixture of aluminium curtain walling to the south, with smaller windows set into brick walls of the remaining elevations. Two courtyards break up the deep-plan nature of the building and so enable cross-ventilation. Lightwells through the first floor mezzanines bring daylight to the deep plan areas of the ground floor.

The Heelis building is mostly naturally-ventilated, with fresh air supplied through

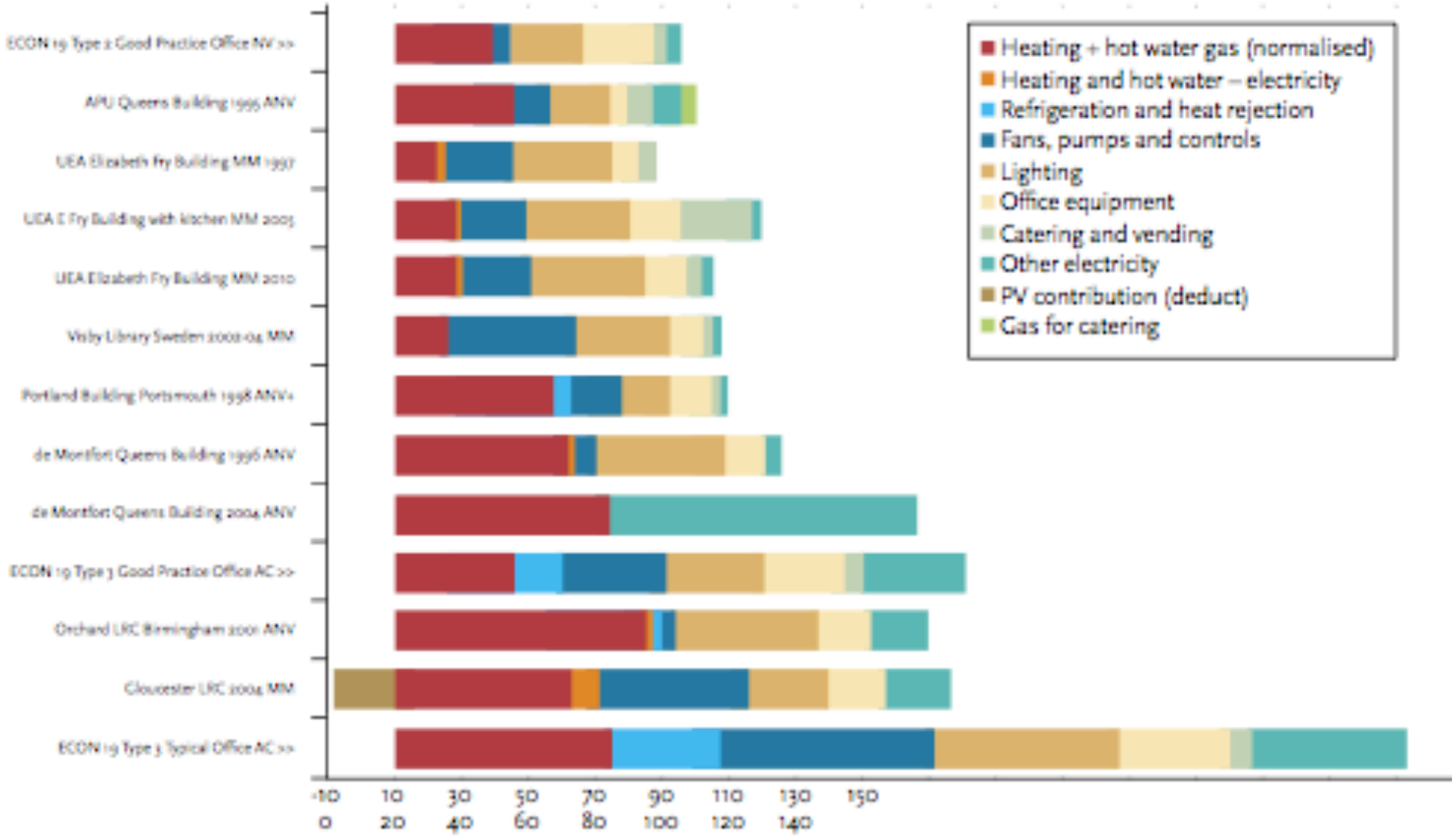
Annual CO_2 emissions from university buildings

kg/m² Treated Floor Area at UK CO_2 factors of 0.184 for gas and 0.525 for electricity



AC= Air Conditioned, ANV = Advanced Natural Ventilation, MM = Mixed Mode.

But watch what happens when graphic designers take over …



Annual CO2 emissions from university buildings (kg/m² Treated Floor Area at UK CO_2 factors of 0.184 for gas and 0.525 for elecricity)

AC = air conditioned, **ANV** = advanced natural ventilation, **MM** = mixed mode, **NV** = naturally ventilated

The diagram shows the estimated breakdown of energy use in 1997, 2005 (when the catering kitchen was in full operation) and 2010, in relation to office benchmarks from the Carbon Trust's Energy Consumption Guide 19 (marked with chevrons) and to other university buildings reviewed in PROBE and related studies. The graphs are expressed as annual CO2 emissions at Defra 2011 UK factors. The data are sorted by CO2 emissions for heating, hot water, cooling, ventilation and lighting.

At all three dates, Elizabeth Fry still maintains its place towards the low-carbon end of the range. The biggest changes between 1997 and 2010 are in heating and hot water, largely due to the change to 24/7 hot water and the appearance of some additional electric heaters. Lighting and office equipment energy use have also gone up owing to increased occupancy and equipment levels.

In relation to other buildings and benchmarks, energy use for heating and hot water is still good, while lighting has deteriorated owing to the low efficiency of the original pelmet system and greater hours of use now. CO2 emissions from fans, pumps and controls (mostly fans) are reasonable in relation to the other mixed-mode buildings and to air-conditioned benchmarks, but nevertheless of a similar magnitude to those from heating and hot water.

1998 (with 2011 benchmarks)

Temperature in summer overall	Uncomfortable :1	Tsover	7: Comfortable
Temperature in winter overall	Uncomfortable :1	Twover	7: Comfortable
Air in summer overall	Unsatisfactory :1	Airsover	7: Satisfactory
Air in winter overall	Unsatisfactory :1	Airwover	7: Satisfactory
Lighting overall	Unsatisfactory :1	Ltover	7: Satisfactory
Noise overall	Unsatisfactory :1	Nseover	7: Satisfactory
Comfort overall	Unsatisfactory :1	Comfover	7: Satisfactory
Design	Unsatisfactory :1	Design	7: Satisfactory
Needs	Very poorly :1	Needs	7: Very well
Health	Less healthy :1	Health	7: More healthy
Image to visitors			
Perceived productivity	Decreased: -20%	Prod	Increased: +20%

2011

Temperature in summer overall	Uncomfortable :1	Tsover	7: Comfortable
Temperature in winter overall	Uncomfortable :1	Twover	7: Comfortable
Air in summer overall	Unsatisfactory :1	Airsover	7: Satisfactory
Air in winter overall	Unsatisfactory :1	Airwover	7: Satisfactory
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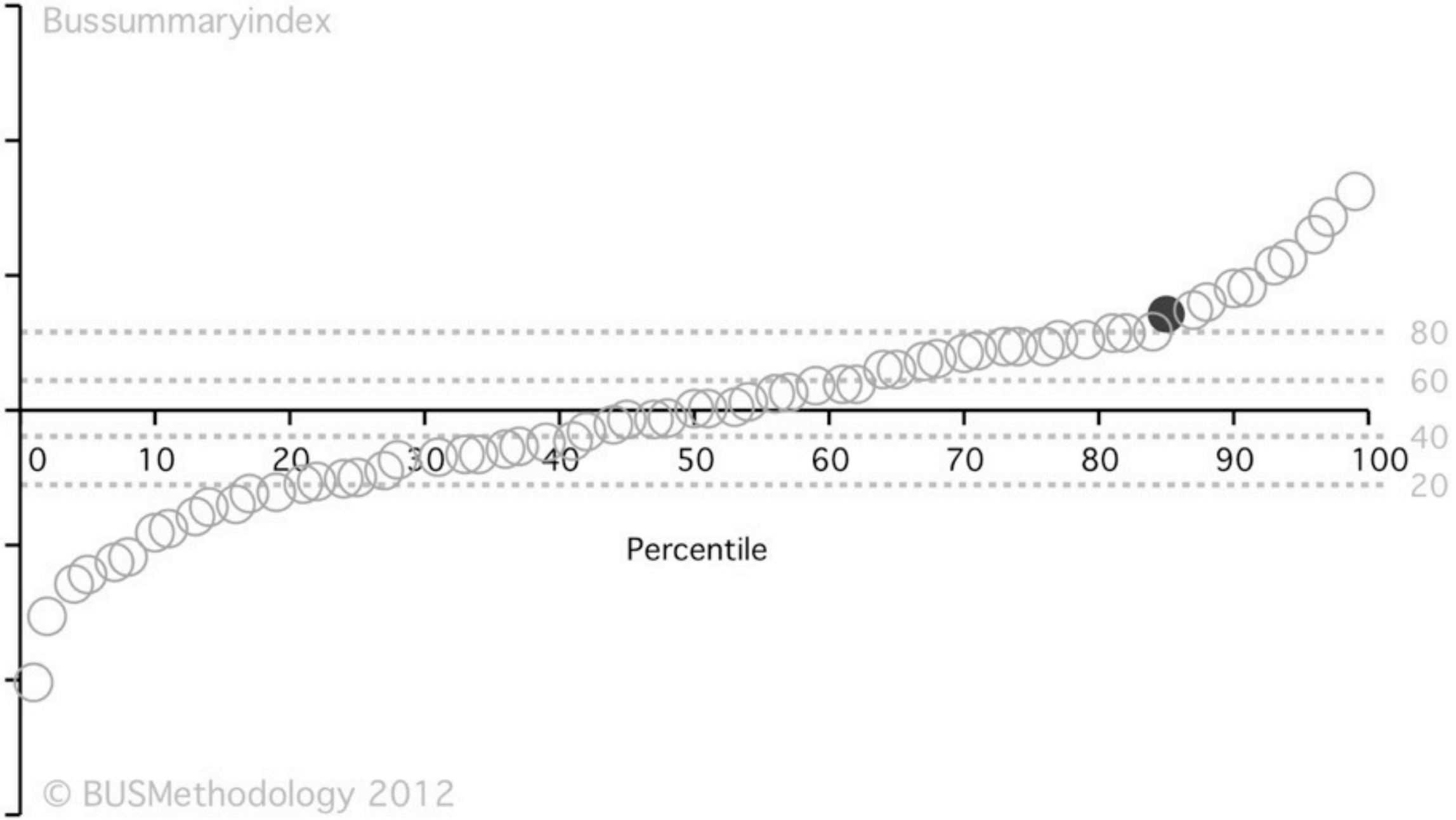
Comfort overall	Unsatisfactory :1	Comfover	7: Satisfactory
Design	Unsatisfactory :1	Design	7: Satisfactory
Needs	Very poorly :1	Needs	7: Very well
Health	Less healthy :1	Health	7: More healthy
Image to visitors	Poor :1	Image	7: Good
Perceived productivity	Decreased: -20%	Prod	Increased: +20%



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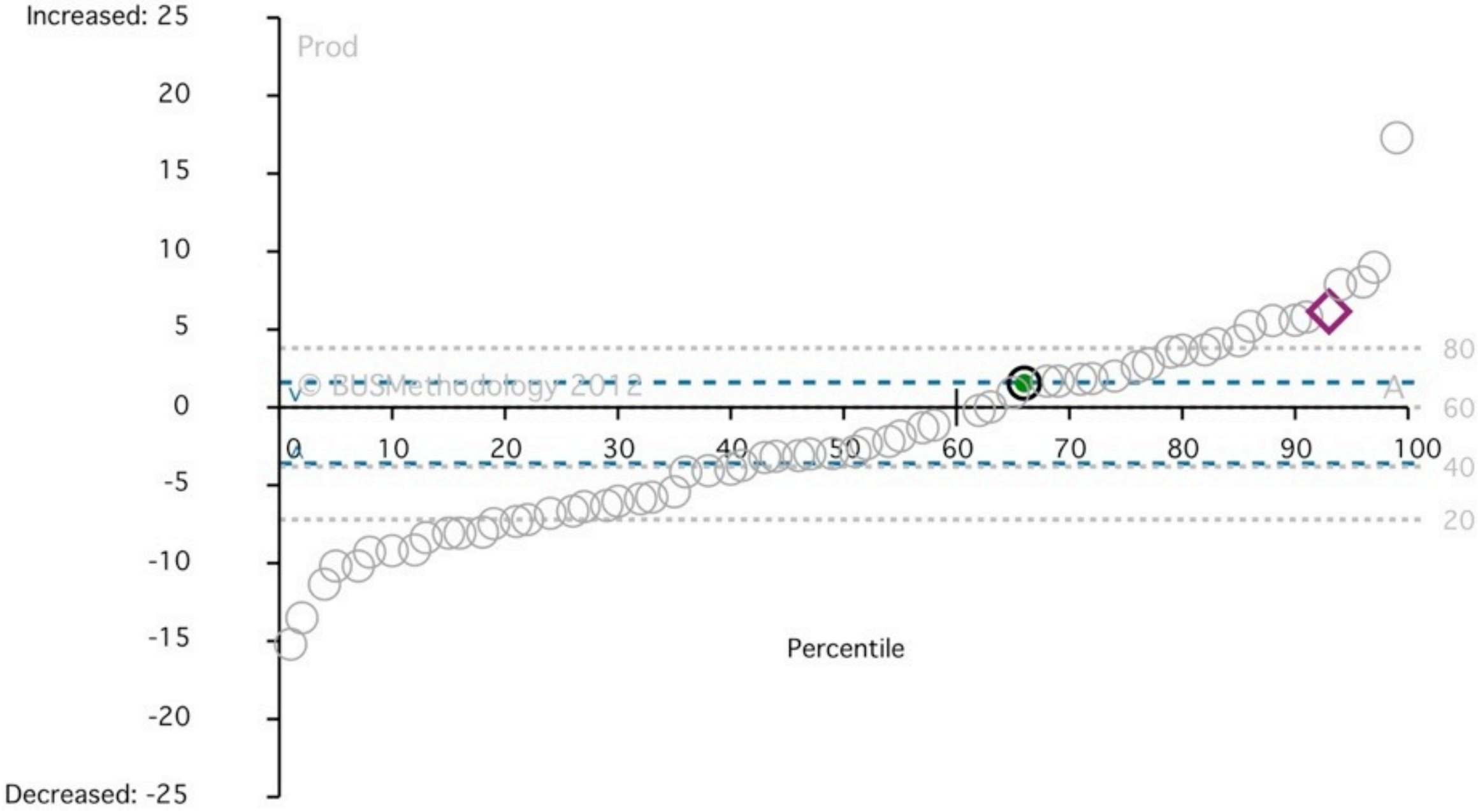
Increased: 25
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-10
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Decreased: -25
Prod
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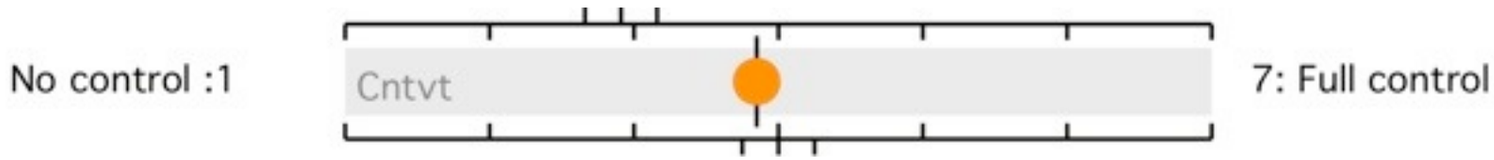
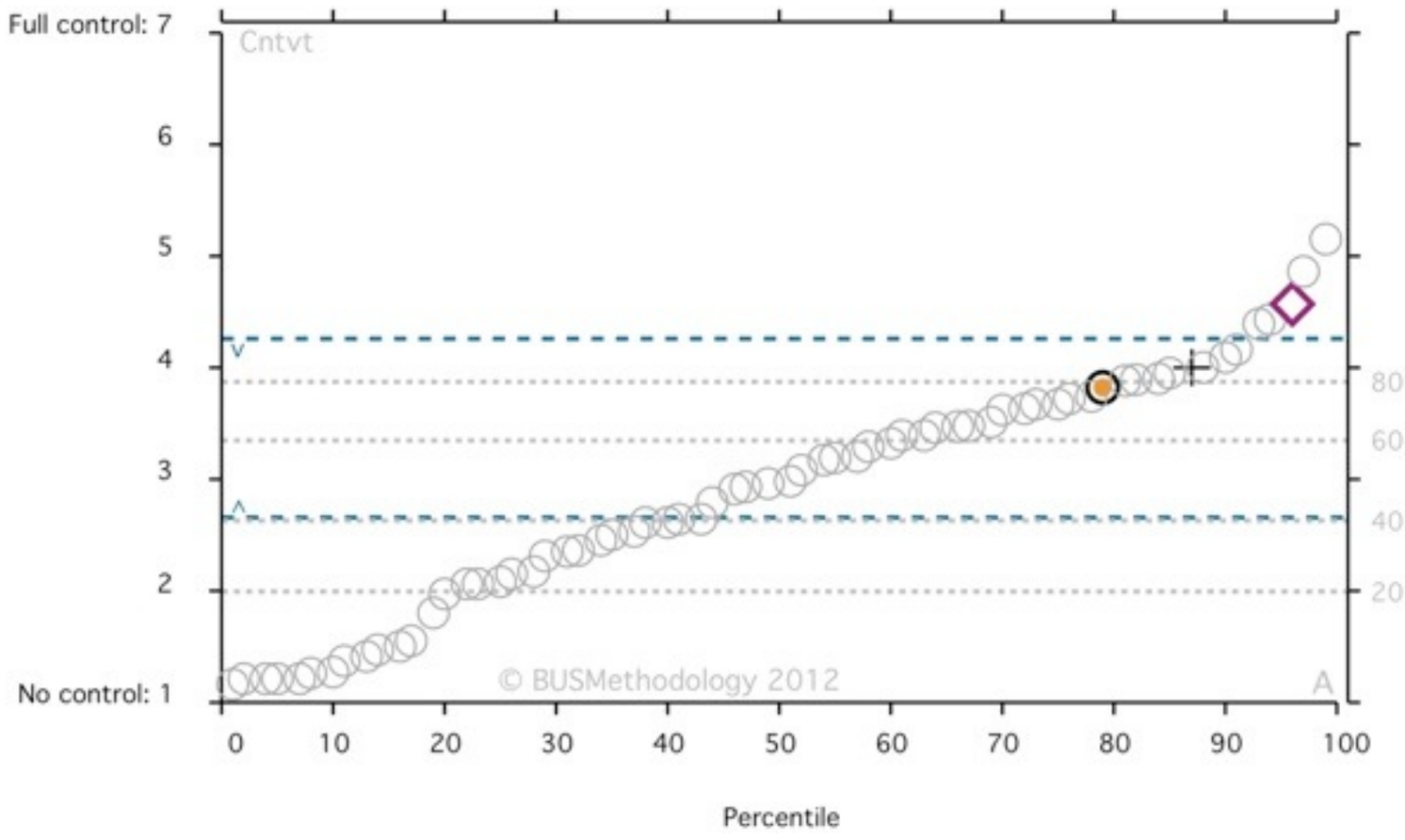
Percentile


No control :1
Cntvt
7: Full control


Full control: 7
Cntvt
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No control: 1
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Percentile

Changed behaviour because of conditions in building

Adapt clothing. In summer it's harder to dress as professionally when the office is very warm.

Avoid leaving office to find people.

Can feel very uncomfortable when in open plan office, as far too hot in summer. Work productivity decreases and feel unwell.

Constantly opening and closing windows, turning fans on and off. Consideration to clothing.

Drink hot drinks to keep warm in winter.

During building work I have avoided holding meetings in EFB .

During recent building I sometimes stay away - work at home.

have to wear headphones all the time due to noise .

Heat, noise can make me leave early.

I drink less water!

I have a big jumper always there for when it gets cold.

I leave if I cannot work effectively and in privacy .

I use my heater in the winter and open windows, or use a fan in summer, so manage to stay reasonably comfortable.

I wear a fleece in winter over my jacket. I also provided myself with a fan heater.

I work at home.

I'm quieter.

If cold, try to move around to warm up.

If I am too hot I find it hard to concentrate.

Noise etc impacts on ability to write etc.

Open windows (not advised in EFB) for ventilation, use electric light at all times.

Recent building work has caused me to rearrange meetings and work at home.

… and the graphic design version …

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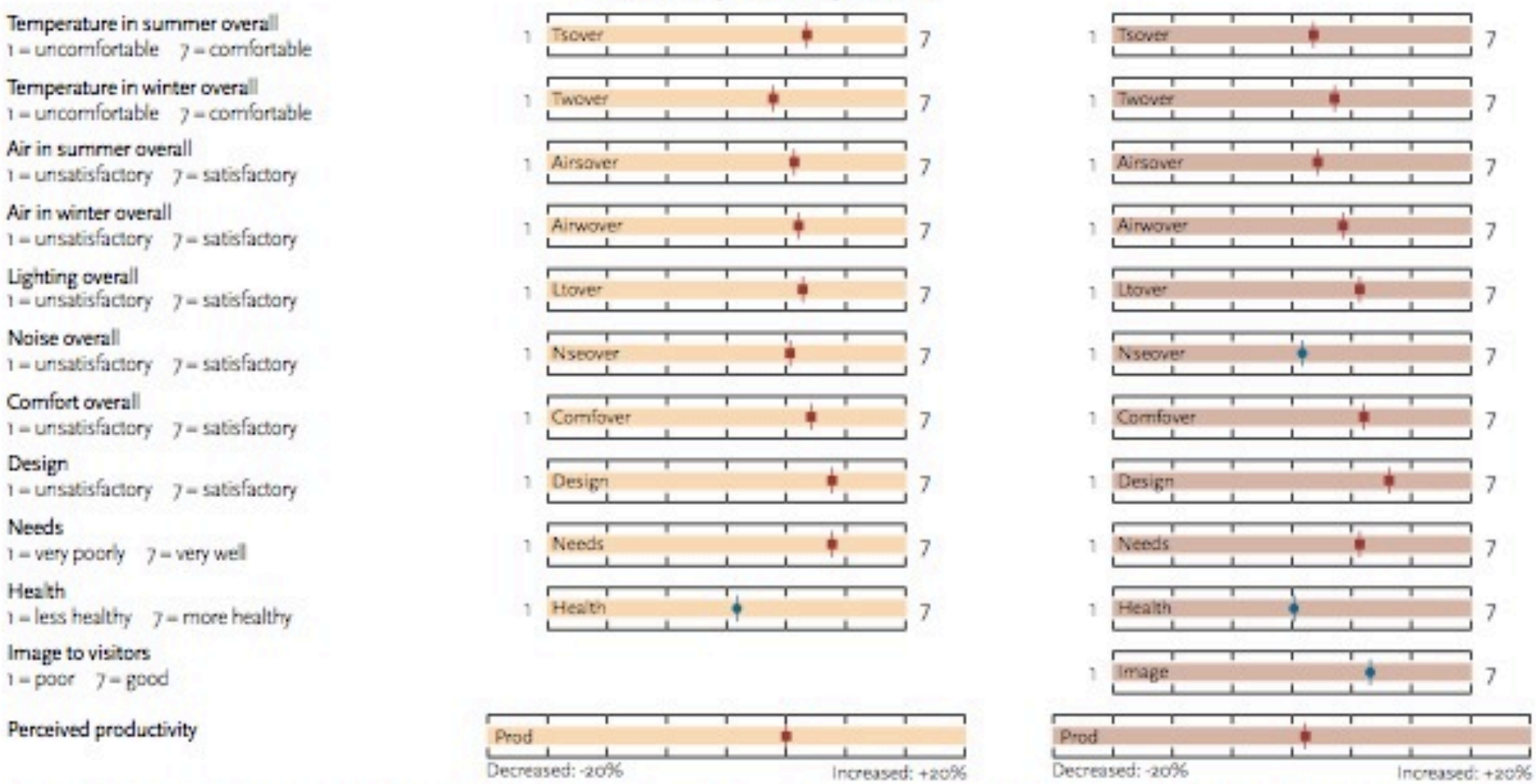
Bus Occupant Survey Results



The diagrams above show average responses by staff to twelve key questions in the BUS surveys in 1998 (on the left) and 2011 (on the right), just before the recent changes. For comparability, the 2011 survey excludes occupants in the converted kitchen and dining area. The satisfaction scales run from 1 (poor, on the left) to 7 (good), apart from the final question – the effect of environment in the building on perceived productivity – which goes from –20% to +20%. Green squares show where average scores are significantly better than benchmark values at the 95% confidence level. Orange circles indicate averages that are similar. For most occupant satisfaction variables, E Fry remains significantly above average. There are no red triangles, which would indicate scores significantly worse than average. The question about image (to visitors) was not asked in 1998.

The score for overall comfort in 2011 is at the 79th percentile of the reference data set, while in 1998 it was at the very top. Two things have happened since then: perceived conditions in the building are not quite as good (e.g. the overall comfort score has fallen from 5.41 to 5.20), whilst buildings with better comfort levels have subsequently been surveyed. The 1998 result for Elizabeth Fry now falls at the 90th percentile of the 2011 reference dataset.

The main influence on comfort is likely to be the higher occupation density. The variable most affected is summertime temperature, where the average score has fallen from what was a very good 5.30 (the most comfortable in the 1998 dataset) to 4.24. The effect is exacerbated by a loss of perceived control in the open plan areas. Perceived air quality in summer has also fallen, but remains significantly above average. The average score for Noise has dropped from 5.05 to 4.24, and is now indistinguishable from the average. The main causes are probably the creation of open plan offices and the growth in traffic on Chancellor's Drive – particularly regular buses, which did not go past the building in 1998. Some people also mentioned noise from the ventilation plant.

Revised but still not clear …

Building Use Studies (BUS) occupant survey results for 1998 and 2011

The diagrams above show average responses by staff to 12 key questions in the BUS surveys in 1998 (on the left) and 2011 (on the right), just before the recent changes. For comparability, the 2011 survey excludes occupants in the converted kitchen and dining area. The satisfaction scales run from 1 (poor, on the left) to 7 (good), apart from the final question – the effect of environment in the building on perceived productivity – which goes from –20% to +20%. Green squares show where average scores are significantly better than benchmark values at the 95% confidence level. Orange circles indicate averages that are similar. For most occupant satisfaction variables, The Elizabeth Fry Building remains significantly above average. There are no red triangles, which would indicate scores significantly worse than average. The question about image (to visitors) was not asked in 1998.

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Usable BUILDINGS

... for feedback and strategy

... from the Usable Buildings Trust

Usable Buildings is a free resource for practitioners, managers, building owners, developers, students and anyone else who wants to make buildings more suitable for the people who use them, less damaging to the natural environment and a better long-term investment. Usable Buildings is run by the Usable Buildings Trust.

The Usable Buildings Trust (UBT) is an independent charity, registered in the United Kingdom. UBT promotes better buildings through the more effective use of feedback on how they actually work. It spreads the results through its website, user groups, collaborative working and input to postgraduate courses. UBT is also a home for approaches which are not quite ready for widespread application and an incubator for their development. Aims Background

Who we are and what we do: Trustees' Report summarises activities and plans. What Do We Do?

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