Designing the "mind the gap" project – investigating the difference, in performance, between design and the building "in-use"

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Abstract: *We have the ability to design good buildings and the knowledge to operate them in an effective and efficient manner – so why doesn't it happen?*

The "Mind the Gap" project intends to collect evidence from exemplar office buildings with a range of performance; investigate the reasons for their performance; determine the underpinning causes; and then present practical solutions to solve any underperformance.

The first phase will to produce a methodology based on the learnings from the trial buildings. This will be streamlined with the process then rolled out in a second phase over a larger number of buildings to produce a statistically significant sample which covers office buildings with a full range of servicing and age.

This paper:

- *Introduces the performance gap.*
- *Describes the "Mind the Gap" project and its methodology.*
- *Presents some initial data and findings.*

Keywords: Performance gap; Asset performance; Operational performance

1. Introduction

The construction industry has in general been "designing for compliance" using software with "standardised driving conditions" – see below. We know how to build good performance buildings but the issue seems to be having the design feed through to performance-in-use [1].

This has led to what has been termed the performance gap. In reality this has two components (see Figure 1):

- The compliance gap; and
- Actual performance gap.

The overall gap has been estimated at between 200-450% [2] of which the modelers estimate 50-70% is the compliance gap [3] and can be solved with more realistic modelling mirroring the conditions in operation more closely.

However, the underpinning reasons for the second and larger actual performance gap are generally unknown. There is a lot of speculation and hypothesis but little investigation and hard evidence.

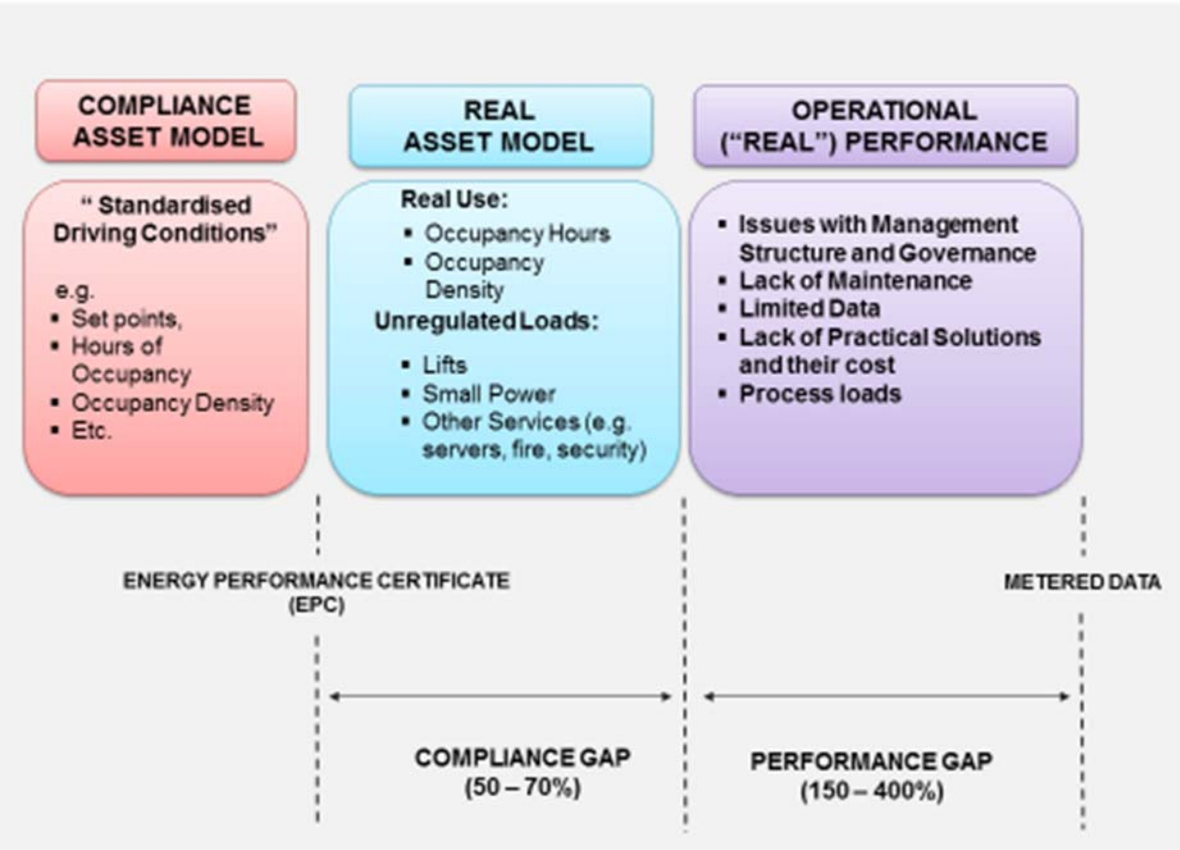

Figure 1. The difference between design and the building "in-use"

2. Why is the important?

The Management of real estate investments aimed at maximising property value and return on investment [4] via

- Effective risk management;
- Efficient property management;
- Identification and implementation of valuable improvements.

A high-performing building generates maximum profit via:

- High and continuous rental income;
- Low operating & maintenance cost;
- Low depreciation.

However, poor operational management undermines the aims of asset management and leads to:

- Increased tenant complaints regarding comfort conditions and loss of reputation;
- Higher service charges;
- Longer void periods leading to a reduction of income;
- Lower and shorter rental values, as a consequence of high service charges and poor comfort conditions;
- Capital expenditure on HVAC equipment failures, due to poor maintenance;
- Tenants wanting to renegotiate rent values based on comfort and maintenance issues.

On a pure cost basis, the operation energy or the energy used in using a building is up to 50% of the operation costs or 40% of the total cost of a building; see Figure 2 below:

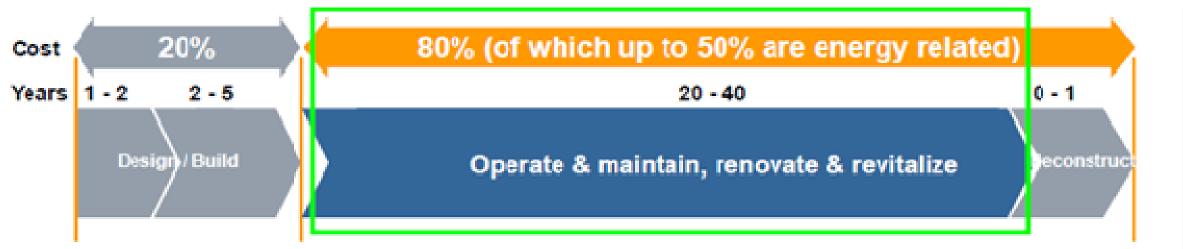

Figure 2. The life costs of a building

If this is inflated by a multiple of 2 to 4.5 the cost to the end user is considerable. However, if the occupier is leasing these may just be passed onto them and they more not have much say in the management of the building.

The effect on the asset and its value is just as dramatic with:

- Deterioration of value;
- Service life of plant reduced;
- Fabric lifetime reduced;

- Costly remedial works to maintain value;
- In 'void' periods there is likely to be still further deterioration through lack of use;
- Loss of reputation.

3. Investigating the gap

BRE have previously attempted to close the gap by using the Green Deal Tool to map Energy Performance Certificates (EPCs) onto Meters readings [5,6], although this approach has merit the sliding energy management scale has little underpinning research to support the assumptions and no verification has been carried out to support these judgement calls by expert groups.

Anecdotal evidence from the asset management industry has indicated a number of possible reasons:

- Issues with the management structure and governance;
- Lack of maintenance due to resource and skills shortage;
- Limited data;
- Lack of practical solutions and their costs.

However, the real truth is nobody knows and this present an opportunity for whoever finds the evidence for the underpinning causes and then presents practical solutions to solve them. This has been recognised by the construction industry and priorities that were fed back from the UKGBC Delivering Building Performance task group; the UK Innovate building performance project and a BSRIA workshop on Building Performance were:

- There was data on the performance gap but no systematic investigation of the reasons why and the magnitude of the issues – what was needed was a controlled study to investigate this; not attempting to link datasets;

- Design was not an issue but operation and the associated issues seemed to be the cause, however there is only anecdotal evidence to support this. A study is needed to codify and quantify the causes of poor performance in use;

- The "gap" seems to increase with time, again anecdotal evidence is available with no quantification of the underlying reasons; with a long-term study needed to identify, qualify and quantify any affect;

- Health and wellbeing is associated with this effect but, as before, there is not true quantification, model or tool; as a result, a monetary value cannot be assigned to the loss/gain of productivity leading to an incomplete business case. A desk study is needed to identify knowledge gaps following by field study producing data leading to a model/tool for quantification of productivity loss/gains.

The main barrier to this is quality data from a large enough sample with full access to the building and their occupants – we have now been presented with that opportunity. What was missing is "real-life" exemplars to investigate the actual causes of the performance gap and propose practical solutions.

3. The "Mind the Gap" research project

This research project is in two stages where the on-going first stage defines the methodology using trial buildings to determine the correct data to collect and the right questions to ask; with a proposed second stage rolling this out over a larger number of buildings.

The objective of this project will be:

1. Scope proposed buildings and choose suitable exemplars for the purpose of collection and analysis of metered, asset and energy audit data.

2. Using the results, from 1., propose reasons for the performance gap; produce operational and asset recommendations; and model the benefits.

3. Based on the learning from these trial buildings produce a methodology that can be rolled out to a larger number of buildings.

4. Propose a second phase covering more office buildings, which covers the breath of the building stock in this sector and aims to produce a tested generic methodology for the office sector, which includes

    a. Fully air-conditioned;
    b. Mechanical vented;
    c. Naturally ventilated.

3.1. The initial Methodology

The initial methodology:

1. Scope proposed buildings and choose suitable exemplars – see figure 3.

2. Hold an inception workshop for each of the buildings, along with targeted follow-up, to map the data and produce a data gap analysis. From this and consideration of the other research questions produce a full project action plan for the project.

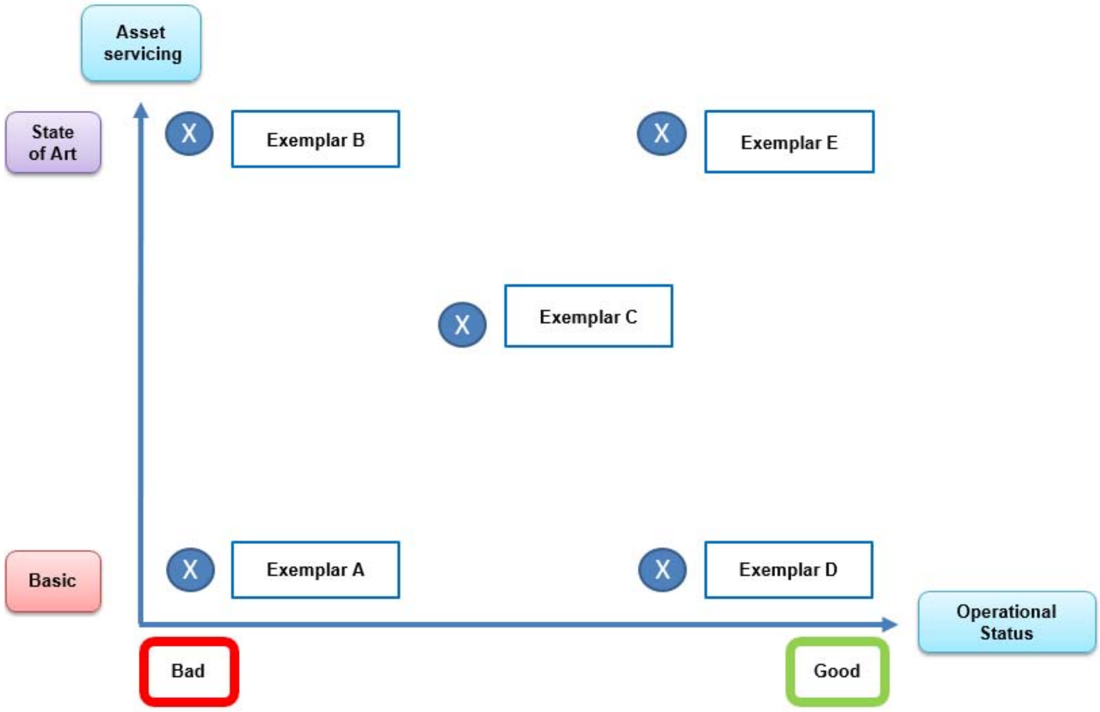

Figure 3. The choice of exemplar buildings

3. The modelled data will be in the form of a NCT file from the Interface to Simplified Energy Model (iSBEM) software. The NCT file will be checked to ensure it reflects the buildings current geometry, usage and servicing.

    a. The metered data will be in a ½ hourly form and transferred into a spreadsheet.
    b. At this point operational data will be required and will be collected by a mini-audit including interviewing key members of the operational, facilities and maintenance staff.

4. Basic information about the population and lifts were sourced from the building operators. These inputs were used to run simulations using the generic Energy Model in the Elevate elevator simulation software [7]. Calibration of the model is based on measurements made as part of a research project with ThyssenKrupp [8]. The simulations were run applying a full day traffic demand template, reflecting the rise and fall of passenger demand during a typical day, and the impact this has on energy consumption. Out of hours and weekend energy consumption was assumed to reflect standby load only. Lifts of the same basic specification from different sources have dramatically different energy performance, thus the results are indicative only. There is insufficient measurement data in the public domain at this point to be able to give a range of expected results.

5. Determine any data gaps and proposed how they will be filled.
6. On the basis of the gap analysis above install and commission sub-metering if required.

7. Collect additional data if required, especially with respect to energy management activities – this will include the use of "energy matrices [9].

8. Analyse the modelled data and input into the Green Deal (GD) Tool along with Energy management, operational and bill data [6] to join the asset and operational data up. If carry out a calculation of the lift energy usage.

9. Analyse the metered and produce energy profiles [9] for day/night; weekday/weekend and seasonal; look for high base consumption and any unusual usage patterns. Compare to the Real Estate Environmental Benchmark (REEB) for energy [10] – these are produced by Better Building Partnership (BBP) and are:

- Based on the performance of buildings 'in-use';
- Publicly available operational benchmarks;
- Based on the annual consumption data of BBP members property portfolios;
- based on a 3-year rolling average;
- Updated each year;
- Office sample size for air-condition can be considered representative (185);
- Limited sample (25) for naturally ventilated offices;
- Can probably be seen to represent good practice.

10. Carry out a targeted energy audit, in line with BS EN 16247 [11] and best practice [12], to:

a. Investigate user behavior;
b. Investigate working practices including maintenance regimes;
c. Examine high and unusual energy consumption patterns.

11. From consideration of the analysis of the asset and operations data, use the GD to run recommendations based on business case parameters and best practice [13].

12. The methodology will be based on the learnings from the trial buildings and aims to streamline the process with the aim of designing a second phase where this will be run out over a larger number of buildings to produce a statistically significant sample which covers office buildings with a full range of servicing and age.

4. Initial results and discussions

The initial results in terms of energy performance are given in Table 1.

This table shows energy performance in terms of:

- the modelled asset usage including lift energy;
- the operational usage from metered data; and
- the performance gap in terms of a percentage.

Observations from this initial data are:

- The performance gap was confirmed as real and in the range 209 to 491%.
- The values observed were similar to that observed by previous studies which were between 200 and 450% (see Figure 1).
- There was no relationship between the perceived operational status (Figure 3) and that observed;
  - Exemplar E was perceived to have good operational status; has one of the best two asset ratings (61 C) and the lowest metered usage. However, it has a performance gap of 280% which is around the average of 300% for the 5 buildings.
  - Exemplar C on the other hand was perceived to have averaged operational status; has the best asset rating (58 C); the highest metered usage; which results in the highest value for the performance gap at 490%.

Table 1

Exemplar building energy performance

	Exemplar	A	B	C	D	E
Metered data						
2017 unadjusted gas data KWh/yr.		1,098,666	1,062,816	95,184	212,242	4,176,555
Total 2017 electricity KWh/yr.		775,445	1,675,704	788,268	775,445	9,424,437
Total unadjusted usage KWh/yr.		1,874,111	2,738,520	883,452	987,687	13,600,992
Total unadjusted usage KWh/m²/yr.		**340**	**268**	**527**	**340**	**264**
Asset rating & iSBEM Version		79 D - 5.3.a	96 D - 5.3.a	58 C - 5.3.a	114 E - 5.3.a	61 C - 5.3.a
building environment		Air Conditioning	Air Conditioning	Air Conditioning	Air Conditioning	Air Conditioning
floor area (m²)		5515	10211	1676	2906	51608
Total KWh/m²/yr.		118	97.0	87.6	146.7	89.2
Lift energy KWh/m²/yr.		8.80	10.12	19.87	16.29	5.90
Total asset model KWh/m²/yr.		127	107	107	163	95.0
Performance gap (%)		**267**	**250**	**491**	**209**	**277**

5. Conclusion

The initial data collection was difficult to collect and the remaining data required for the first phase will be collected or measured on-site. Current data collection and storage processes are ineffective due to the lack of management and a dedicated resource.

The second stage will concentrate on investigating both the asset, operational and management features of 5 buildings in order to obtain more granularity in terms of key performance aspects/indicators and the underpinning reasons/drivers for the poor performance.

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