Institute for Sustainability and FLASH+
Building confidence in low-carbon solutions
Stanhill Court Hotel, 27 September 2011

What works, what doesn't work, and how we can fix it:

Using Building Performance Evaluation (BPE) for rapid improvement

Bill Bordass
the Usable Buildings Trust
www.usablebuildings.co.uk

Structure of the talk

1. **Flying Blind?**

1. **Improving new construction and refurbishment**
2. **Tuning-up our buildings**
3. **Getting started on BPE**
4. **Changing the way the industry does things**
5. **Concluding remarks**

1

FLYING BLIND?

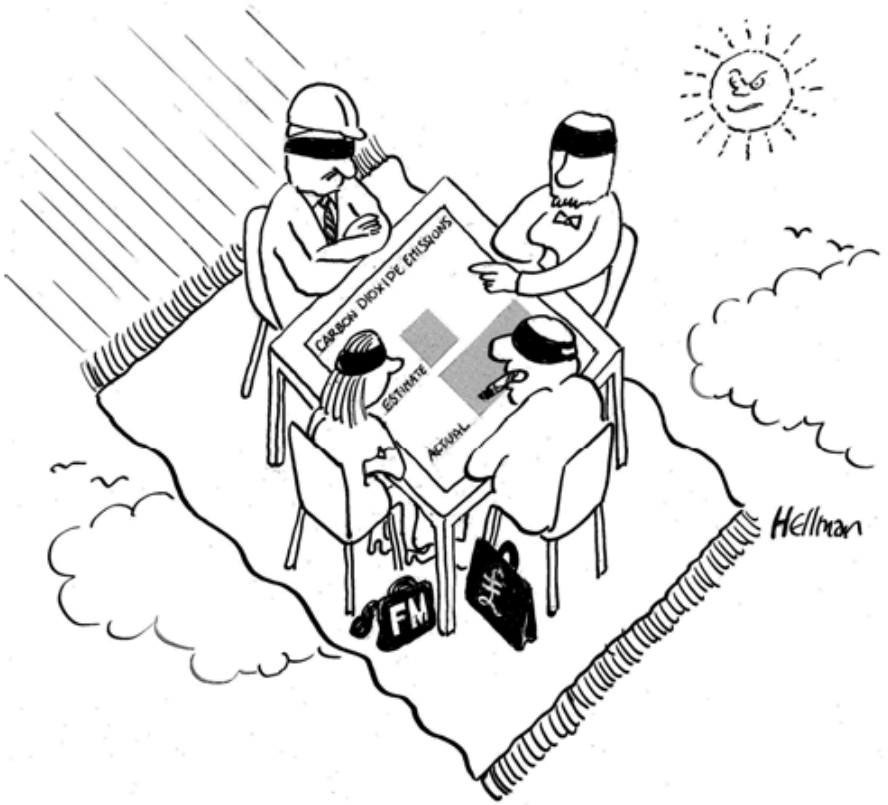
What BPE tells us:

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

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

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

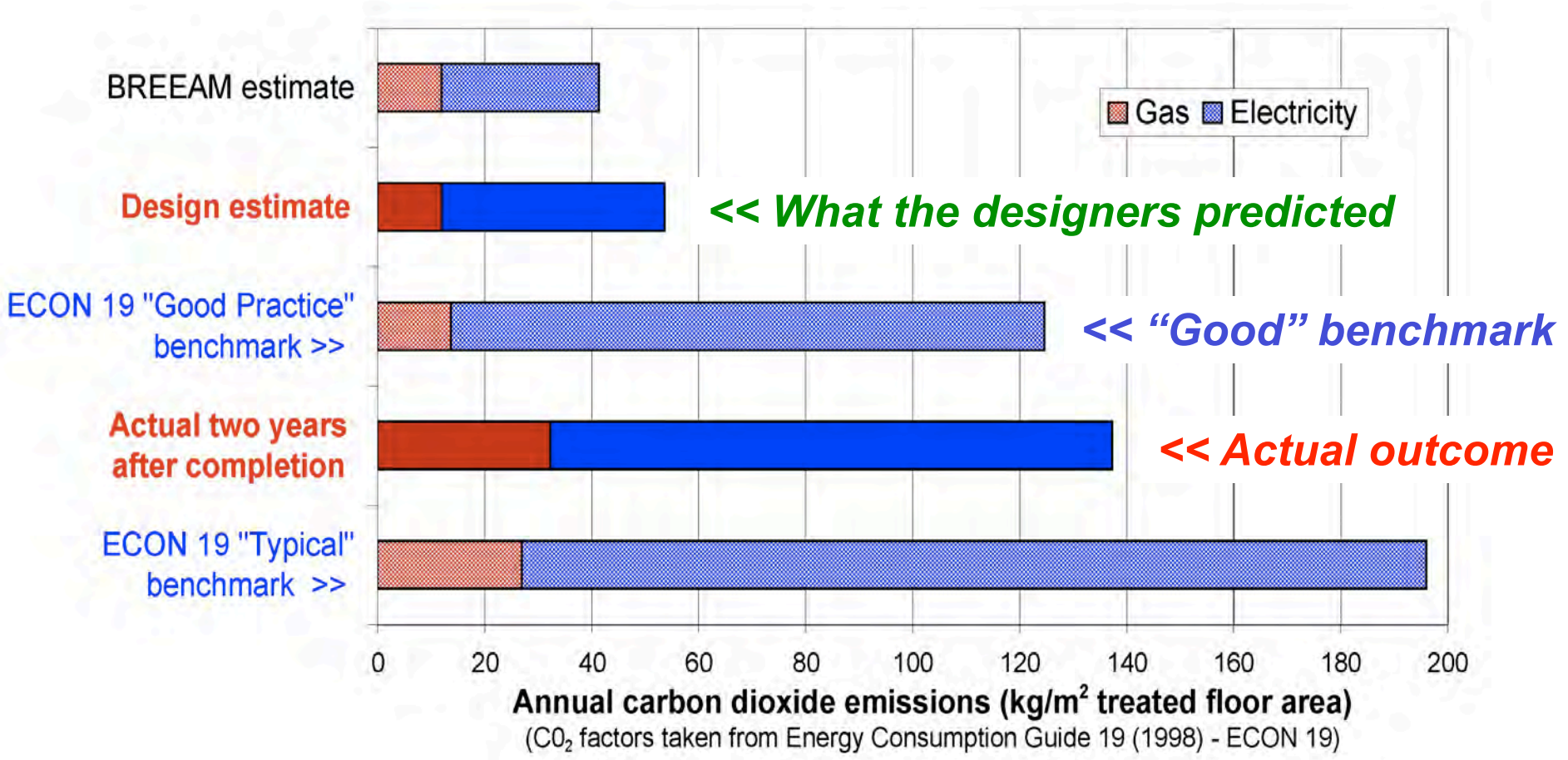
"I've seen many low-carbon designs, but hardly any low-carbon buildings"
ANDY SHEPPARD, Arup, 2009



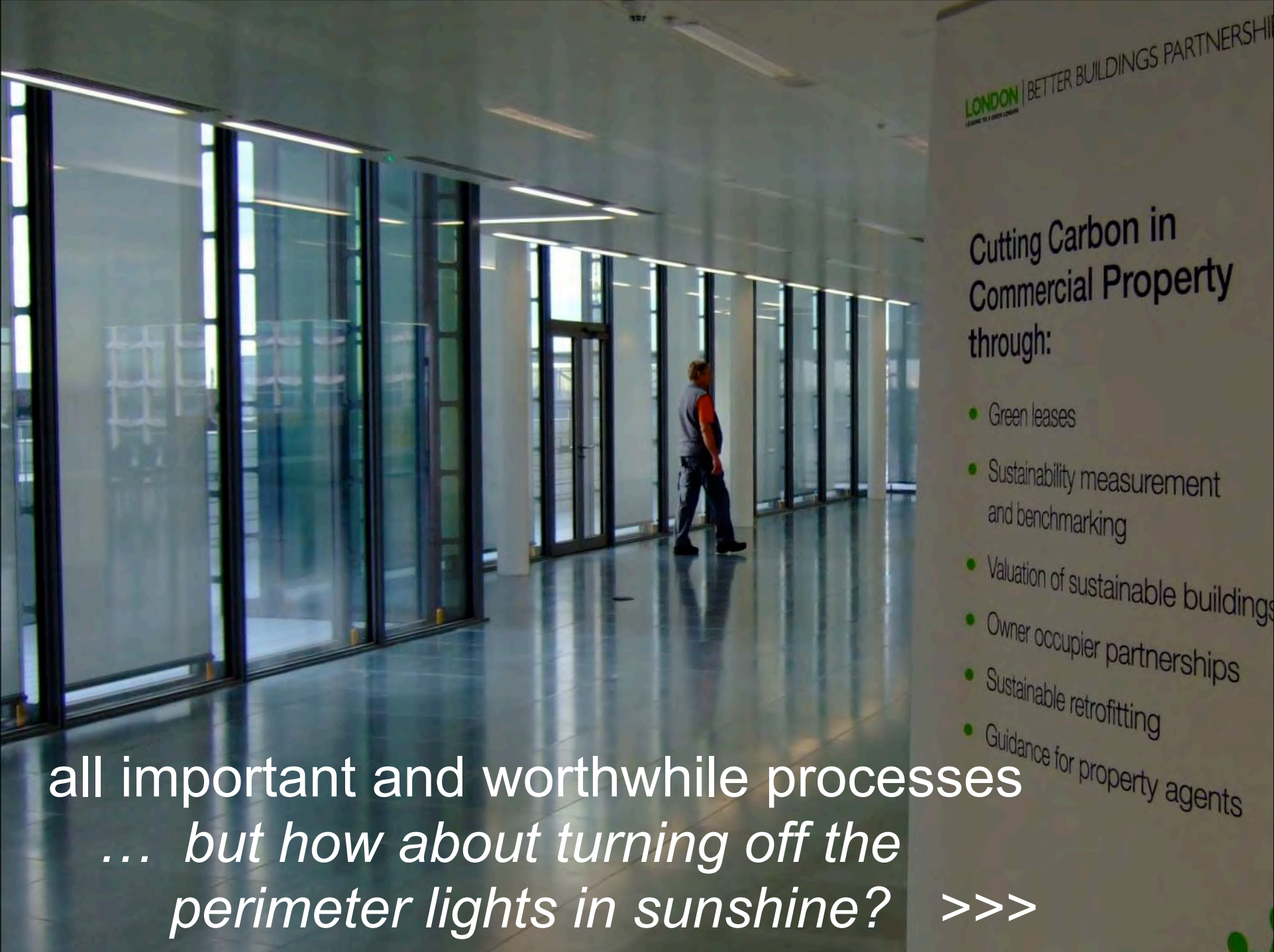
SOURCE: Hellman cartoon for W Bordass, *Flying Blind,* Association for the Conservation of Energy & OXEAS (2001)

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).



all important and worthwhile processes

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

And what about this?

In a new "low energy" building's kitchen

Some typical examples from recent buildings: *Poor window design, leading to overheating*

Why don't we take more account of *the evidence under our noses?*

"… 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

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

When natural ventilation was all the rage, a novel form of mechanical ventilation was quietly slipping into Britain: the Swedish Termodeck system. One of the first buildings to use Termodeck and other Swedish detailing was an academic facility at the University of East Anglia. How has it fared?

BY THE PROBE TEAM

PROBE

14: Elizabeth Fry Building

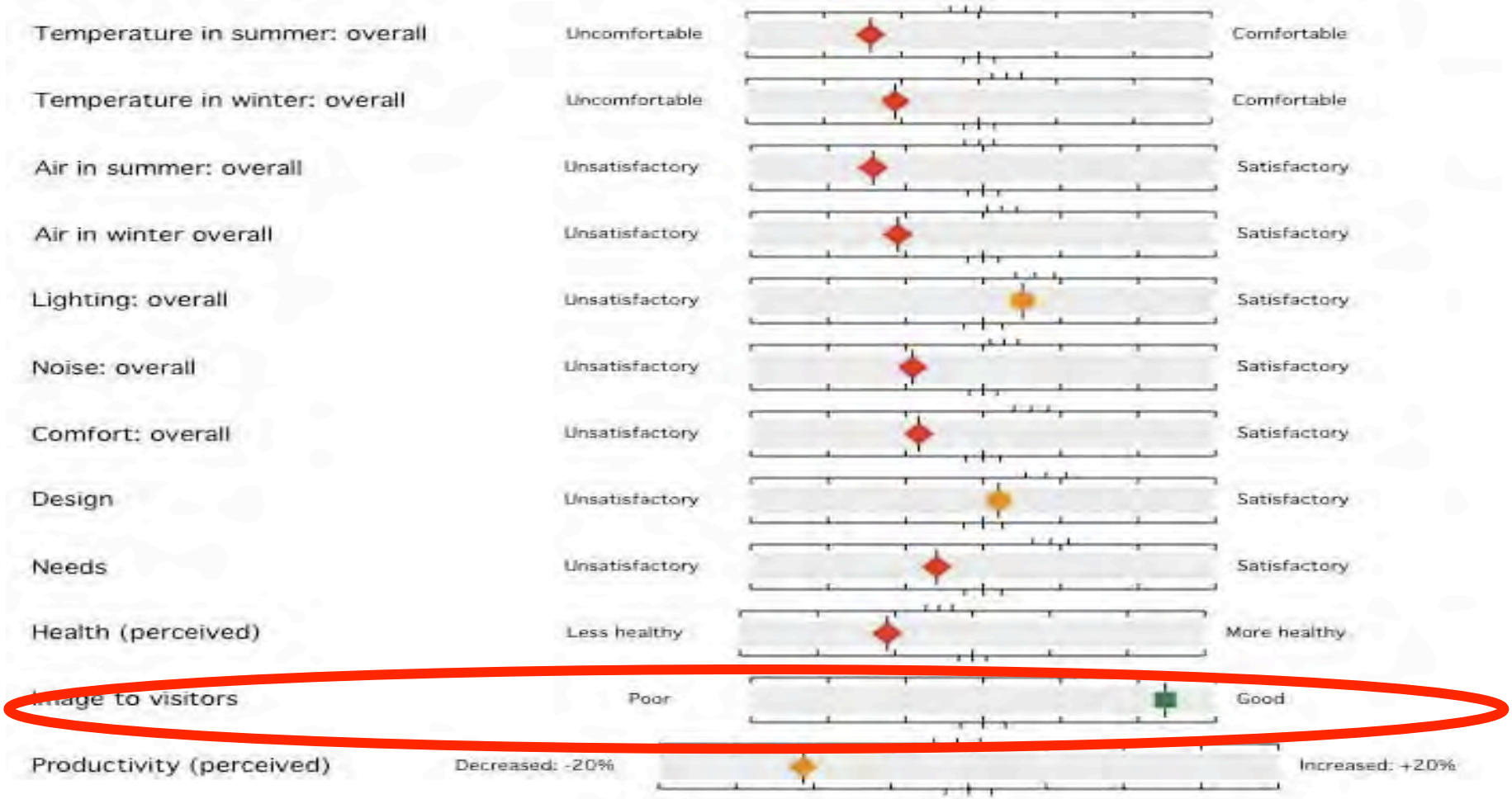
LETTER TO ARCHITECTS' JOURNAL

The good performers don't necessarily impress the judges

SOURCE: Probe reports available for download from www.usablebuildings.co.uk

Credibility gaps: Occupant satisfaction

Staff questionnaire survey, award-winning school, UK

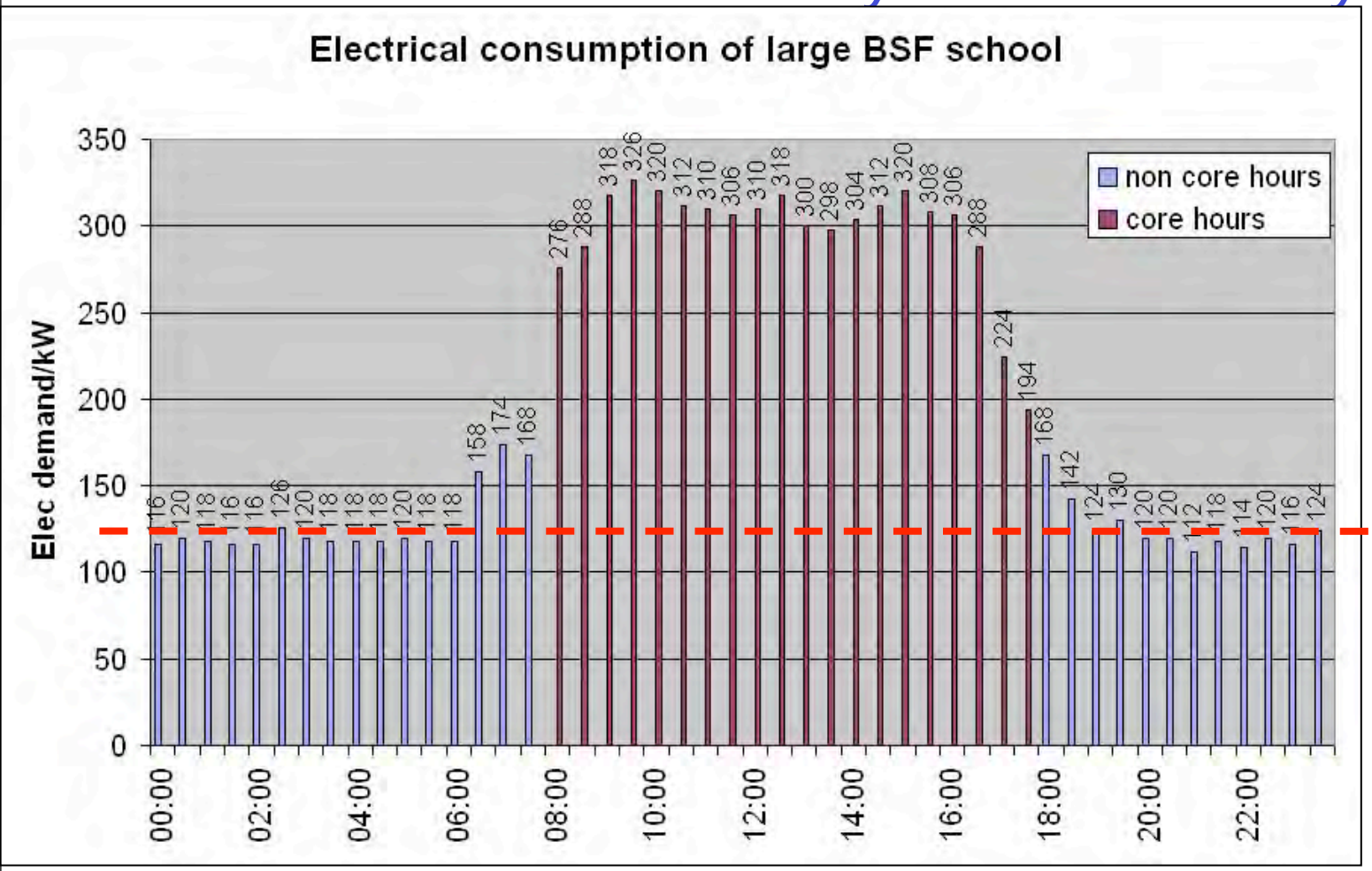


The judges may not experience what the occupants do!

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

The electrical tail can often wag the dog

kWh/half hour in a recently-built 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.

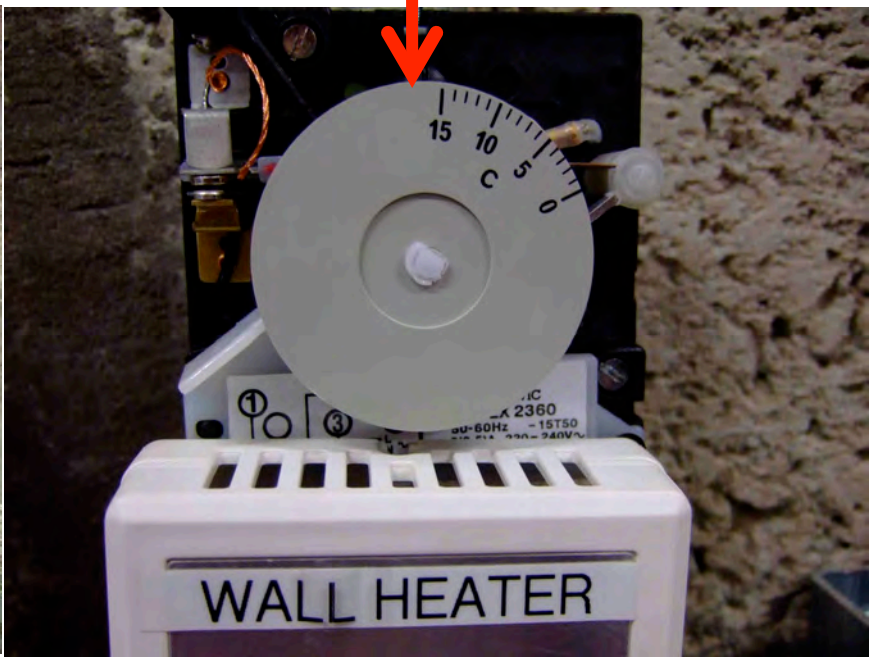
Breakdown of annual electricity use: **44% used between 0800-1800 on term time days**

56% (~£75,000) of electricity used at other times: 14% term weekends, 26% term nights, 16% holidays

SOURCE: Buro Happold (October 2009)

We must trap unintended consequences

Take account of everything, in design and in use.



In 2008-09, this frost thermostat *(improperly set at 17°C on installation)* energised the wall heater in a plant room of a new low-energy school, and wasted more electricity than the wind generator *(intended to offset the entire building's annual heating energy use)* created.

Why haven't we tuned into outcomes?

- Not what clients have asked the industry to do: *"hand over and walk away" is systemically embedded in standard procedures and contracts, so follow-through is not part of the standard offering*.
- Clients and government haven't set aside time and money for tuning-up after handover, *and have often preferred to bury bad news.*
- Rigid divisions between funding of capital and operational costs, *getting worse if anything, in spite of all the talk.*
- Policy emphasis on construction, not performance in use, *even when feedback information has been revealing problems.*
- Outsourcing of technical expertise, research and performance feedback by central and local government, *e.g. privatisation of works departments, PSA and the BRE.*
- "Post-Occupancy Evaluation" (POE) is a construction industry

2

IMPROVING NEW CONSTRUCTION AND REFURBISHMENT

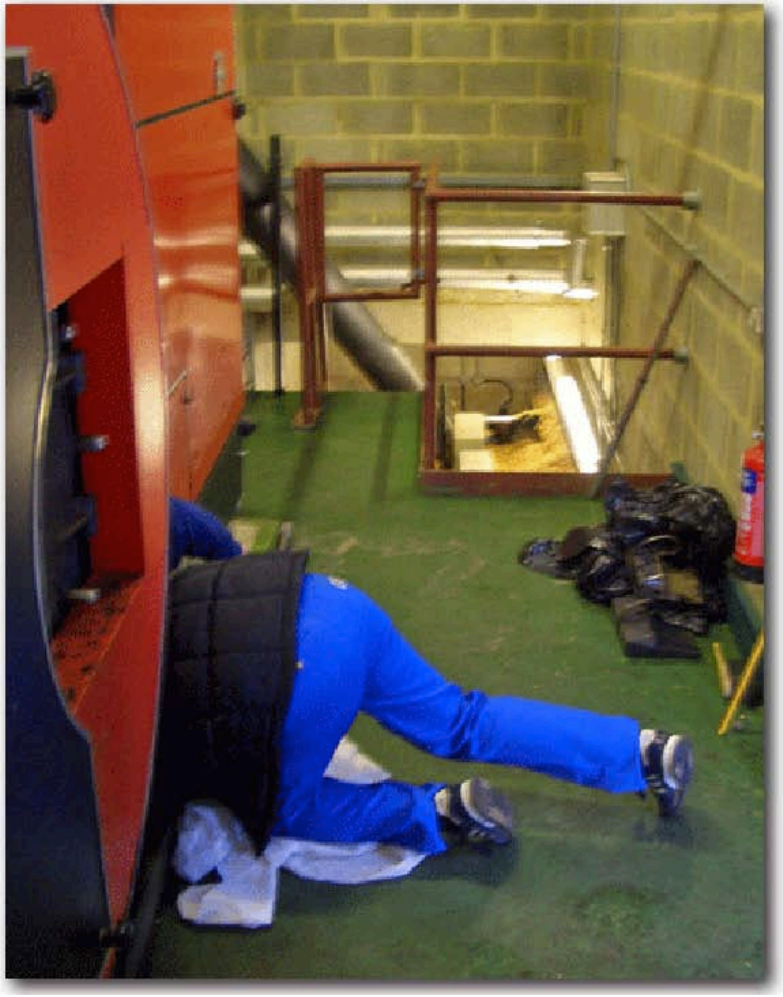
New non-domestic buildings:
What have we tended to find, for many years now?

- 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 seldom communicated well to users and managers. *Designers and builders go away at handover.*
- Unmanageable complication is the enemy of good performance. *So why are we making buildings technically and bureaucratically complicated in the name of sustainability, when we can't get the simple things right?*
- Buildings are seldom tuned-up properly. Controls are a mess. *If we have more to do, what chance do we have?*
- Modern procurement systems make it difficult to pay attention to critical detail. ***A bad idea when promoting innovation.***
- ***"The British spare no expense to get something on the cheap".*** ***... NIKOLAUS PEVSNER***

KEEP IT SIMPLE, DO IT WELL, FOLLOW IT THROUGH, TUNE IT UP, CAPTURE THE FEEDBACK

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

Don’t provide what occupiers can’t afford to manage



Dwellings have now caught the nondomestic disease of unmanageable complication

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.

The energy-to-carbon hierarchy
when improving performance

1. Engage people: *make energy and carbon performance visible and actionable.*
2. Reduce demand: *change habits, question standards and provision, use passive measures.*
3. Increase efficiency: *of building services, ICT and other appliances; and improve integration.*
4. Improve controls and monitoring: *massive opportunities here, not least with better ergonomics.*
5. Avoid waste: *the place to start in existing buildings - avoid Default-to-ON.* ***AND ONLY THEN …***

---

6. Decarbonise energy supplies: *both on and off-site.*

Fabric First:

Efficient services need to be able to rely on it

Air pressure test of the Maths Building Cambridge as part of a Probe POE


Bun sgoil Ath-Tharracaill
Acharacle Primary School
Air Leakage Index
@ 50Pa
0.44
Air Permeability Index
@ 50Pa
0.27

Gentle engineering
Not over-engineering

"Evening out fluctuations has become an egalitarian enterprise which it is heresy to question."

MICHAEL YOUNG, *The Metronomic Society (1988).*

"There is something inelegant in the mass of energy-consuming machinery needed at present to maintain constant RH … something inappropriate in an expense which is beyond most of the world's museums."

GARRY THOMSON, *The Museum Environment (1978).*

"What we've got used to, we're not entitled to" … R BUNN (2008)

In 1994, two of these boilers heated a 3200 m^2 university building – *E Fry (@ 15 W/m^2).*

So why does a recently-completed UK "zero-carbon" school have 60 W/m^2 of biomass boiler power with gas backup?

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

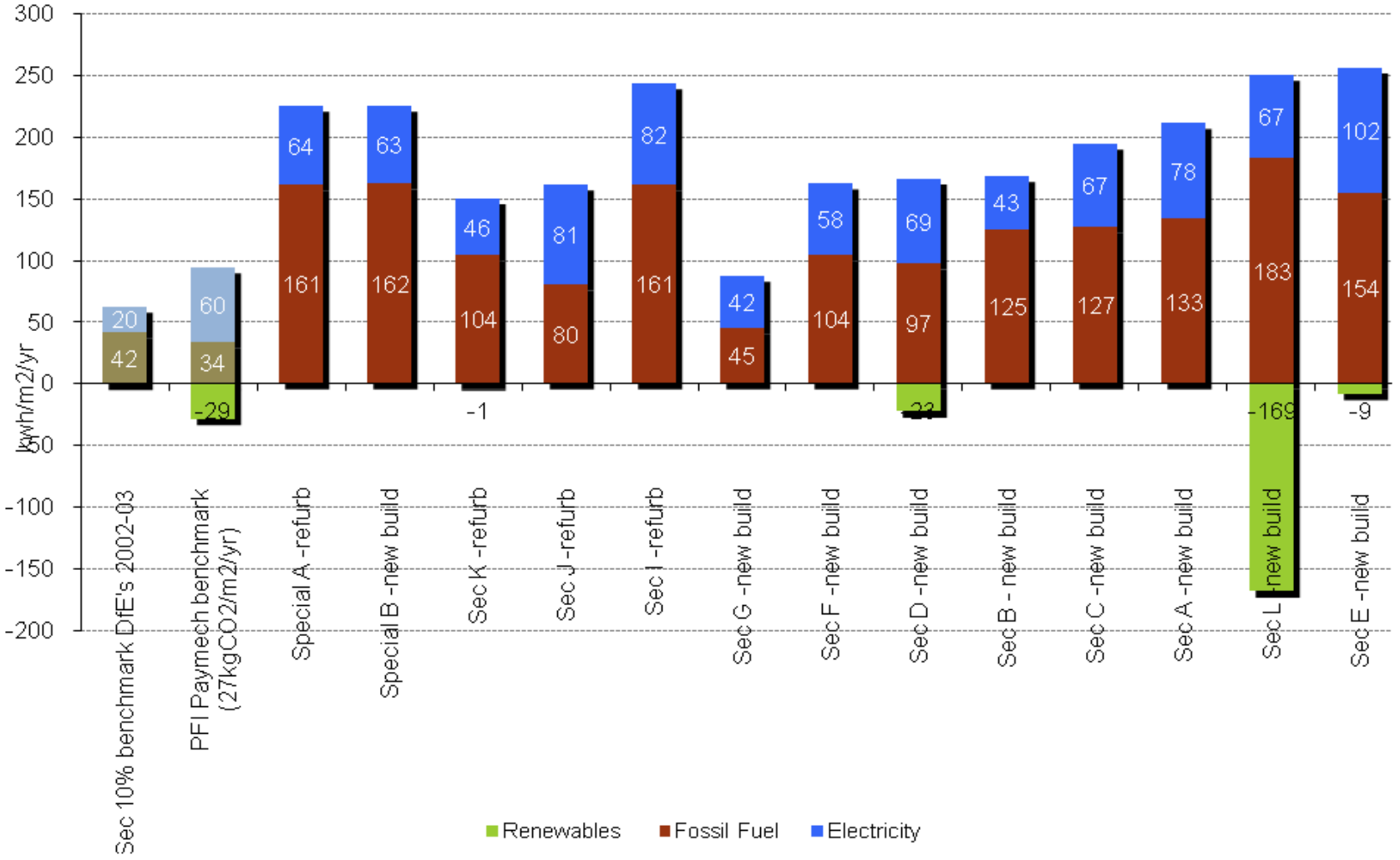
"We sell dreams and install nightmares"…BMS SUPPLIER

Don’t add “green bling”

unless you’ve got the fundamentals right

Energy use in new secondary schools …

the more renewables, the less efficient?



SOURCE: Private communication, 2011

Getting the leverage on emissions:
First people, then energy, then carbon

- Engage people - *if not, there may well be unintended consequences.*
- Reduce demand - *prevention is better than cure!*
- Increase efficiency – *of the services that meet the demand.*
- **Improve controls** – *and their management and user interfaces*
- **Avoid waste** ***<< usually where to start in existing buildings.***
- Decarbonise supplies - *but low-carbon energy is a scarce resource not to be squandered: get the demand down first.*
- Get results by doing things simply, cheaply **… and well!**
- Make use of **Opportunity Points**. *Don't do expensive stuff for its own sake.*

BIG SAVINGS ARE POSSIBLE USING THE MULTIPLIER EFFECT, e.g.

- Halve the demand **X**
- Double the efficiency **X**
- Halve the carbon in the supplies … AND

You are down to one-eighth of the carbon.

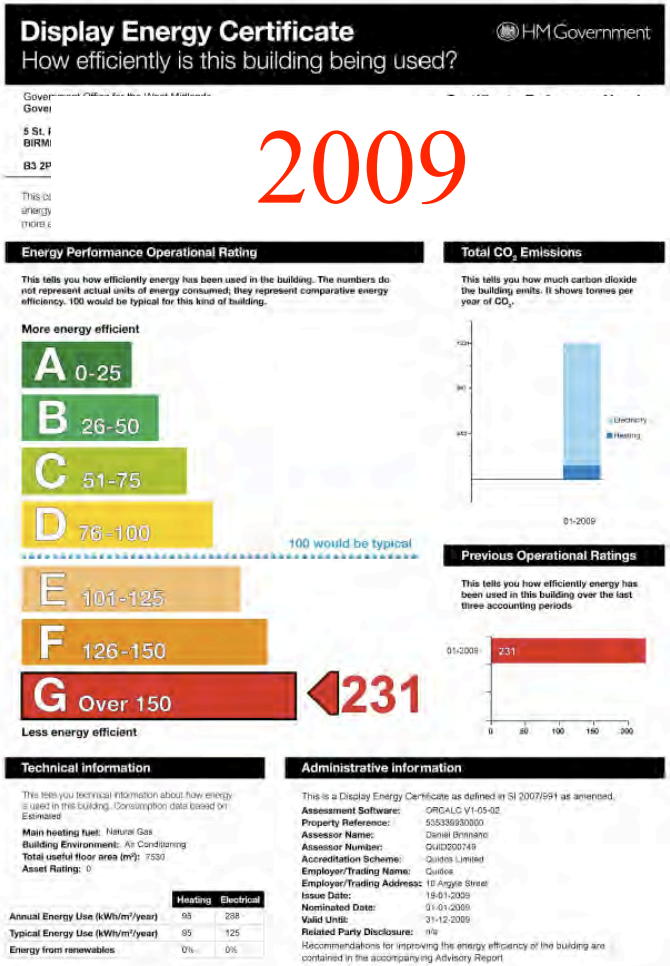
Much energy use comes from the compounding of unnecessary loads

… A LOVINS **PREVENTION IS BETTER THAN CURE!**

3

TUNING-UP EXISTING BUILDINGS

A focus on performance can mobilise management *without spending vast amounts of money*



Display Energy Certificate
How efficiently is this building being used?

HM Government

2009

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
F 126-150
G Over 150 ◀231

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.

01-2009

Previous Operational Ratings

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

01-2009 231

Technical information

This tells you technical information about how energy is used in this building. Consumption data based on Estimated

Main heating fuel: Natural Gas
Building Environment: Air Conditioning
Total useful floor area (m^2): 7530
Asset Rating: D

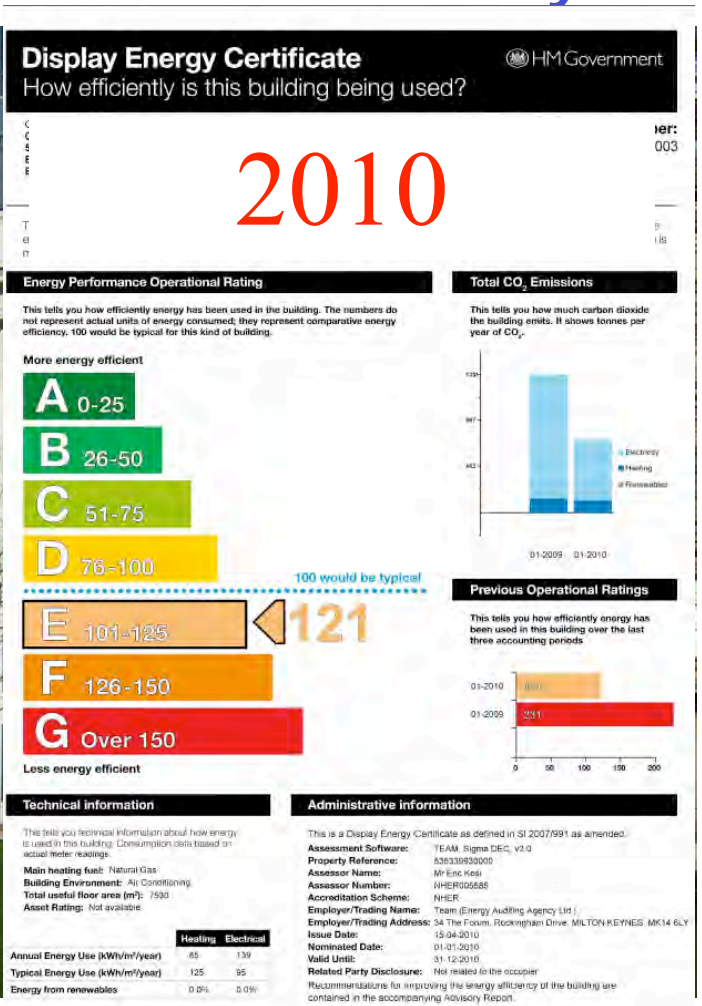
	Heating	Electrical
Annual Energy Use (kWh/m^2/year)	93	238
Typical Energy Use (kWh/m^2/year)	95	125
Energy from renewables	0%	0%

Administrative information

This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software: ORCALC V1-05-02
Property Reference: 53533930000
Assessor Name: Daniel Brimacombe
Assessor Number: QUID200749
Accreditation Scheme: Quidos Limited
Employer/Trading Name: Quidos
Employer/Trading Address: 10 Argyle Street
Issue Date: 19-01-2009
Nominated Date: 01-01-2009
Valid Until: 31-12-2009
Related Party Disclosure: n/a

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report



Display Energy Certificate
How efficiently is this building being used?

HM Government

2010

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 ◀121
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.

01-2009 01-2010

Previous Operational Ratings

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

01-2010
01-2009 231

Technical information

This tells you technical information about how energy is used in this building. Consumption data based on actual meter readings

Main heating fuel: Natural Gas
Building Environment: Air Conditioning
Total useful floor area (m^2): 7530
Asset Rating: Not available

	Heating	Electrical
Annual Energy Use (kWh/m^2/year)	85	139
Typical Energy Use (kWh/m^2/year)	125	95
Energy from renewables	0.0%	0.0%

Administrative information

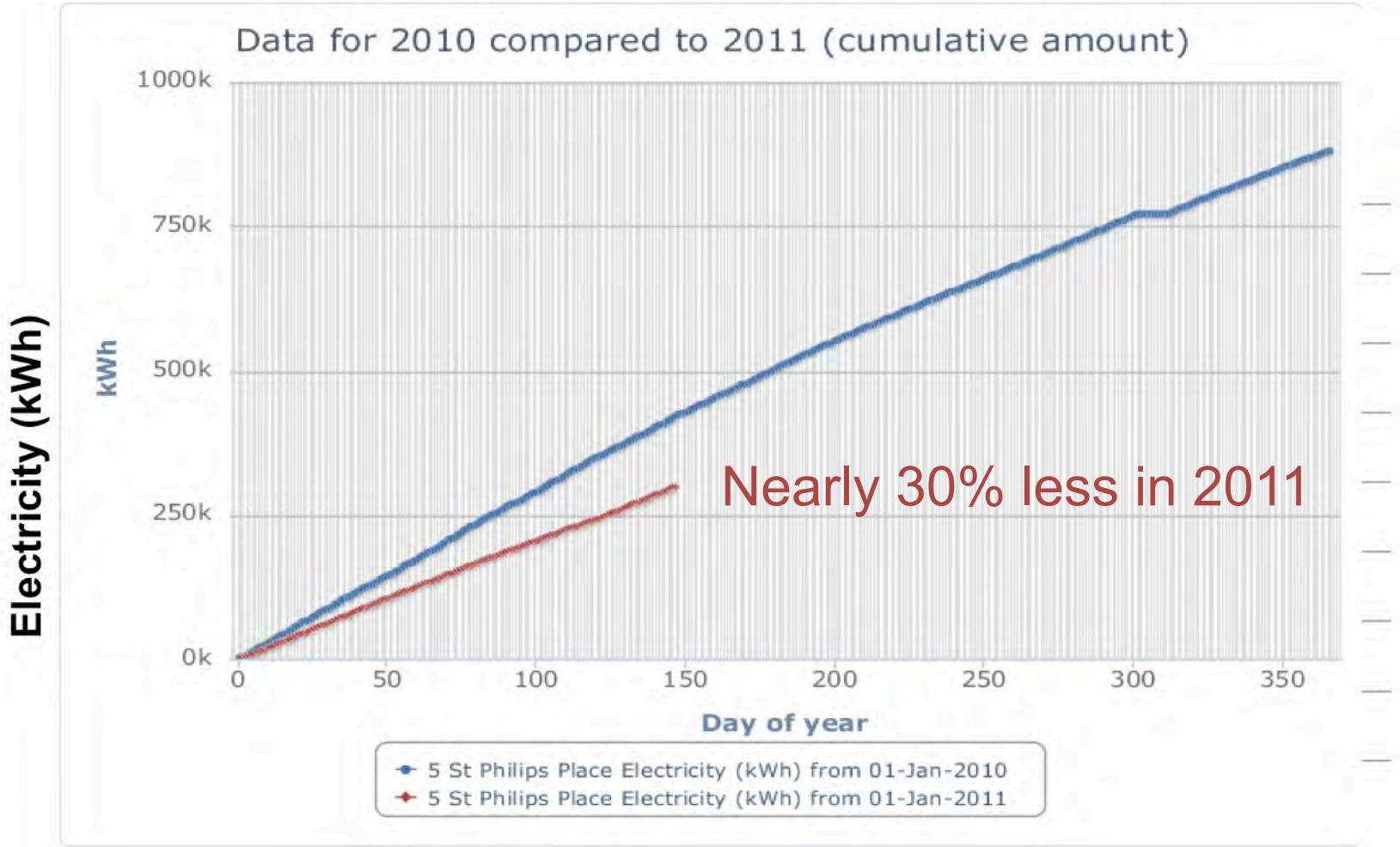
This is a Display Energy Certificate as defined in SI 2007/991 as amended.

Assessment Software: TEAM, Sigma DEC, v3.0
Property Reference: 53533930000
Assessor Name: Mr Eric Kesi
Assessor Number: NHER005688
Accreditation Scheme: NHER
Employer/Trading Name: Team (Energy Auditing Agency Ltd.)
Employer/Trading Address: 34 The Forum, Rockingham Drive, MILTON KEYNES, MK14 6LY
Issue Date: 15-04-2010
Nominated Date: 01-01-2010
Valid Until: 31-12-2010
Related Party Disclosure: Not related to the occupier

Recommendations for improving the energy efficiency of the building are contained in the accompanying Advisory Report.

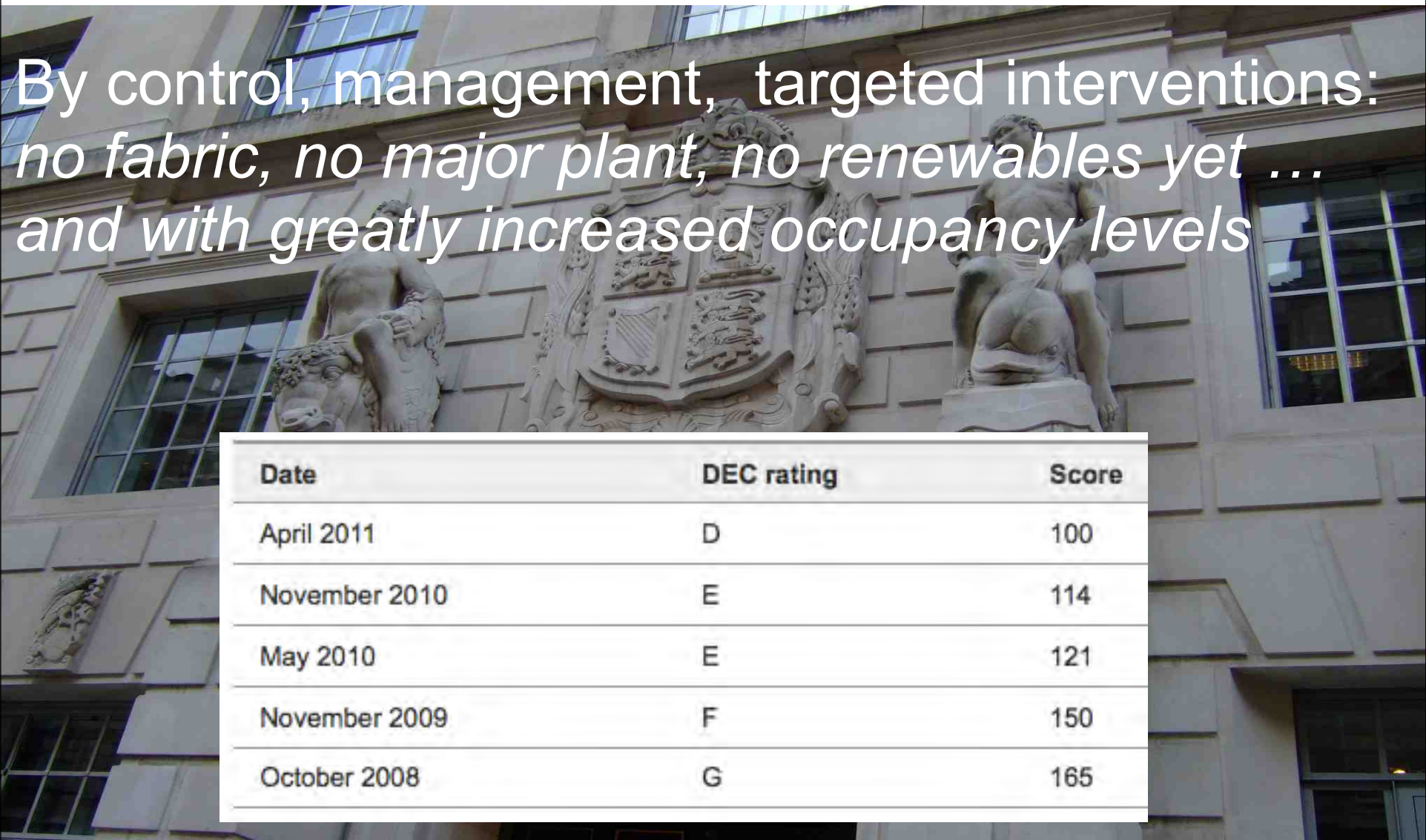
SOURCE: W Bordass, *Flying Blind,* published by the Association for the Conservation of Energy and EEASOX

Further savings in 2011 *with sub-metering and support on Continuous Commissioning by ABS*



SOURCE: Continuous Commissioning with Energy Monitoring Optimising Targeting & Reporting (EMOTR) by absconsulting.uk.com

And in DECC's own offices, *at 3 Whitehall Place, London*



By control, management, targeted interventions:
no fabric, no major plant, no renewables yet …
and with greatly increased occupancy levels

Date	DEC rating	Score
April 2011	D	100
November 2010	E	114
May 2010	E	121
November 2009	F	150
October 2008	G	165

BPEs in recent domestic buildings
reveal massive potential for improvement

- Frequent shortcomings in thermal integrity.
- Design for natural ventilation and cooling is often compromised.
- Controls were often far from intuitive, poorly located, and giving little or no feedback on performance and unintended operation.
- As programmers become more powerful, fewer people can programme them, and so cease to make adjustments to suit need.
- How systems are supposed to work was usually poorly recorded.
- Developer or landlord representatives who explained the technology to occupiers usually didn't understand it themselves!
- MVHR systems were often poorly understood, installed and maintained. Maintenance access could be poor too.
- Many solar hot water systems weren't working properly; or their potential was being usurped by boiler controls, unintended use of immersion heaters, or over-zealous anti-legionella measures.

4

GETTING STARTED ON BPE:

It's not that difficult

What is BPE?

- Finding out how buildings actually work.
- Using multiple methods, *to develop better insights.*
- It's not that complicated: *many things are blindingly obvious, once you open your eyes.*
- It doesn't need to take a lot of time or money: *you just need to get going.*
- It's about improving practice, not developing theories, *though it may help others to develop theories.*
- The key ingredient is a focus on outcomes and actions.
- When should I do it? **START NOW!**
  - ***Foresight****:* before doing work.
  - ***Hindsight****:* after doing work.
  - ***Insight****:* while doing work.

Why you need to get involved in BPE

- There's a big job to do, *in making new and existing buildings more sustainable.*
- We're short of money:
  we can't afford to spend it on the wrong things.
- Our current procurement systems are not fit for purpose:
  we need to do things very differently.
- We can't change everything tomorrow …
  but we can change our attitudes to what we do.

- **If you don't start doing it, guess who will?**
  Your competitors!

Getting started on BPE

- Adopt a drill-down approach where practicable:
  1. BASIC: *the wet finger*
  2. INTERMEDIATE: *get some useful data*
  3. ADVANCED: *deeper investigation.*
- None of these levels is academic research in the traditional sense – we see that as Level 4.
- Ideally, beyond the Basic level, work should be both:
  - ***Separate*** from the client, design and building team, to provide objectivity and a wider view. *This can involve a mentor, consultants, or academic input.*
  - ***Connected****,* so the people and organisations directly involved learn through personal experience, and take this back into their organisations and the wider world.

SOURCE: The three-level classification follow that in the ASHRAE *Performance Measurement Protocols* Guide (2010).

LEVEL 1 – Basic

Half to one day on site for 1 or 2 people

- Short pre-visit questionnaire to collect basic data.
- Semi-structured interview with occupier – *in managed buildings, frequently the building or facilities manager.*
- Walk-around with the occupier/manager.
- Inspection of mechanical & electrical plant and controls, *with operating and maintenance staff if available.*
- Inspection of record drawings, user guides, O&M manuals and commissioning and test results.
- Review of basic energy data, if available.
- Observations and spot checks of internal conditions.
- Casual discussions with other occupants, if possible.
- Take photos, *including infra-red if you have a camera.*

COMING SOON
The IfS – UBT Primer on BPE

- Initial draft available for review on the FLASH+ website, probably in late October.
- Short period for comments and initial feedback.
- Final version available to FLASH+ partners at the end of the year.
- Testing in use during 2012, with feedback leading to revisions as necessary.

CONTENTS LIST of current draft *The IfS – UBT Primer on BPE*

- What is BPE?
- What does BPE tell us in general?
- Specific lessons that may emerge from BPE
- How to approach BPE
- Getting started
- Getting into more detail
- Reporting results
- Making BPE routine

APPENDICES

- BPE techniques: domestic and non-domestic
- Analysis, graphics and reporting
- Glossary, Bibliography, References, Contacts.

5

CHANGING THE WAY THE INDUSTRY DOES THINGS

BPE has been around for a long time
So why isn't it routine?

- Often too remote from the delivery process.
  So the uninvolved are seen as being wise after the event, while the closely involved don't learn.
- The supply side detaches at handover
  Even the procurement departments of repeat clients.
- There tends to be more bad news than good.
  So blame someone or shoot the messenger!
- It can be difficult to get problems fixed …
  if everybody is not on board.
- Everyone benefits, but nobody wants to pay,
  and not always seen to be good value for money.

It's the process, 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.
- 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).*
- 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 *(easier now, but must be sustained).*

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

Getting more sense into procurement
Soft Landings can help

1. **Inception and Briefing**
   Appropriate processes, better relationships.
   Assigned responsibilities, including client.
   Well-informed targets related to outcomes.
2. **Design and construction**
   Including expectations management.
3. **Preparation for handover**
   Better operational readiness.
4. **Initial aftercare**
   Information, troubleshooting, liaison, fine tuning, training.
5. **Longer-term aftercare**
   monitoring, review, independent POE, feedback and feedforward.

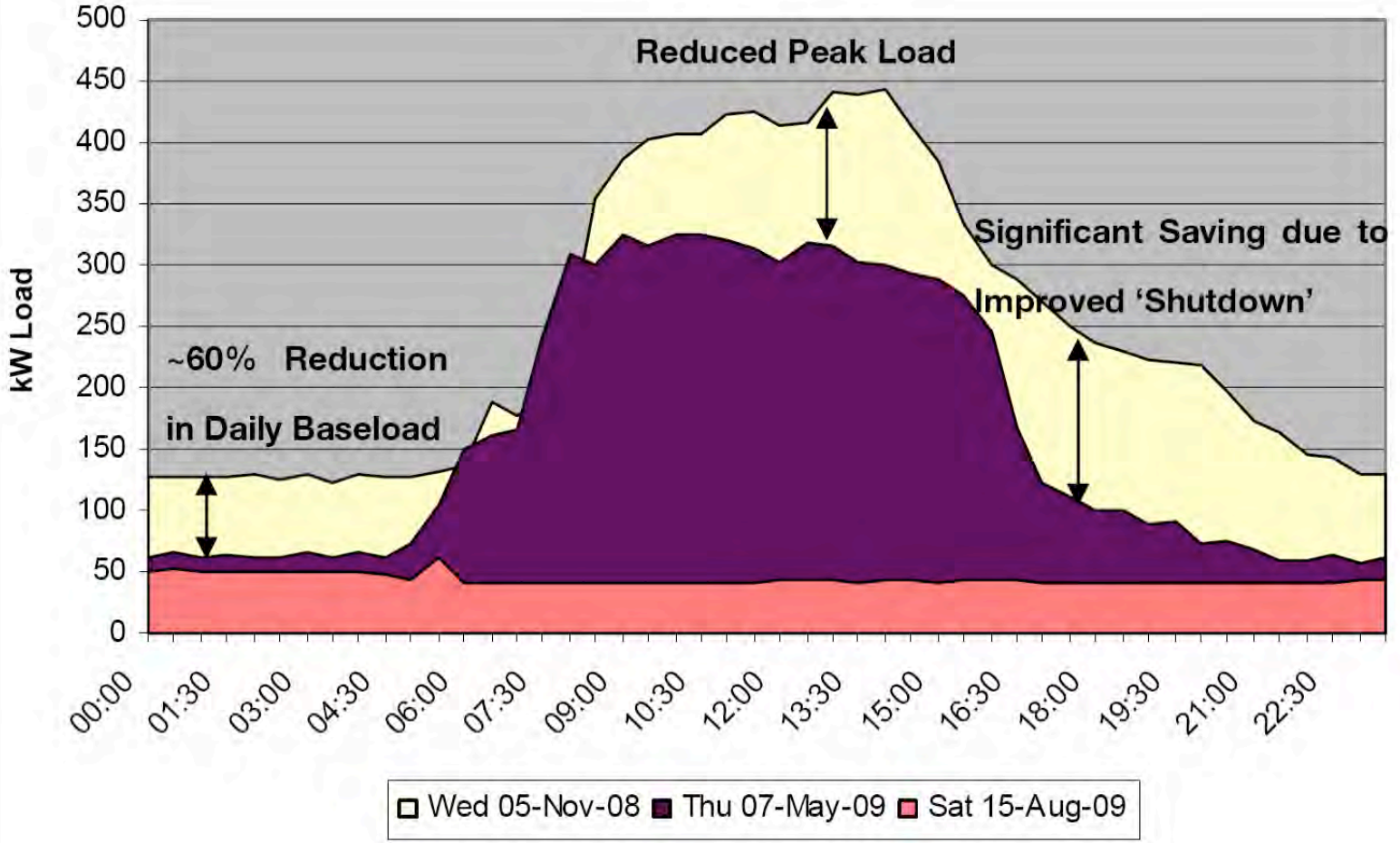
Runs alongside any construction process

Downloadable free
from www.usablebuildings.co.uk
and www.softlandings.org.uk

SOURCE: downloadable from www.usablebuildings.co.uk and www.softlandings.org.uk

Follow-through can pay for itself

Intervention in a recently-completed school



Saving over £ 40,000 p.a. in electricity bills: avoiding default to ON … and occupant satisfaction will often improve too!

SOURCE: Buro Happold Engineers, Soft Landings Trials (2009).

Feeding forward in phased projects: *Window control improvements at Cambridge Maths building*

PHASE 1 **>>>**

- Difficult to understand
- Some poorly located
- Remote control problems

PHASE 2

- Improved, custom design
- Better located
- Not yet perfect

Soft Landings:
Everybody can win

- Better communication, proper expectations management, *fewer nasty surprises.*
- More effective building readiness. *Less rework.*
- Natural route for feedback and Post-occupancy evaluation, *to improve the product and its performance in use.*
- Teams can develop reputations for customer service and performance delivery, *building relationships, retaining customers, commercial advantage.*
- Vital for rapid progress towards more sustainable, low-energy, low-carbon, well-liked buildings and refurbishments, *closing the credibility gaps.*

SO WHAT IS STOPPING US?

- *ATTITUDES: Everybody needs to be committed, starting with the client - perhaps the biggest obstacle. The "golden thread" needs to be put in place.*
- *PROCESSES: There is a learning curve to pay for (probably best from marketing budgets), and the feedback has to be managed.*
- *TECHNIQUES: Independent POE surveys cost money (but not much).*
- *CAPACITY: We need facilitators, investigators, troubleshooters and fixers.*
- *MONEY: Particularly allocation for tune-up etc. after practical completion.*
- ***IMAGINATION: Often constrained by burgeoning bureaucracy!***

6

CONCLUSIONS

Tuning-up our brains

Can we afford to do BPE?
Surely we can't afford not to!

- Construction-related institutions require their members to understand and practice sustainable development.
- How can we do this, unless we understand the consequences of our actions?

SO HOW ABOUT?

- Changing our attitudes to the nature of the job.
- Re-defining perceptions of the practitioner's role, making follow-through, feedback and BPE routine.
- Closing the feedback loop – rapidly and effectively.
- Making much more immediate and direct links between research, practice and policymaking.

Evaluation into action:
What teams can do with BPE information

- **Improve the performance of the building in use:**
  Nearly always possible, but needs motivation, from occupiers too.
- **Improve the goods and services of those who provided it.**
  Always possible. Needs connection, motivation, and organisational knowledge management; and of course paying for!
- **Improve their procurement and delivery processes.**
  e.g. using Soft Landings procedures.
- **Learn personally from the experience**
  Nothing has greater impact than first hand exposure.
- **Contribute to the wider knowledge base,**
  In the past, BPE information was often not well communicated, or regarded as anecdotal, so people didn't take the lessons to heart.
- **Save money** *by spending on the things that really make a difference*
- **Build relationships, retain customers, build reputations**
  Leading firms have often used marketing budgets to get started.

OVER TO YOU

Will you be the change …
or will you be overtaken?

BPE: LET'S JUST GET ON WITH IT!

Supporting information is downloadable free at
www.usablebuildings.co.uk