Welcome to YEPG
Rethinking Energy Performance

Performance Gap – does it really exist?
To become an official member of the group - please email groups@cibse.org stating that you would like to join the Young Energy Performance Group.
6.30pm Welcome
6.35pm Our Speakers
7.30pm Discussion
Networking & Drinks
The performance gap | expectations vs. outcomes
Joining up the dots | cross-industry reach

- **L**
  - Fixed building services at notional occupancy and operating hours

- **EPC**
  - Part L results benchmarked against same 'notional' building as Part L but nat vent

- **GLA**
  - Part L results + some plug-loads

- **DEC**
THE PERFORMANCE GAP: A CULTURAL PROBLEM

Bill Bordass
bilbordass@aol.com
the Usable Buildings Trust
www.usablebuildings.co.uk
The performance gap: is there really one?

What a revealing question!

For most of the building and property industry, performance in use has been another country.

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

“I’ve seen many low-carbon designs, but hardly any low-carbon buildings.”
ANDY SHEPPARD, Arup, 2009

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.
The evidence is now overwhelming:
slide from Carbon Buzz launch in June

Distributions of estimated and actual annual CO₂ emissions/ m² usable floor area in Carbon Buzz data base. www.carbonbuzz.org

SOURCE: Ian Taylor and Judit Kimpian, Carbon Buzz Launch slides, 6 June 2013. www.carbonbuzz.org
The gaps occur in housing too:

*40 years after the 1973 oil crisis*

Minister launches Hub-led project to tackle the performance exchange.

**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

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<td>Temperature in winter:</td>
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<tr>
<td>Productivity (perceived)</td>
<td>Decreased: -20%</td>
<td>Increased: +20%</td>
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“... 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 are not only for energy: 

*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.

Why haven’t we taken more account of the evidence under our noses?

“Any system without feedback is stupid.” ... AMORY LOVINS

“... 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, PPRIBA, Building Research & Information, 2008

• Most designers and builders hand over the keys and go away.
• Government has disconnected from many of its feedback loops, and nothing has been put in its place.
• Too many people want to bury bad news ... or point the finger.
• Evidence from case studies has been dismissed as anecdotal, not used to provide feedback, insights and advance warnings.

THE ONCE-SOUGHT STEP-CHANGE IN PERFORMANCE WILL NEED A SEA CHANGE IN HOW WE GO ABOUT THINGS COLLECTIVELY

SEE: B Flyvbjerg, Five misunderstandings about case study research, Qualitative Enquiry 12, 219-245 (2006),
If you wanted to improve building performance in use, what would you do ...

A. Focus on building performance in use?

OR

B. Do lots of other things and hope that performance will improve ...

Why are we doing things the long way round? Why is actual performance the hole in the middle?
The elephant isn’t in the room, 

*IT IS THE ROOM!*
Which industry and market is really responsible for building performance?

None of these: it’s much more complicated than that.

The lack of traction is not a market failure, but a category error!
As part of your education and training...

DID YOU INVESTIGATE BUILDING PERFORMANCE IN USE?

DO YOU NOW?
So where are we now?  *A confused situation.*

- Building performance is confused with construction and markets.
- Building-related policy measures don’t join up, *theoretically* based and conflicting: not converging effectively onto actual performance in use.
- Policies add complication, *instead of getting people to focus on what really needs doing to get things to work better.*
- Salami-sliced, transactional procurement processes not fit for purpose.

**FOR BUILDING ENERGY PERFORMANCE IN USE:**

- Government has failed to provide core technical infrastructure that could help organisations, individuals and markets to self-organise: *e.g. no investment in in-use benchmarking for more than a decade.*
- Nobody else can do it without government buy-in and focus.
- Designers are trapped in the ghetto of “Regulated Loads”.
- DECs that do disclose performance are being sidelined by DCLG.
- Too much emphasis on carbon. *First energy, then carbon.*

**MARKETS CAN’T SOLVE THIS ALONE: IT NEEDS SUPPORT**
So many barriers to surmount ... what could we do that could enable people to come together in the middle, quickly?

SOURCE: Cambridge Centre for Sustainable Development, Barriers to energy efficiency in the built environment (2012)
A vision for energy performance:

*Where good performance becomes normal*

**Make actual performance in use the objective function:**

• Everyone must own their bit of the problem and concentrate their efforts.
• Count everything. Benchmark its elements where practical.
• Develop effective methods of communicating the results clearly, transparent between design, operation and policy.

*With collective understanding that performance in use is the goal, systems used in producing, owning, occupying, using, managing, equipping, maintaining and altering buildings can measure their contribution towards it, based on what actually works; and identify what needs attention.*

• DECs could then drive better performance ... **BUT**
• **They need sound technical support & authoritative benchmarking.**

How things could then join up for energy

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<th>ACTIVITY</th>
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<td>Briefing, design and alteration</td>
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<td>Completion and commissioning</td>
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<td>Handover</td>
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<td>Operation and fine tuning</td>
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<td>Technical data and portfolio management</td>
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<td>Other purposes</td>
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Carbon Buzz www.carbonbuzz.org can help with this, but it needs strategic integration.
What do we need to support this?

- A shared vision for all building professionals. Environmental responsibility means proper integration and proper engagement with outcomes.

- Recognise that building performance in use should be a properly-resourced knowledge domain, with its own independent voice, able to represent the demand side and both to support and to challenge industry and government.

- For energy, an authoritative Technical Platform: a focal point that can develop the technical infrastructure that will allow the plethora of different systems to converge.
Ricardo Moreira
XCO2 Energy
EXPLAINING THE PERFORMANCE GAP

XCO2 Energy
Evidence of the Performance Gap

- Carbon Buzz tracks energy use from design to operation
- Most projects show a significant increase in energy use in operation
Carbon Buzz Risk Factors

1. Part L calculations
2. Design vs As Built
3. ICT
4. Small power
5. Special functions
6. Operating hours
7. Occupant density
8. Building management
What is BPE/POE?
From Concept

Sketch Design

Technical Design

Enabling Works

DEFINE AFTERCARE/BOE SCOPE WITH CLIENT

CONSULTATION WITH CONTRACTOR & DESIGN TEAM

PREPARE FOR SOFT LANDING

DEFINE COMMISSIONING PLAN

REVIEW METERING & CONTROLS STRATEGY

DISCUSS FINDINGS FROM RELEVANT PAST PROJECTS

SET TARGETS AND METRICS

DEFINE COMMISSIONING PLAN

CONSULTATION WITH CONTRACTOR & DESIGN TEAM

EPC

ENERGY

XCO2
ENERGY OCCUPANT SATISFACTION STUDY
ENERGY ANALYSIS & BENCHMARKING
FINE TUNING (CONTROLS AND BMS)
ENERGY MONITORING
INTERNAL CONDITIONS MONITORING
HINDSIGHT REVIEW

REVIEW HANDOVER
HANDOVER AND COMPLIANCE DOCUMENTATION

FABRIC TESTING

Construction

Practical Completion

to In Use

DEC
Technology Strategy Board

BPE

• Government funded holistic BPE
• Approx 100 buildings (50 non-domestic)
• BPE teams led by client on project team
• Independent BPE expert required to input on evaluation
• Typical funding £40-60k
• Aims:
  • Reduce the performance gap
  • Integrate BPE into the construction industry
  • Understand what affects building performance
  • Generate BPE case studies
Cressex Community School

- EPC B rating
- BREEAM Very Good
- Secondary School
- Located in High Wycombe, Buckinghamshire
- Capacity for 1,100 pupils
- Current occupancy ~630 pupils
- Floor area 11,600 m²
- Biomass boilers
- Gas boilers
- GSHP
- Fully mechanically ventilated
Design vs actual emissions (kg CO2/m2/yr)

- Design prediction
- Actual usage

Carbon footprint (kg CO2/m2/yr)
SBEM predicts carbon emissions from:
- Heating
- Hot water
- Cooling
- Ventilation
- Fixed lighting

Based on assumptions about:
- Set occupancy and
- Operating hours
What is not Covered?

- Plug loads
- Energy use is not zero out of hours
- Server rooms and catering for other schools
- Design changes
- School is under-occupied
- Commissioning problems
- Initial lack of FM

The contributing impact of each factor is very difficult to separate out as they combine in complex ways.
Building Use Factors

• Appointment of FM

Electricity Use Month by Month for 2011 and 2012

Electricity use in 2012 has been reduced compared to 2011 in all but two months.

Electricity use in summer is generally lower than winter. This is likely to be due to the longer school holidays in these months.
Building Use Factors

- Significant building use at weekends and after teaching hours
- Equipment left running out of hours
- Low occupancy
  - Servers run constantly
  - Heavier use (plugloads)

**Average Winter Electricity Usage**

*in Term Time, Holiday and Weekends*
Commissioning Issues

- Incomplete commissioning
- Proprietary systems
- Inability to commission some systems

For example:
- Lighting PIRs
- Daylight sensors
- Proprietary systems
Metering

- Metering documentation from design to in use
- Commissioning - meters reading “0”
- Omissions in submetering (e.g. Biomass and GSHP)
- Mislabelling
- Unhelpful grouping of end uses in submetering
- BMS logging issues

All these factors result in lack of information for the user

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<td>Log book</td>
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<td>Descriptions of Operation</td>
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<tr>
<td>BMS graphical user interface</td>
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</table>
Biomass

Design
• Under roadway
• Complex lid system resulted

Installation
• Lid dropped during construction
• Drainage holes did not match guidance

As a result fuel gets damp, biomass boiler breaks down and gas boilers have to be used instead. This has a significant impact on CO$_2$ emissions.
Design vs actual emissions (kgCO$_2$/m$^2$/yr)

- **Design prediction**
- **Including additional factors**
- **Actual usage**

- **Electricity**
- **Gas**
- **Biofuel**
- **Base prediction**
- **Plug loads and ICT**
Design vs actual emissions (kgCO₂/m²/yr)

- **Design prediction**
- **Including additional factors**
- **Actual usage**

**Energy sources**
- Electricity
- Gas
- Biofuel
- Base prediction
- Plug loads and ICT
- Out of hours usage
Design vs actual emissions (kgCO₂/m²/yr)

- **Design prediction**
- **Including additional factors**
- **Actual usage**

**Indicative**

- **Electricity**
- **Gas**
- **Biofuel**
- **Base prediction**
- **Plug loads and ICT**
- **Out of hours usage**
- **Low occupancy**
Design vs actual emissions (kgCO₂/m²/yr)

- Design prediction
- Including additional factors
- Actual usage

Indicative

- Electricity
- Gas
- Biofuel
- Base prediction
- Plug loads and ICT
- Out of hours usage
- Low occupancy
- Build Quality
Design vs actual emissions (kgCO₂/m²/yr)

- **Design prediction**
- **Including additional factors**
- **Actual usage**

- **Electricity**
- **Gas**
- **Biofuel**
- **Base prediction**
- **Plug loads and ICT**
- **Out of hours usage**
- **Low occupancy**
- **Build Quality**
- **Commissioning**

Indicative
Design vs actual emissions (kgCO$_2$/m$^2$/yr)

- **Design prediction**
- **Including additional factors**
- **Actual usage**

The bar chart compares the design prediction, actual usage, and the breakdown of emissions from various sources:

- **Electricity**
- **Gas**
- **Biofuel**
- **Base prediction**
- **Plug loads and ICT**
- **Out of hours usage**
- **Low occupancy**
- **Build Quality**
- **Commissioning**
- **More intensive usage**
Unpredictable factors might include weather, occupancy patterns, behaviour, sheer chance...

Methodology

Design, construction and operation

Indicative

Design vs actual emissions (kgCO₂/m²/yr)

[Bar chart showing comparison of design prediction, including additional factors, and actual usage]

Actual usage

- Electricity
- Gas
- Biofuel
- Base prediction
- Plug loads and ICT
- Out of hours usage
- Low occupancy
- Build Quality
- Commissioning
- More intensive usage
Conclusion

Methodology needs to be improved:
• Out of hours
• Plug loads and ICT

Design issues need to be more integrated into construction process and subsequent operation.
Is there a Performance Gap?
Esfandiar Burman
UCL EngD Candidate
Aedas R&D
Performance Gap – Does it really exist?!

Review of design vs. actual energy performance of schools

Esfand Burman
3 July 2013
Agenda

• Design vs. actual energy performance of schools
• CarbonBuzz evidence
• Review of Aedas/UCL case studies
• Energy performance analysis: different perspectives
• Procurement gap vs. operational gap
• Compliance approach vs. performance in-use
• Conclusions
Schools and seasonal public buildings

Design Spread

Actual Spread

Source: CarbonBuzz, 2013
TSB BPE Programme

- £8 million funding for building performance evaluation studies on domestic & non-domestic buildings
- Aedas/UCL carried out building performance evaluation on 5 schools designed by Aedas Architects
- Major components of the studies: Building Use Studies, design vs. as-built review, TM22 energy assessment
- Feedback the findings to the designers, various stakeholders and the industry
- Feedfoward lessons learned to future projects
Loxford Secondary School

- 14,600 m² GIA, East London
- Design & Build procurement
- Part L 2006 compliant
- Completed in 2010
- BER 18.5 (kg CO₂/m²/annum)
- BREEAM Excellent
- Predominantly Naturally ventilated
- Ground Source Heat Pump supplemented by gas-fired boilers

Brine Leas Sixth Form

- 2,800 m² GIA, Cheshire
- Design & Build procurement
- Part L 2006 compliant
- Completed in 2010
- BER 17 (kg CO₂/m²/annum)
- BREEAM Very Good
- Full mechanical ventilation
- Solar thermal system for DHW
Stockport Academy

- 10,400 m² GIA, Stockport
- Traditional procurement
- Part L 2006 compliant
- Completed in 2008
- BER 21.8 (kg CO₂/m²/annum)
- Mechanical Ventilation
- GSHP supplemented by gas-fired boilers
Petchey Academy

- 10,500 m² GIA, East London
- Design & Build procurement
- Part L 2002 compliant, completed in 2007
- No thermal modelling at design stage
- BREEAM Very Good
- Mechanical Ventilation
- Air conditioning (Air cooled chillers)
Academy 360

- 10,200 m² GIA, Sunderland
- Design & Build procurement
- Part L 2006 compliant, completed in 2009
- BER 14.9 (kg CO₂/m²/annum)
- BREEAM Very Good
- Predominantly Naturally ventilated
- Biomass boiler, solar thermal panels
Carbon emissions conversion factors: 0.19 kg CO₂/kWh for gas & 0.55 kg CO₂/kWh for electricity
Electrical loads - Normalised by internal gross floor area

- Night time Mech. Vent. & Cooling
- Full Mech. Vent. (no VSD)
- Full Mech. Vent. (VSD)
- Nat. Vent. Strategy

Electrical load (W/m²) vs. Time (00:00-23:00)

- Stockport Academy
- Brine Leas School
- Loxford School
- Petchey Academy
Detailed analysis of the electrical loads

Daily electrical power demand: Stockport Academy

24 hours lighting & power energy trend (weekday)

Average weekday

- Night time lighting demand: 1.3 W/m²
- Daily lighting demand: 10.5 W/m²
- Night time power demand: 2.6 W/m²
- Daily power demand: 6.0 W/m²

Average weekend

- Non-regulated operation of heating and mechanical ventilation systems

Power

- Daily power demand: 6.0 W/m²
- Night time power demand: 2.6 W/m²

Lighting

- Daily lighting demand: 10.5 W/m²
- Night time lighting demand: 1.3 W/m²
Bottom up energy analysis: Lighting

**Lighting (kWh/m²)**
- B: 10.3
- A: 21.6

**Lighting (W/m²)**
- B: 7.5
- A: 9.0

**Illuminance (lux)**
- B: 300
- A: 450

**Efficiency ((W/m²)/100 lux)**
- B: 2.5
- A: 2.0

**Effective hours**
- B: 1368
- A: 2398

**Hours of use**
- B: 1520
- A: 2180

**Management factor**
- B: 0.9
- A: 1.1

B: Baseline, A: Actual
Bottom up energy analysis: Fans

- Ventilation (kWh/m²)
  - B: 11.1
  - A: 36.2

- Ventilation (W/m²)
  - B: 5.5
  - A: 7.2

- Efficiency (W/(L/s))
  - B: 2.5
  - A: 2.78

- Ventilation rate ((L/s)/m²)
  - B: 2.21
  - A: 2.59

- Hours of use
  - B: 2521
  - A: 4192

- Effective hours
  - B: 2017
  - A: 5030

- Management factor
  - B: 0.8
  - A: 1.2

B: Baseline, A: Actual
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B: Baseline, A: Actual
Asset Rating vs. Operational Rating

EPC vs. TM22 energy breakdown: Stockport Academy

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<td>Lighting</td>
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<td>29</td>
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<td>DHW</td>
<td>19.9</td>
<td>10.4</td>
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<tr>
<td>Non-regulated end-use</td>
<td>27.7</td>
<td>48.6</td>
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Energy Performance Asset Rating

EPC: The energy performance of a building

DEC: The UCL Department of Energy and Climate Change

Technical Information:

- More energy efficient
- Less energy efficient

Benchmarks:

- A: 0-25
- B: 26-50
- C: 51-75
- D: 76-100
- E: 101-125
- F: 126-150
- G: Over 150

Energy Reference Standard Rating

- Natural Gas
- Electric Heating
- Electric End-Uses
- Solar

Pressure: 1 bar

Notes:

- Net energy demand
- Net energy use
- Net energy expenditure
- Net energy efficiency
- Net energy generation
• Building Regulations compliance & EPC calculations are carried out under ‘standardised’ conditions.

• A like-for-like comparison is only possible under identical conditions (set points, schedules of operation, occupant density, flow rates, etc.).
Methodology to separate procurement & operational gaps

Design projection
- Regulated loads
- As-built performance gap

Verified As-built performance:
- Benchmark against design projection
  - NCM setpoints, schedules, and internal gains
  - Non-regulated end-use excluded

Total energy use
- Operational Rating
  - Occupant behaviour
  - Non-regulated end-uses

Special functions
- Inefficiencies and uncertainties

Thermal model validated with metered energy
- Procurement and commissioning issues account for up to **20%** of total energy performance in case study buildings!

- Operational issues account for almost **30%**.
Major findings

• Actual energy performance of new-built schools is typically 1.5-2.0 times the design estimations derived in accordance with the NCM ‘standardised’ conditions.

• Heating & cooling energy in all buildings significantly higher than design estimations.

• HVAC zoning often not effectively used for out-of-hours & extra-curricular activities.

• Interface control between Low or Zero Carbon technologies and supplementary HVAC systems is critical!

• Automated lighting control zoning & set up too often compromised at the commissioning stage.
Major findings (Contd.)

- High risk of mechanical ventilation (could be successful but requires proper commissioning, optimal control and proactive maintenance regime).

- Equipment load accounts for 20-30% of total electricity consumption.
Wider lessons

- Unintended consequences of Part L
- Rebound effects in BSF schools
- Compliance approach vs. performance in-use
- Building fine-tuning/Soft Landings necessary
- Feedback loop necessary
Thank you for your attention!

Contact: esfandiar.burman.10@ucl.ac.uk
Our next event is – Future Proofing: Do we need to bother?

Register at
cibseyepgsummerseries.eventbrite.co.uk