Buildings, people, energy and carbon: *myths and realities*

Bill Bordass
bilbordass@aol.com
the **USABLE BUILDINGS TRUST**
www.usablebuildings.co.uk

With thanks to Arup for the video link from London

Sorry I can't be here in person

but I'm hoping to reduce my footprint

The **rebound effect** *(Brookes-Khazzoom paradox)*, or :
Greater energy efficiency can increase energy use!

SOURCE: Advertisement in the *Independent,* 4 April 2009.

Structure of the talk

1. **Paradox, transition and the Age of Consequences**
2. **How much do we need to change our buildings?**
3. **Design intent and reality: the Credibility Gaps**
4. **Making in-use performance visible and actionable**
5. **Communicating energy and carbon performance**
6. **Get real about building performance**

1

PARADOX, TRANSITION AND THE AGE OF CONSEQUENCES

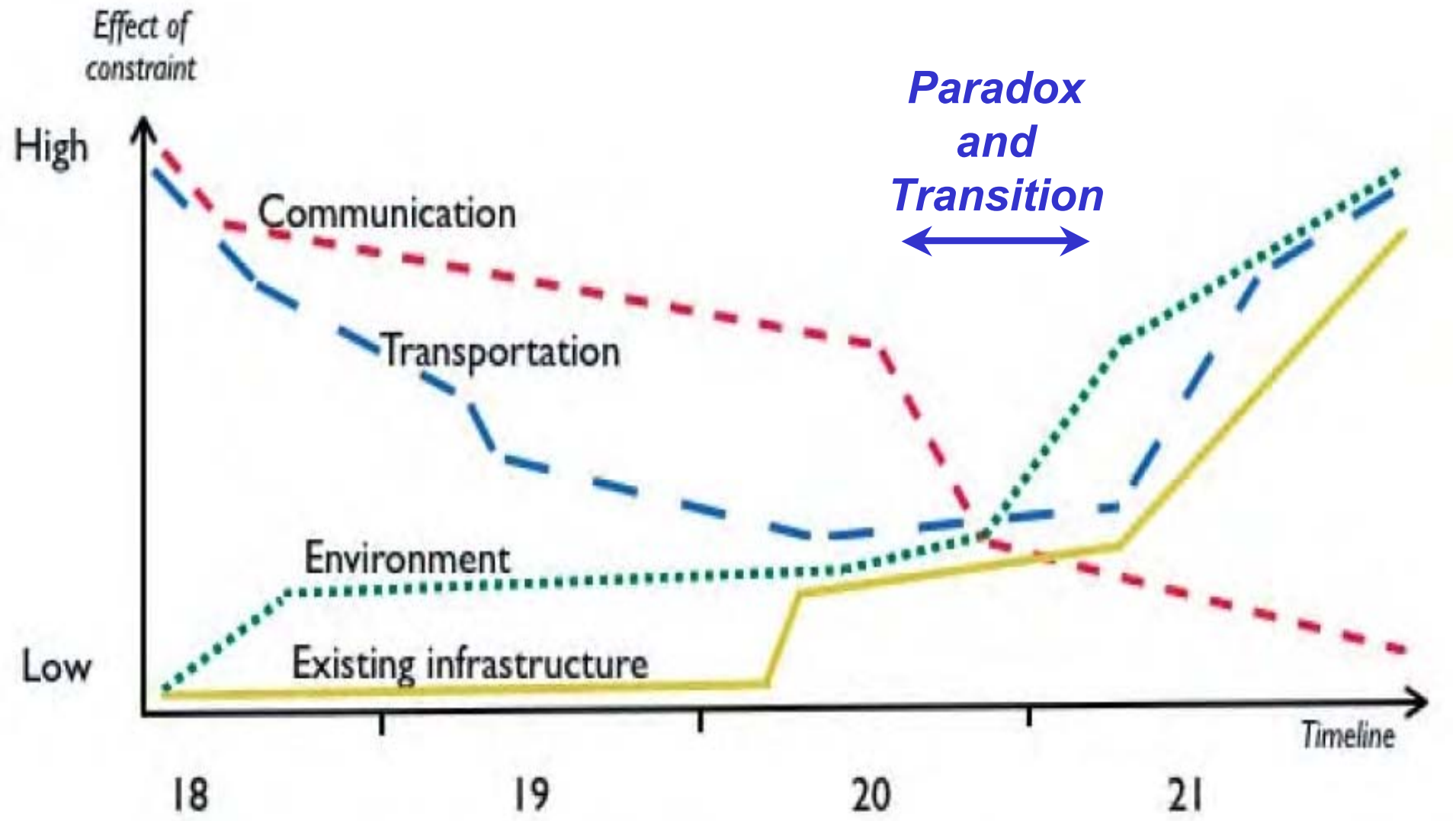
Vision 2000: *the building environment*
Buildings in the age of Paradox

- A study we helped undertake for a UK utility in 1993-94.
- It examined social, economic and technical trends affecting building electricity use in 20 years' time.
- Identified that we were in an ***Age of Paradox*****,** *with the economy and our buildings not taking proper account of the world in which they would find themselves.*
- Predicted a ***Period of Transition****,* which we now seem to be in, *though it is also full of shock and paradox.*
- Towards an ***Age of Consequences,*** *in which decisions would be much more strongly influenced by their likely downstream effects.*

REFERENCE: A Leaman (ed) Buildings in the Age of Paradox, Institute of Advanced Architectural Studies, York, UK (1996).

Paradox and transition:

adapting to changing constraints over time



SOURCE: A Leaman, Chapter 1 of J Worthington (ed) *Reinventing the Workplace, 5*, Butterworth (1997, 2004). Figure 1.

The UK lights 4, Australia 3, the World 200. ***We don't put them out, so about 2000 of these fires are burning as we speak.***

We need real data to save real energy and carbon, *not virtual carbon … and*

- Where we get to in 2050 is important …
- but much more important is the route we take - since it is the cumulative emissions that count; and
- there are lots of low-cost or cost-reducing savings; but …
- cap and trade doesn't help us to beat the target.

Home » Blog » Sandbag's blog

EU emissions plunge leaving emissions trading scheme high and dry

Thu, 01/04/2010 - 14:54 — Sandbag

New data released today reveals greenhouse gas emissions across the EU are in steep decline. Emissions covered by the EU Emissions Trading Scheme between 2008 and 2009 dropped by 11%, following on from a cut of 6% the year before.

This would be welcome news for the environment and provide a silver-lining to the grim economic recession that has contributed to the cuts, if it were not for one thing: unless caps are tightened there will be no overall reduction in pollution levels. Permits issued under the EU trading scheme can be banked forward indefinitely meaning they will sooner or later be used to pollute.

2

HOW MUCH DO WE NEED TO CHANGE OUR BUILDINGS?

Buildings are increasingly under the policy spotlight

- In the developed world, their operation accounts for about 40% of fossil fuel emissions, with construction and alteration adding another 5-10 percentage points.
- They last a long time.
- They appear to offer a wider range of opportunities than transport, industry or infrastructure.
- From a strategic point of view, policymakers would like new buildings to cease to be a problem for the future *(hence ambitions for zero-energy or zero-carbon) …*
- while existing buildings improve as rapidly as possible.

But how do we invest wisely?

Some myths and realities
in getting lower energy and carbon buildings

- It is all about new construction.
  NO: *most of the buildings we will have in 2050 are already here.*
- It is mostly about heating and insulation.
  NO: *electricity dominates in many UK non-domestic buildings.*
- It's all about carbon. ***NO:*** *it is about lots of things.*
- The fuel industries can sort it out. ***NO:*** *we need to reduce demand too.*
- It's all about economics and technology:
  NO: *It's firstly about commitment, use, monitoring and management, joining things up sensibly, and paying attention to detail.*
- It is up to the construction industry to put things right.
  YES & NO: *the occupier's habits, management and equipment have a major influence … but the industry also needs to understand them*
- The construction industry knows what to do.
  NO: *it builds the buildings, it doesn't follow through into use.*
- We need a massive refurbishment programme:
  YES & NO: *not until we know how to get things to work as intended.*

Some levels of refurbishment
in order of decreasing cost

1. Major reconstruction *(effort similar to new construction, e.g. strip back to frame; or redevelop behind retained facades).*
2. Major internal reconstruction.
3. Major external renovation *(e.g. overcladding)*
4. Major renovation or replacement of services *(e.g. heating, lighting).*
5. Addition of renewable or community energy systems.
6. Fitout alterations to suit changes in tenants or requirements.
7. Maintenance-related replacements and upgrades *(fabric and services)*.
8. Dedicated energy-saving investments.
9. Changes to controls, management and occupancy. *Use things differently.*
10. Minor repairs and improvements.

The measures with the largest and fastest effects tend to be at the bottom.

*For the more expensive ones, use **"Opportunity Points"** where work needs doing for other reasons, or where groups of buildings can be altered together.*

Refurbish to what level?

- It seems sensible to aim for the best possible performance …
  ***BUT** is the best the enemy of the good?*
- Complicated systems can need a lot of attention in design, specification, construction, commissioning and operation if they are to work properly:
  ***BUT** is this complication worthwhile?*
- **SHOULD WE USE THE PARETO PRINCIPLE?**
  Can we get 80% of the result for 20% of the effort and cost?
  ***IF SO,** to spread the same amount of effort and cost over five buildings, would give four times the savings nationally - **except at opportunity points,** where marginal costs of energy savings will be a small part of total project costs.*

  HOWEVER, Sometimes one needs to do something very well to get assured results. For example:
- You may make something else simpler and cheaper. *For example, if you improve fabric performance radically, HVAC systems and controls can become smaller, simpler and lower cost. User behaviour can also become less of an influence, owing to thermal stability; and small systems having little power to spare to waste energy.*
- Work at University College London suggests that if thermal performance of existing houses in the UK is improved a little, in practice their energy use can go up too, because people may decide it is worth heating them better.

How can we make changes most effective?

Tune into outcomes - the evidence under our noses

"in theory, theory and practice are the same, in practice they aren't"
SANTA FE INSTITUTE for research into complex systems

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

"unlike medicine, the professions in construction
have not developed a tradition of practice-based user research …
Plentiful data about design performance are out there, in the field …
Our shame is that we don't make anything like enough use of it"
FRANK DUFFY Building Research & Information, 2008

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

Some people who need to be motivated

- CLIENTS - to build or alter buildings so they perform much better.
- DESIGNERS - to make solutions truly low energy and carbon in use, realising the design intent, and minimising the credibility gaps.
- ADVISERS and MODELLERS - to provide services that focus more directly and reliably on energy and carbon saving.
- BUILDERS - to pay attention to detail, to handover, and to tuning up.
- SUPPLIERS - to provide more appropriate and usable equipment and controls.
- OCCUPIERS - to adopt sensible standards, buy efficient equipment, use it efficiently and have a culture of waste avoidance.
- MANAGEMENT - to focus on energy and carbon performance.
- SERVICE PROVIDERS: FM, Maintenance etc. - to balance service with economy.
- INDIVIDUALS - to play an effective part in avoiding waste.
- AGENTS - to tune into the signals and influence the market.
- GOVERNMENT - to maximise added value from statutory processes, to make effective use of all the data collected by helping things to interlock, and to minimise bureaucracy, unintended consequences and transaction costs.

Moving to a sustainable, low-carbon economy ought to be
an inspiring challenge, *not a bureaucratic obstacle race.*

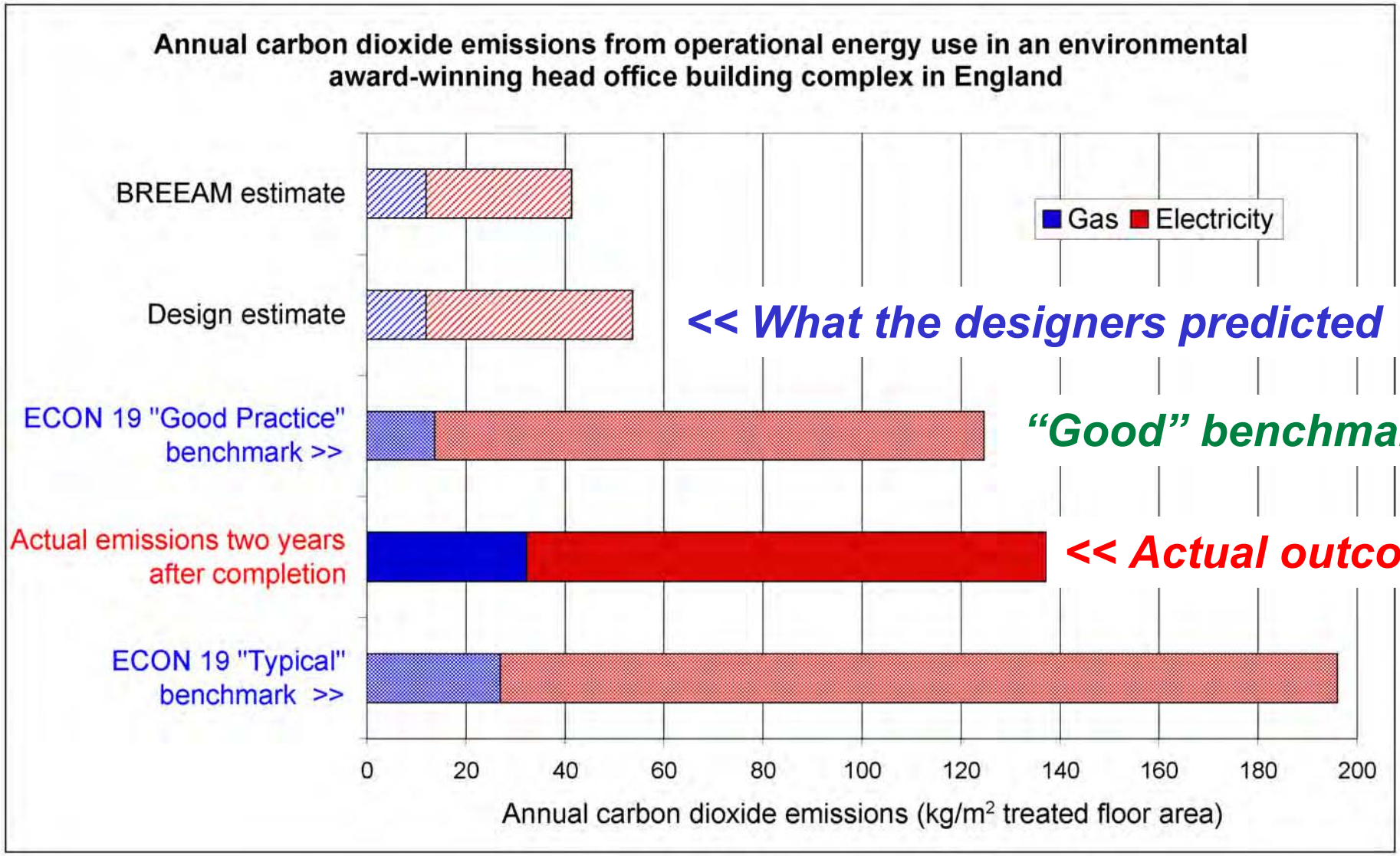
3

DESIGN EXPECTATION AND REALITY: *THE CREDIBILITY GAPS*

The Credibility Gap: *We couldn't deliver low-energy and carbon performance reliably ten years ago. In the UK we're still finding it difficult.*


Green office increases energy use

BUILDING DESIGN 26 NOV 04



SOURCE: data from S Curwell et al, *The Green Building Challenge in the UK,* Building Research & Information **27** (4/5) 286 (1999).

We've been trying to close the feedback loop at ***www.usablebuildings.co.uk***

Usable BUILDINGS ... for feedback and strategy

... from the Usable Buildings Trust

Password
Publications
Events
One-liners
Probe
Incubator
Portfolio
Quick intro
Donations
Latest
Books
Leader
Links
Contact us

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

Donations: We welcome donations. Please use the Donations and Gift Aid form on the Sponsorship section of our Brochure. Thank you.

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

Website: Our website is text-based and designed primarily to deliver pdf files. Website set-up.

Latest posted : The Building Services Brief of the Future | 89 Culford Road | Surpassing Expectations | Human Factors: the bottom line | Soft Landings | The Great Escape |

Basics: POE and Feedback: Getting Started | Probe 9 | A Guide to Feedback and Post-Occupancy Evaluation |

Full Latest list Live (real-time) monitoring [Please send in more examples!]

Latest one liners: "Who are you going to believe? Me, or your own eyes?" Groucho Marx | "If the choice is between cooking alive and wasting money unnecessarily I would rather waste some money, because long before we cook we are going to kill each other if we don't deal with climate change." George Soros | "The paradox of public transport is the better it does its job the less 'efficient' it may be." Tony Judt | "I got rid of the Ferrari: it was bad for my hamstrings." Ryan Giggs More

Hosting : We host the Feedback Portfolio: Techniques and the Probe archive.

Support : We support Soft Landings.

Searching : Most of the material available here is in pdf files, about two-thirds of which are password protected. If you wish to search within files that are not password protected use the Google search syntax:"filetype:pdf site:www.usablebuildings.co.uk *search term*" . Example: for articles on health type in the Google search area: "filetype:pdf site:www.usablebuildings.co.uk health" Show example

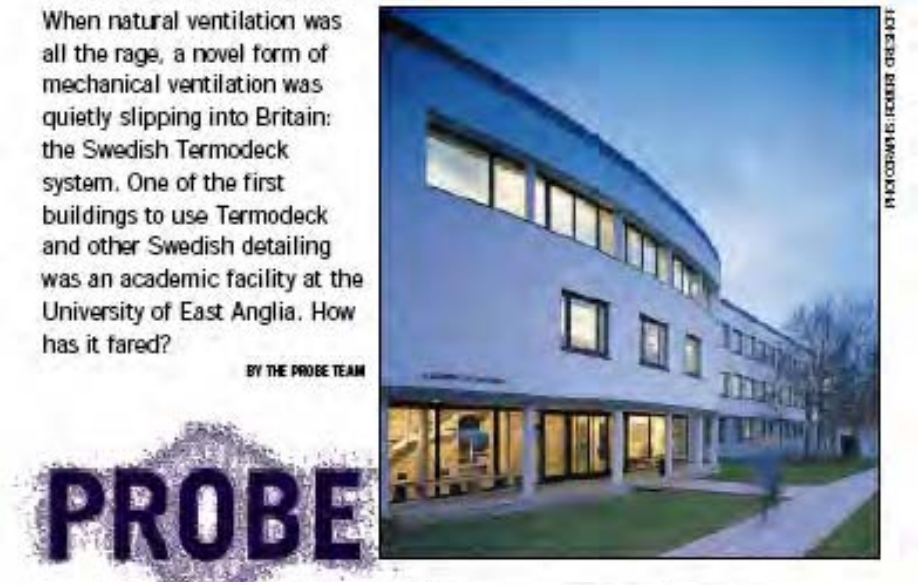
Thursday, March 18

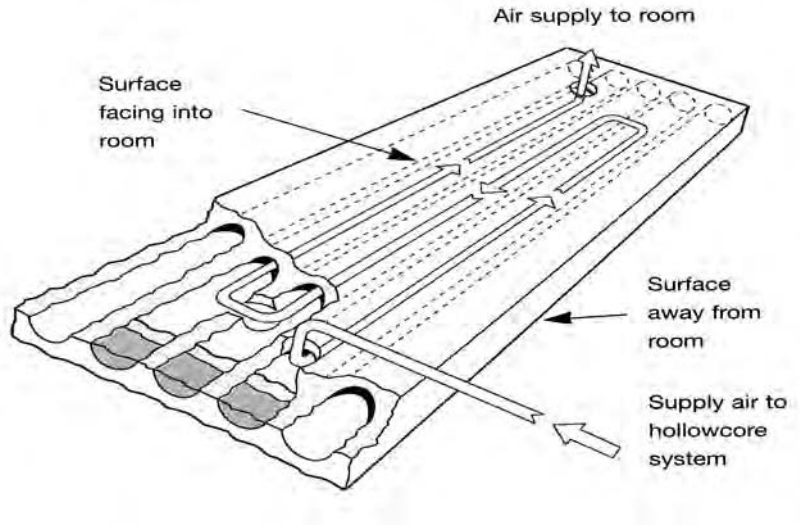
What do we tend to find?

- New buildings often perform much worse than anticipated, *especially for energy and carbon.*
- Unmanageable complication is the enemy of good performance. *So why are we making buildings more complicated in the name of sustainability?*
- Design intent is seldom communicated well to users. *Designers and builders tend to go away at handover.*
- Buildings are seldom tuned-up properly. *So if we have more to do, what chance do we have?*
- Good environmental performance and good occupant satisfaction tend to go hand in hand, *but only because good, committed people have made it so.*

KEEP IT SIMPLE, DO IT WELL,
FOLLOW IT THROUGH, TUNE IT UP

Credibility Gaps: Features or outcomes?
What was the winner competing against?





Elizabeth Fry building, University of East Anglia

- Mixed mode, highly insulated, construction with ventilated hollow core concrete floors.
- To a normal budget.

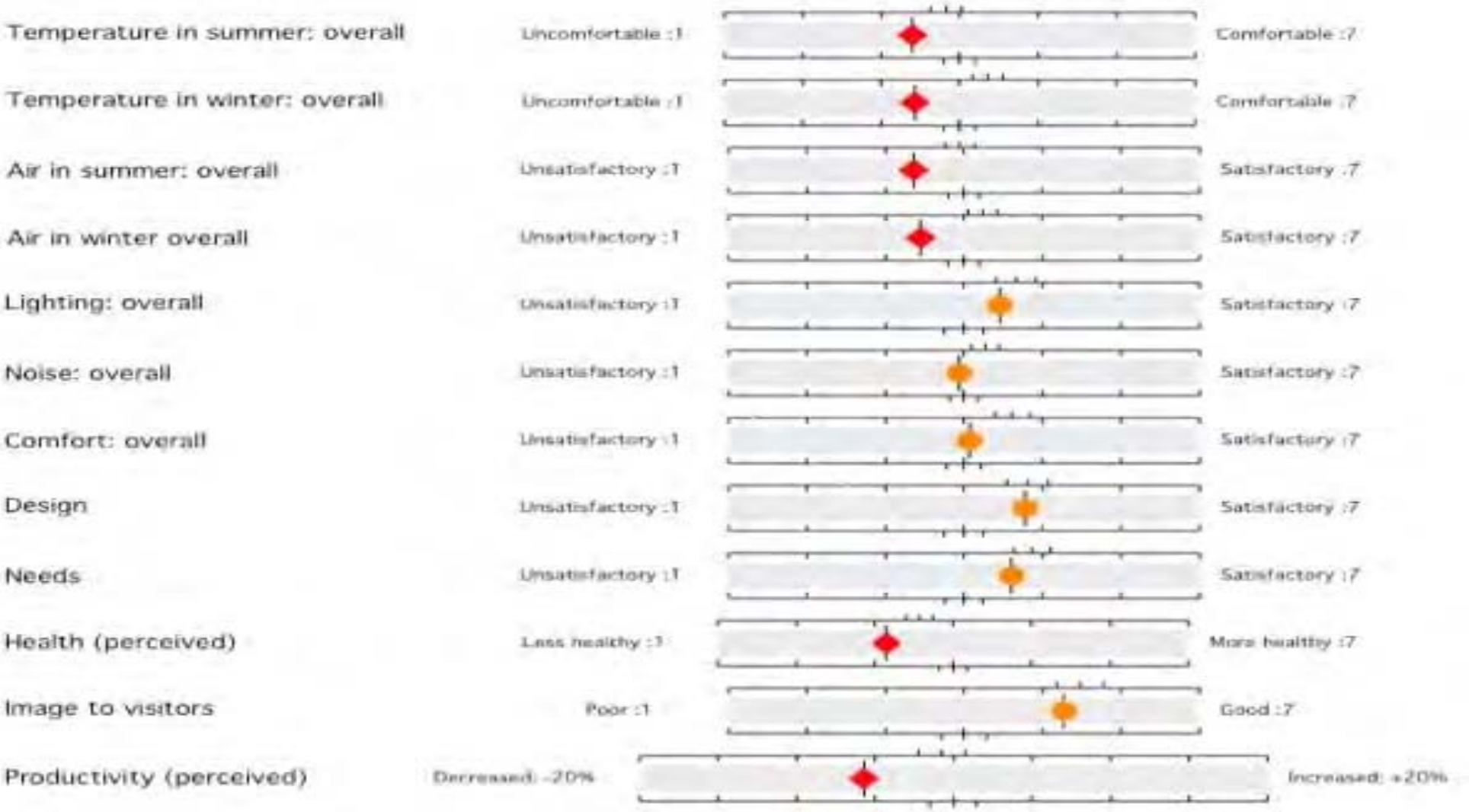
At the time of publication (1998):

- Best energy performer of the Probe studies.
- Best occupant satisfaction.
- Highest occupant satisfaction with summer temperatures of all BUS surveys, although cooling is by night ventilation only.
- ***Didn't even reach the shortlist for the award.***

The good performers don't necessarily impress the judges

Credibility gaps: Occupant satisfaction

Occupant survey, five year old office, January 2010

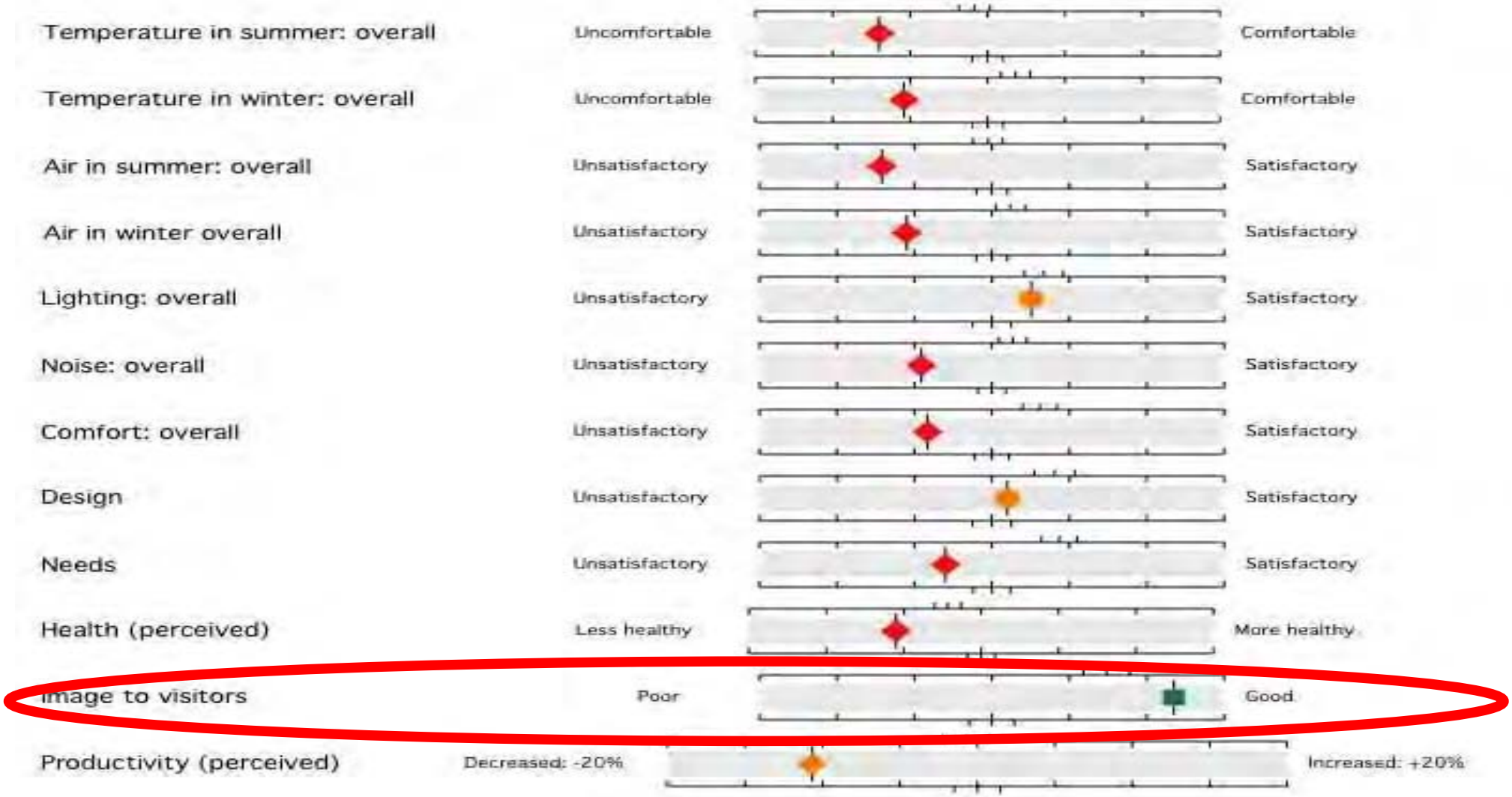


Do pilot projects of improvements where you can.

SOURCE: Unpublished occupant survey of an open-plan air-conditioned office 2010. Courtesy of Building Use Studies Ltd.

Credibility gaps: Occupant satisfaction

Occupant survey, new award-winning school July 2009



What impresses the judges may not impress the users!

SOURCE: Unpublished occupant survey of an award-winning school 2009. Courtesy of Building Use Studies Ltd.

Why the Credibility Gaps?

Expectations not set realistically, and not managed through the process

- Design estimates often don't count everything: *only normal services in typical spaces (e.g. those subject to building regulations), no night loads, perfect control, some or all occupier loads often omitted or underestimated (for energy, if not for connected loads).*
- Slippage during design development: *changes in client requirements, fabric, services, VE. Consequences not reviewed.*
- Slippage during construction and commissioning: *negotiations, substitutions, build quality, systems, controls, delays.*
- Changes after completion: *fitout changes and clashes, no follow-through, no fine tuning or training, unintended outcomes.*
- Spilt responsibilities: *developer/owner, landlord/manager/tenant, outsourcing.* Principal/agent problems. Procurement of controls.
- Unintended consequences and revenge effects, *technical surprises, management shortcomings, undetected waste, controls problems, poor user interfaces, systems defaulting to ON.*

Credibility gaps also occur in Australia

you will have heard from Paul Bannister this morning

SOURCE: Ecolibrium, the Journal of the Australian Institute of Refrigeration, AC and Heating, 24-32 (February 2009)

It's not just the product, but the process

"Soft" factors for success at the Elizabeth Fry Building, UEA

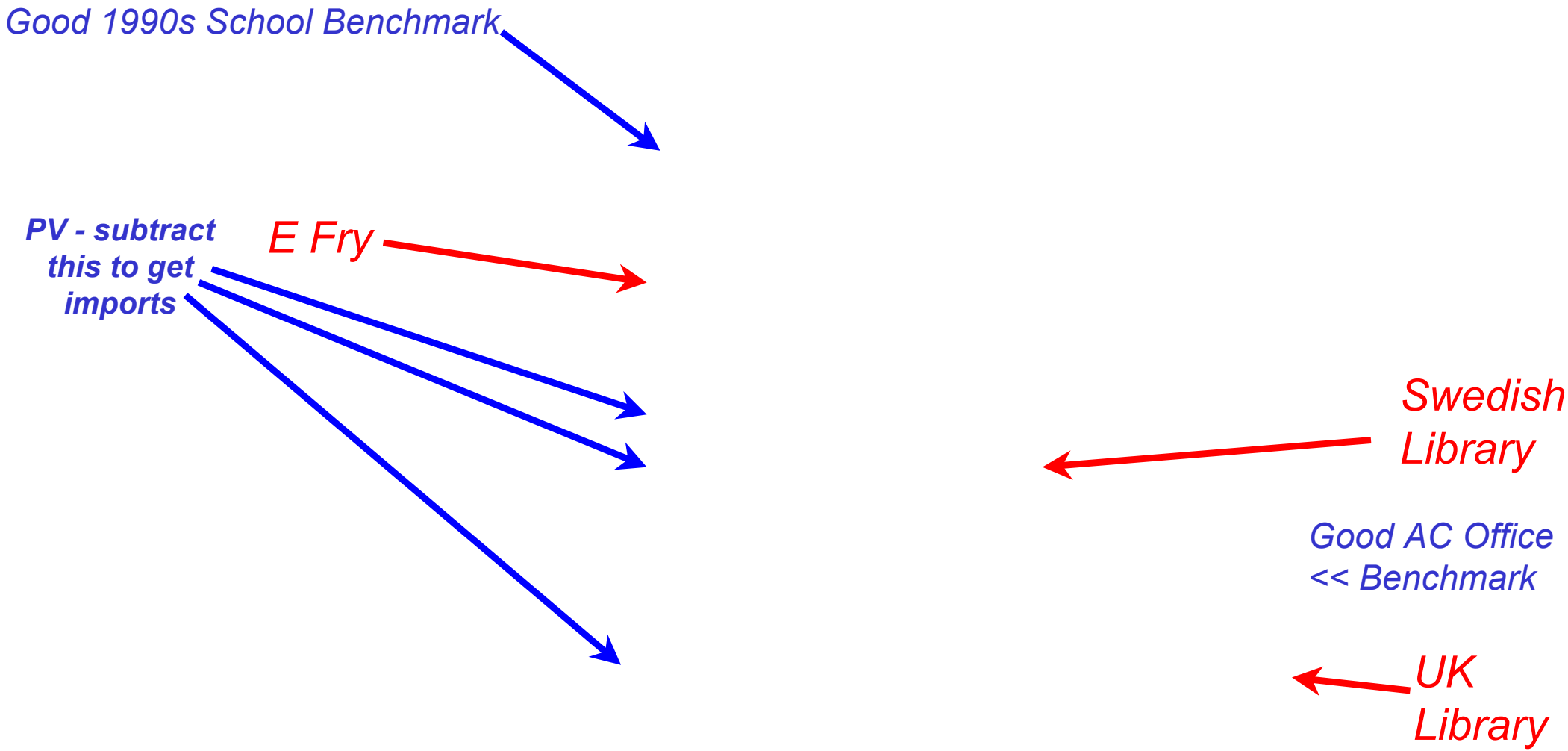
- A good client.
- A good brief.
- A good team *(worked together before on the site).*
- Specialist support *(e.g. on insulation and airtightness).*
- A good, robust design, efficiently serviced *(mostly).*
- Enough time and money *(but to a normal budget).*
- An appropriate specification *(and not too clever).*
- A good, 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 *(easier now, but needs to be sustained).*

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

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

How do newer buildings compare with E Fry?

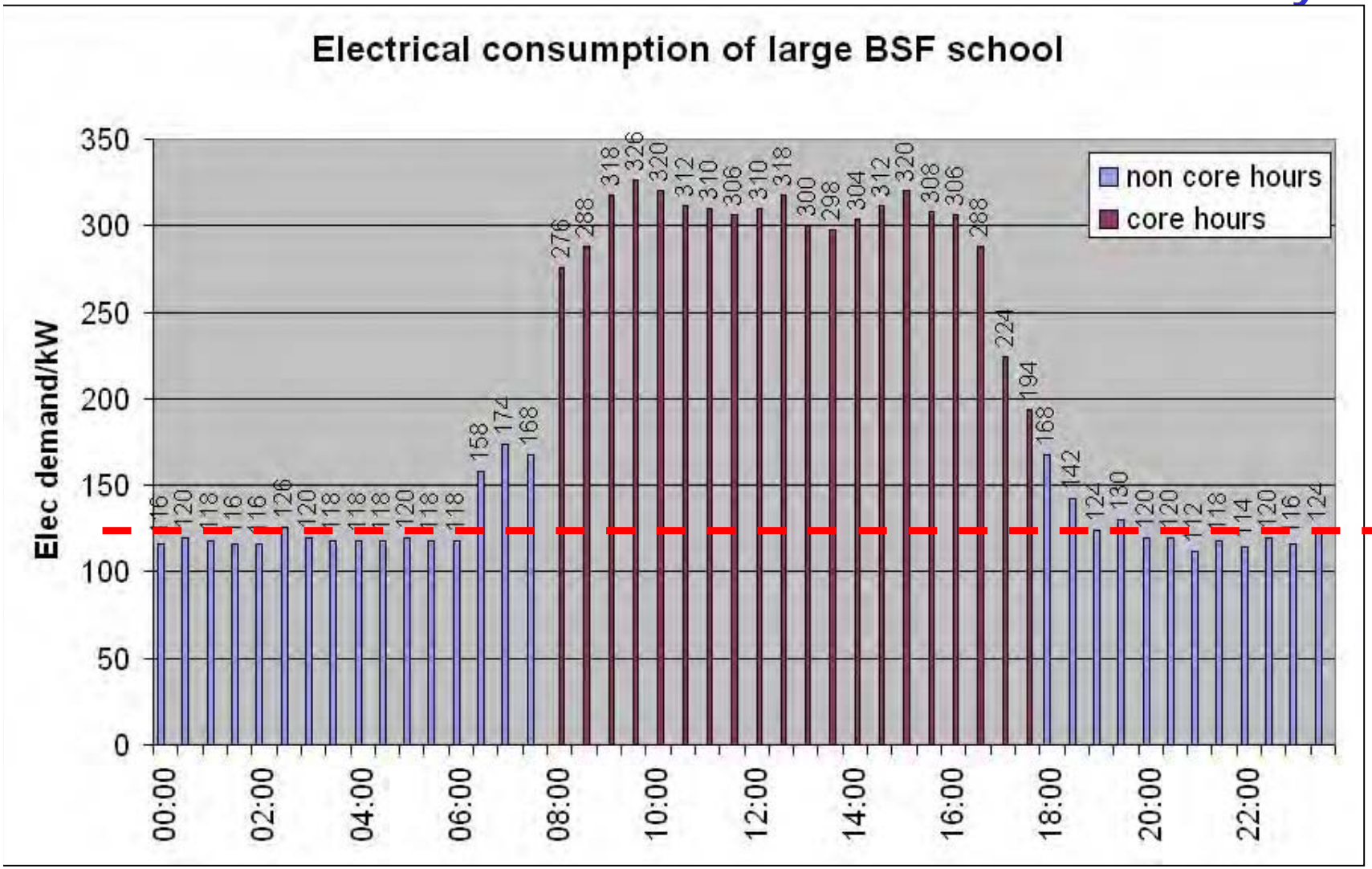
Annual energy use expressed as kg CO_2/m^2 (UK factors)



SOURCE: Various. UK and Swedish library data from: *Eubart - Intelligent Buildings, Final technical brochure* (2004), figure 5.

The electrical tail can easily wag the dog

kWh/half hour in a recent UK secondary school



120 kW baseload: ca. 7 W/m² or 45 kWh/m² p.a.

Equivalent to 60% of all lighting or 1000 PCs including screens. printers etc.

Breakdown of annual electricity use: **44% used between 0800-1800 on term time days**

56% (~ $ 125 k) of electricity used at other times: 14% term weekends, 26% term nights, 16% holidays

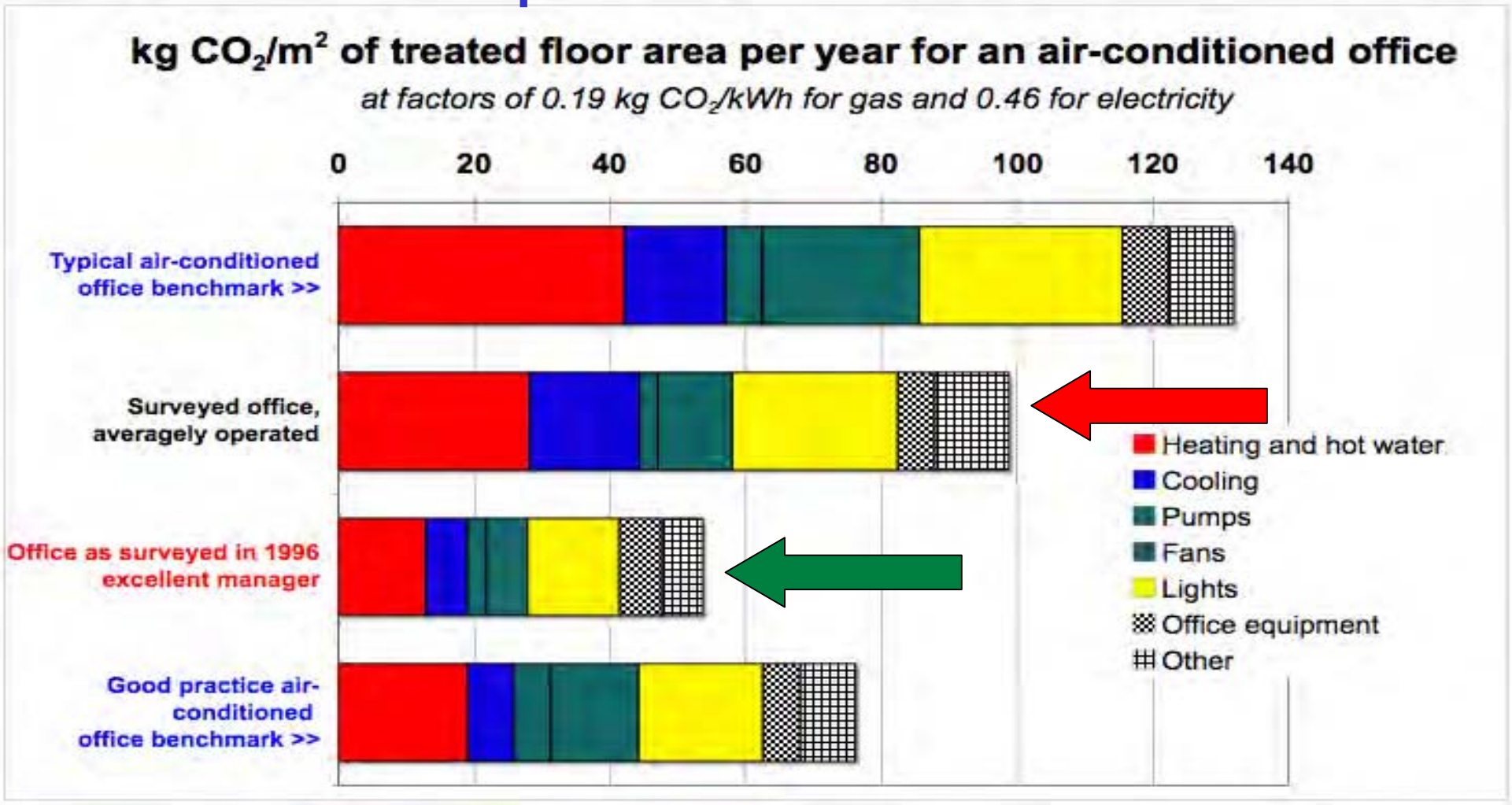
SOURCE: Buro Happold monitoring (October 2009)

So why are we being encouraged to spend money on green bling when we can't get the fundamentals right?

4

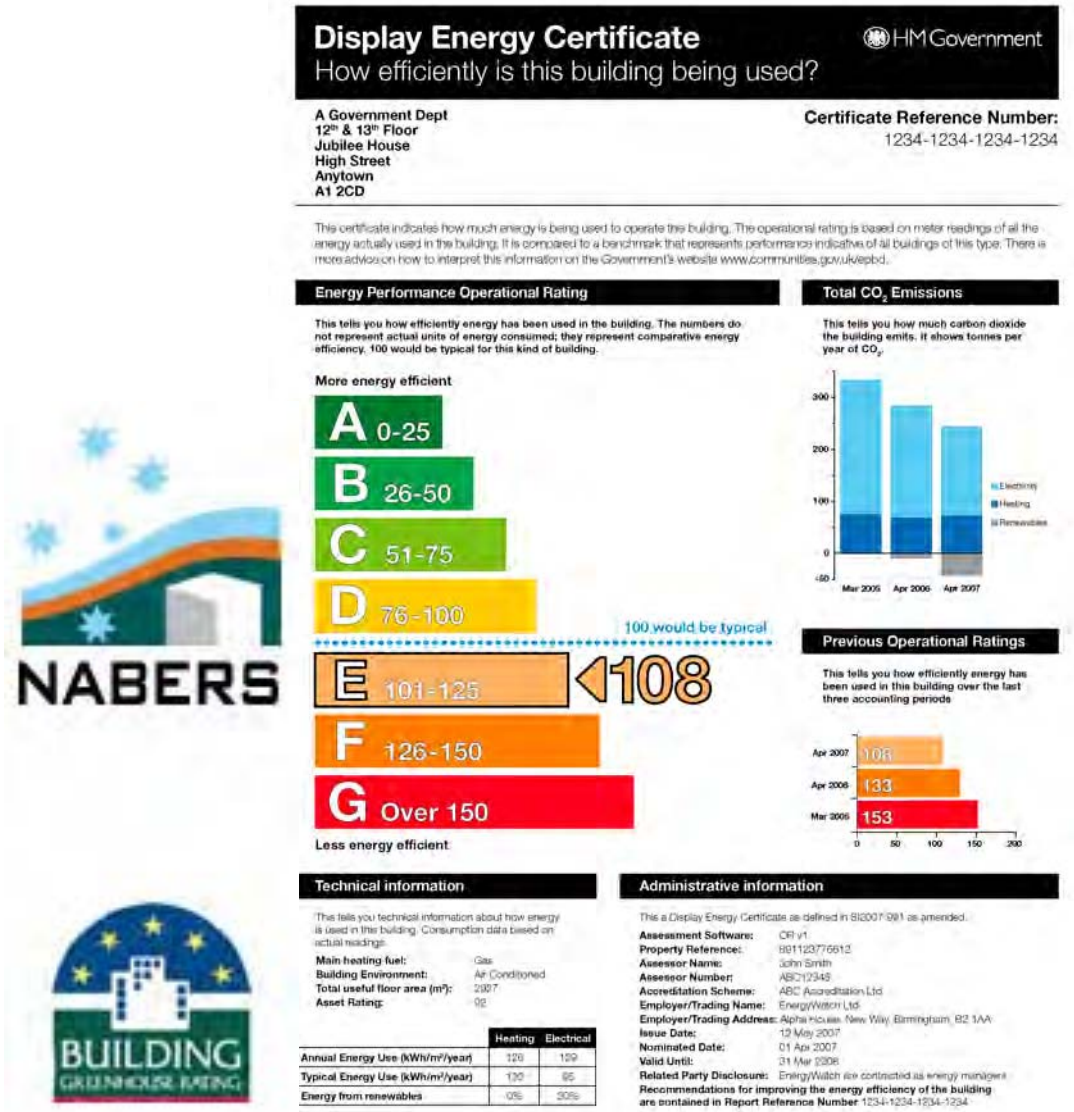
MAKING IN-USE PERFORMANCE VISIBLE AND ACTIONABLE

Management can have an enormous effect on performance in use …



In 2000, the excellent office and energy manager was replaced by an outsourced FM company, and the annual energy use nearly doubled.

… so making performance visible and actionable can lead to big improvements



NABERS

BUILDING GREENHOUSE RATING

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

Previous Operational Ratings

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

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 (m^2):	2307
Asset Rating:	92

	Heating	Electrical
Annual Energy Use (kWh/m^2/year)	126	129
Typical Energy Use (kWh/m^2/year)	130	95
Energy from renewables	0%	20%

Administrative information

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

Assessment Software:	OR v1
Property Reference:	89112376512
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

Effect of better awareness on energy performance of a UK office building

Making performance visible:
Sub-metering is mandated, but is it used?

This high voltage utility meter was wrongly calibrated, leading to substantial overcharging. This is rare, but not unique.

The rincipal sub-meter was not working, so the utility meter fault went five years undetected. The other two were wrongly calibrated, so impossible to do cross checks.

5

COMMUNICATING ENERGY and CARBON PERFORMANCE

Communicating energy performance:

Houston, we have a problem …

WE'RE NOT VERY GOOD AT COMMUNICATING CLEARLY:

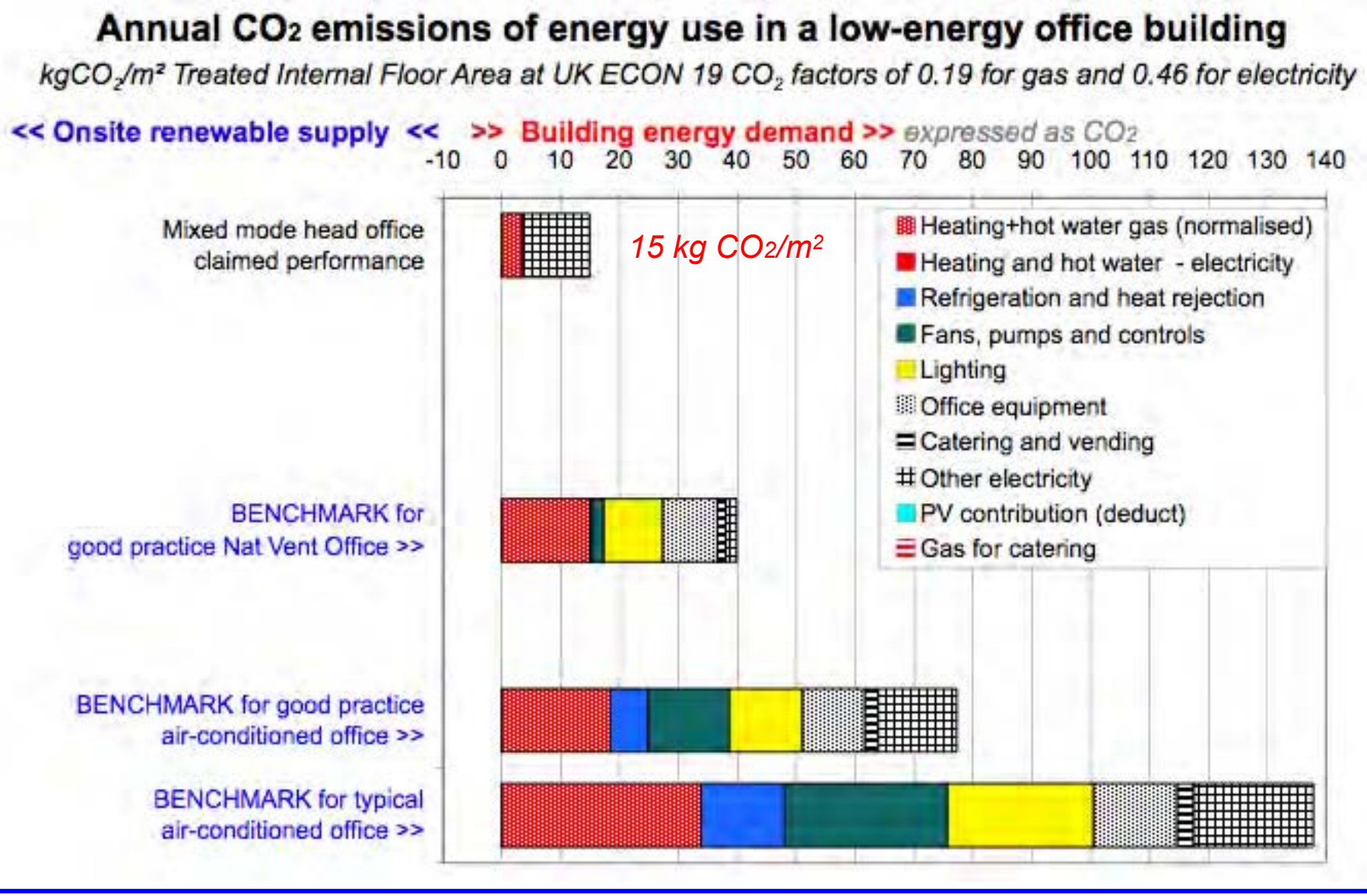
- Between modellers and designers.
- Within design and building teams.
- From designers to clients and other stakeholders.
- From designers and builders to operators.
- Between estimated and actual performance.
- Between buildings, business and policymakers.
- From loads to energy, to CO_2 and other emissions.

and it's been getting worse as more people pile in and buildings get more complicated with renewables etc!

Design intent and building performance need to be communicated much more openly, clearly and consistently.

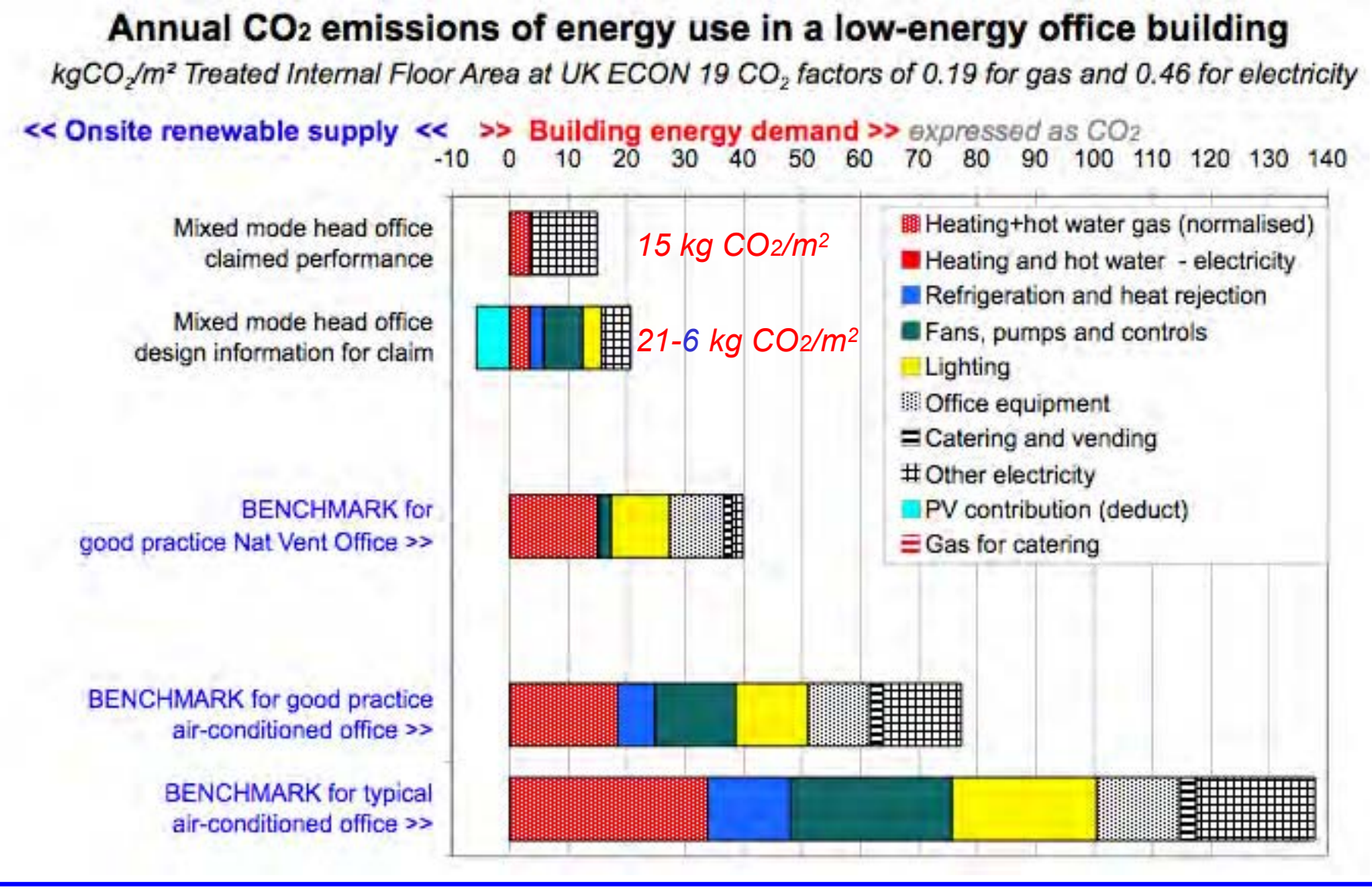
Perspectives on energy performance:

1: the design claim, as published



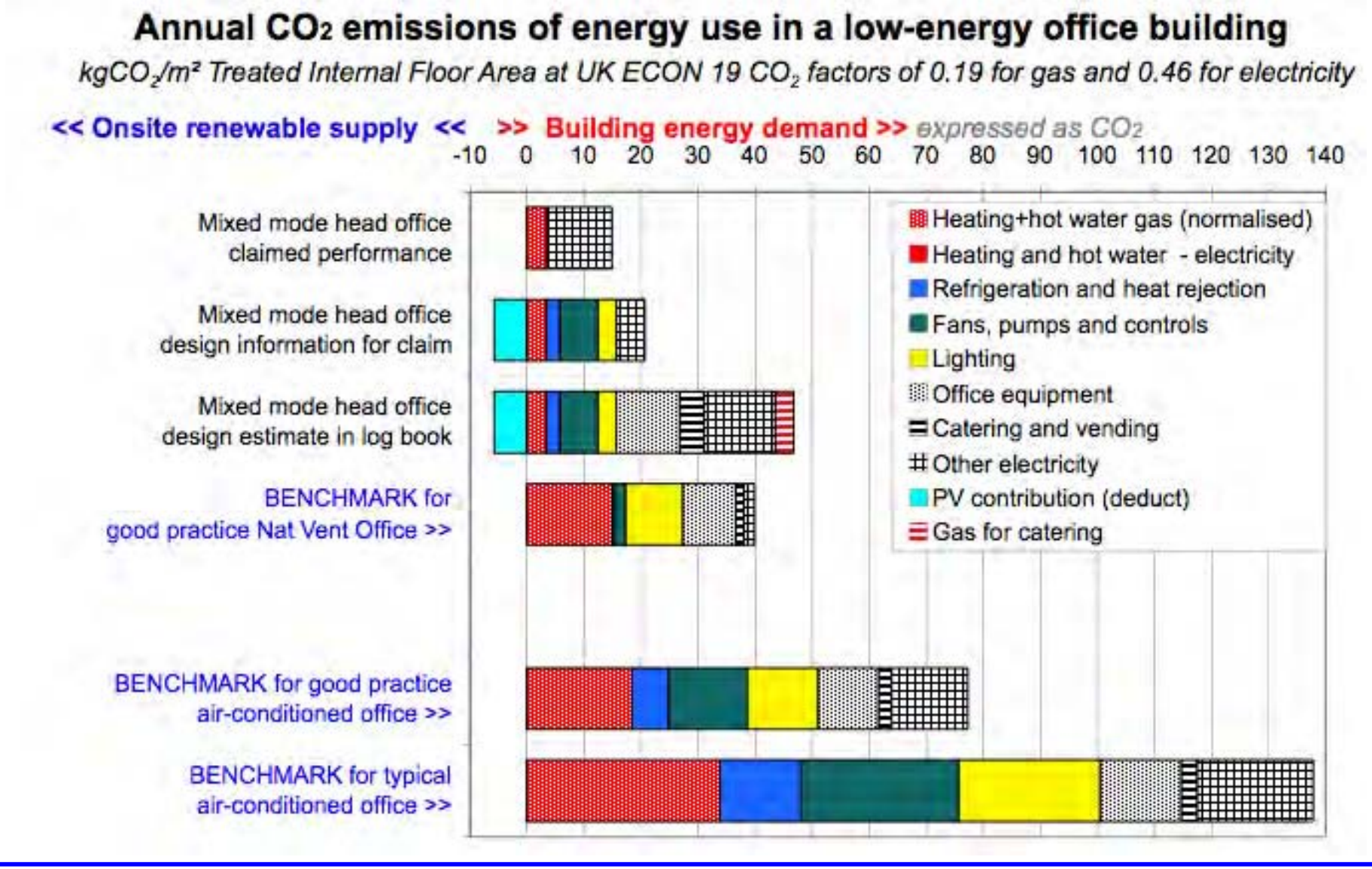
Design intent to reality: how the gap widens

2: the basis for the design claim



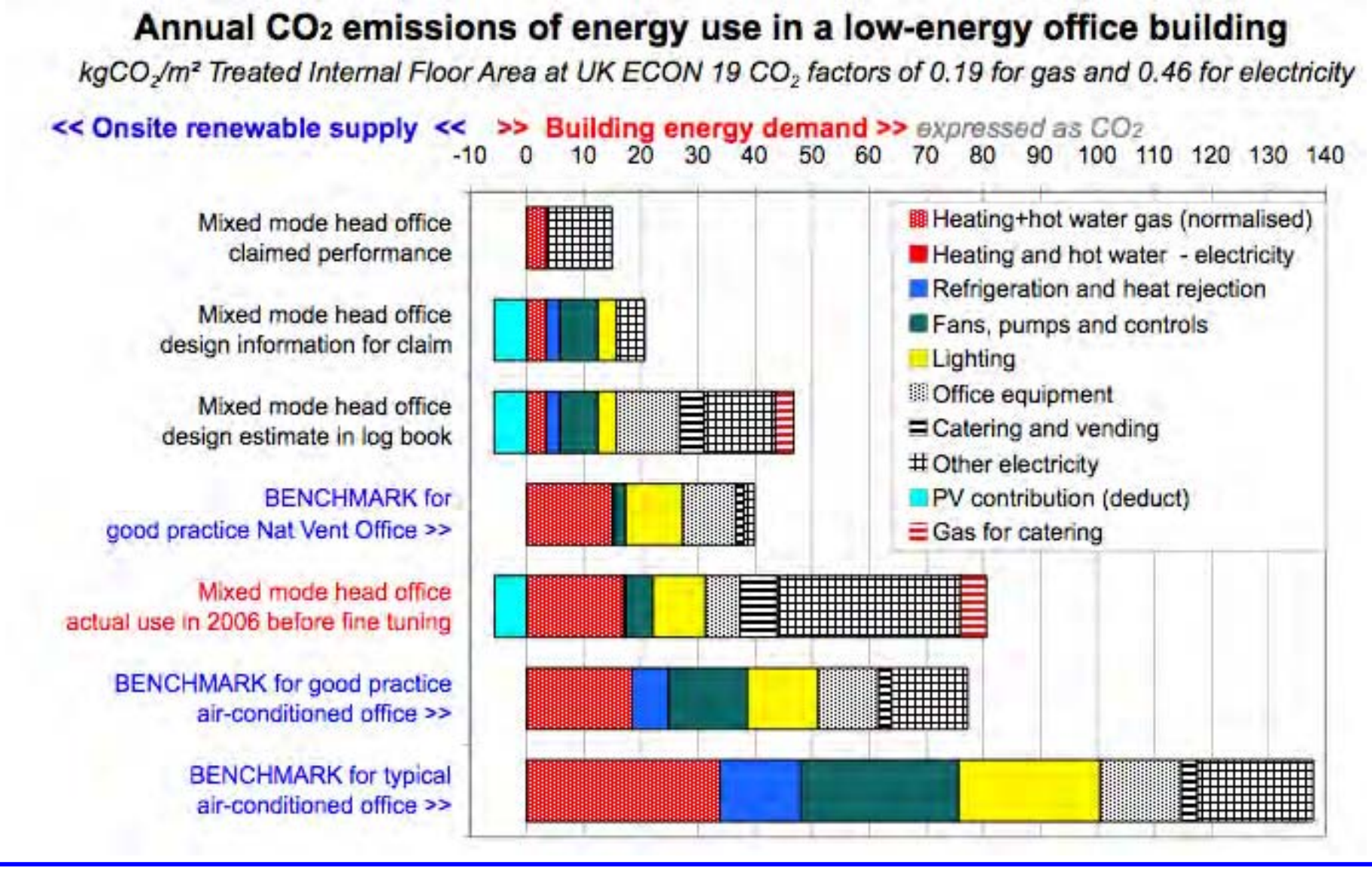
Design intent to reality: how the gap widens

3: what it said in the log book supplied at handover



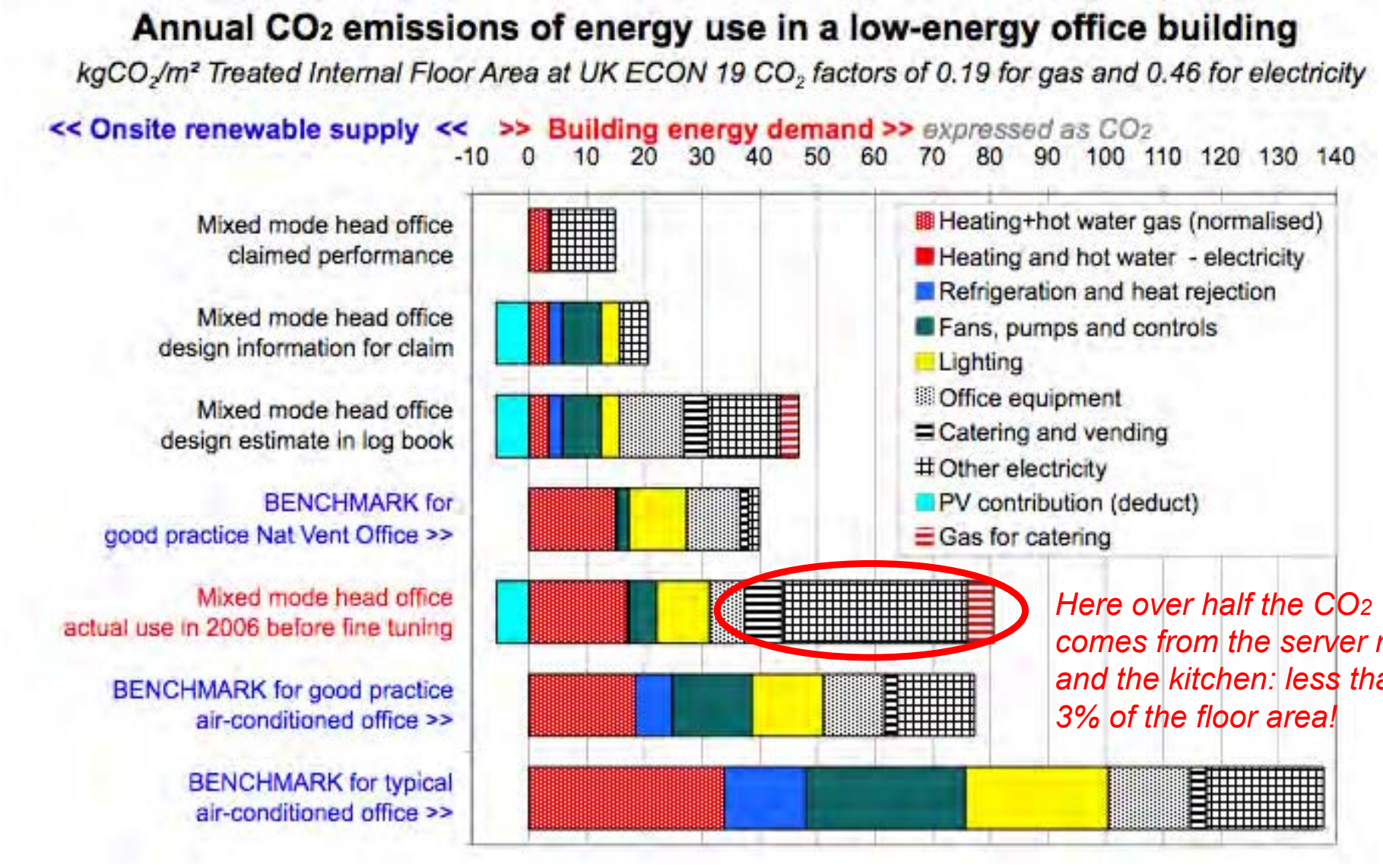
Design intent to reality: how the gap widens

4: actual performance in use, before fine tuning



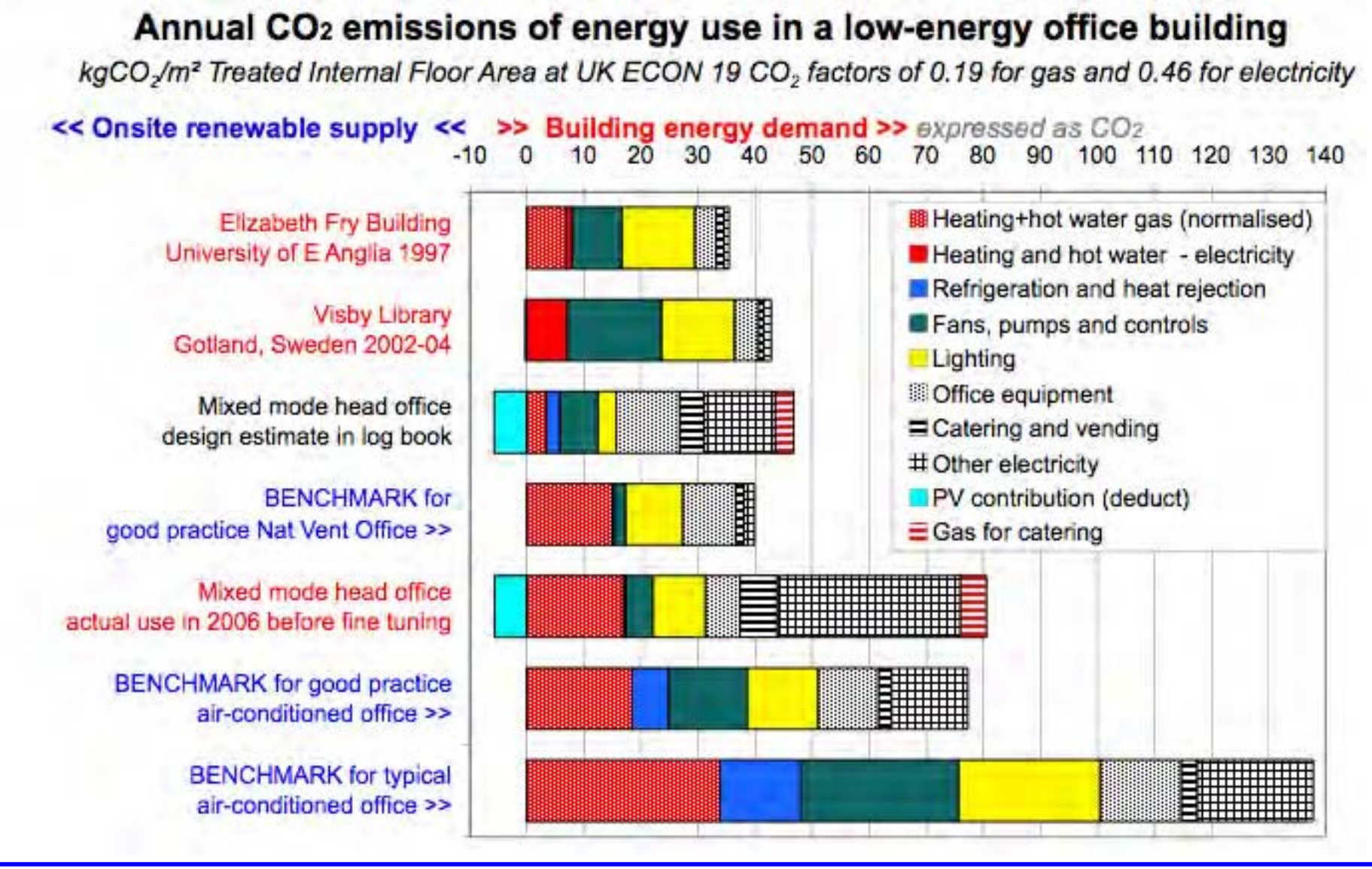
Components of energy performance:

5: designers need to influence "unregulated" loads!



We must learn from the fine structure:

6: how it relates to two other low-energy buildings



A framework for clear communication of energy and carbon performance

1. Agree core data collection, reporting and presentation output formats for annual energy use, which can count everything, and get down into critical details as needed.
2. Provide opportunities to incorporate more detail, *e.g. on monthly and half-hourly patterns of energy use.*
3. Allow use of multiple performance indicators and emissions factors, *but agree defaults where practicable.*
4. Incorporate the core in reporting devices to suit a wide range of stakeholders.
5. Include *graduated response procedures* to allow additional contextual data to be incorporated where it is available. *Start simple, add detail.*
6. Progressively develop and agree common standards for data interchange.

CO_2 may be the headline indicator, *but it's not just about carbon:*

WE NEED A RANGE OF PERFORMANCE INDICATORS

- What is the building's use of **thermal** energy?
  How does it benchmark? Can we do better?
- What is the building's use of **electricity**?
  How does it benchmark? Can we do better?
- Do any **special features** need considering?
  e.g. special energy end-uses, occupation densities.
- What is the effect of **on-site renewables**?
  The energy that is used in the building but not imported.
- What energy supplies are imported to site? *What are their CO_2 emissions? How do they benchmark?*

AND What are the **profiles** of energy use? *Effect on CO_2 factors. Are things on when we don't need them?*

PLUS wider performance**:** human, economic, environment.

6

GET REAL ABOUT BUILDING PERFORMANCE

Designers and builders need to tune in to outcomes … *and fast!*

- Clients and government are getting more interested in performance.
  We need to set realistic expectations and manage them through the design and production process, and into use.
- Sustainability requires much more focus on achieved performance.
  And not just of the regulated items designers currently regard as being their responsibility - this misses many opportunities.
- We are being asked to jump through many hoops - we need to understand what really adds value and what needs to be improved.
  For the planet's sake, we can't afford to invest in the wrong things.
- Things are changing fast, so we need rapid feedback on how well things are actually working. We have to learn as much as possible from our own experiences, and to share them with others.
  We no longer have the time to rely on somebody else doing it for us.

Don’t procure what the occupier can’t afford to manage

Controls, manageability and usability need to receive much more attention

"An intelligent building is one that doesn't make its occupants feel stupid"… ADRIAN LEAMAN

"We sell dreams and install nightmares"… BMS SUPPLIER

We can make massive savings
if we use the multiplier effect

ENGAGE PEOPLE to start with, AND …

BE LEAN - Halve the demand

Review standards, reduce losses, avoid waste.

times

BE MEAN - Double the efficiency

Buy efficient equipment, use it effectively, minimise system losses, tune it up.

times

BE GREEN - Halve the carbon in the supplies

With on-and off-site measures

equals

You're down to one-eighth of the CO_2

Design intent to reality

- Know what is needed — *strategic briefing/ programming*
- Be clear what you want — *strategic design*
- Be ambitious, but realistic — *review the role of modelling*
- Follow it through — *e.g.* ***Soft Landings*** *procedures*
- Review what you do — *manage expectations, undertake reality checks*
- Say what you want — *specify: what, why and how*
- Check that it works — *technical feasibility, usability and manageability*
- Get it done well — *communicate, train, inspect*
- Finish it off — *commission, operational readiness, handover, dialogue*
- Help the users to take ownership — *provide aftercare support*
- Review its performance — *including* ***post-occupancy evaluation***
- Make it work better — *monitoring, review and fine tuning*
- Spot unintended consequences — *revenge effects*
- Learn from it all — ***and share your experiences***

KEEP IT SIMPLE AND DO IT WELL

and go to Roderic Bunn's session on ***SOFT LANDINGS*** *tomorrow*

www.usablebuildings.co.uk