Embracing variations in patterns of use, pre and post design phase, to improve tenant energy performance

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Abstract
This paper elaborates a new energy performance benchmarking method to support green tenancy agreements and other energy performance contracts. The existing national energy reporting method does not categorise systemic variations in patterns of use.

Results of a case study monitoring operational data of a multi-tenanted office building are presented. The data reveals the actual designed spectrum of occupant density accounts for a 44% increase in tenant energy demand per square meter and a 112% increase in tenant energy demand per full time employees [FTE], dramatically affecting the buildings internal gains, heating and cooling requirements. The study highlights how low levels of occupancy and extended operational hours can give a false representation of energy efficiency.

Keywords Benchmarking, Energy Performance, Occupant Density, Tenant Energy Demand

1.0 Introduction

The proposed method allows landlords, owners or subtenants of office buildings to measure and compare their energy performance against benchmarks adjusted for similar occupant densities, operational hours, and number of FTE. The impact of occupant density on actual tenant energy consumption is expressed and compared in terms of kW-h/fte and kW-h/m^2.

Modelling is utilised to analyse and define the building's operational limits, accounting for varying levels of occupant density and building use patterns. A building specific optimum energy performance range and a sensitivity analysis is derived. The method and its outputs are intended to provide useful feedback in building design and in operation, which can be integrated into EPC and TM54 methods.

The application of the proposed method is described for a multi-tenanted office building. The more general application to other building types is discussed.

2.0 Occupant Density Benchmarks

By April 2016, The Tenant Energy Efficiency Regulations[1] will come into force. Provisions set out in the Energy Act 2011, will make it unlawful to rent out an office below the stated minimum energy efficiency standards. Necessitating an initial retrofit of 22%[2] of offices in the UK, to enforce a proposed minimum Band E Rating.[1, 3, 4]The existing national energy reporting method does not categorise systemic variations in patterns of use, which occur between tenancies in its assessment. The absence of occupant density related benchmarks is due to a 'lack of robust, low cost methods for collecting accurate density information, 'potential for abuse' and 'poor correlation between energy use and occupancy levels'.[5] It has been recognised that a robust method of measuring and recording occupant density is required, however, benchmarking per m^2 is favoured by CIBSE until a suitable method is developed. The Better Building Partnership intimated in 2009, 'variations in energy consumptions due to patterns of use and occupancy should be recognised' and 'building occupancy should be recorded and reviewed to reduce excessive consumption in periods of low occupancy,' [6] however, to date little, if any, known research has been presented in this area.

2.1 Existing Methodology

Currently a Simplified Building Energy Model [SBEM] or approved dynamic simulation model is used to calculate the energy performance of office buildings in the UK. The requirements of an Energy Performance Certificate [EPC] are highlighted in figure 1.

Heating system	Tenant 1
	Tenant 2
	Tenant 3
Multi-tenant office building with shared heating system. Communal areas included in calculation. EPC required for entire building only.	

OR

Heating system	Tenant 1
Heating system	Tenant 2
Heating system	Tenant 3
Multi-tenant office building with individual heating systems. Communal areas not included in calculation. EPC required for each tenant.	

Source: Adapted from *Improving the energy efficiency of our buildings: A guide to energy performance certificates for the construction, sale and let of non-dwellings.*[7]

Fig. 1 The current EPC requirement options for a multi-tenanted office building.

"An EPC for a simple unit within a building maybe based on an assessment of a similar representative unit or apartment in the same block," [7] irrespective of the *patterns of use,* which refers to variations in occupant density, associated energy use patterns and operational hours. The National Calculation Method [NCM] ensures consistent comparison of similar building types by predicting how the building will perform through defining a schedule of standard building activities.[8] A number of usage factors that affect energy demand are standardised in order to regulate and compare energy use. They include; heating and cooling set points during unoccupied or occupied hours, ventilation and infiltration rates, lighting levels, standard occupancy day schedules [weekday, weekend and holiday profiles], hot water and heat gains [occupants, appliances and lighting]. The standard activities are predefined in the NCM database, which applies a rule of thumb, for occupant densities and the associated internal room heat gains. Factors represent a standardised intended usage pattern rather than physical design constraints. [9] The profiles are intended to be typical and do not attempt to represent variations in patterns of use that can exist between tenants. SBEM guidance stipulates that SBEM is not a design tool for operating conditions to be considered. As such, predicted performance does not meet the tenant's energy performance aspirations. As tenants concerns primarily are: annual utility bills, savings on consumption year on year and how savings can be used to invest in assets, the current system compromises the tenant if calculations are wrong. Tenants and clients need to understand the implications of the brief through transparency of the calculations and statements of design assumptions. Absolute figures are both dangerous for designers, due to threat of litigation, and financially for tenants, especially in the wake of 2016 legislation. It's important to highlight the sensitivities of the building in operation to the users. This results in an ensuing need to predetermine an occupant density range by which the building and tenants energy use can be fairly tested against. To establish a range industry benchmarks were reviewed and have been used to set down principles of maximum and lower design limits. [See table 1].

Table 1 Existing occupant density benchmarks

Design Standard	Occupant Density [NIA]
Building Regulations Document Part B	6m2/person
NCM office density	9m2/ person
British Council for offices: Work place density	10m2/person
British Council for offices: 2008 occupant density survey sensible lower limit	23m2/person

2.2 Calculating Variations in Tenant Energy Use

The metric adopted by the EPBD, EPC and the NCM is articulated as "*delivered energy used per unit of floor area (kW-h/m2).*" This metric is used to calculate both electrical and fossil fuel energy consumption. Display Energy Certificates [DEC] evaluate a buildings energy use based on real energy consumption data. This is used to establish energy benchmarks to compare buildings of a similar nature. TM46 allows two adjustments to the benchmarks, firstly, an adjustment to degree-day data, to give more accurate response to climate, which is not relevant to this study. The second is an occupancy adjustment, which is only carried out if the buildings annual hours are confirmed to exceed the standard benchmark values. However this does not convey the impacts of high or low occupancy. To calculate variations in tenant energy demand the case study measured and compared variations in each tenants Nett Lettable Area [NLA], occupant density and energy use patterns by comparing kW-h/fte and kW-h/m^2, in design and in use, as shown in Box 1. The method of measuring and benchmarking regulated and unregulated loads to consider the impact of occupant density on variations in patterns of use is tested in the case study. This can be calculated for yearly, monthly or daily comparisons.

Box 1. Calculating variations in tenant energy use per square meter and per FTE

Tenant energy use [kW-h/m^2] = [tenant energy use/ tenant area]
Tenant energy use [kW-h/fte] = [tenant energy use/ tenant area] x occupant density

3.0 Case Study and Outcomes

Taking a case study approach, the impact of tenants *patterns of use* in design and in use were tested against a multi-tenanted office building. The Carbon Buzz and the TM22 methodology guided the assessment. Deviations from the methodologies were adopted to deliver a dynamic correlation between occupancy loads and energy demand profiles. Monitoring of the occupancy patterns are accumulated by observing the number of occupants entering and leaving the main building entrance and the entrances of the three individual office simultaneously. Energy monitoring focused solely on individual tenant energy consumption to include small power, HVAC and lighting. The measurements were carried out for each one of the three offices by taking meter reading thrice daily and by data loggers measuring each one of the three phase electricity supplies at minute intervals. The study excluded the electrical consumption for the common landlord areas.

The results of the monitoring exercise detailing the actual energy performance of the tenants were compared to the predicted calculations submitted as part of the building Regulations Section 6 Energy Performance Compliance Report. The study period reported the energy use over a 6-week period during January and February.

3.1 Tenant Energy Demand and Variations of Patterns of Use

Figure 2 illustrates the tenant energy use for (a) the predicted compliance report assumptions used to calculate the predicted regulated occupancy loads and energy use for a typical 24-hour day in January. [Note, the same occupancy load calculation is used irrespective of the tenants intended patterns of use] (b) the predicted tenants regulated and unregulated loads [in this instance an allowance for additional office equipment, catering equipment and IT servers is included] and (c) the actual monitored operational data. There is a large disparity from the predicted values. This is due to variations in patterns of use, which exists between the building tenants. The occupant density varies between 8m^2 and 19.3m^2 per FTE. The NCM uses kW-h/m^2 as a reliable way to assess and compare building energy efficiency. However, if you consider the occupant density, tenant 2 has the lowest number of staff but the highest energy use per FTE. This shows that low occupancy [tenant 2] and high occupancy [tenant 3] can be misrepresented under the current calculation method, highlighting a potential area of concern under the current EPC benchmarking method.

Variations in patterns of use account for up to a 44% increase in energy use per m^2 and 112% increase per employee. Figure 3 illustrates that the current method of predicting energy consumption patterns based on fixed occupancy and set operational hours for a sole tenant is misleading and allows for a large margin of uncertainty unless the exact patterns of use can be established or are known at design stage. The predicted energy use of the design brief occupancy should therefore be explicitly ***an optimum building design standard*** rather than a demonstration of ***predicted tenant energy performance*** by which tenant energy efficiency is assessed against.

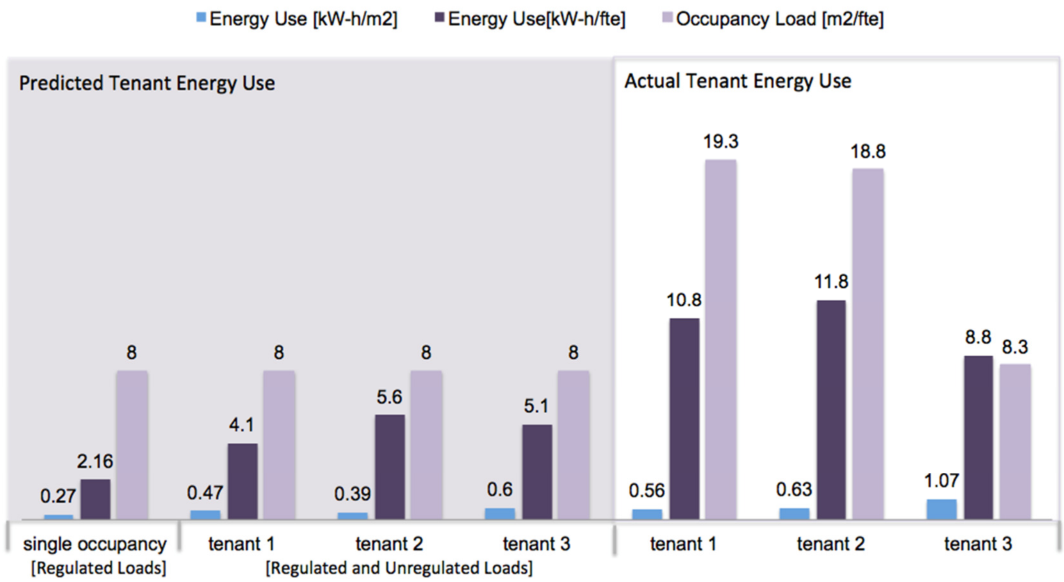


Fig. 2 Predicted and actual total tenant energy use over a 24-hour period in January.

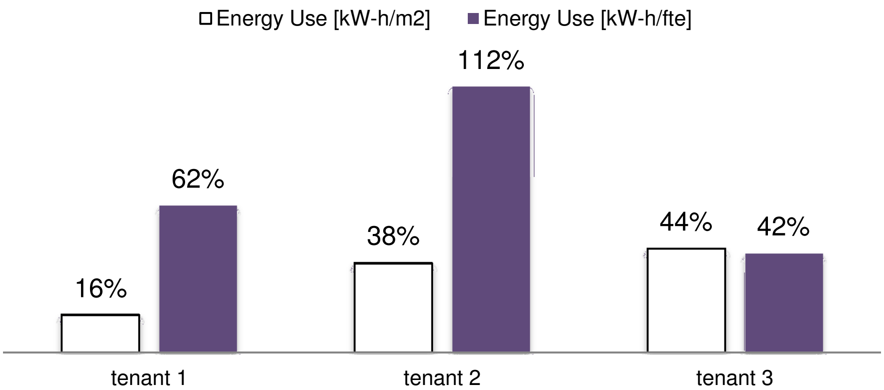


Fig. 3 Percentage increase in tenant energy use from design estimates to actual tenant energy use over a 24-hour period in January.

3.2 Operational Hours

The case study exemplifies that although the working hours of the offices are largely from 9.00am - 5.00pm, each of the tenant's operational hours extend beyond these limits. In particular Tenant 3 operational hours extend from the forecast 8hrs to 12 hrs. This accounts for a 40% increase in occupied hours and subsequently impacts on energy use over the course of a day. The tenants of this office work in shifts with periods of very low occupancy in the mornings due to a cleaner and one FTE starting at 6am.

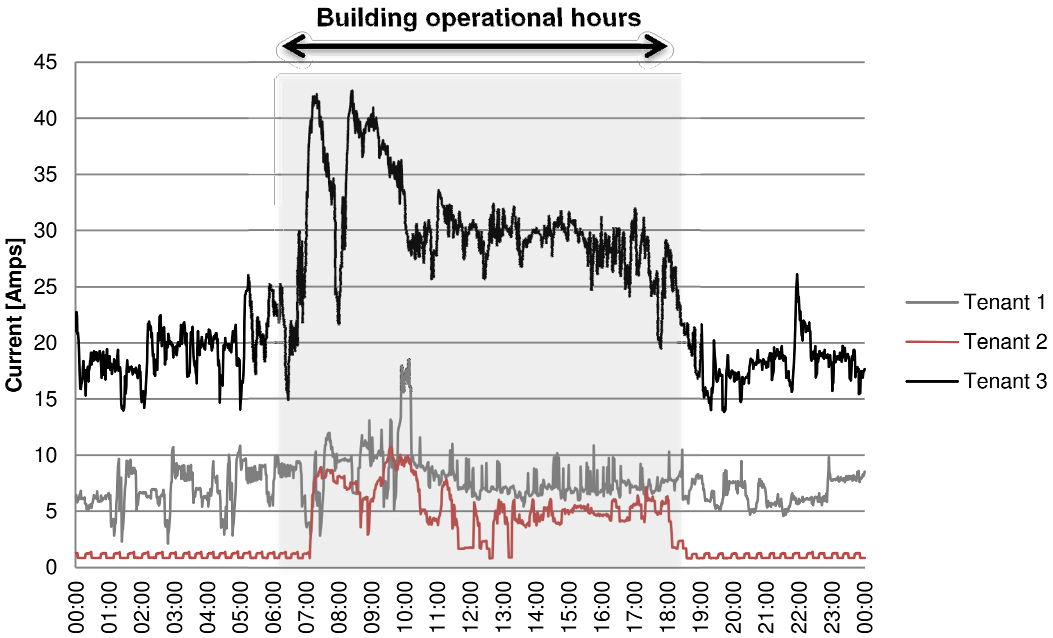
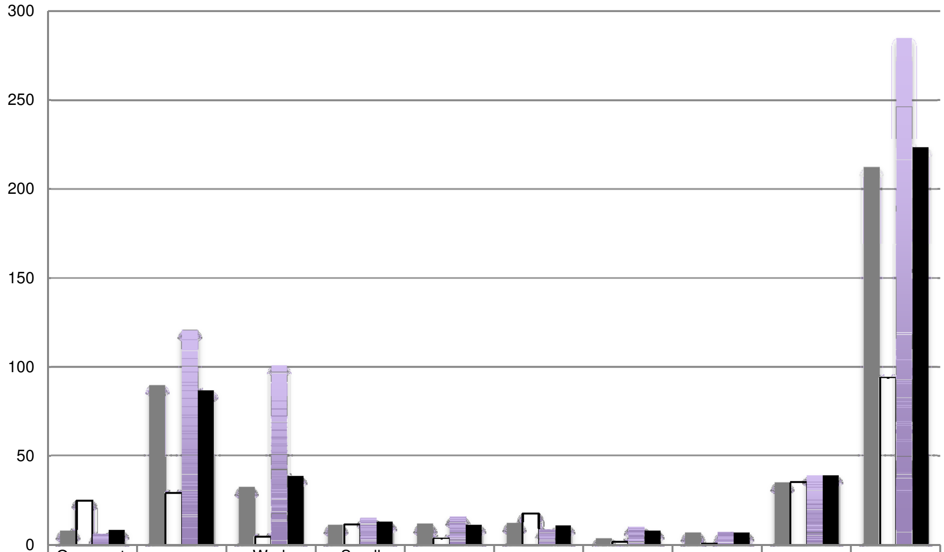


Fig. 4 Monitored energy consumption data over a 24hr period in January, showing variations in patterns of energy use between building tenants.

This office also uses more energy when the building is unoccupied than when the other offices are occupied as the heating is left on over night at a set temperature of 23 degrees, in addition to back up servers operating during the night and associated cooling and generally a greater amount of IT equipment being left on. The monitoring exercise highlighted that the energy demand of the high capacity office space, which is close to the designed occupant density, can be reduced more easily than the energy demand of the low capacity office space through simple management measures.

3.3 Minimum and Maximum Patterns of Use

A further study ascertains how the building will perform under extreme conditions in comparison to the proposed design standard and the actual monitored data [figure 5]. The first scenario assumes minimum occupancy, standard working hours and low IT use, with an energy star rating of 4.0. The second scenario assumes maximum occupancy, extended working hours and high IT use, with regular IT equipment. This is a useful tool to help tenants and landlord understand how their office will work by conveying a probalistic energy performance specification range and a sensitivity analysis based on probalistic building occupant levels, in addition to the activities highlighted in TM54. This sets limits on tenant energy use and acts as an early warning system if an activity is not performing as expected. Although it is not conceivable to model every potential pattern of tenant use, demonstrating the optimum designed standard with the maximum and minimum proposed limits is an honest representation of energy performance.



	Occupant density [m2/fte]	No. of FTE	Work stations [MW-h/yr]	Small Power [MW-h/yr]	Hot Water [MW-h/yr]	Heating [MW-h/yr]	Cooling [MW-h/yr]	Server [MW-h/yr]	lighting [MW-h/yr]	Total [MW-h/yr]
Design standard	8	90	32.6	11.5	11.9	12.3	3.9	7.2	35.1	212.5
Minimum	25	29	4.7	11.5	3.7	17.7	1.8	0.7	35.1	94.1
Maximum	6	121	100.9	15	16	8.6	10.2	7.1	39	284.8
Actual	8.3	87	38.7	13	11.5	10.9	8.1	7.1	39	223.6

Fig. 5 Predicted and actual patterns of energy use: Tenant 3.

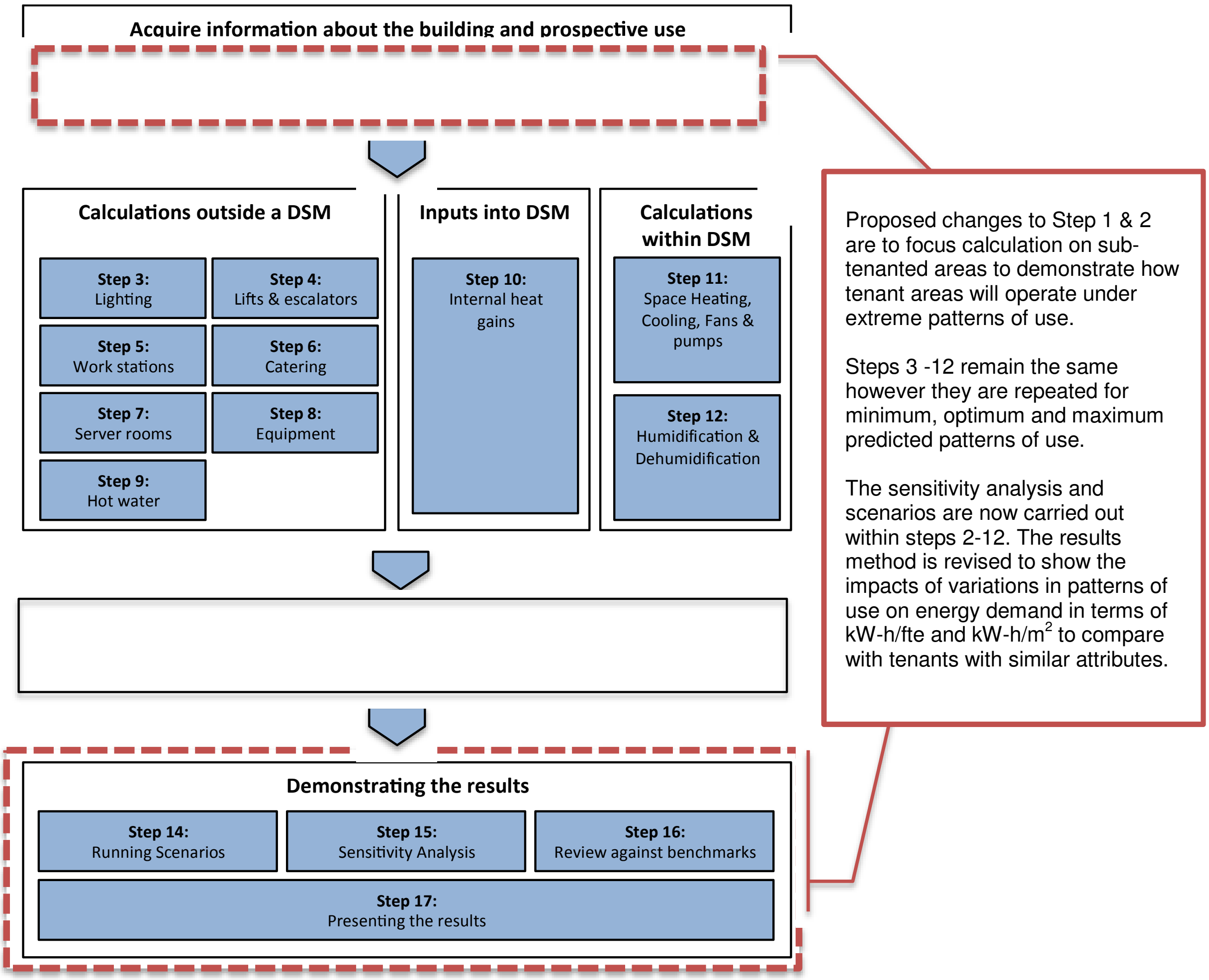
3.4 Study Conclusions

The method and its outputs are intended to provide useful feedback in design and in building operation, which can be integrated into DEC, EPC and TM54 methods. The following measures are recommended in order for this method to become effective:

- Define design brief occupancy explicitly as *an optimum design standard* rather than a demonstration of *predicted energy performance*.
- Demonstrate the impact of occupant density on tenant energy use throughout the design concept, design and handover stage to communicate how a building performs under different usage patterns pre and post–occupancy.
- Define probalistic minimum and maximum patterns of use to demonstrate the sensitivity analysis in TM54.
- Promote kW-h/fte as a method of evaluating an office buildings energy performance in addition to kW-h/m2.

4.0 The Methodology

Figure 6 summarises the proposed changes to the TM54 methodology 'evaluating energy performance at design stage' to integrate systemic variation in patterns of use, which exist between tenants in a multitenant office building. A worked example showing the key changes at each step is demonstrated and cross-referenced. New occupancy and operating hours calculations are offered to identify a proposed tenants energy performance range driven by individual patterns of use.



Source: Adapted from evaluating operational energy performance of buildings at design stage.

Fig. 6 Methodology for evaluating tenant operational energy use at design stage: proposed changes to TM54 method.

4.1 Step 1: Calculating Tenant Floor Area

As highlighted in the EPC guidance a building can be under single tenancy or multi-tenancy. The tenant floor area is calculated by measuring the NLA. TM54 method promotes that a consistent floor area be established for the building for comparison to the energy benchmarks set out in CIBSE Guide F. This is beneficial to the tenant if they are the sole building user but this does not demonstrate how the tenant will be affected by the office orientation and patterns of use, which are tenant specific. To demonstrate tenant energy demand tenant data should be articulated, calculated and reviewed by the tenant as a tool to improve efficiency and reduce energy costs. This would form the base of green tenancy agreements and disambiguate EPC's. The new method calculates the proposed tenant floor areas, which is necessary to calculate the tenant occupancy load, in design and in use. The calculations are tenant specific to allow for variations in patterns of use to be accounted for in all the steps listed in figure 5. The worked example given is for tenant three Box 2], which has offices in two wings of the building accessed by a common entrance area shown in figure 7.

Box 2. Worked Example: Area Calculation.

Tenant 3 Total NLA	= Area A [NLA] + Area B [NLA]
	= 377 + 349
	= 726m^2

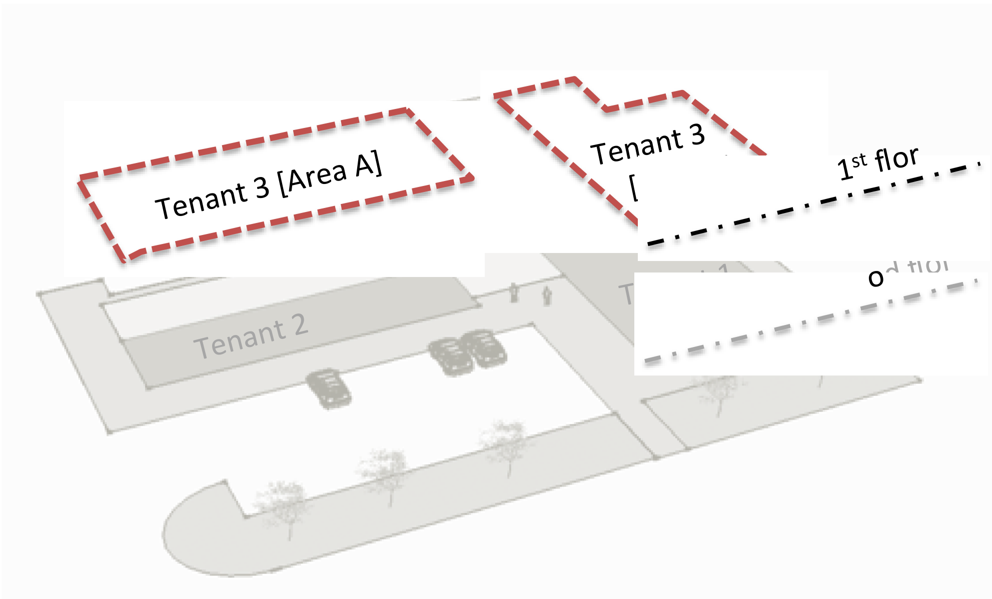


Fig. 7 Illustrates the area of the building occupied by tenant 3 referred to in the worked examples.

4.2 Step 2: Occupancy Factors and Establishing Operating Hours

The occupant density scope is established from dividing the tenant area by the proposed range of occupant densities [Box 3]. The buildings operational limits are set based on the number maximum number of occupants the building can safely use in the event of a fire. The minimum number of occupants is guided by BCO recommendations. The designed occupancy is client and design driven to maximise letting potential, efficiency and cost. The NCM standard can be included to allow for comparison to existing CIBSE benchmarks and EPC documentation. Benchmarks 1-3 can be project specific, if required. The NCM standard can be used to allow the existing methodology to be carried out in tandem with this study. Occupant density is used to explain how the building area under the tenants control is expected to perform at its extremities, in addition to the design optimum standard [opposed to predicted performance] and the NCM benchmarking category.

This sets tenant led energy use limits and a method to tailor office behaviour within the specified limits.

Box 3. Worked example: Occupant Density Scope

Input data:

Minimum occupant density	= 25m^2/fte
Maximum occupant density	= 6m^2/fte
Design standard occupant density	= 8m^2/fte
NCM occupant density	= 9m^2/fte
Minimum occupant capacity	= [NLA/ minimum occupant density] = [726/ 25] = 29
Maximum occupant capacity	= [NLA/ maximum occupant density] = [726/ 6] = 121
Designed occupant capacity	= [NLA/ designed standard occupant density] =[726/ 8] = 91
NCM occupant capacity	= [NLA/ NCM standard occupant density] =726/9 = 81

4.3 Operating Hours

Operating hours varied significantly between the three different tenants in the case study, which highlighted three main occupancy periods: the operational hours, the swing shift and the twilight shift. The existing TM54 methodology does not allow for swing shift periods. The swing shifts are now allowed for in the calculations in steps 5 - 8 and 11 by calculating the extended working period as a separate estimate. This is to imitate the ramp up and ramp down in energy represented in the monitored data to its expected value [figure 8]. A worked example showing how this can be integrated into steps, in this instance step 5, small power, is indicated in Box 4. The building operations should account for the offices hours of business to include weekday, weeknight or weekend shifts, as required. The occupancy of the building and efficient working hours and practices can then be altered to suit individual tenants needs. Working out with hours of business should be considered a swing shift requirement.

Box 4. Worked example for small power loads [adapted from TM54]

<u>Communal small power consumption [Tenant 3]</u>

Input data:

Typical equipment installed (a) = 1 photocopier + 2 printers + 1 counter fridge + 1 Fridge + 2 vending machines + 4 water coolers

Average power demand	= 250 W/photocopier + 460 W/ printer + 65 W/ fridge + 200 W/ fridge + 345 W/vending + 80 W/ cooler = 2445W
Swing shift power demand	= 2445W/2 = 1222.5W
Sleep mode power demand	= 40 W/photocopier + 17 W/ printer + 10 W/ fridge + 25 W/ vending + 5 W/ cooler= 374
Hours of operation	
[Occupied hours]	= 7 days x 8 hours x 52 weeks = 2912 hours

[Swing shift hours 0600-0900] = [7 days x 3 hours x 52 weeks]/2 = 546 hours
[Swing shift hours 1700-1800] = [7 days x 1 hours x 52 weeks]/2 = 182 hours
= 2912 + 1274 + 546 = 4732 hours
Total hours per year = 8760 hours

Annual energy consumption for tenant 3 communal small power [kW-h/year] = [(power demand during operation x hours of operation) + (out of hours power demand x (8760 – hours of operation)]/1000

= [(2445 x 2912) + (1222.5 x 546) + (1222.5 x 182) + (374 x (8760 – 4732))]/1000
= [7 119 840 + 667 485 + 222 495 + 1 506 472] /1000
= 9 516 kW-h/year

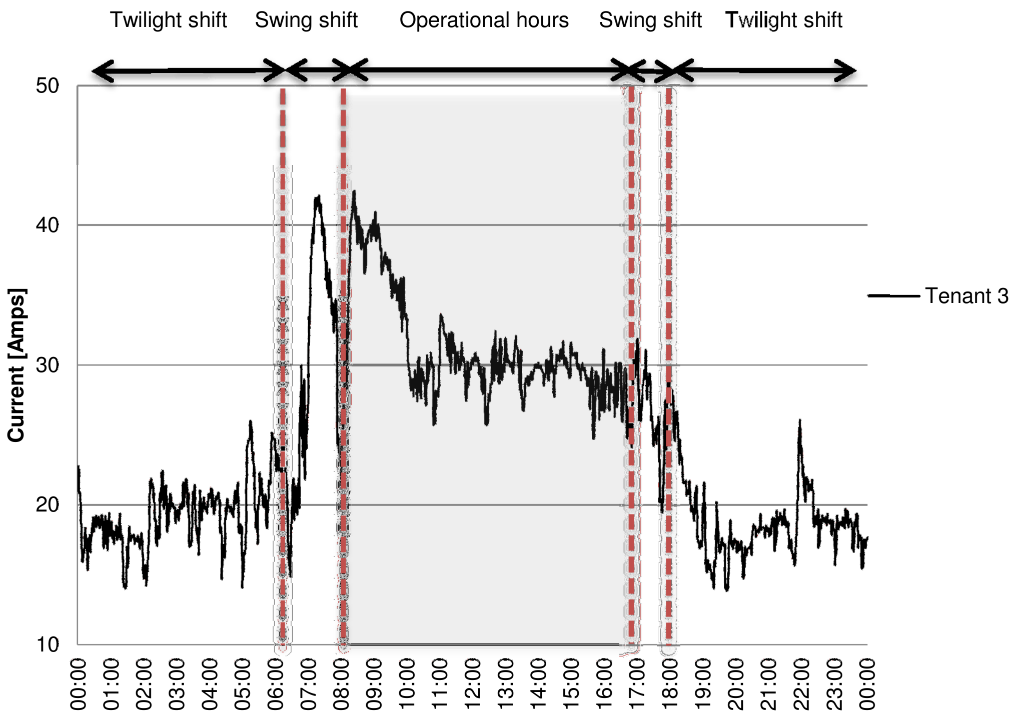


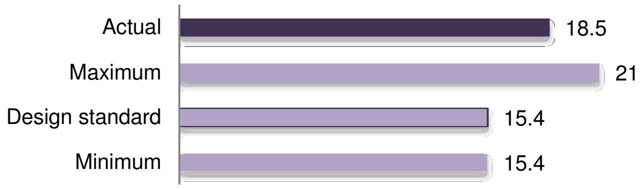
Fig. 8 Tenant 3: Illustration of energy use over a typical 24hr period in winter.

4.4 Sensitivity Analysis and Scenarios [previously steps 14 & 15]

TM54 presents the results 'as a range to demonstrate that there is a significant level of uncertainty' in predicting the patterns of use and the results. The intended purpose of the TM54 calculations is to target as closely as possible an intended *building* usage pattern and show how management factors and extended working hours may affect energy use in steps 3-12 by generating high and low end scenarios. The new method differs, as its intention is to demonstrate how the *tenanted area* will perform at its *extremes* in addition to the optimum or intended building usage pattern. Specific scenarios are considered to determine the minimum and maximum patterns of use. The occupancy, operational hours and energy loads scenarios are determined first as they will impact on the calculations carried out for steps 3-12 [fig. 9]. The four densities outlined in figure 9 together with the tenants intended operational hours would determine the base calculations and extent of the sensitivity analysis.

Scenario 1 Minimum patterns of use	**Scenario 2** Design Standard	**Scenario 3** Maximum patterns of use	**Actual** Actual patterns of use
Low occupancy Occupant density: 25m2/FTE FTE'S: 29	Designed occupancy Occupant density: 8m2/FTE FTE'S: 90	Maximum occupancy Occupant density: 6m2/FTE FTE'S: 121	Actual occupancy Occupant density: 8.3m2/FTE FTE'S: 87
Minimum hours [0900 to 1700] No weekend hours	Minimum hours [0900 to 1700] No weekend hours	Maximum hours [0600 to 1800] No weekend hours	Actual hours [0600 to 1800] No weekend hours
Low IT use [good energy star rating of 4.0].	Moderate IT use [CIBSE Guide A].	High IT use [average energy star rating].	High IT use [average energy star rating].

Tenant 3 Small Power [kW-h/m^2]



Tenant 3 Small Power [kW-h/fte]

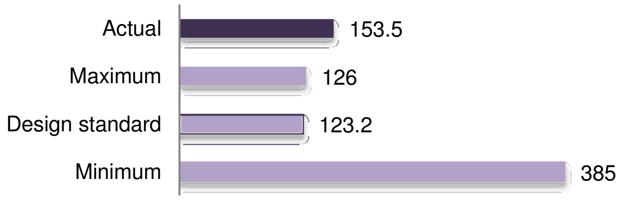


Fig. 9 Small power estimates for extreme [minimum and maximum], design standard and actual patterns of use.

4.5 Steps 3-12: Calculations and DSM

Calculations are necessary for the four scenarios established in steps 1-2 to determine the building performance range. The internal loads are then input into the DSM, which calculates the heating and cooling loads. The process and the calculations are repeated for steps 3-12 for all the scenarios. The scenarios are then modelled in the DSM to calculate the impact on heating and cooling requirements and determine if the building will cope with the extreme patterns of use.

4.6 Step 17: Presenting the Results

The results are documented in a Tenant Energy Report [TER], which records the assumptions set down in the calculations and the DSM for comparison to the building in use. The data is summarised by tenant energy use per square meter and by energy use per FTE. This allows the impacts of low and high occupancy to be demonstrated, assessed and compared with tenants and buildings with similar patterns of use for all activities [fig. 9] and for the tenants total annual consumption. The method of calculation total *minimum* annual energy demand is illustrated in Box 4. This is repeated for all scenarios.

Box 4. Worked Example: Total Minimum Annual Energy Demand [Tenant 3]

Input data:

Days of operation	= 5 days x 52 weeks = 260 days
Tenant Area	= 726m2
Tenant occupant density	= 25m2/ fte

Total predicted annual energy consumption (kW-h/year) is equal to the sum of the regulated loads [Hot water + fans, pumps, control + lights + small power for work stations + heating + cooling] and the unregulated loads [communal small power + servers].

= 3725 + 26310 + 378 + 9306 + 1850 + 704 + 35179 + 17 722 + 1834
= 97 008 kW-h/year

Tenant annual energy use per m2	= tenant annual energy use/ tenant area = 133.6 kW-h/m2/year
Tennant annual energy use per fte occupant density)	= (tenant annual energy use/ tenant area) x tenant = 3340 kW-h/fte/year

4.7 Tenant Energy Performance Range

This exercise is repeated to calculate the designed standard, maximum and NCM energy use, stipulating what the design assumptions are, which are reported in the TER. The tenant energy performance range can then be derived from the calculation [Box 5].

Box 5. Worked Example: Annual Energy Performance Range

Tenant Annual Energy Performance Range = Tenant annual energy performance minimum - Tenant annual energy performance maximum

= 97 008 - 233 889 kW-h/year

Tenant Annual Energy Performance Range [m2] = Tenant annual energy performance minimum [m2] - Tenant annual energy performance maximum [m2]

= 133.6 - 322 kW-h/m2/year

FTE Performance Range = FTE energy performance minimum – FTE energy performance maximum

= 3340 - 1932 kW-h/fte/year

The results of the TER are handed over from the design team to the tenant as feedback to provide transparency of how the building and tenant energy efficiency calculations are carried out and how changes in patterns of use will affect the buildings performance and operation.

4.8 Post Occupancy Evaluation

The results can then be compared to the building in use. The calculations or model can be updated to simulate the exact building operation; if any of the working practices differ they can be updated within their section or to record adjustments for a new tenant. The in use energy consumption can be calculated as shown in Box 5. If the *actual* [in use] FTE related energy regulated or unregulated loads falls within the *proposed* [in design] FTE related energy parameters then the office energy performance is performing as expected. The evaluation can be carried out, year on year, to compare the *actual* patterns of use of the tenant [or landlord] to the *designed* patterns of use the building [fig. 11]. A detailed sub-metering strategy will act as an early warning system to indicate if any of the HVAC or building operations are not running as expected and prevent costly monitoring and evaluation exercises. This allows tenants to compare their energy performance with similar tenants and other building users for accurate reporting.

Box 5. Worked Example: Annual Tenant Energy Performance in Use

Tenant actual energy use per m2	= tenant annual energy use/ tenant area = 139421/ 726 = 192 kW-h/m2/year
Tenant actual energy use per fte density	= tenant annual energy use/ tenant area x occupant = [139421/ 726] x 8.3 = 1594 kW-h/fte/year

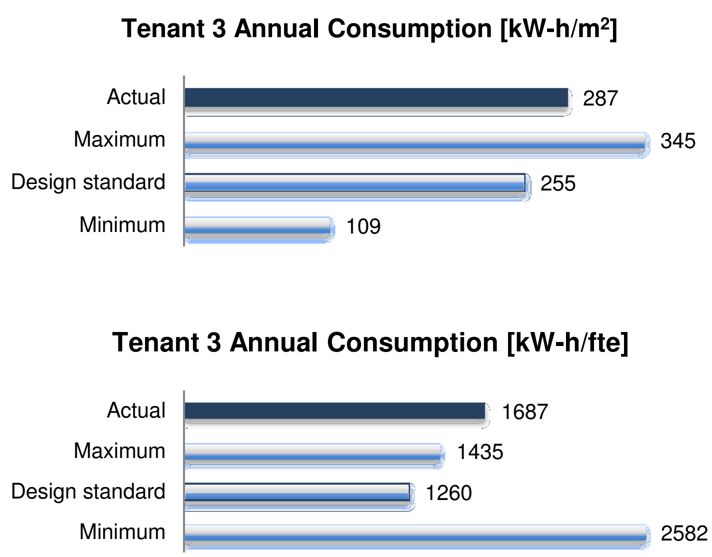


Fig. 11. Annual consumption estimates for extreme and optimum patterns of use.

4.9 Conclusion

Due to the Tenant Energy Efficiency Regulations, there is an immediate need to articulate tenant energy consumption so that tenants can better predict, understand and compare their energy use patterns. Working area, energy consumption and occupant density need to be considered together to give an accurate depiction of tenant energy demand. An occupant led metric [kW-h/fte] is a useful tool to illustrate the impact of low and high occupancy and determine when the building is operating at its limits when used in conjunction with existing benchmarks. This method can be incorporated into TM54 to set limits on patterns of use and propose an optimum design standard.

5.0 Beyond Offices

The proposed methodology considers and compares buildings area [kW-h/m^2], energy use [kWh] and occupant density kW-h/ occupant [in design] or [in use] together with patterns of operational use. This is transferable to other building types such as education, healthcare and public buildings. Evaluating building traffic and 24 hour energy use profiles can determine efficient design proposals, efficient management strategies to optimise building energy efficiency e.g. practical design measures to ensure the areas of use in the building during swing and twilight phases of operation are located together to reduce the footprint and energy use of the beyond peak occupancy hours. This could be applied to hospitals, libraries, schools and universities where the number of occupants fluctuates over a 24-hour period.

6.0 Future Work

Future work will explore fine-tuning the evaluation of extreme patterns of use to indicate specific criteria for when the building will break. Informing design restrictions and behavior patterns aimed at efficient building operation to prevent over or under heating in highly insulated buildings.

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