GETTING REAL ABOUT BUILDING PERFORMANCE

DR JUDIT KIMPIAN
Over 20 academic papers, UKGBC, AJ100, GreenBuild, CIBSE awards recognition
Building Performance?

A **resource efficient** way of providing...

... a healthy, comfortable, safe, environment over a building's life span

*Source: Artist Maria Arceo*
Innovate UK BPE deliverables

TM22 Energy Use Assessment

Final Report

BUS
Get REAL about building energy consumption

Our figures show that on average, buildings consume between 1.5 and 2.5 times predicted values.

CarbonBuzz will help you close the gap between calculations and actual building performance.

Get Started or Find out more

Upload
Download template to gather data
Register to add new project
Enter project details and energy consumption

Share
Add users to your account
Specify their access rights
Share a locked or an editable project across organisations
Publish project to add attributable data to the public domain

Compare
Compare your design estimate against operational energy use
Find out how your building performs against others
Study the end use composition and contributing factors of other projects
Detailed CarbonBuzz energy records at key project stages

Automatic upload from TM22 & EPC

- Heating
- DHW
- Cooling
- Auxiliary
- Lighting
- Non-regulated load
Performance Gap | calculated vs operational data medians

CO₂ emissions (kg/m²/yr) for various sectors:
- Education: (89) (142)
- Offices: (51) (97)
- Residential: (10) (3)
- Non-domestic accommodation: (14) (12)
- Retail: (4) (14)
- Health: (4) (15)
- Transport: (0) (0)
- Civic: (4) (1)
- Industrial: (1) (1)
- Hospitality: (7) (2)
- Sport & Leisure: (9) (11)

Source: CarbonBuzz.org, an RIBA CIBSE platform
Sector by sector data | calculated vs achieved performance

- **Schools**
  - Heat: 1.48
  - Electricity: 1.9

- **Universities**
  - Heat: 1.2
  - Electricity: 2.3

- **Offices**
  - Heat: 1.59
  - Electricity: 1.71

The graphs show a comparison of calculated vs actual performance with bars indicating the deviation.
“£5Bn spent on new buildings each year, these buildings use 2-3x more energy than designed”

2014 Green Construction Board Report
Legislative drivers for Energy Reporting
Comparing apples and pears...
Compliance calculations are not predictions and evaluate a building’s energy performance potential while disregarding major energy risk factors:

- **EPC**
  - As Built Building & System Properties
  - Standard conditions

- **+ All equipment**
  - Appliance
  - IT
  - Lifts
  - External lights
  - Special equipment
  - Etc. see list in CB Controls

- **+ As built Factors**
  - Actual system and fabric performance inc controls
  - Commissioning
  - Metering
  - Energy management setup

- **+ Management Factors**
  - Hours
  - Occupancy
  - Zoning, set points, schedules
  - FM regime
  - Maintenance
  - Occupant engagement
  - Actual weather & climate
Innovate UK CarbonBuzz Forecast Beta tool assists users to estimate total energy use of schools and offices from EPCs:
Innovate UK AHR Building Performance Evaluations
AHR BPE projects compared to CarbonBuzz published and anonymised projects
AHR BPE projects compared to published and anonymised projects

PIC

TIC

Published offices

All published projects
TSB BPE Portfolio on CarbonBuzz to be launched soon

Tremough Innovation Centre

Pool Innovation Centre
Pool and Tremough Innovation Centres | ‘fabric first’ approach

<table>
<thead>
<tr>
<th>Second floor</th>
<th>First floor</th>
<th>Ground floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>B1</td>
<td>C1</td>
</tr>
<tr>
<td>D1</td>
<td>E1</td>
<td>F1</td>
</tr>
<tr>
<td>G1</td>
<td>H1</td>
<td>I1</td>
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</tbody>
</table>

![FLIR image]

Trefl=20 Tatm=20 Dst=15 FOV 23
2012-04-13 08:43:05 -10 - +55 e=0.98 °C
Windowmaster system, façade pvs, copper, slate, timber, glass

Sedum roof, Monodraft wind catchers, rainwater harvesting

Rooftop PV, biomass boiler, woodchip storage
Tremough Innovation Centre | Passive design measures

1. Exposed concrete soffits provide thermal mass.
2. High ceilings aid good air movement.
3. Raised floor provides flexibility and service zone.
4. High level windows are BMS controlled with temperature and CO2 sensors with manual override.
5. Low level windows provide a good view out when closed and allow manual control of ventilation.
6. Perforated roller blinds allow views but allow view out.
7. Perimeter radiators temper incoming cold air and counteract cold down draughts in windows.
8. Bi-folding doors on southern façade shades the windows during summertime whilst allowing an uninterrupted view out. Solar gain is utilised in winter.
9. Deeper offices on southern sides have cross ventilation with BMS/motorised dampers in wind chimes and opening windows.
10. Less deep northern side offices can have single-sided ventilation without overheating.
11. Lighting incorporates acoustic treatment with hanging baffles between to allow tuning of offices as tenant zones and so on.
12. Lighting dims nearest windows with light sensor control and manual override.
13. Lights have proximity sensor to ensure lights are turned off in vacant spaces.
14. Weather station helps temperature control and can shut windows in high winds.
15. Earth Tubs – pre-cool/pre-warm supply air into conference room – no air conditioning in the building.
16. Natural ventilation to server rooms (high and low level).
17. Roof suitable for retrofit solar PV panels.
    a. High insulation levels.
    b. Good air tightness.
20. Biomass fuel for space and water heating with gas backup.
22. Low flow showers and taps with leak detection.
Tremough Innovation Centre

Brise soleil, Velfac windows

Biomass boiler, earth tubes
Collection of metered and submetered energy data
<table>
<thead>
<tr>
<th>Security cameras</th>
<th>Number plate recognition</th>
<th>BMS</th>
<th>Alarms</th>
</tr>
</thead>
</table>

**BMS control systems** | multiple systems, lack of logging function
AHR Visualisation of tenant energy consumption

Pool Innovation Centre

From opening to 29/02/2012

From 29/02/12 to 13/04/2012

From 01/03/12 to 29/06/2012
Energy end use reconciliation

**EPC vs. TM22 energy breakdown: Tremough Innovation Centre**

<table>
<thead>
<tr>
<th>End Use</th>
<th>EPC (kWh/m²/annum)</th>
<th>TM22 (kWh/m²/annum)</th>
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</thead>
<tbody>
<tr>
<td>Heating</td>
<td>29.3</td>
<td>88.1</td>
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<tr>
<td>Cooling</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Auxiliary</td>
<td>2.1</td>
<td>6.8</td>
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<tr>
<td>Lighting</td>
<td>22.5</td>
<td>19.4</td>
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<tr>
<td>DHW</td>
<td>33.9</td>
<td>20.1</td>
</tr>
<tr>
<td>Non-regulated end-use</td>
<td>42.3</td>
<td>46.7</td>
</tr>
</tbody>
</table>

**EPC vs. TM22 energy breakdown: Pool Innovation Centre**

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<th>EPC (kWh/m²/annum)</th>
<th>TM22 (kWh/m²/annum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating</td>
<td>48.6</td>
<td>59.4</td>
</tr>
<tr>
<td>Cooling</td>
<td>0.2</td>
<td>2.2</td>
</tr>
<tr>
<td>Auxiliary</td>
<td>6.4</td>
<td>7.3</td>
</tr>
<tr>
<td>Lighting</td>
<td>21.9</td>
<td>20.1</td>
</tr>
<tr>
<td>DHW</td>
<td>35.3</td>
<td>10</td>
</tr>
<tr>
<td>Non-regulated end-use</td>
<td>29.8</td>
<td>46.6</td>
</tr>
</tbody>
</table>
BUS Summary | PIC and TIC | TIC Occupier: “This building makes me feel human”
“Aesthetically well designed. Good layout”
“Modern & bright, nice exterior”
“Good design -winter -warm summer-cold”
“Impressive design &very modern”
“Interesting without being overtly different. Nice use of materials reflecting Cornwall”
“Very smart, clean and crisp looking”
“Well designed building, good features”
“Local, secure, available 24hrs, well placed”
“Facilities are great, all needs met.”
“Love the way it looks but some of the functions let it down, kitchens, heating & lighting”
“The kitchen space is not sufficient. Meeting rooms are good”
“No small offices, poor reception layout, inadequate parking”
“Window, noise, blinds, toilets”
“Love the way it looks but some of the functions let it down, kitchens, heating & lighting”

“Good work environment”
“We work "smarter here than we did in our old office. Hard to translate into % on productivity”
“Good facilities generally “
“Communal area would be nice-a relaxed café environment where we could all mingle”
“Styling, bold & attractive, fits with our surroundings”
“Building looks impressive. Nice offices & communal space. Shower rooms & locker nice touch”
“Modern & stylish”
“Nice & clean- looked after”
“Serious issues with ventilation-automatic window opening/closing”
“Spacious, light, warm”
Occipier feedback | Architecture is a key determinant of building performance

<table>
<thead>
<tr>
<th>Academy 360</th>
<th>Petchey</th>
<th>Stockport</th>
<th>Loxford</th>
<th>Brine Leas</th>
<th>Pool IC</th>
<th>Tremough IC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>47%</td>
<td></td>
<td>53%</td>
<td>25%</td>
<td>2%</td>
</tr>
<tr>
<td>21%</td>
<td>43%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>29%</td>
</tr>
</tbody>
</table>

“This building makes me feel human”
Unintended consequences of EPBD | complexity of services

15-44% potential savings | on average £30-40K/yr/building
Capital and whole life cost of mechanical systems | fabric first?

MEP services for typical office can account for...

20-30% of Capital Cost

Over 85% of Whole life cost
Capital cost of unused/underutilised equipment: Metering, BMS, sensors and controls, AHU inverters, actuators, LZCs, etc. can amount to 2-5% of capital cost.

Misplaced value engineering: fabric performance and air-tightness, all openings, floor to floor heights, thermal mass, entrance lobbies, seasonal commissioning, daylighting, controls, training, manuals & log book – compliance or architecture?

Increased management, maintenance and energy costs: between 15-44% of total annual energy costs could be saved amounting to potentially tens of thousands of pounds per year.

Mitigation costs: ~ 50% of annual energy costs – Soft Landings with energy disclosure approximately 0.1% of construction budget.

Profit loss of consultants and contractors.

Productivity loss for occupiers and FM.

Policy change is needed to encourage disclosure – reinforce DECs.
Conclusions | the cost of POEs

50% of our time went on gathering energy data

20% on chasing client, consultant and contractor teams for design vs as-built data

25% on analysis of the data gathered and additional energy modelling

5% on gathering occupant feedback

Collection and benchmarking must be the contractors responsibility
Investment KPIs

Virtual Information Models

Validation

Architecture creates better links between CapEx and OpEx imperatives
Beyond compliance – target operational performance

Fabric first approach was successfully implemented due to nZEB aims

Identify & track risks – include in contractors prelims

Any opening is a risk – user interface is key

Contractor to start data collection in first few months of operation

Metering and submeter logs need to work via BMS – contractor should submit readings during the first year of occupation on a monthly basis

Controls need substantial innovation – BMS, windows, security, heat, light, ventilation

Low carbon systems – biomass was problematic but works, don’t underestimate the maintenance requirements

Involve FM early – a major contributor to occupier satisfaction

Soft Landings implementation to include energy data drops from design to operation
New types of contracts are needed to enable data sharing from start to end
Some of the design features won:

- Timber windows with 150mm acoustic louvres
- Floor to floor heights – 3.05m
- Vent voids
- Lighting: light shelves, task lighting and voids to North
- Thermal Mass incorporating cooling pipe work
PROJECT BRIEF

- Reducing council offices from 10 to 4
- Working environment with a ‘one council’ culture
- Halve the council’s buildings energy use
- Efficient working: 688 people to 455 workstations – 3/2 desk sharing
- Targeting DEC A rating from the outset rather than BREEAM
- The first project to use BSRIA Soft Landings to achieve DEC A by 2\textsuperscript{nd} year of operation
THE SITE

- A landmark scheme to regenerate the town centre
- 50% site given over to new public space
- Robust ‘no maintenance’ materials
- Stone for ground level and brass and aluminium cladding above
TYPICAL OFFICE LAYOUT

- Open plan offices
- Maximise NS orientation
- Voids on North perimeter
- Voids adjacent to circulation
- Meeting rooms and kitchenettes on W perimeter
- Tea points, meeting rooms & copy areas at east & west ends
Keynsham Civic Centre

WINDOW DESIGN

- Acoustic buffer
- Light shelves
- Night ventilation
- High level automated glazed vents
Keynsham Civic Centre

THE BUILDING

- Ventilation voids
- Visual integration of office and meeting areas
- Cross laminated timber structure
- Thermal mass in ceiling
- Good daylight penetration throughout
THE BUILDING

- Cross-laminated timber (CLT) structure
- Visual integration of common areas
- Breakout spaces
Keynsham Civic Centre

THE BUILDING

- Steel supports
- Thermal mass in ceiling
- High level automated glazed vents
Architecture is key beneficiary of performance contracting
R&D CONTRIBUTIONS TO NATIONAL & INTERNATIONAL AWARDS.

R&D-LED GOVERNMENT & INDUSTRY PARTNER-FUNDED RESEARCH PROJECTS AMOUNTING TO OVER £2M OVER THE PAST 5 YEARS
AHR COMMITMENT TO SHARING PUBLICLY FUNDED RESEARCH OUTCOMES

PUBLISHED PEER REVIEWED RESEARCH

CHAIR – ARCHITECTS COUNCIL OF EUROPE SUSTAINABILITY GROUP

DG ENVIRONMENT, ENERGY, ENTERPRISE EXPERT STEERING GROUP MEMBER

RIBA SUSTAINABLE FUTURES GROUP

CIBSE ENERGY PERFORMANCE GROUP

BSRIA SOFT LANDINGS GROUP MEMBER

HALVING WASTE TO LANDFILL SIGNATORY

UKGBC MEMBER COMMITMENT

UKGBC TASK GROUP CONTRIBUTOR

EDUCATION FUNDING AGENCY STEERING GROUP MEMBER
SMALL COMPANY TAX CREDIT
~ 25% OF ALLOWABLE SPEND
LARGE COMPANY TAX CREDIT
– 7.9% OF ALLOWABLE SPEND
ENERGY PEOPLE BUILDINGS

MORE ABOUT OUR BOOK

With Hattie Hartmann and Sofie Pelsmakers