CAT Machynlleth

Building Performance Assessment and Evaluation 12 May 2015

PART 1.1

BUILDING PERFORMANCE IN USE: *THE GREAT UNKNOWN*

Failing to see the evidence under our noses

Bill Bordass and Adrian Leaman

the Usable Buildings Trust

www.usablebuildings.co.uk

Part 1.1: *Failing to see the evidence under our noses*

1. **Flying Blind?**
2. **Strategic findings from case studies**
3. **What put us on the track?**

OVERVIEW *of the day*

- After decades studying building performance in use and attempting to embed the implications in government policy and client and industry practices, we have concluded that *the way society procures building work is not capable of tackling the problems we now face.*
- The industrial revolution led to a similar mismatch:
  This eventually led to the growth in building professions, starting with architecture.
- Over the past 40 years, the role of building professionals has been eroded, being seen as just another business … ***However,***
- Regulations and markets alone are proving insufficient to respond to the challenges of sustainability and the protection of the commons, *so we get left with mismatches and performance gaps.*
- **We need to re-examine professionalism. This must include a shared ethic and much more awareness of outcomes.**

1

FLYING BLIND?

What Building Performance Evaluation tells us: *the evidence under our noses*

Building performance in use is in the public interest

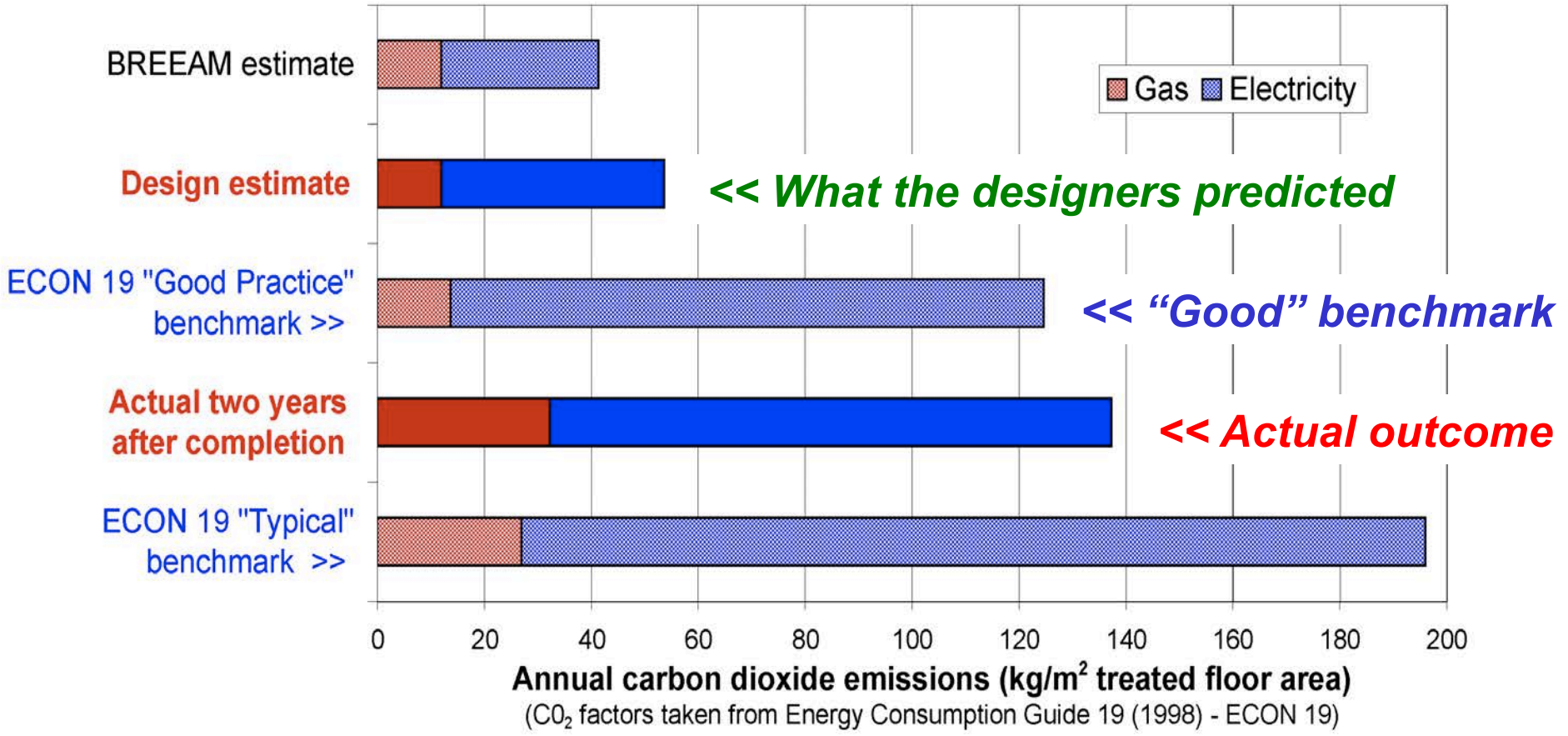
- Buildings last a long time, well beyond the time horizons of their creators, with many players involved in different roles.
- As building users, the whole population has an interest in them working better in every respect.

- **Now we want to improve the performance of the stock,** *especially (but by no means only) in terms of energy and carbon …* ***BUT***
- The feedback loop from performance in use to construction and policymaking is poorly closed, *a disastrous oversight.*

SO DO WE UNDERSTAND WHAT WE ARE DOING?

The Design-Performance Gap: *We couldn't deliver low-energy performance reliably in the 1990s. It is still difficult.*

Data from the winner of the Green Building of the Year Award 1996



SOURCE: see discussion in S Curwell et al, *Green Building Challenge in the UK,* Building Research+Information **27**(4/5) 286 (1999).

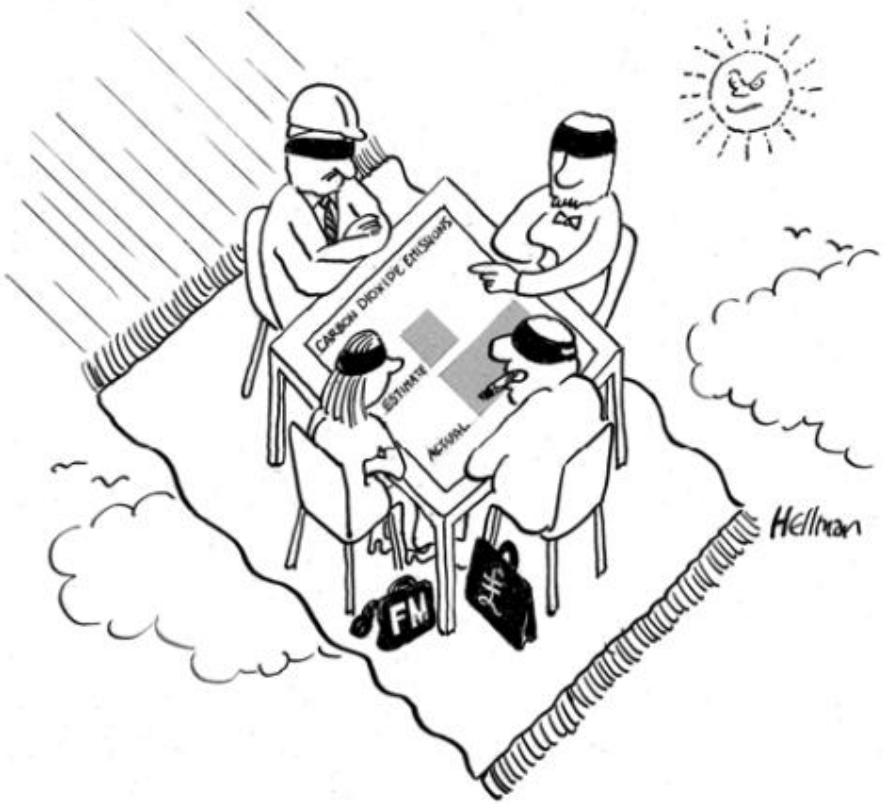
For most of the construction and property industry, *performance in use has been another country …*

"in theory, theory and practice are the same, in practice they aren't."
SANTA FE INSTITUTE

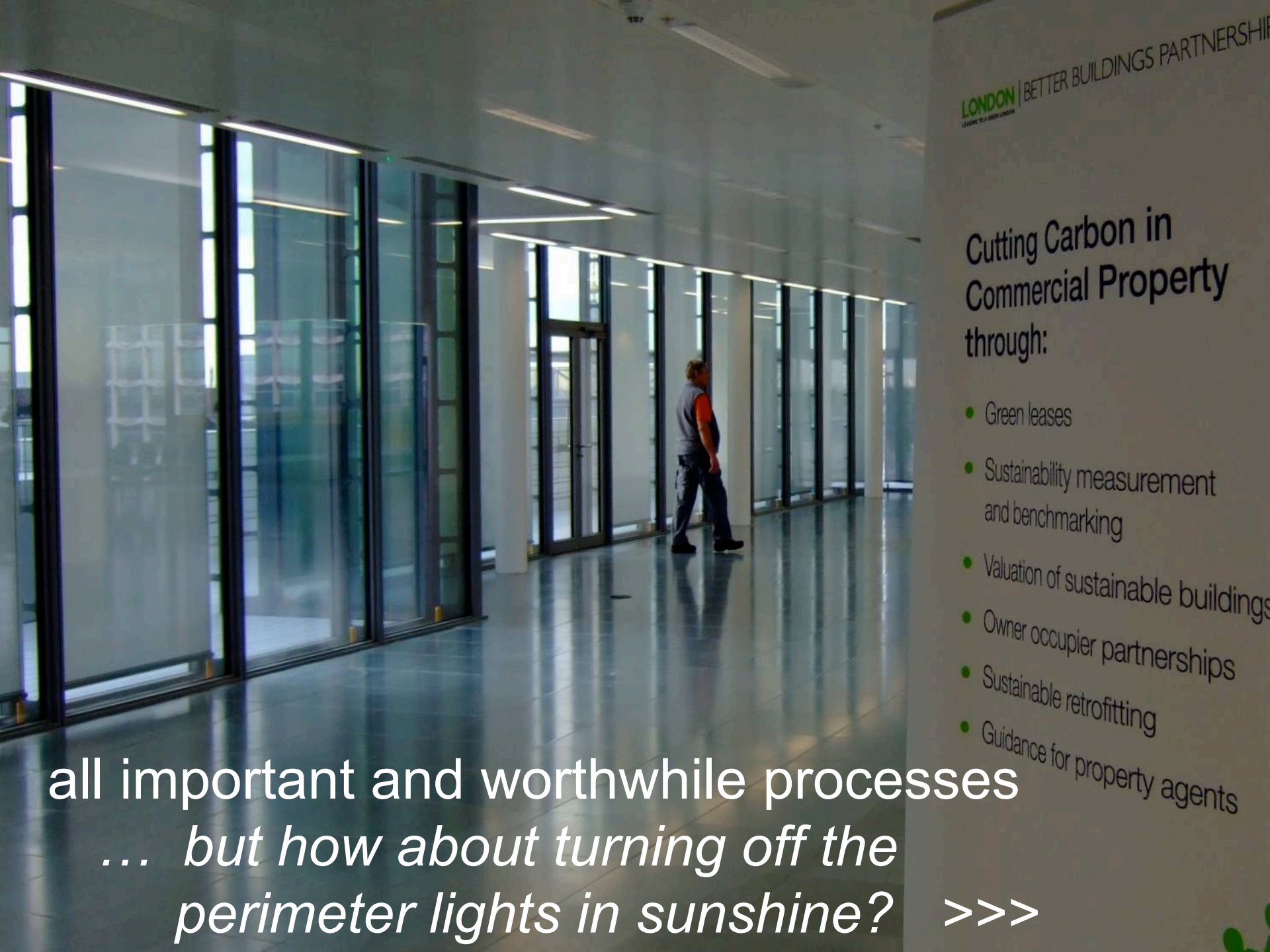
"Missing feedback is a common cause of system malfunction"
DONELLA MEADOWS

"designers seldom get feedback, and only notice problems when asked to investigate a failure."
ALASTAIR BLYTH
CRISP Commission 00/02

"I've seen many low-carbon designs, but hardly any low-carbon buildings"
ANDY SHEPPARD, Arup, 2009



SOURCE: Hellman cartoon for W Bordass, *Flying Blind,* Association for the Conservation of Energy & OXEAS (2001)



all important and worthwhile processes

… *but how about turning off the perimeter lights in sunshine?* >>>

I was writing about this 20 years ago too!

Optimising the irrelevant

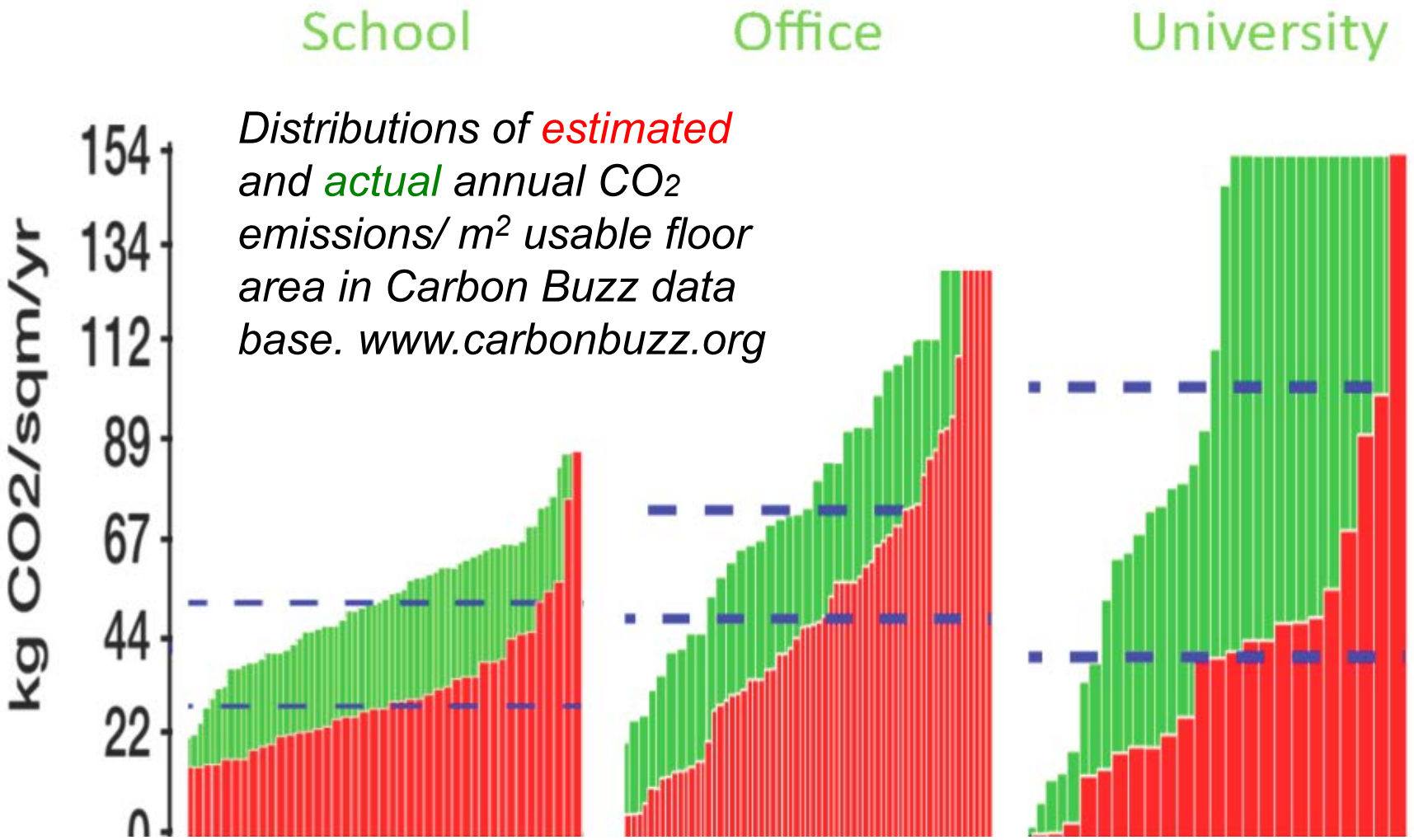
by Bill Bordass CIBSE Journal, February 1993, p 32-34

Why is the hi-tech office failing to meet users' needs? Is it the technology or the design process that's at fault? Bill Bordass identifies some of the problems and offers some solutions.

When people think of designing low energy buildings, they tend to fall into one of two traps. One is: "If we get the principles right, everything will automatically follow" or, "all you need is a lovely new bit of technology and it will solve the world's problems".

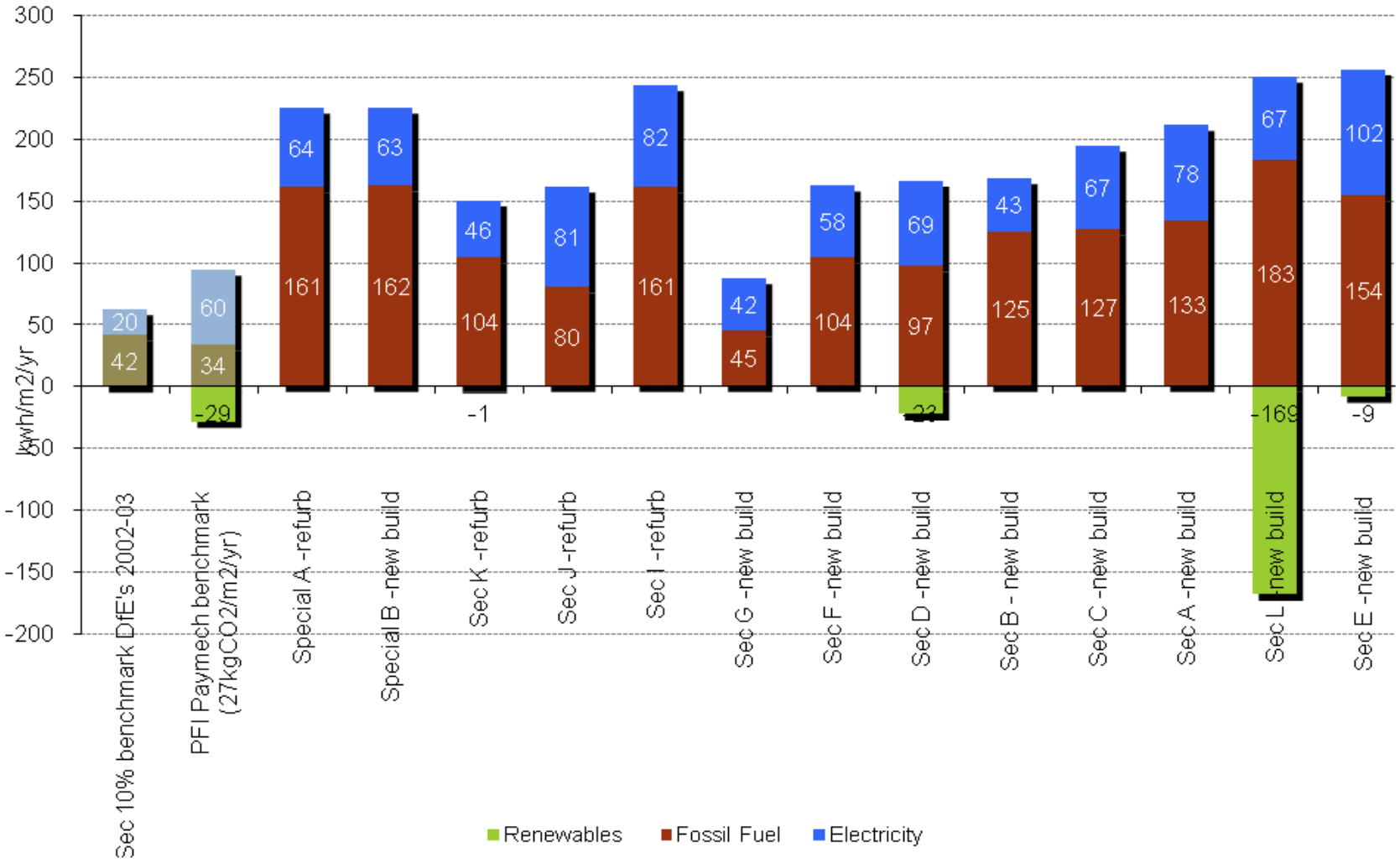
However, when you actually start looking at and analysing buildings they don't tend to give you the same messages. For

The evidence is now overwhelming:
slide from Carbon Buzz Launch June 2013



SOURCE: Ian Taylor and Judit Kimpian, *Carbon Buzz Launch slides,* 6 June 2013. www.carbonbuzz.org

Energy use in new secondary schools …
the more renewables, the less efficient?



SOURCE: Private communication, 2011

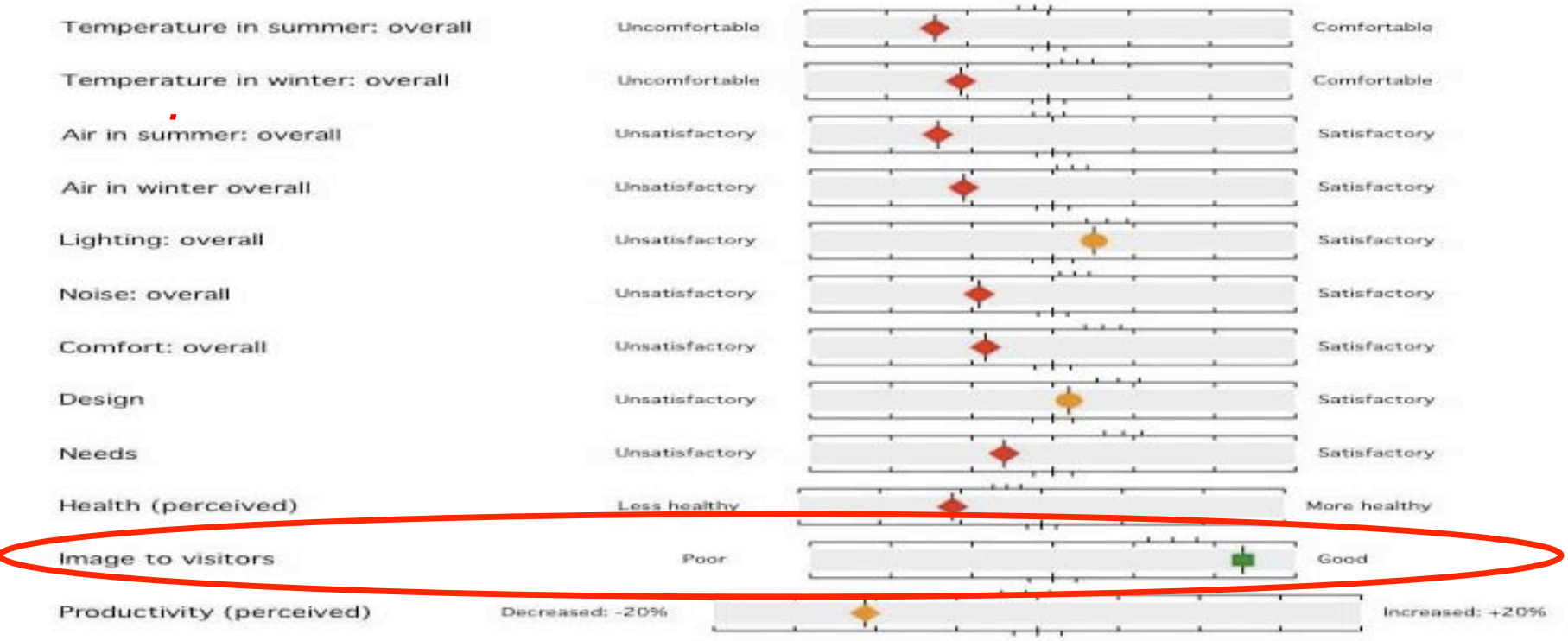
The gaps occur in new housing too:
a full 40 years after the 1973 oil crisis

Minister launches Hub-led project to tackle the performance challenge **Ecobuild 6 March 2013**

A new project to examine the energy performance of new homes is unveiled today. The industry-backed project brings together leading housebuilders and industry experts to investigate the actual performance of homes and better understand how this compares to that expected by the original design. Communities and Local Government minister Rt Hon Don Foster MP announced a new £380,000 grant for

The gaps are not only for energy: *occupant survey, multi-award-winning school*

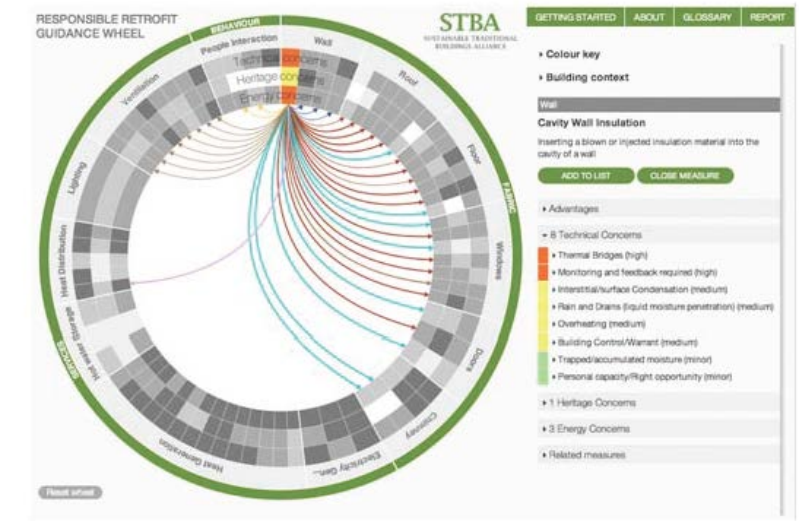
RED: below average; AMBER: Average; GREEN: Above average



" … the architecture showed next to no sense. It leaked in the rain and was intolerably hot in sunlight. Pretty perhaps, sustainable maybe, but practical it is not." … STUDENT

SOURCE: BUS Method survey of a building services engineering award-winning Academy school in South East England, 2009

The gaps do not only affect new buildings:
Knowledge base for retrofit



SOME CONCLUSIONS

Industry and policy lack understanding of traditional building performance.

Lack of connection between research intelligence and guidance procedures.

Significant uncertainty in application of models and software.

Some methods used are inappropriate.

A systemic approach is necessary to avoid unintended consequences.

There are good opportunities, but some will need to be developed using a rather different basis and structure.

SOURCES: Report (Sept 2012) downloadable from www.stbauk.org Guidance Wheel at www.responsible-retrofit.org/wheel

Simple dysfunctions in recent buildings:
Poor window design, leading to overheating

Wasteful overprovision in new buildings:

In a "low energy" building's kitchen

… and widely dysfunctional controls

BCIA
Building Controls Industry Association

Controls for End Users

Usability criteria	Ranking (controller as supplied) Poor – Excellent
Clarity of purpose	●
Intuitive switching	●
Labelling and annotation	●
Ease of use	▬
Indication of system response	▬▬
Degree of fine control	●

This control for lighting has clear switching with four settings clearly illuminated, plus an off setting. The numbers by the setting are arbitrary.

Apart from the numbering, the switch is not labelled as to what it does. The red light for setting 1 is on the far left of its button, hinting that there be more than one stage for each setting. Is the off button for system off, or does it apply to each of the four stages in turn? Does the vertical button to the right raise or lower the lighting generally, or on each setting? In the absence of clear annotation, the user is forced to experiment.

Usability criteria	Ranking (controller as supplied) Poor – Excellent
Clarity of purpose	▬
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Labelling and annotation	▬
Ease of use	▬▬
Indication of system response	●
Degree of fine control	▬

This controller is clearly a control device for ventilation. The knob at the lower left appears to offer control over a setpoint (presumably for temperature), against an arbitrary scale of plus or minus. In the absence of controller feedback, the user would need to learn the settings by experimentation. The function of the knob on the right is clearer, with three fan speed settings, but is it for room ventilation or a fan in a heating/cooling unit? Probably the latter, as experience has forced the facilities manager to append a label telling users not to switch off the fan.

"we sell dreams and install nightmares"
– CONTROLS SUPPLIER

SOURCE: www.usablebuildings.co.uk/Pages/Publications/UBPubsControlsForEndUsers.html and BSRIA

2

STRATEGIC FINDINGS FROM CASE STUDIES OF BUILDINGS IN USE

BPE – Building Performance Evaluation
POE – Post-Occupancy Evaluation

UBT regards POE as BPE carried out within the first few years after completion of building work, and which has some connection to its designers, client and builders.

New non-domestic buildings:
What we found in the Probe studies 1995-2002

- They often perform much worse than anticipated, *especially for energy and carbon, often for occupants, and with high running costs, and sometimes technical risks.*

- Design intent is not communicated well through the process; and designers and builders go away at handover.

- **Unmanageable complication: the enemy of good performance**.

- Buildings are seldom tuned-up and controls are a muddle. So why are we making things complicated?

- Modern procurement systems make it difficult to pay attention to critical detail. ***A bad idea when promoting innovation.***

- ***"The English spare no expense to get something on the cheap".*** ***… NIKOLAUS PEVSNER***

SOURCE: For more information, go the Probe section of www.usablebuildings.co.uk

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What we found in the Probe studies 1995-2002

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- Design intent is not communicated well through the process. **SO …** ***Understand how buildings work in use, follow through after handover, and learn from the experience.***

- **Unmanageable complication: the enemy of good performance**. **SO …** ***Stop making buildings complicated in the name of sustainability and get the simple things right.***

- Buildings are seldom tuned-up and controls are a muddle. **SO** … ***Design and deliver usability and manageability.***

- Modern procurement systems make it difficult to pay attention to critical detail. **SO** … ***Change the processes.***

- **AND THEREFORE**… **Focus on in-use performance, communicate it clearly and manage it properly.**

SOURCE: For more information, go the Probe section of www.usablebuildings.co.uk

In spite of these warnings in the 1990s, *complication has burgeoned in recent years*

- Technical complication
- Legislative complication
- Contractual complication
- Bureaucratic complication
- Tick-box procedures: feature creep
- Complication for building users and managers

So less money to spend on basics

The complication disease has now spread to housing too!

AND NOTHING JOINS UP PROPERLY!

"Complexity is profitable, [it] makes people believe you understand it."

JON DANIELSSON

F Stevenson et al,: *The usability of control interfaces in low-carbon housing,* Architectural Science Review, 1-13 (2013).

Examples of unmanageable complication in domestic buildings

SIGMA HOUSE, BRE *(illustrated)*

- Extensive feedback from occupants, including comfort, ergonomics, space.
- Complicated, confusing and unreliable technologies and renewables.
- Energy use much more than anticipated.

ELMSWELL, ORWELL

- Two-thirds of residents could not programme their thermostats.
- MVHR was present, but 95% of people opened windows in winter.
- Design air change was 0.5 to 1 ac/h. One open window could provide 17 ac/h!

SORCE: Sigma monitoring by Oxford Brookes University, Elmswell by Buro Happold in KTP with Bristol University.

and yet again ... *Some conclusions from report on TSB Building Performance Evaluation programme*

- *Significant problems with integrating new technologies,*
  especially configuring and optimising BMSs.
  Insufficient thought given to how occupants need to use them.

- *"Controls are something of a minefield."*
  Tendency to make control of heating, lighting and renewable energy systems over-complicated. The one air source heat pump had operational issues in cold weather.

- *Problems with automatic window controls.*

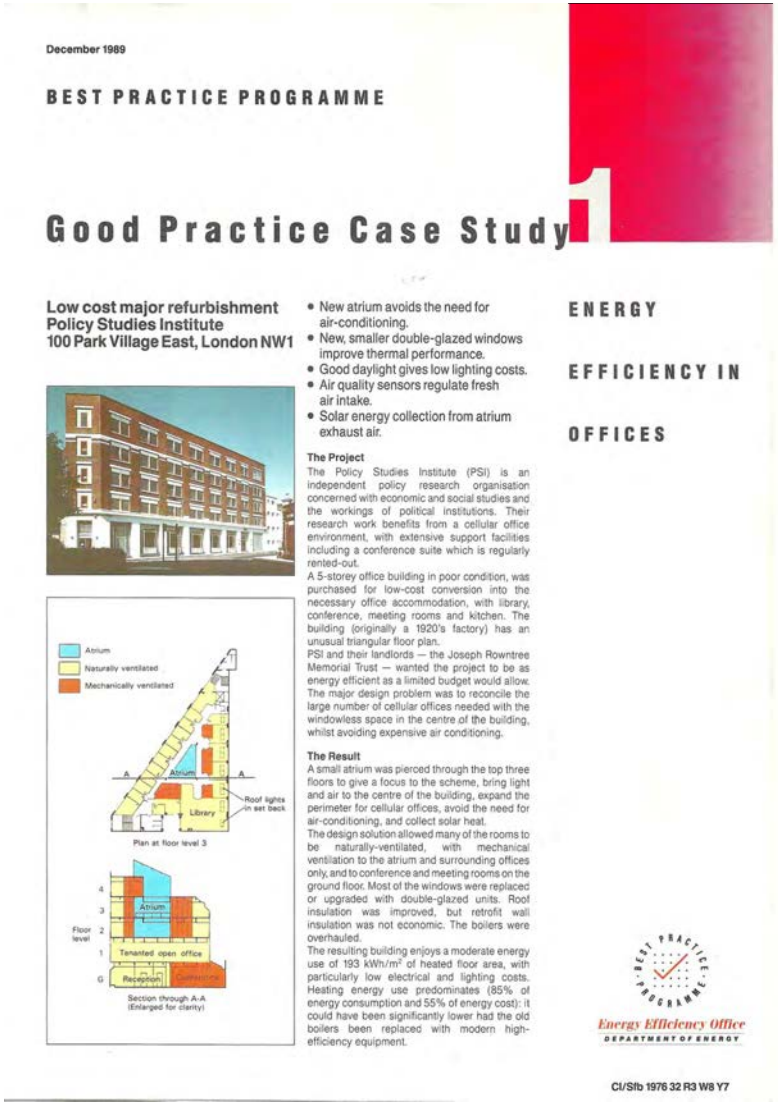
- *Multiple systems fighting each other: e.g* cooling vs heating,
  or different heating systems jockeying for control.

- *Maintenance, control & metering problems,*
  especially with biomass boilers, PVs and solar heating.

SOURCE: J Palmer & P Armitage, BPE Programme, Early finding from non-domestic projects, Innovate UK (Nov 2014)

3
WHAT PUT US ON THE TRACK?

What put us on the track (1989)?



December 1989

BEST PRACTICE PROGRAMME

Good Practice Case Study 1

ENERGY EFFICIENCY IN OFFICES

Low cost major refurbishment
Policy Studies Institute
100 Park Village East, London NW1

- New atrium avoids the need for air-conditioning.
- New, smaller double-glazed windows improve thermal performance.
- Good daylight gives low lighting costs.
- Air quality sensors regulate fresh air intake.
- Solar energy collection from atrium exhaust air.

The Project

The Policy Studies Institute (PSI) is an independent policy research organisation concerned with economic and social studies and the workings of political institutions. Their research work benefits from a cellular office environment, with extensive support facilities including a conference suite which is regularly rented-out.

A 5-storey office building in poor condition, was purchased for low-cost conversion into the necessary office accommodation, with library, conference, meeting rooms and kitchen. The building (originally a 1920's factory) has an unusual triangular floor plan.

PSI and their landlords — the Joseph Rowntree Memorial Trust — wanted the project to be as energy efficient as a limited budget would allow. The major design problem was to reconcile the large number of cellular offices needed with the windowless space in the centre of the building, whilst avoiding expensive air conditioning.

The Result

A small atrium was pierced through the top three floors to give a focus to the scheme, bring light and air to the centre of the building, expand the perimeter for cellular offices, avoid the need for air-conditioning, and collect solar heat.

The design solution allowed many of the rooms to be naturally-ventilated, with mechanical ventilation to the atrium and surrounding offices only, and to conference and meeting rooms on the ground floor. Most of the windows were replaced or upgraded with double-glazed units. Roof insulation was improved, but retrofit wall insulation was not economic. The boilers were overhauled.

The resulting building enjoys a moderate energy use of 193 kWh/m² of heated floor area, with particularly low electrical and lighting costs. Heating energy use predominates (85% of energy consumption and 55% of energy cost): it could have been significantly lower had the old boilers been replaced with modern high-efficiency equipment.

Energy Efficiency Office
DEPARTMENT OF ENERGY

CI/SfB 1976 32 R3 W8 Y7

1998: Energy Efficiency Best Practice programme replaced the Energy Efficiency Demonstration Scheme, *where results had been disappointing.*

Case Study 1 performed well in terms of its energy use, particularly electricity.

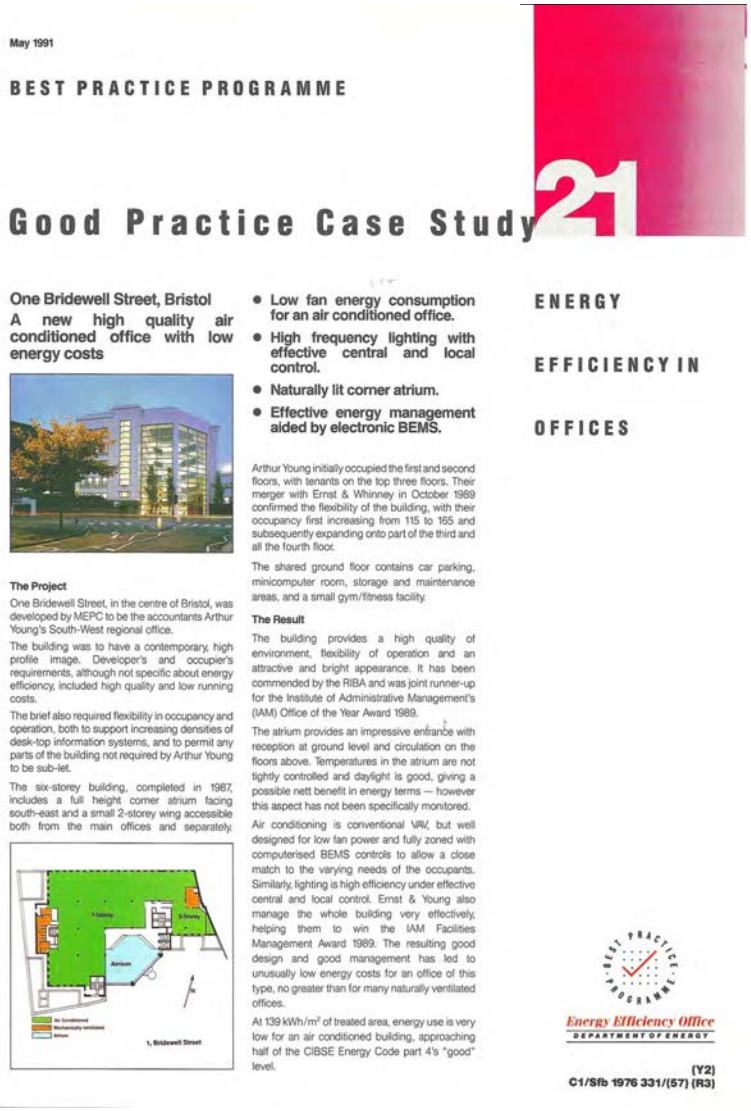
It had also been studied as part of the Building Use Studies (BUS) *Office Environment Survey* of occupant satisfaction in 50 buildings, where it also performed unusually well.

Was there a link?

We sought opportunities to combine occupant and energy surveys.

SOURCE: Energy Efficiency Best Practice Programme, Case Study 1, *Policy Studies Institute* (December 1989)

What put us on the track (1991)?



May 1991

BEST PRACTICE PROGRAMME

Good Practice Case Study 21

ENERGY EFFICIENCY IN OFFICES

One Bridewell Street, Bristol
A new high quality air conditioned office with low energy costs

- Low fan energy consumption for an air conditioned office.
- High frequency lighting with effective central and local control.
- Naturally lit corner atrium.
- Effective energy management aided by electronic BEMS.

The Project

One Bridewell Street, in the centre of Bristol, was developed by MEPC to be the accountants Arthur Young's South-West regional office.

The building was to have a contemporary, high profile image. Developer's and occupier's requirements, although not specific about energy efficiency, included high quality and low running costs.

The brief also required flexibility in occupancy and operation, both to support increasing densities of desk-top information systems, and to permit any parts of the building not required by Arthur Young to be sub-let.

The six-storey building, completed in 1987, includes a full height corner atrium facing south-east and a small 2-storey wing accessible both from the main offices and separately.

Arthur Young initially occupied the first and second floors, with tenants on the top three floors. Their merger with Ernst & Whinney in October 1989 confirmed the flexibility of the building, with their occupancy first increasing from 115 to 165 and subsequently expanding onto part of the third and all the fourth floor.

The shared ground floor contains car parking, minicomputer room, storage and maintenance areas, and a small gym/fitness facility.

The Result

The building provides a high quality of environment, flexibility of operation and an attractive and bright appearance. It has been commended by the RIBA and was joint runner-up for the Institute of Administrative Management's (IAM) Office of the Year Award 1989.

The atrium provides an impressive entrance with reception at ground level and circulation on the floors above. Temperatures in the atrium are not tightly controlled and daylight is good, giving a possible nett benefit in energy terms — however this aspect has not been specifically monitored.

Air conditioning is conventional VAV, but well designed for low fan power and fully zoned with computerised BEMS controls to allow a close match to the varying needs of the occupants. Similarly, lighting is high efficiency under effective central and local control. Ernst & Young also manage the whole building very effectively, helping them to win the IAM Facilities Management Award 1989. The resulting good design and good management has led to unusually low energy costs for an office of this type, no greater than for many naturally ventilated offices.

At 139 kWh/m² of treated area, energy use is very low for an air conditioned building, approaching half of the CIBSE Energy Code part 4's "good" level.

Energy Efficiency Office
DEPARTMENT OF ENERGY

(Y2)
C1/Sfb 1976 331/(57) (R3)

This air-conditioned building had an energy performance similar to some of the good naturally-ventilated buildings.

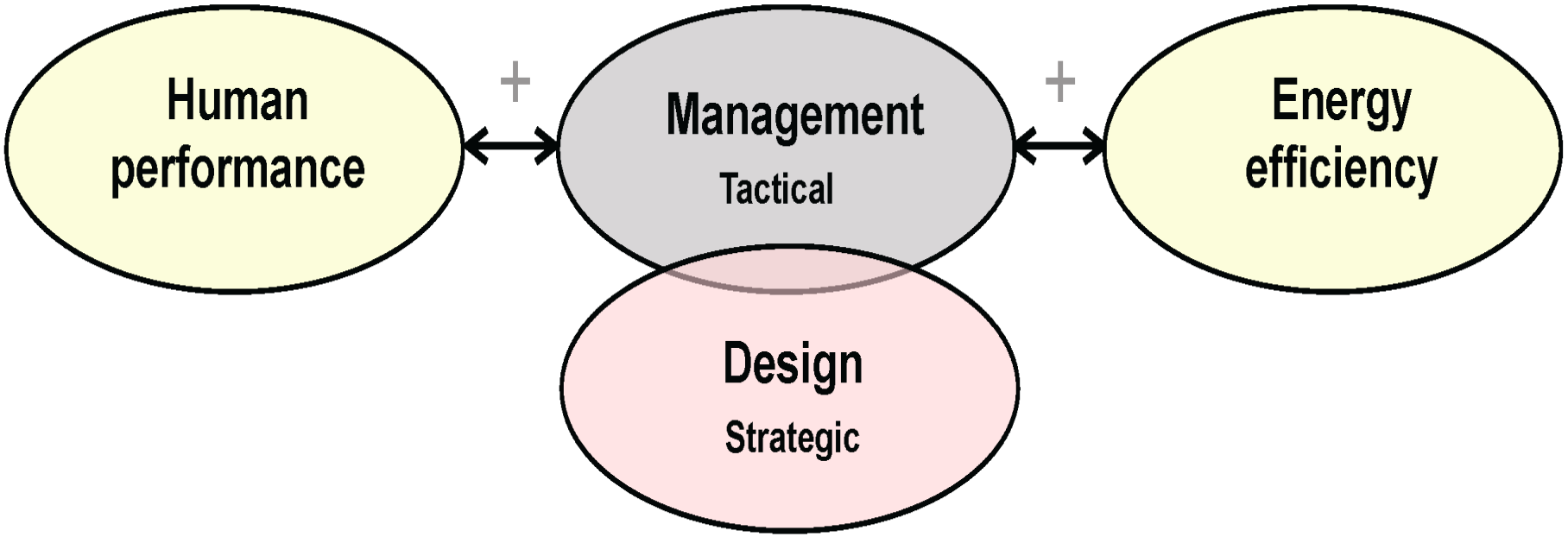
A building in London, with the same design team and a similar technical specification had three times the carbon footprint from annual energy use.

What was going on?

We sought opportunities to do a deeper investigation, including an occupant survey by Building Use Studies.

SOURCE: Energy Efficiency Best Practice Programme, Case Study 21. *One Bridewell Street* (May1991)

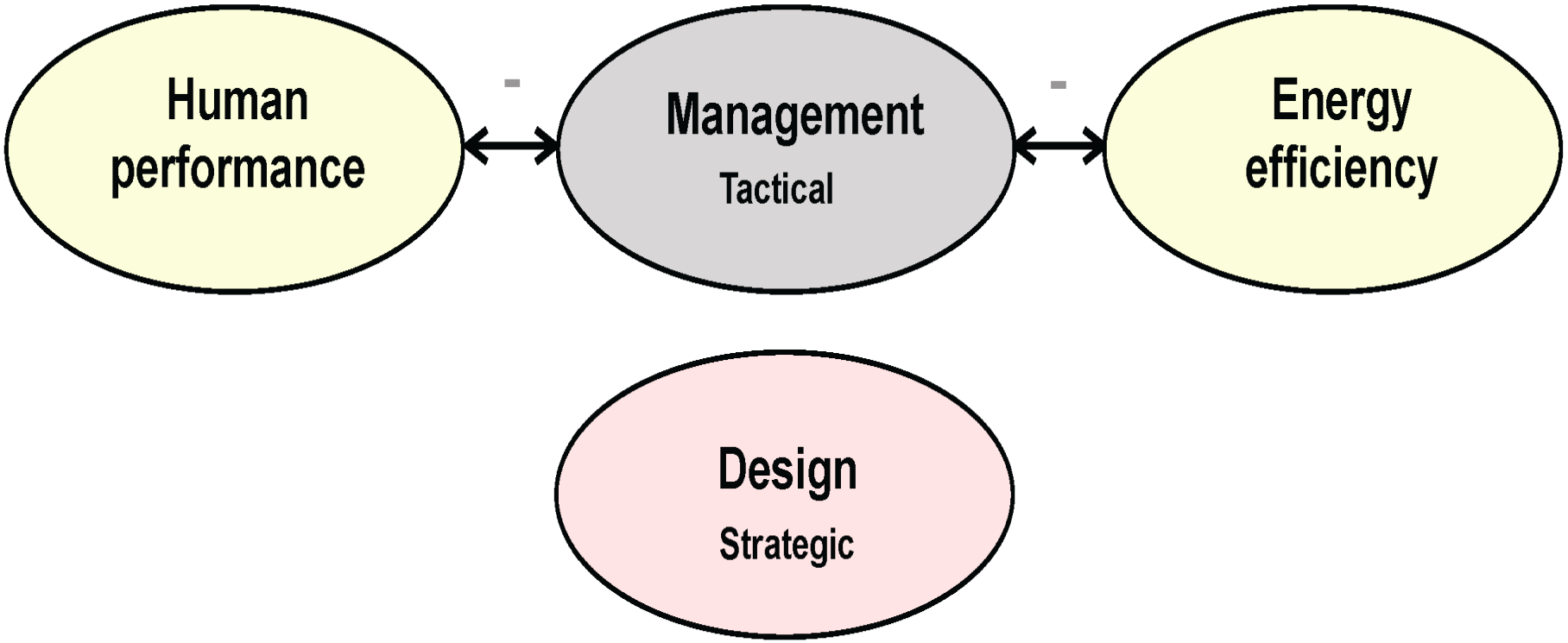
Where good things happened …
associations of low energy with happy occupants



The better-performing buildings tended to be where there was a better understanding of user requirements during procurement, and better follow-through to good management in use.

One could usually name the individual or individuals responsible for championing the building in use and driving the virtuous circles.

… and where they didn't
no positive associations



Without this understanding and commitment - linking design to use and management – performance in use could be disappointing, in terms of energy and/or occupant satisfaction. *So we need to bring out the leaders*.

You can't tell if you have a good building

… *unless you find out how it is working*

Elizabeth Fry building has the last laugh

The story of the Elizabeth Fry building (AJ 23.4.98) contains a number of ironies. My favourite is that it didn't even make the shortlist of the Green Building of the Year Award in 1996.

DR ROBERT LOWE
Leeds Metropolitan University

LETTER TO ARCHITECTS' JOURNAL

The good performers don't necessarily impress the judges

The original Elizabeth Fry Probe paper was published in *Building Services Journal,* 37-41 (April 1998).

It was the practice, not just the product

Factors for success at the Elizabeth Fry Building, UEA

But only its technical features were mentioned when a Royal Commission used it an exemplar

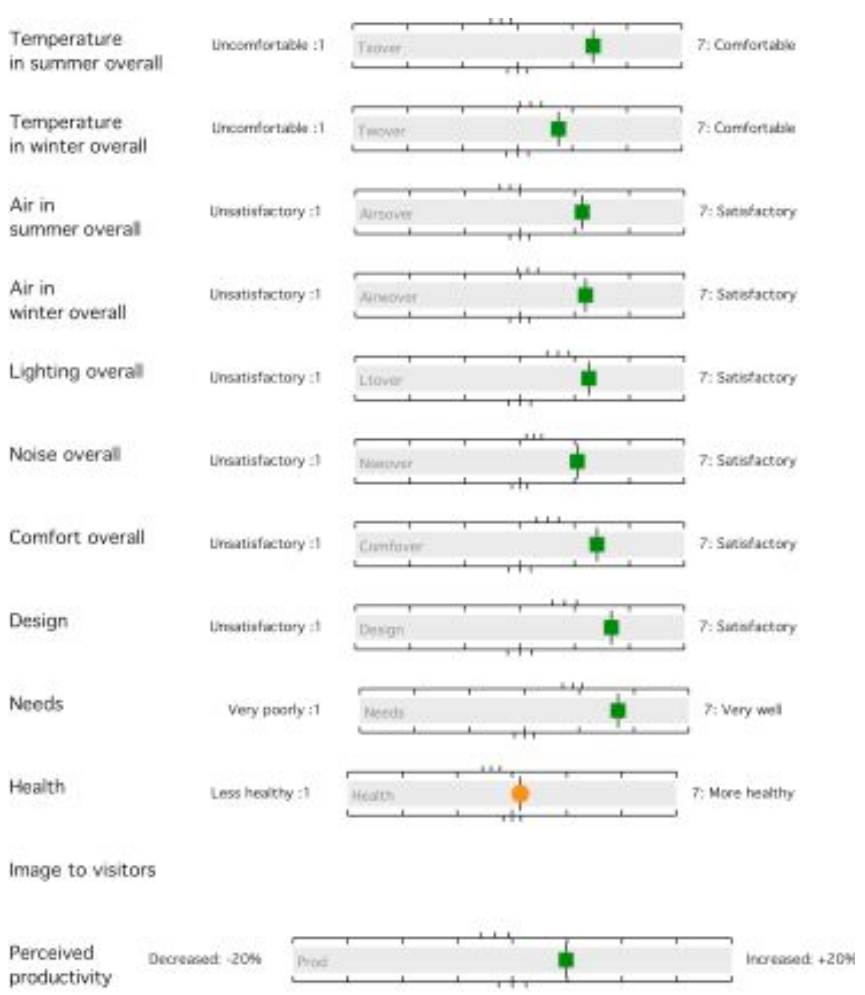
- A good client
- A good brief *incorporating the client's previous experience.*
- A good team *(worked together before on the site).*
- Specialist support *(especially on insulation and airtightness).*

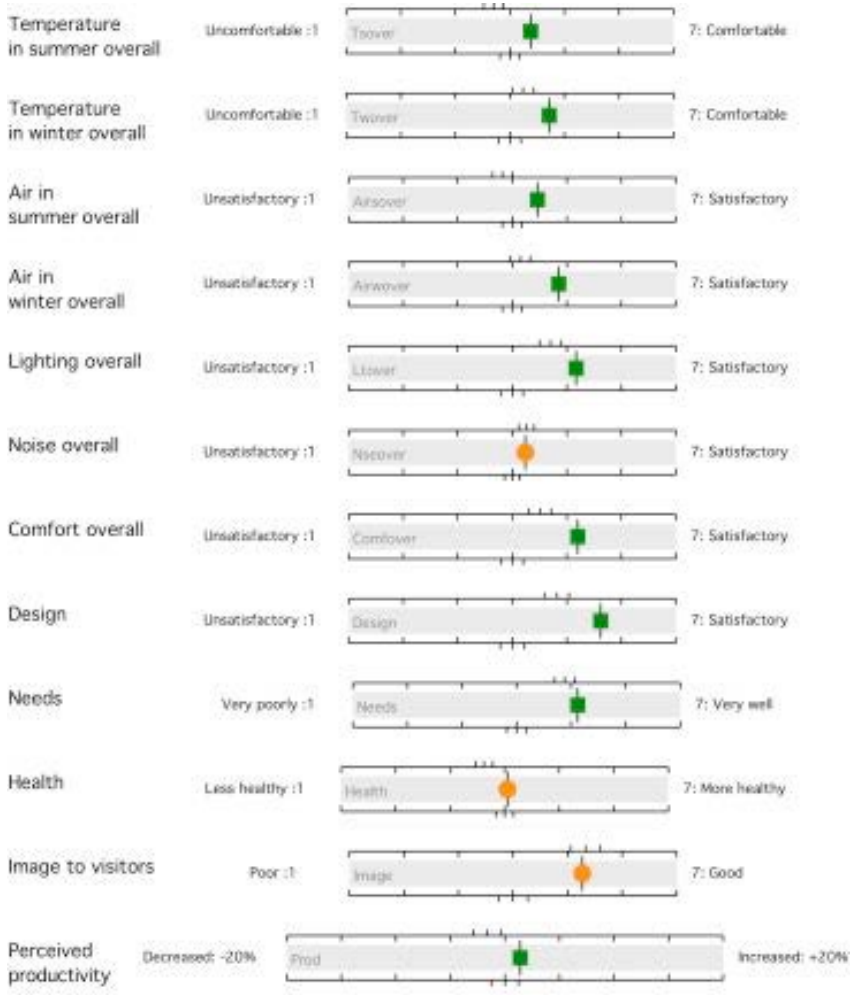
- A good, robust design, efficiently serviced *(mostly).*
- Enough time and money *(but to a normal budget).*
- An appropriate specification *(and not too clever).*
- An interested contractor *(with a traditional contract).*

- Well-built *(attention to detail, but still room for improvement).*
- Well controlled *(but only eventually, after monitoring and refit).*
- Post-handover support *(triggered by independent monitoring).*
- Management vigilance *(which has been largely sustained).*

SOURCE: W Bordass et al, *Assessing building performance in use 5*, BR&I **29** (2), 144-157 (March-April 2001), Figure 6.

Elizabeth Fry Revisit - *Occupant Survey*





SOURCE: W Bordass and A Leaman, *The Elizabeth Fry Building revisited,* Building Services Journal, 30-36, (March 2012).

So what do we need to do?

- If we are to meet the challenges of sustainability, the role of the building professional must change.
- We need to be concerned not just with inputs and outputs, but in-use outcomes.
- We must close the feedback loop and initiate virtuous circles of rapid improvement, involving all players.
- This is a systemic problem: we need to widen the perspective beyond buildings and construction.
- Building performance in use needs to become an independent and properly-resourced knowledge domain, in the public interest.

MORE IN PART 1.2

www.usablebuildings.co.uk