Implementing the Use of Operational Data in Buildings

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Abstract

This paper considers how Operational Data might address both legislative and operational requirements from the viewpoint of an operational estate. It is framed within the context of the IEE iSERVcmb project procedures for describing operational energy data against the building activities and assets.

The observations and findings from the paper show that there appear no practical reasons why the same operational data should not be used to show compliance with legislative procedures, if these were to be framed appropriately, and to provide the detailed information needed to enable action to achieve efficiency improvements in an Estate. The paper shows the significant measured energy savings possible from the use of Operational Data, as well as the ability to understand the physical estate more accurately.

The work is based on characterizing utility use in an Operational Estate by reference to performance achieved in other operational buildings, but the procedure could be used to characterize any efficiency measure with practical derived metrics.

Keywords - Operational Data; iSERVcmb; Tailored Energy Benchmarks; Measured Energy Savings

1. Introduction

Following on from the Europe-wide iSERVcmb IEE Project [1], this paper examines the implementation of an Operational Data approach to help manage Cardiff University Estate in the UK from the viewpoint of the Estate Operators. It considers how the practical needs of the operators are mirrored by existing standards, but not by the existing legislation with which they have to comply.

The paper explores the real benefits the Operational Data approach brings to understanding the Estate, its services and the most promising potential areas for investing money, time and effort to achieve lower utility use.

The paper is presented from a series of viewpoints, which briefly cover the issues involved in each:

- The requirements of ISO Standard 50001 - Energy Management Systems [2]
- The requirements of the Estate Operators
- The data to be collected and collated
- The outputs from the process
- The framing of new legislation for using Operational Data.

The paper shows the approach addresses the requirements of ISO50001, suggesting a straightforward route into legislation might be possible.

2. Methodology

The paper is based on a mixed methods approach, using quantitative based approaches for the measurable aspects of the study such as room areas, energy consumption, services components, etc., mixed with qualitative descriptions of the activities serviced in the buildings. It describes the approaches taken to transcribing this information on the existing buildings, meters and components into the online application. The findings and results are illustrated via Case Studies drawn from the Cardiff University Estate.

3. Operational Data Viewpoints

3.1. Energy Management Practice and Standards

Existing practice revolves around general guidance published by government agencies, trade and professional bodies, and manufacturers. This guidance tends to focus on demonstrating how to implement sustainable facility management programs and energy management action plans [3][4], presenting best practices of energy management and benchmarking specific to energy intensive building typologies such as data centres and schools [5][6][7][8], or identifying and quantifying energy savings [9][10]. Data driven approaches are more prevalent in the category of guidance identifying and quantifying energy savings. However, it would appear that there is an absence of a standard workflow to analyse and contextualise data, and existing guidance provides advice based on best practice and rules of thumb.

Existing international standards on energy management in buildings include ISO 14001 [11], ISO 9001 [12], and ISO 50001, the most pertinent of which to this paper is the more data driven ISO 50001 and its companion guidance standards ISO 50002 [13], ISO 50003 [14] and ISO 50004 [15].

ISO 50001 provides a framework to understand and reduce energy consumption using operational data. According to this standard, organisations are expected to develop, record, and maintain an energy review through analysis of energy use and consumption based on measurement and other data, which can include identification of present energy sources and evaluation of both present and past energy use.

The review is also to include the identification of energy intensive areas, determine their present and estimate their future energy use, with the ability to achieve a level of detail reaching individual systems, facilities, processes, equipment and personnel. Finally the review is to identify, hierarchize and record opportunities for improving energy performance.

The iSERVcmb approach addresses the analysis required from organisations in order to compile the ISO 50001 energy review, as it allows the understanding of consumption and opportunities for improvement at the level of energy use per space or component, enabling compliance with the requirements of the ISO 50001 route to effective energy management.

3.2. The Requirements of the Estate Operators

Cardiff University's Estate consists of 25,414 individual spaces covering very diverse activities and occupying 424,720m^2. The management of this Estate to ensure it meets the needs of the activities and occupants has in recent years expanded into data analysis to enable it to meet environmentally driven legislative targets.

However, proving an environmental **impact** from the Estates efforts is still difficult as some of the necessary practical metrics are not available. This means the activity of energy management still struggles to formally prove its practical value to management and therefore is often unable to achieve all the impact it could have on utility use, either through lack of resources or lack of support for changes proposed.

The advent of low cost sources of detailed Operational Data provides the opportunity to develop environmental indicators which help address legislative requirements (usually annual reporting), and provide the detailed information about where action could be taken to improve performance, including more frequent reports for users to enable this to be timely.

From an Estates professional practitioner viewpoint, the key issues to be covered by any procedure based on Operational Data are to:

- Address as many legislative requirements as possible
- Take account of specific circumstances i.e. based on sufficient detail to be relevant to the Estate operation
- Provide information in sufficient detail to understand when and where to take action
- Ensure unusual data patterns are reported in the form of exception reports i.e. reduce data overload
- Involve Estate Users in reducing their environmental impact, including information for internal energy management campaigns aimed at the end users
- Help address Maintenance requirements, including frequency and timing where feasible
- Improve the efficiency of use of Estates staff/resources

- Help identify inefficient equipment, and the potential savings from replacement with modern alternatives
- Provide Case Studies of the 'before' and 'after' effects of investment in energy efficiency to provide confidence in the impact actually achieved
- Provide information on the operational costs of providing various types of activities, to enable their energy consumption to be costed properly by the organization e.g. major research project bids.
- Provide insights into the likely future energy use and costs of Estates changes such as additional buildings, etc. This is crucial for accurate and efficient budgeting
- Use the sub-hourly nature of the data to understand services operation and demand for spaces, particularly out-of-hours use.

Many of the above needs are encompassed by ISO 50001 and its framework for the use of operational data.

The other key issues to be addressed are how to keep data up-to-date and relevant. This means that the data should also address all the current legislation and standards in operation such as, for the United Kingdom, Carbon Reduction Commitment (CRC) [16], Heat networks [17], ISO 14001 [11], ISO 50001 [2], HESA Estates Record [18], Home Office requirements [19], Welsh Government Legislation/Funding requirements [20], DECs/EPCs [21], BREEAM [22].

It can be seen that, in current practice, an Estate Operator spends a lot of time collecting and collating information to meet legislation. The information to meet these needs does not necessarily also fulfil the requirement of being detailed enough to enable focused actions to be undertaken to improve actual performance. It is this disconnect which needs addressing.

3.3. The Data to be Collected and Collated

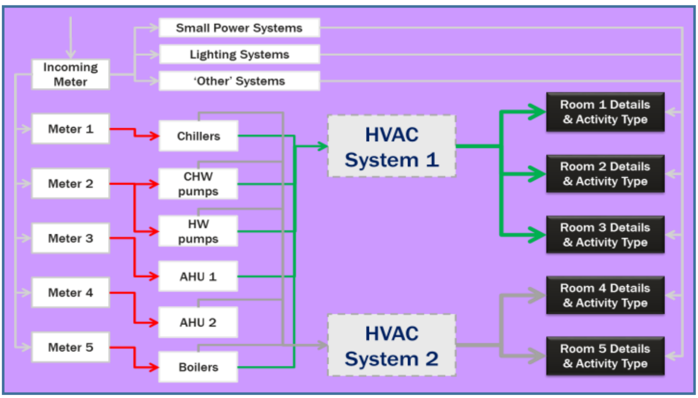

Figure 1 - Data to be collected and collation graphic

Cardiff University is implementing the iSERVcmb data collection and collation methodology [1]. The approach requires information to be collected about the utility metering, the building services components, the servicing strategy, the small power use, lighting systems, individual spaces serviced, and the activities undertaken in each space. This data is then collated as shown graphically in Figure 1, to enable the procedure to link the data together.

3.4. Lessons Learnt and Reports Produced

The process of describing the buildings for Cardiff has reconfirmed the findings of the iSERVcmb project i.e. that the initial assembly of data sources which have been rarely used before this date takes effort. Cardiff is spending time in re-establishing where its meters serve, and that the data is accurate, as part of this process. The application used also helps ensure data robustness via automatic reports on meter problems. Identifying anomalies, errors and missing data is critical to provide confidence in the data on which decisions are to be made.

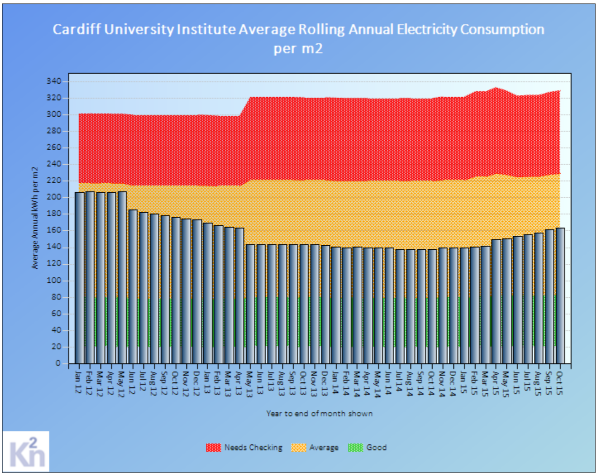

Figure 2 - Benchmark ranges for Cardiff University Annual Electricity Use per m^2 over last 4 years, and measured overall consumption

The collection and collation of this information is of value to all aspects of operation of the Estate, so repays the effort of its collection and verification. Also reconfirmed are the value of the reports which include the utility data, in providing the detailed information needed to enable improvements to be undertaken with more confidence in the likely impact to be obtained.

Figure 2 and Figure 3 present examples of the current performance of Cardiff University from the Estate as a whole down to a single component.

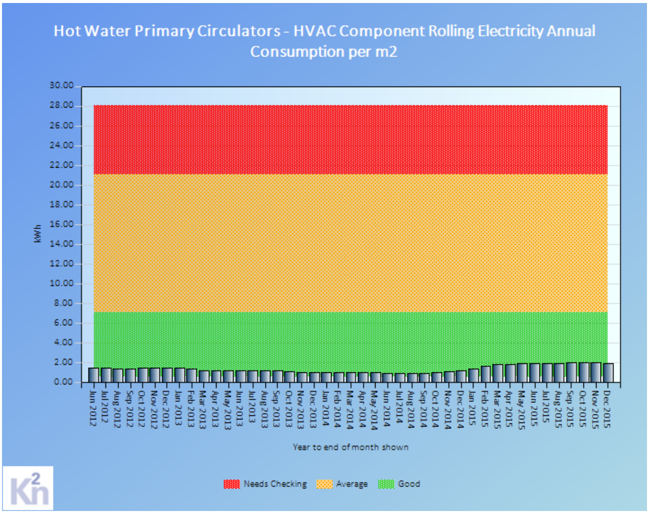

Figure 3 - Benchmark and performance at an individual component level

Table 1 shows that the data can also be used to estimate consumption at the level of a single space.

Table 1 - Estimates of use and cost can be produced for single spaces

Date: Dec 15					
10 Museum Place Space	Activity	Floor Area m2	Month	kWh/m^2 year to month	m^2 year to month £
[AO3300/001/]	Open Plan Office Area	24.21	Oct 2015	25.57	3.32
[AO3300/002/]	Open Plan Office Area	18.16	Oct 2015	25.57	3.32
[AO3300/003/]	Toilet	4.06	Oct 2015	32.58	4.23
[AO3300/004/]	Open Plan Office Area	20.06	Oct 2015	25.57	3.32
[AO3300/005/]	Light Plant Room	4.59	Oct 2015	1.67	0.22
[AO3300/Z01/]	Circulation area	17.38	Oct 2015	15.22	1.98
[AO3300/Z02/]	Circulation area	1.71	Oct 2015	15.22	1.98
[AO3301/001/]	Meeting Room	33.01	Oct 2015	33.84	4.40
[AO3301/002/]	Cellular Office Area	18.67	Oct 2015	48.39	6.29

Table 2 shows the data being used to estimate potential savings at building level. Detailed operational data from individual components can also be used to show whether they meet, for example, EcoDesign targets while in operation.

3.1. The Framing of New Legislation for Using Operational Data

The downfall of much current energy efficiency legislation is that it is unable to deal with the real-world complexity of the legitimate impact of occupancy, activities and location on the real energy demand from a building as a whole. This is driven by a lack of detailed up-to-date 'big data' on the

Table 2 - Estimation of potential savings from the tailored benchmarks

Cardiff University Buildings with Highest Potential Electricity Savings						
Potential annual savings if systems configured and operated to good practice						
Month	Building Name	Consumption Saving £	Consumption Saving kWh	Consumption Saving %	Annual Consumption	Good Practice Annual Consumption
Dec 15	38/39 Park Place	21,481.67	165,243.63	76.93	214,805.03	49,561.40
Dec 15	LTYB, Field Hall	14,659.08	112,762.14	58.54	192,637.30	79,875.16
Oct 15	42-45 Park Place	6,940.99	53,392.22	51.42	103,844.00	50,451.78
Dec 15	LTYB, 25 T-D Place	1,768.80	13,606.12	47.60	28,582.00	14,975.88
Oct 15	1-3 Museum Place	991.67	7,628.20	11.35	67,192.00	59,563.80
Dec 15	47 Park Place	854.27	6,571.28	22.42	29,309.90	22,738.62

energy consumption of buildings, spaces and components in use in relation to the activities being supported. The result is that many buildings can be wrongly categorized as good or poor performers for reasons that have nothing to do with the efficiency of the design or operation of the building. This is distorting the energy efficiency marketplace and the impact that organizations can realistically have on their 'apparent' energy performance. It is also affecting the value of property portfolios in a way which could cost billions of euros in badly targeted or unnecessary 'improvements'.

This paper therefore proposes that there should be a legislative route to enabling detailed operational data to be an acceptable alternative to many prescribed legislation routes currently addressing energy efficiency in buildings and systems. The rationale behind this proposal is that all the other legislation has, as its primary aim, the intention to reduce energy consumption and to move the market towards energy efficiency in operation. If an organization is willing to use operational data benchmarks and to invest in the equipment and manpower required to obtain, maintain and use data at this level of detail, then it does not need further legislation to persuade it of the benefits of this approach.

It is possible that new legislation could be implemented relatively simply through reference to ISO 50001 and its supporting standards. A requirement to meet the detailed aspects of ISO 50001 i.e. '*the ability to achieve a level of detail reaching individual systems, facilities, processes, equipment and personnel. The review is to identify, hierarchize and record opportunities for improving energy performance'* should enable the desired practical impacts on energy consumption to be achieved. It will empower organizations already committed to reducing their energy consumption by rewarding their efforts through removing unnecessary legislative burdens.

4. Impact of Implementation

The impact to date of the use of an Operational Data approach within Cardiff is very encouraging. The iSERVcmb procedure is still being implemented across the whole Estate, but its main Administrative Building, McKenzie House, has been using the basic principles for a decade. It has achieved a 43% reduction in its total electricity use over this period, worth over €100 000/a as shown in Figure 4.

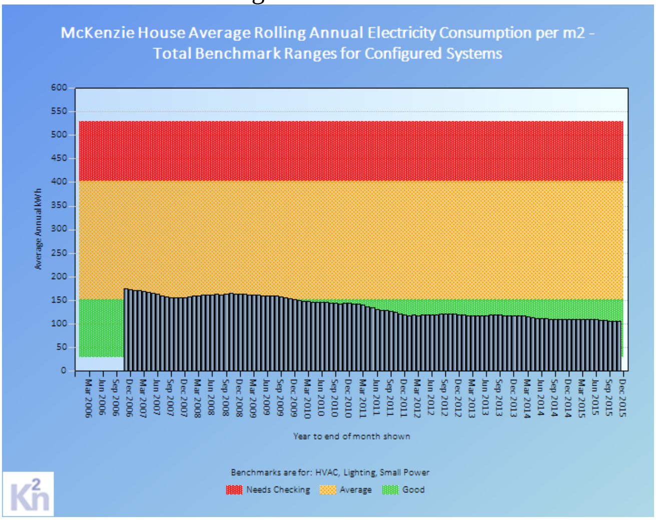

Figure 4 - 43% savings achieved in McKenzie House over time

Approximately 50% of the University properties are now using the approach.

Table 3 shows some of the residential properties measured electrical performance/m^2.a against their benchmarks. These buildings are all naturally ventilated, and mainly gas heated, so the annual electrical energy use variation between 20 to 100 kWh/m^2 shows the impact occupancy behaviour is having on electrical energy use in these buildings.

Table 3 - Selected residential building performance against benchmarks

Cardiff University Yearly Building Electricity Consumption m2			Annual kWh per m2				
Status	Building Name	Year to end of	Measured	Benchmark Min	Benchmark 25%	Benchmark 75%	Benchmark Max
	Neuadd Meirionnydd (MI)	Dec 2013	137.70	9.82	46.33	122.45	160.76
	LTYB, 25 Trotman-Dickenson Place	Nov 2015	94.94	12.94	48.73	137.80	193.30
	Cartwright Court, Block A (MI)	Oct 2015	97.12	14.58	61.14	173.28	241.00
	Cartwright Court, Block B (MI)	Oct 2015	90.51	14.12	60.18	170.88	237.64
	LTYB, 9 Trotman-Dickenson Place	Jan 2015	68.15	14.09	52.67	149.31	209.65
	LTYB, Court House 2	Mar 2015	119.15	15.79	104.08	299.99	525.18
	Cartwright Court, House 11 (MI)	Oct 2015	63.26	13.10	55.40	157.00	218.51
	LTYB, 18 Trotman-Dickenson Place	Nov 2015	58.05	14.95	55.13	156.28	219.52
	LTYB, 13 Trotman-Dickenson Place	Aug 2015	53.66	14.19	52.95	150.10	210.78
	LTYB, Court House 3	Nov 2015	138.15	16.99	149.42	432.84	791.10
	LTYB, 23 Trotman-Dickenson Place	Nov 2015	46.00	14.70	54.77	155.49	218.43
	LTYB, 4 Trotman-Dickenson Place	Aug 2015	41.36	13.17	49.27	139.28	195.45
	LTYB, 16 Trotman-Dickenson Place	Nov 2015	45.09	14.50	54.23	154.00	216.28
	Cartwright Court, House 30 (MI)	Nov 2015	51.61	14.77	62.18	176.67	245.77
	LTYB, 26 Trotman-Dickenson Place	Nov 2015	45.27	14.80	55.06	156.33	219.64

Section 3.4 has shown that the use of Operational Data can not only provide tailored benchmarks, but also an indication of the range of potential savings in both energy and cost terms, from the level of an Estate down to an individual component. The accuracy of these estimates is dependent on the amount and design of the sub-metering, if any.

The Cardiff University Estates team are using this emerging information to understand and prioritize their future approaches to managing the energy use on the Estate.

Implementation of the Operational Data approach in Cardiff has shown that all buildings are capable of being economically described at a level of detail that enables the approach to be a practical option for the Estate.

From this section it is clear that the use of robust, well-structured Operational Data has had a measurable impact on operational utility use within the Cardiff University Estate, along with other significant benefits.

5. Conclusions

The results show that using an Operational Data approach in a large estate helps to clarify current performance and the potential for improvement from a practical perspective. It improves existing operating procedures and supports new investment and decision making. Measured whole building electrical energy savings of >40% being demonstrated are only part of the benefits of using operational data. The benefits in terms of maintenance and targeting of the use of finite labour and financial resources are also important. Future work will quantify these benefits.

Data emerging from Cardiff University Estate include the wide range of consumptions being achieved in buildings with near-identical function and design. This helps highlight the importance of the occupant in achieved energy use for buildings, and underlines the importance of separating building energy use from occupant energy use to properly describe the inherent efficiency of a building, and the efficiency with which it is being operated.

The quantification of potential savings by reference to the tailored energy benchmarks for each building also helps target cost-effective improvements.

The paper has illustrated how numerous data streams in the Estate can be processed in a variety of ways to produce the practical day-to-day information needed to help improve the operation of the Estate as its needs and use evolve.

Achieving the impact possible from the use of Operational Data requires legislation to enable it to be a compliance route. This appears to be a relatively straightforward task as there are existing standards that can be referenced. If achieved, this could help achieve the €6Bn+ annual savings iSERVcmb suggested could be available across the EU from this approach.

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