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Energy benchmarking in UK commercial kitchens

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Abstract

Commercial kitchens are some of the most profligate users of gas and electricity in the UK and can leave a large carbon footprint. Categorising these types of establishments is challenging. New datasets of pub and restaurant energy performance metrics are presented. A preliminary study analyses annual electricity use data from automated meter readings from a large UK operator for the purpose of benchmarking and discusses it in terms of factors such as premises size and food output. The study finds that currently published benchmarks require updating. A wider subsequent study then applies the most useful benchmarking methodology to the majority of the UK's managed pub and restaurant estate. From the analysed results, consumption is found to be much larger than previous sector estimates; 7.52 TWh compared with 0.02 TWh per year. Recommendations are made to further improve the current benchmarks in order to attain robust, reliable and transparent figures, such as the introduction of performance indicators to include number of meals, kitchen size (m^2) and kWh per pound turnover. A new universal energy use benchmark of 0.37 kWh/£(turnover) is established for commercial kitchens.

Practical application: The methods and results outlined in this publication enable operators within the hospitality sector to compare their energy efficiency against the wider sector and understand how and where to improve their energy performance. The results allow building service engineers and designers at the design phase of new builds to take more accurate account of the projected energy use of the premises in its use phase by using more modern and relevant benchmarks. This in turn should assist in reducing the current performance gap. A modern and large sample size is used in forming the benchmarks, making this work very applicable to modern industrial practice.

Keywords

Restaurant, public house, energy use, benchmarking, catering

Introduction

Commercial kitchens are some of the most profligate users of gas and electricity in the UK and can leave a large carbon footprint. The total

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energy consumption of Britain's catering industry is estimated by CIBSE to be in excess of 21,600 million kWh per year.[1]

Before the introduction of energy saving strategies, procedures must be in place to monitor and target energy use. Benchmarking should be considered as a tool to compare the energy performance of a building with sector-specific averages, as well as to identify poor performers within a set of businesses, such as chains of commercial eateries.

This paper focuses on energy use from a recent, comprehensive sample of commercial catering facilities, and aims to construct a useful energy benchmark. Once energy use is normalised by the most reliable and appropriate metric and an energy use benchmark is published, operators and facilities managers may calculate their own figure for their business. If their figure is above the published energy benchmark, the site is performing poorly compared with similar businesses.

Benchmarking the electricity use in these premises raised several issues requiring further investigation. Current benchmarking methods from the Chartered Institute of Building Services (CIBSE) could not be adequately applied to the commercial catering facilities under consideration; hence new benchmarks, datasets and corresponding analyses are presented in this paper.

Current methods and figures

Current published benchmarks related to commercial catering facilities are given in Table 1. There are many discrepancies within the current catering benchmarks, suggesting the need for standardisation. The CIBSE benchmarks 'TM46 – Energy benchmarks',[2] 'Guide F'[3] and 'TM50 – Energy Efficiency in Commercial Kitchens'[1] are all derived from GIA normalised (kWh/m^2) figures originating from the 1980s.[4] The more recent TM50 endeavoured to relate

Table 1. Previously published catering benchmarks.

Kitchen type	Good practice	Typical practice	Basis of benchmark	
CIBSE Guide F 'restaurants with bar'[3]	650	730	kWh/m^2	(GIA)
CIBSE Guide F 'restaurants in public house'[3]	1300	1500	kWh/cover	(Place settings)
CIBSE Guide F 'fast food outlet'[3]	820	890	kWh/m^2	(GIA)
CIBSE Guide F 'public houses'[3]	0.8	1.8	kWh/m^2 per £1000 turnover	(GIA) and £
BSRIA 'Restaurants'[5]	–	90	kWh/m^2	(GIA)
CIBSE TM46 'Category 7; Restaurants'[2]	–	90	kWh/m^2	(GIA)
CIBSE TM46 'Category 8; Bar, pub or licensed club'[2]	–	130	kWh/m^2	(GIA)
CIBSE TM50 'Traditional Restaurant'[1]	4.15	4.7	kWh/meal	CIBSE Guide F 'restaurants with bar'[3] kWh/m^2 benchmark is multiplied by the area to support one place setting (m^2) and then divided by number of meals per place setting

energy use to number of meals but this figure is still based on the Guide F 1980s figures and further supplemented with data concerning number of meals, place size and number of place settings from the same decade.[4] These operations are likely to have significantly different energy use and food output when compared with this ageing data, hence the need to review them against modern data.

Energy attributed to catering facilities, regardless of premises type, can be omitted from declaration in display energy certificates (DECs) and declared as a separate, 'special usage' due to their large, volatile energy use and small size relative to the whole building.[6] However, on-going research suggests that the energy attributed to these facilities is often 70% of the site's energy use. [7]

Difficulties in benchmarking commercial kitchens

What kitchen? Distinguishing between categories is problematic. In most restaurants, fast food buildings and pubs serving food (here known as 'commercial catering'), it is likely that the building operators are responsible for the energy use of the entire premises. Conversely, in large organisations where 'contract catering' is the norm, the catering operation will usually be managed by a business which is not concerned with the whole building. Often these operators are not responsible for the energy bill.[8]

Concerning 'commercial catering' there are further issues pertaining to categorisation. Economic circumstances have influenced the majority of British pubs to include food services, and there is now little practical difference between pubs and licenced restaurants.[9] During initial consultation with site operators, facilities managers reported that they did not know if their premises were considered a 'pub' or a 'restaurant'. For the purposes of benchmarking, this remains unclear.

What data? The Valuation Office Agency (VOA) of England and Wales determine rateable value by financial turnover for pubs and licensed restaurants and classifies them based on proportions of food and drink sales.[10] Gross floor area (GIA m^2) is not commonly recorded for these premises and therefore current benchmarking methods (from Table 1) are difficult to apply.

More recent CIBSE TM50 suggests that the traditional metric of kWh/m^2 is largely inappropriate for a commercial kitchen. This is because a kitchen producing 30 covers (place settings) from a given area is likely to record different energy performance statistics to a kitchen producing 60 covers from the same area.[1] Contrary to this notion, a recent study commissioned for the Carbon Trust and DEFRA suggests that energy use does not correlate well with food volume or capacity, as energy use appears to be 'fixed' by poor behaviours e.g. leaving cooking appliances on maximum all day, regardless of food output.[8]

CIBSE Guide F 'restaurant in public house' benchmarks energy use in terms of 'covers' or place settings.[3] This presents a challenge for some kitchen businesses as the exact number of covers is often not known because the number and size of place settings changes on a daily basis.

Given the difficulties outlined above, providing an easily accessible benchmarking figure is challenging. The data commonly recorded in all premises are limited to effective drinking/dining area (EDA), number of meals and drinks served, financial turnover and kitchen size. EDA and kitchen size are routinely recorded by all kitchen operators, regardless of type of facilities, as they are required and obtained by all operators for planning purposes. EDA commonly excludes any office, kitchen, toilets, cellar, stores, staff room, meeting rooms and plant rooms. EDA coupled with kitchen size (referred to here as 'usable floor area') gives a good indication of the size of the premises relative to food-related business and is used to investigate electricity use correlations with the size of the premises, in an attempt to compare with the published figures.

The restaurant sector has previously been reluctant to share building energy performance and relevant data, hence the lack of updated values in Table 1. In a recent review of CIBSE benchmarks,[2] both the 'public house and bar' and 'restaurant' sector figures did not yield meaningful results when compared with DEC results, due to lack of data and small sample size.[11]

It is apparent that the current methodologies and benchmarking figures require evaluation. It is hoped that the introduction of these new datasets and corresponding analyses will be considered in further revisions of CIBSE benchmarks for catering businesses.

Methods

Preliminary case study

A dataset was derived from one of the largest pub and restaurant operators in the UK, comprising over 14 brands and 1500 commercial eateries, to be used as a preliminary case study for benchmark construction.

Electricity consumption data were retrieved from automated meter readings (AMR) for a period of 1 year (March 2011–2012). Meters transmitting the electricity consumption data (kWh) to intermediate communication controllers at half-hourly intervals were installed at each outlet. These data were then routed to a central server. Gas data were not available for the full year and so has been omitted from the preliminary study.

Data concerning the estimated drinking/dining area, number of covers and financial turnover were obtained from the operators' databases. All entries with incomplete data in any field during the year were omitted. The final data set was reduced from 1506 sites to 772.

The sample was a mix of drink or food marketed businesses, each serving at least 80,000 drinks with a combined average of approximately 277,000 meals served during the year. The number of meals and drinks served are automatically logged at the point of purchase and routed via till logging software to a central server.

Individual site data was analysed based on summation and averages for the entire dataset and for each brand. The dataset was firstly characterised into electricity consumption and then by food output. Currently, all the sites may be viewed as either 'public houses' or 'restaurants' for comparison with figures in Table 1 and consequently the full dataset is used for further analysis. Carbon emissions were calculated using 0.517 $kgCO_2/kWh$ for 'grid electricity' usage figures from BSRIA 'Rules of Thumb'.[5]

Data were analysed for correlations between electricity use and number of meals, covers and financial turnover in accordance with current benchmarking methods. The average statistics were compared with the current published benchmark figures. Using linear regression, the results are discussed.

Wider sector study

The most suitable benchmark method established from the preliminary study is applied to a much larger, more recent and more comprehensive dataset, also comprising electricity AMR data. Annual gas consumption (kWh) is also studied. The dataset (calendar year 2014) is compiled from 11,328 managed pubs and restaurants (21 operators) which comprise approximately 65% of the UK's total managed pub and restaurant estate (total of 17,385).[12]

Results

Preliminary study results

Statistical measures of correlations (R^2 values) for each relationship investigated are given in Table 7. All benchmarks based on the preliminary dataset have been rounded to the nearest ten to avoid overestimation of their exactitude when compared to the published benchmarks.

Characterisation of the preliminary dataset. The distribution of the basic electricity

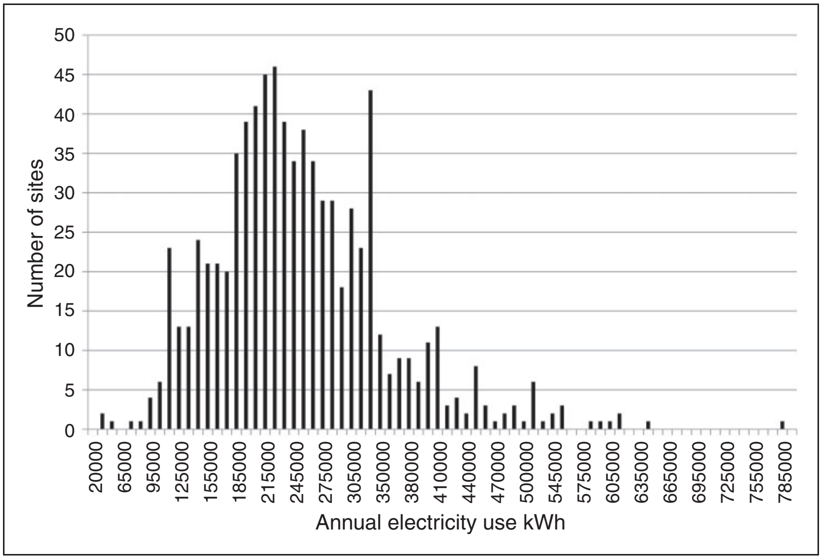

Figure 1. Consumption of electricity (kWh) by number of sites.

consumption is illustrated in Figure 1. Electricity usage follows the trend of a normal distribution, with a slight tail towards increased consumption. The average electricity usage is 249,965 kWh. In all, 46 sites have an annual electricity usage of 225–235 MWh and 43 sites have usage of 340–350 MWh.

Food and drink proportions and categorisation. Table 2 presents relevant statistics of each of the brands studied. Following discussions with site operators, no difference between each of the building's classification in terms of licensing, local authority planning, market focus or image was found. Rateable value was unable to be studied due to its commercially sensitive nature.

Each of the brands offers a menu of hot dishes together with similar staple items (burgers, pies, hot sandwiches). Some brands have wider, or more sophisticated menus with, typically, larger kitchens and equipment volumes. Sites were grouped by brand to account for these 'management' variations.

Table 2 indicates that the brands with larger proportion of food output and serving larger numbers of meals, such as Brands 4, 6 and 13, have larger electricity consumption than the less busy kitchens, such as Brands 8, 9 and 10. However, wide variations of data were found across all fields within each of the brands, as well as across the whole dataset. This variation points to a strong behavioural/management influence over electricity use. Regardless of the parameters (kitchen size, total usable size, number of meals etc.), energy use is highly variable. As such, it was impossible to distinguish between the buildings as 'pub' or 'restaurant' in any current classification scheme, therefore the full dataset was used to investigate further relationships.

Relationship between number of meals and capacity (covers). There was no significant relationship between the number of covers and the number of meals served; Figure 2 shows significant scatter of results. A smaller restaurant in a busier location, or those which are particularly popular, will likely cook more meals regardless of the maximum capacity of place settings.

Table 2. Relevant statistics from the preliminary dataset.

Brand	Sample size (n)	Ave. kitchen size (m^2)	Ave. electricity usage (kWh)	Ave. carbon emissions from electricity use ($kgCO_2$)	Food output (% of total sales)	No. meals	Ave. turnover (£Mil)
1	17	46	216,058	111,702	14	53,626	1.26
2	13	114	468,766	242,352	24	110,205	2.59
3	49	30	140,734	72,759	8	23,471	0.99
4	78	66	289,330	149,584	40	166,363	1.09
5	37	44	214,987	111,149	13	49,910	1.05
6	55	68	280,441	144,988	37	144,919	1.51
7	17	51	259,670	134,249	29	95,798	1.82
8	28	26	140,459	72,618	9	28,892	0.98
9	35	32	186,168	96,249	9	38,859	0.92
10	28	29	230,415	119,124	8	36,291	1.36
11	45	69	279,552	144,528	22	58,990	1.44
12	151	36	184,147	95,204	15	50,443	0.81
13	110	82	389,552	201,398	36	153,053	1.49
14	109	71	236,393	122,215	28	69,596	1.10

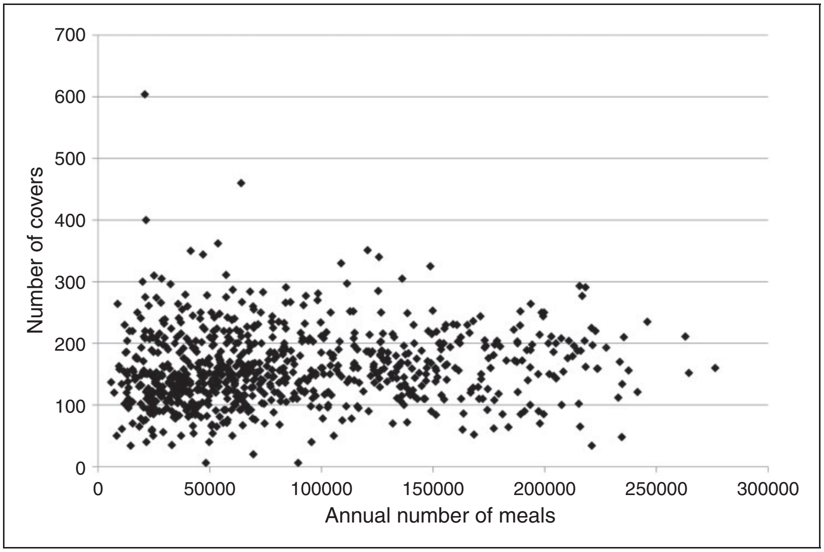

Figure 2. Relationship between annual number of meals and covers.

Electricity use and floor area. Electricity use is analysed against usable floor space (EDA + kitchen floor area). Figure 3 shows electricity use is unrelated to the useable size of the premises. From this result, normalising EUI on the basis of useable floor area in kWh/m^2 is unlikely to yield meaningful and reliable benchmarks in premises producing food.

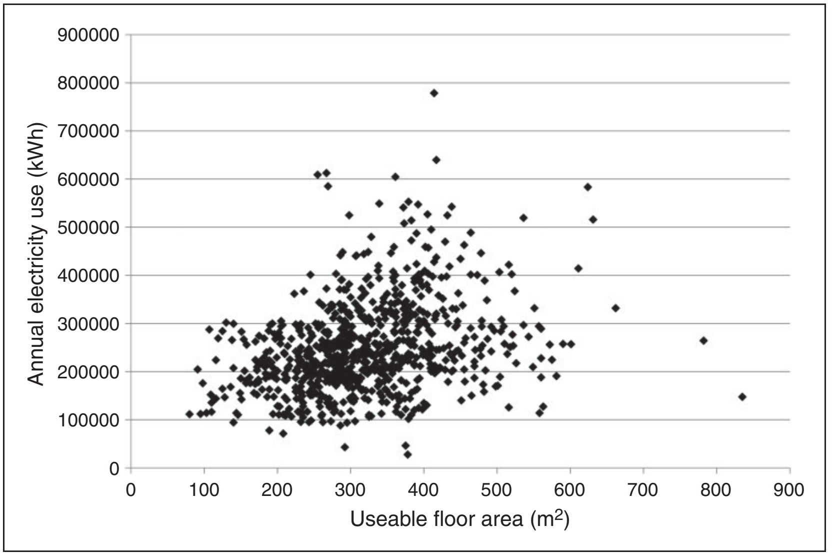

Figure 3. Relationship between usable floor area (m^2) and annual electricity use (kWh).

Table 3. Comparison of benchmarks relative to floor area (typical practice).

Statistic	CIBSE Guide F 'restaurants with bar' (kWh/m^2).[3]	BSRIA 'restaurants',[5] and CIBSE TM46 'category 7; restaurants' (kWh/m^2).[2]	CIBSE TM46 'category 8; bar, pub or licensed club' (kWh/m^2).[2]	New dataset (full range) (kWh/m^2).
Average	730	90	130	830
Standard deviation (SD)	–	–	–	350
SD/Average	–	–	–	0.42
Difference between published benchmark and new dataset average	12.18%	89.17%	84.36%	–

Comparisons of the new dataset with current published benchmarks (relative to floor area) are given in Table 3. This suggests that the CIBSE TM46 and BSRIA benchmarks require updating.

There was less scatter between kitchen size and electricity use across the entire sample set, as shown in Figure 4.

Electricity use and number of meals. Results from electricity use plotted against number of meals served, Figure 5, illustrates a moderately good relationship, (R^2 0.5868). It is likely that at least some of the scatter was due to behavioural issues associated with appliance operations, together with differences in relative complexities of cooking operations.

Comparisons of the new dataset with current published benchmarks relative to number of meals are given in Table 4. Comparison clearly demonstrates that even the most recent published benchmarks (CIBSE TM50 2009)[1] require updating.

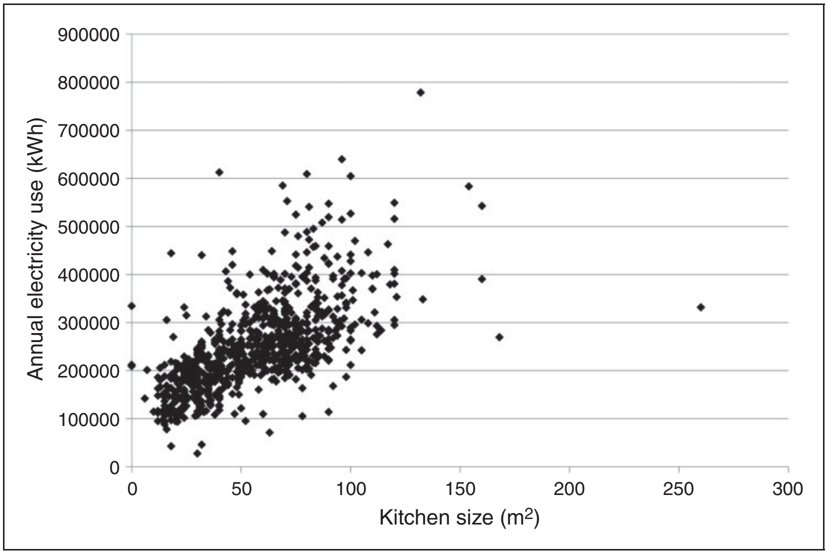

Figure 4. Relationship between annual electricity use (kWh) and kitchen size (m^2).

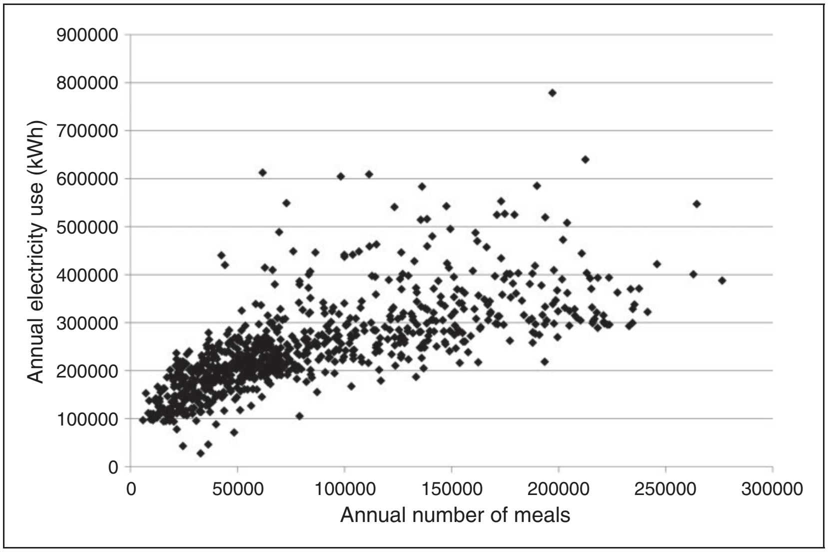

Figure 5. Relationship between annual electricity use (kWh) and annual number of meals.

Electricity use and number of covers. Figure 6 demonstrates the poor relationship between the capacities of a restaurant, i.e. number of covers, with electricity use. This is understandable as capacity has no real bearing on the electricity use given the behavioural and management styles.

Table 5 shows comparisons of the new dataset with published benchmarks relative to covers; there is a large standard deviation relative to the mean as well as large variance to the benchmark.

Electricity use and financial turnover. In accordance with the CIBSE Guide F 'public houses' benchmarking metric, the relationship between floor-normalised energy-use per £1000 financial turnover was investigated and the results are displayed in Figure 7. The wide range of scatter demonstrates a weak relationship.

Comparisons of the new dataset with current published benchmarks (kWh/m^2/ per £1000 turnover) (Table 6) found the CIBSE figure to be remarkably generous.

There were stronger relationships between kWh and direct annual turnover, without normalisation by floor area (Figure 8). Using this metric, 0.22 kWh/£turnover (220.7 kWh/£1000 turnover) is suggested for an electricity use benchmark from the preliminary data.

Preliminary gas data. Whilst complete gas figures for the full year were not available, it is helpful to have an indication of the relative significance of gas demand in the preliminary dataset. CIBSE fossil fuel benchmarks are approximately three times greater than those for electricity across all figures for pubs and restaurants. This is not replicated in the preliminary gas data analysis; gas usage across the whole

Table 4. Comparison of benchmarks relative to number of meals (typical practice).

Statistic	CIBSE TM50 'traditional restaurant' (kWh/meal).[1]	CIBSE TM50 'themed' (kWh/meal).[1]	New dataset (full range) (kWh/meal).
Average	1.73	1.37	4.02
Standard deviation (SD)	–	–	2.32
SD/average	–	–	0.58
Difference between published benchmark and new dataset average	57.01%	65.96%	–

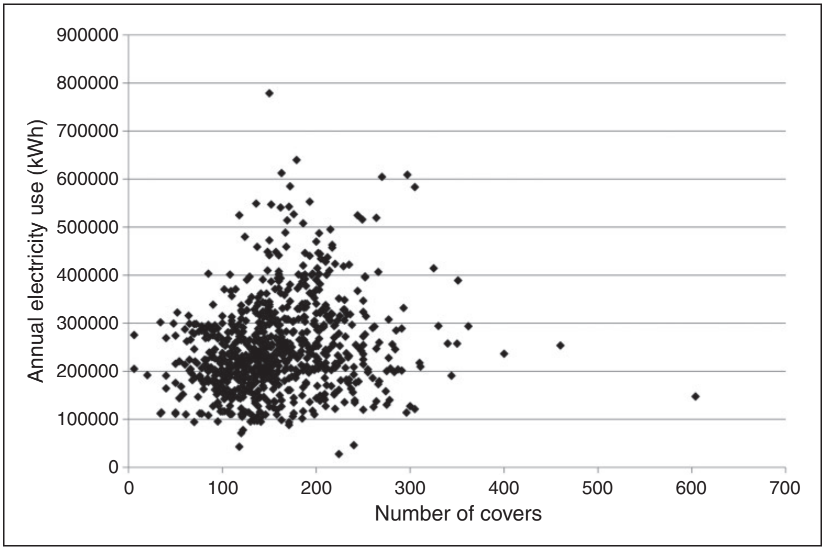

Figure 6. Relationship between annual electricity usage (kWh) and number of covers.

sample set is approximately 1.28 times greater than electricity.

None of the sites were entirely electric or all gas in their appliance set up. There is significant gas variation across brands and between the brands studied. Preliminary data analysis does not indicate that any electricity variation is linked with a corresponding variation in gas usage. Some operators state that they are looking to move away from gas towards electricity due to cost, ease of installation and operating changes (reduced need for ventilation and gas interlocking valves).

Table 5. Comparison of benchmarks relative to covers (typical practice).

Statistic	CIBSE Guide F 'restaurants in public house' (kWh/cover).[3]	New dataset (full range) (kWh/cover)
Average	1500	1870
Standard deviation (SD)	–	2170
SD/average	–	1.16
Difference between published benchmark and new dataset average	19.76%	–

Preliminary dataset relationship summaries. Table 7 summarises the relationships investigated, with the largest correlation highlighted in each row.

Wider study results

Sector energy use. Figure 9 displays the average total energy use (kWh gas and electric) per site and clearly shows that there is no trend between whether the operators classed themselves as a restaurant or pub group.

The average annual energy use per site from the wider dataset was found to be 382,337 kWh.

Sector benchmark rankings. The number of meals, financial turnover and kitchen size were the only commonly known metrics to all forms of catering establishment in the preliminary study.

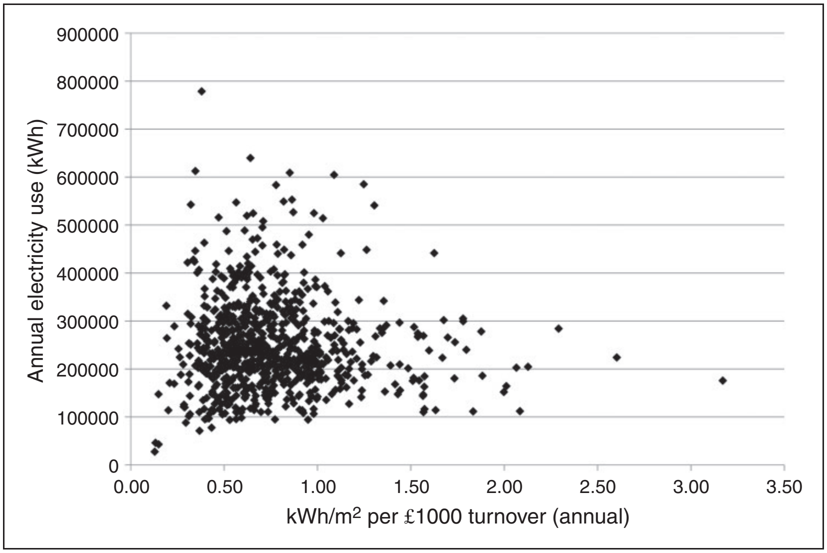

Figure 7. Relationship between annual electricity usage (kWh) and kWh/m^2 per £1000 turnover (annual).

These metrics also provided the closest relationships with electricity use (Table 7). However, what constitutes a 'meal' differs throughout the sector and the quality of data in terms of covers and premises size is highly variable.

Table 6. Comparison of benchmarks relative to financial turnover (typical practice).

Statistic	CIBSE Guide F 'public houses' (kWh/m^2 per £1000 turnover).[3]	New dataset (full range) (kWh/m^2 per £1000 turnover)
Average	1.8	0.76
Standard deviation (SD)		0.34
SD/average		0.45
Difference between published benchmark and new dataset average	−137.13%	–

Turnover (£) is the only highly reliable figure due to the need to provide accurate records of financial matters. It is concluded that a benchmark of kWh/£turnover is the most widely applicable and useful benchmark to operators. Figure 10 displays average kWh per pound turnover per site from the wider sector dataset.

The average kWh/£from the whole dataset was found to be 0.37 kWh per pound annual turnover and should serve as the most suitable figure for a new, reliable and modern sector benchmark for commercial kitchen energy use. The average electricity and gas benchmarks were found to be 0.20 kWh/£turnover and 0.16 kWh/£ turnover, respectively.

Discussion

CIBSE suggests that the commercial catering sector is responsible for energy usage of approximately 6480 million kWh.[1] The most recent figures from the UK Pub Association indicate there are 17,385 managed sites (restaurants, pubs and small hotels) in the UK and 51,178 pubs in total.[12] Given the average site energy consumption of the wider dataset

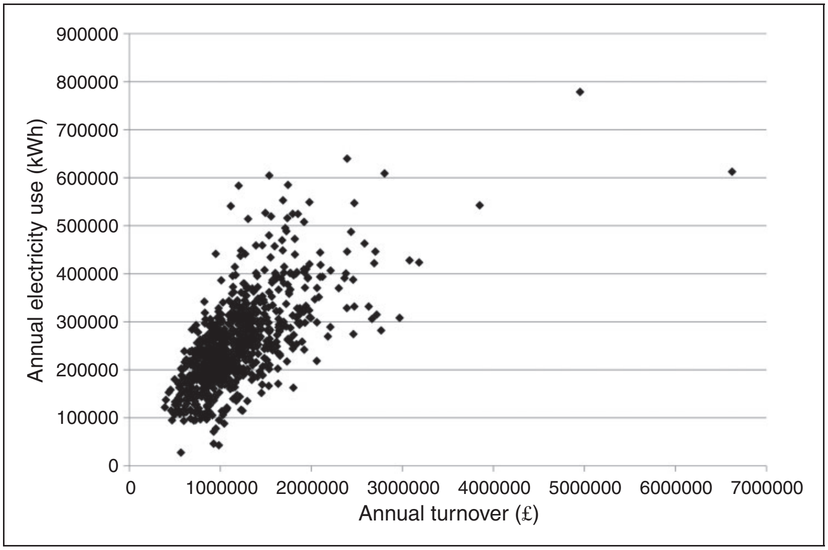

Figure 8. Relationship between annual electricity usage (kWh) and annual turnover (£).

Table 7. Relationship summaries for the preliminary dataset.

Benchmark metric	Correlation (linear)	Correlation (exponential)	Correlation (logarithmic)	Correlation (polynomial)	Correlation (power)
kWh/m^2 (useable floor area)	<0.1000	<0.1000	0.1051	0.1121	0.1000
kWh/m^2 (kitchen size)	0.4108	0.4027	0.4027	0.4309	0.4521
kWh/meal	0.4876	0.4981	0.5175	0.5272	0.5868
kWh/covers	<0.1000	<0.1000	<0.1000	<0.1000	<0.1000
kWh/m^2 per £1000 turnover	<0.1000	<0.1000	<0.1000	<0.1000	<0.1000
kWh/£turnover	0.4700	0.3978	0.4908	0.4966	0.4719

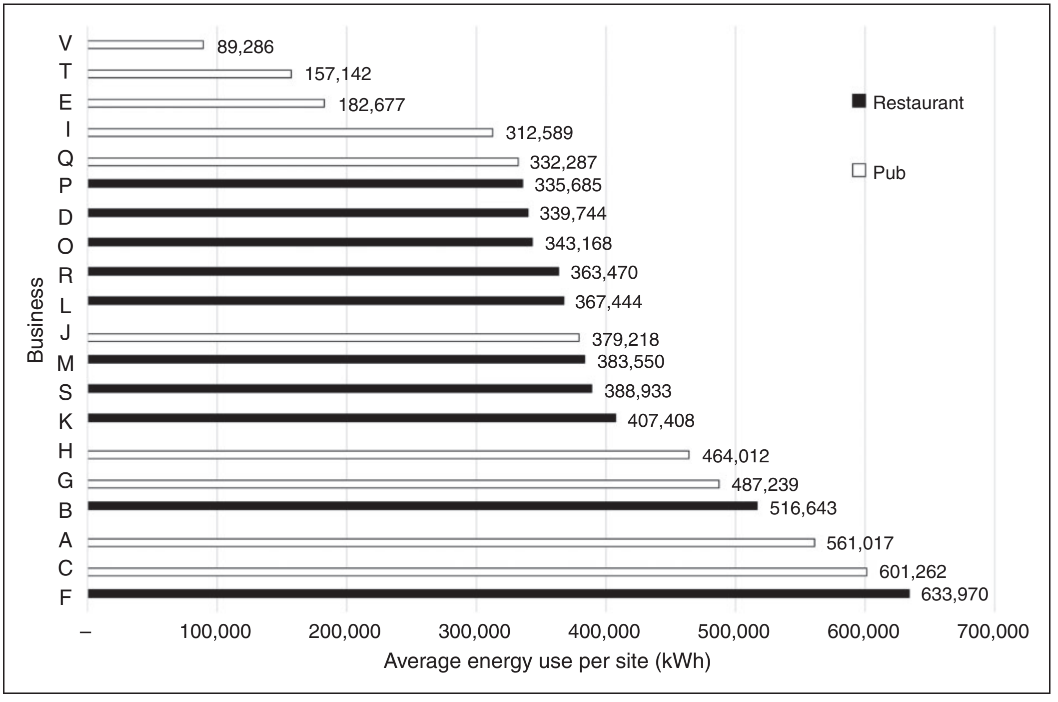

Figure 9. Average annual energy use per site (kWh) (wider sector).

(382,337 kWh), this study indicates that the overlapping pub-restaurant sector consumes several orders of magnitude greater than previous CIBSE estimates; over 19 billion kWh. Total energy consumption of the wider dataset was found to be 2,728,197,926 kWh (electricity) and 2,158,793,731 kWh (gas). Given that this dataset covers 65% of the UK total managed sites, scaled up this gives a total electricity consumption of 4,197,227,578 kWh and 3,321,221,124 kWh gas consumption for managed sites in the sector (total of 7.52 TWh). This consumption is comparable to 246,000 UK households (based on 19,654 kWh total energy consumption for average UK household).[13]

Neither the operators nor energy managers of many of these sites are certain of which establishment category and corresponding

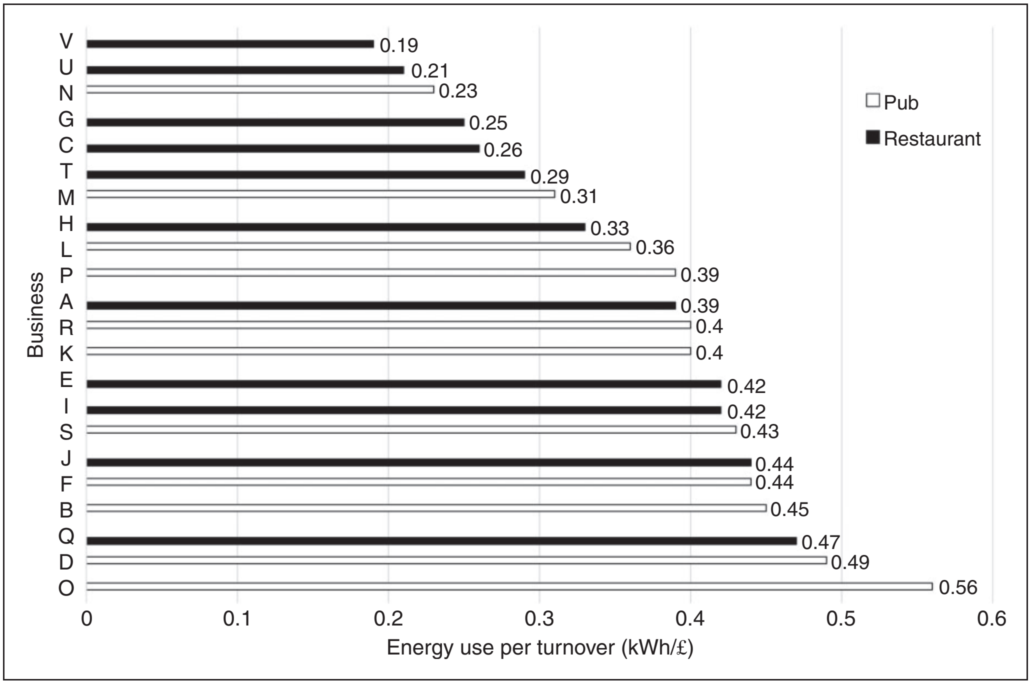

Figure 10. Energy Use per Turnover (kWh/£).

benchmark metric or figure to apply to their business. Additionally no clear groupings are displayed in either Figure 9 or Figure 10 suggesting that current guidance requires clarification; pubs and restaurants are now interchangeable categories.

Wide variations of data were seen across all fields investigated within each of the brands as well as across the whole dataset during the preliminary study. This indicates the complexity of behavioural issues associated with equipment use and the different practices employed to cook similar items.

Figure 3 clearly shows that the usable size of a catering facility does not correlate with energy use and therefore benchmarks based on such are likely to be unreliable. Comparisons of the new dataset against currently published benchmarks (Table 3) suggest that the BSRIA and TM46 'restaurant' sector figures require updating. Whilst the Guide F 'restaurants with bar' figure holds with a 12% difference, it is challenging to make an effective comparison given that GIA data are unknown. However, as shown in Figure 4 and Table 7, the introduction of a kWh/m^2 (kitchen size) benchmark is more reliable with a better correlation, and more useful for a wider range of commercial buildings with catering facilities, especially as these data are more commonly known than m^2 (GIA). Kitchen size is a good proxy for equipment volume; a smaller kitchen is likely to exhibit a lower demand load than larger kitchens, tending to have lower volumes of equipment and less complex cooking operations.

The large scatter overall and the worsening (logarithmic) relationship between number of meals served and electricity use is likely due to the seemingly innate tendency for kitchens to leave equipment on maximum levels regardless of variation in number of meals cooked.[1,7] There is little guidance by CIBSE in their most recent publication TM50 over which category a pub-restaurant may be compared with on the basis of kWh/meal. The logical 'traditional restaurant' figure is clearly not tight enough, as these buildings exhibit a 57% difference when compared with the benchmark.

Although the number of meals served shows the strongest relationship with electricity use (Figure 5), an R^2 value of 0.5868 (power), given in Table 7, is still a weak correlation. Behavioural issues such as switching off unneeded equipment or purchasing more efficient or smaller volume of equipment will have a greater influence on energy use than the variation in the number of meals cooked. The high intercept (Figure 5) indicates that much electricity use appears 'fixed' by factors such as the amount of equipment and the hours of operation and is insensitive to the number of meals cooked.

Comparisons of benchmarks against number of covers yielded a 19% difference suggesting the CIBSE benchmark is too low. Additionally the reporting of number of covers is often vague and changes regularly, hence the large scatter and large standard deviation relative to the mean, as well as the weak R^2 values shown in Table 7. Number of covers was not found to be a reliable metric, even though the category of 'public house with restaurant' is the logical description of this dataset, which suggests the CIBSE benchmark requires updating.

The current CIBSE benchmark for 'public house' of kWh/m^2 per £1000 turnover was found to be overly generous; a –137% difference when compared with the dataset. This discrepancy may be due to the aging figures and that turnover of food serving businesses is likely greater in the modern day. However, the difference is most likely due to electricity usage exhibiting no correlation with this metric, as shown in Table 7. Use of 'usable floor area' rather than GIA may be an issue, but it is unlikely to be that significant and suggests further investigation and potential adjustment is required. A more significant relationship of 0.4966 was found in the kWh/£1000 turnover investigation (polynomial) which was comparable to the R^2 values found in kWh/meal. Turnover was certainly found to be the most reliable metric during the preliminary study and consequently this was used in the wider subsequent study.

Conclusions and further work

CIBSE benchmarks relating to public houses with restaurants (kWh/cover) and the general restaurant benchmarks from TM50 (kWh/meal) and Guide F (kWh/m^2) require updating. Number of meals, financial turnover (not normalised by m^2) and kitchen size are the only common metrics for all forms of catering establishment. These metrics also provide the closest relationships with electricity use. Energy use per pound turnover was found to be the most reliable, and hence most appropriate benchmark for commercial kitchens. The average kWh/£from across the whole dataset was found to be 0.37 kWh per pound annual turnover and should serve to be the most suitable figure for a new, reliable and modern sector benchmark for commercial kitchen energy use. The average electricity and gas benchmarks were found to be 0.20 kWh/£turnover and 0.16 kWh/£turnover, respectively.

It is likely that consumption within the sector is significantly larger than previously reported; 7.52 TWh for managed sites compared with previous CIBSE estimates of 0.02 TWh for the entire catering sector. The results reported in this paper are from a modern and comprehensive dataset. They are significant in that they further simplify CIBSE guidance on benchmarking catering establishments and assist in clarifying the use of DECs in buildings featuring catering facilities. The datasets serve as a comparative tool for commercial buildings with catering facilities as well as highlighting the need for more robust categorisation of these buildings.

Further explanatory relationships such as the building characteristics influencing energy use will be determined from a multiple linear regression model currently being developed. This model will serve as a tool to enable catering facility operators to analyse and predict energy use for individual sites as well as entire brands, given a range of normal business metrics.

Further work is required alongside catering equipment distribution and supply associations to detail benchmarks for individual appliances if realistic predictions for energy consumption are to be achieved.

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