Department for
Business, Energy
& Industrial Strategy

Building Energy Efficiency Survey: Hospitality sector, 2014–15

November 2016

Any enquiries regarding this publication should be sent to us at nondomesticbuildings@decc.gsi.gov.uk

This publication is available for download at www.gov.uk/government/publications.

Contents

Notes on statistical conventions

1. All estimates for energy consumption and greenhouse gas emissions are presented on an annual basis.
2. All results presented relate to 2014–15.
3. All estimates shown in all reports are point estimates and subject to uncertainty as they are based on survey findings. Confidence intervals are shown in Appendix A at sub-sector level for energy intensity for electrical and non-electrical uses.
4. Rounding conventions:
    - All energy values presented in this report are quoted in units of gigawatt-hours (GWh) and rounded to the nearest multiple of 10 with the exception of values below 10, which are presented as integers. For example, a quantity of 316 GWh would be presented in this report as 320 GWh;
    - All greenhouse gas emission values are quoted either in units of kilotonnes of carbon dioxide equivalent ($ktCO_2e$) rounded to the nearest multiple of 10 with the exception of values below 10, which are presented as integers, or in megatonnes of carbon dioxide equivalent ($MtCO_2e$) and rounded to one decimal place. For example, a quantity of 316 $ktCO_2e$ would be presented in this report as 320 $ktCO_2e$, or as 0.3 $MtCO_2e$;
    - All electrical and non-electrical energy intensity values (for example, tables C.5 and C.6) are quoted in units of kilowatt-hours per square meter GIA per year (kWh/m^2), rounded to the nearest integer;
    - All financial figures presented in tabular form in this report are quoted in thousands of pounds (£) and rounded to the nearest multiple of £100,000 unless stated otherwise. For example, a quantity of £65,340,000 would be presented in this report as 65,300 (in units of £ thousands);
    - All figures for total floor areas across the sector are quoted in units of millions of square meters and rounded to the nearest multiple of 1. For example, a floor area of 16,385,312 m^2 would be presented as 16 million m^2;
    - All percentage values are quoted to the nearest integer;
    - Abatement potential payback[1] estimates are shown to the nearest year.
5. Table conventions:
    - For data presented in tabular form, zero values are represented by a ‘dash’ symbol i.e. ‘-’;
    - For data presented in tabular form, the final row shows the total of all individual values. Where such a total is not applicable, a ‘double apostrophe’ symbol is presented i.e. ‘’.
6. All floor area figures are presented in units of Gross Internal Area (GIA). This is the floor area of a building measured to the internal face of the perimeter walls at each floor level. Further information can be found in “Code of measuring practice: definitions for rating purposes”, available at: www.gov.uk/government/publications/measuring-practice-for-voa-property-valuations/code-of-measuring-practice-definitions-for-rating-purposes.

[1] Payback is a measure of the time required for the cumulative savings associated with an energy saving measure to match the cost of installation. It is calculated by dividing the capital installation cost associated with a measure by the annual financial savings achieved based on energy cost reductions accounting for any annual operational costs.

Executive summary

Introduction

The Building Energy Efficiency Survey (BEES) was designed to meet the following research objectives:

- To update the Department's understanding of how energy is used, for a snap-shot in time, across the non-domestic building stock in more detail than is available at present;[2]
- To update the Department's understanding of how energy use can be abated across the non-domestic building stock in more detail than is available at present;
- To understand the barriers and enablers of energy abatement.

The first two objectives are addressed in this and other sector reports. The third objective is addressed in the BEES overarching report.

Overview of project method

The BEES study reports on the non-domestic building stock for England and Wales. Within this overall scope the stock is split into 10 sectors. These are in turn made up of 38 sub-sectors, each of which were analysed separately. This report provides the detailed study findings for the hospitality sector.

The study collected data through a large sample of telephone surveys (3,690) across all sectors. Each survey record is a premises which may represent a whole building or a part of a building. This information was obtained from a single organisation in a premises[3]. A smaller subset of site surveys (214) across all sectors were sampled from within the telephone survey sample. The telephone survey respondents were randomly selected from national level datasets for England and Wales.

The telephone surveys were used as the primary input into two models. One model calculated the records' energy use (the energy use model) and the other calculated the energy saving potential (the abatement model). The energy use model estimated the energy consumption of each premises record at an end use level. The abatement model determined the abatement potential of energy efficiency measures which could be applied to that premises, their capital cost and the amount of energy these measures could save.

The detailed findings from site surveys and a database of matched energy and activity data were used to calibrate the two models. The site surveys were also used to validate the telephone survey responses, and collect information on barriers and enablers from the site contacts.

Overall, the model calibration process has shown that at a sub-sector level the energy use consumption is reliable but that at a single record level the accuracy has a higher level of uncertainty.

---

[2] The current non-domestic stock model (Pout, C (2000) NDEEM: the national non-domestic buildings energy and emissions model) is underpinned by field research conducted by Sheffield Hallam University in the 1990s.

[3] For all telephone surveys, the person responsible for managing energy on site was sought to complete the survey.

The overall project method had weaknesses in two key areas:

- Data inputs were obtained through telephone surveys, which were highly simplified. The telephone survey was designed to ensure it was easy to understand for non-energy experts so this meant questions could not be particularly technical and this further limited the sophistication of the input data to the model;
- The majority of the inputs were self-reported, which meant it was prone to a range of biases, such as differences in interpretation or understanding of a question by the respondent.

Following analysis of the data on the individual premises, the record results were weighted in order to produce results representative of all non-domestic buildings in England and Wales in each sector.

Hospitality sector overview

The hospitality sector consisted of cafes, hotels, public houses (referred to as pubs in this report) and restaurants & takeaways; for the purpose of this study, it did not include hospitality premises that were present in other building types. The hospitality sector had a total floor area of 36 million m^2 (5 per cent of the total non-domestic stock) across 97,100 premises (6 per cent of the total non-domestic stock). The hospitality sector's total energy consumption was 16,980 GWh. The sector's electrical energy consumption was 8,760 GWh (10 per cent of the total non-domestic stock) and non-electrical energy consumption was 8,230 GWh (11 per cent of total non-domestic stock).

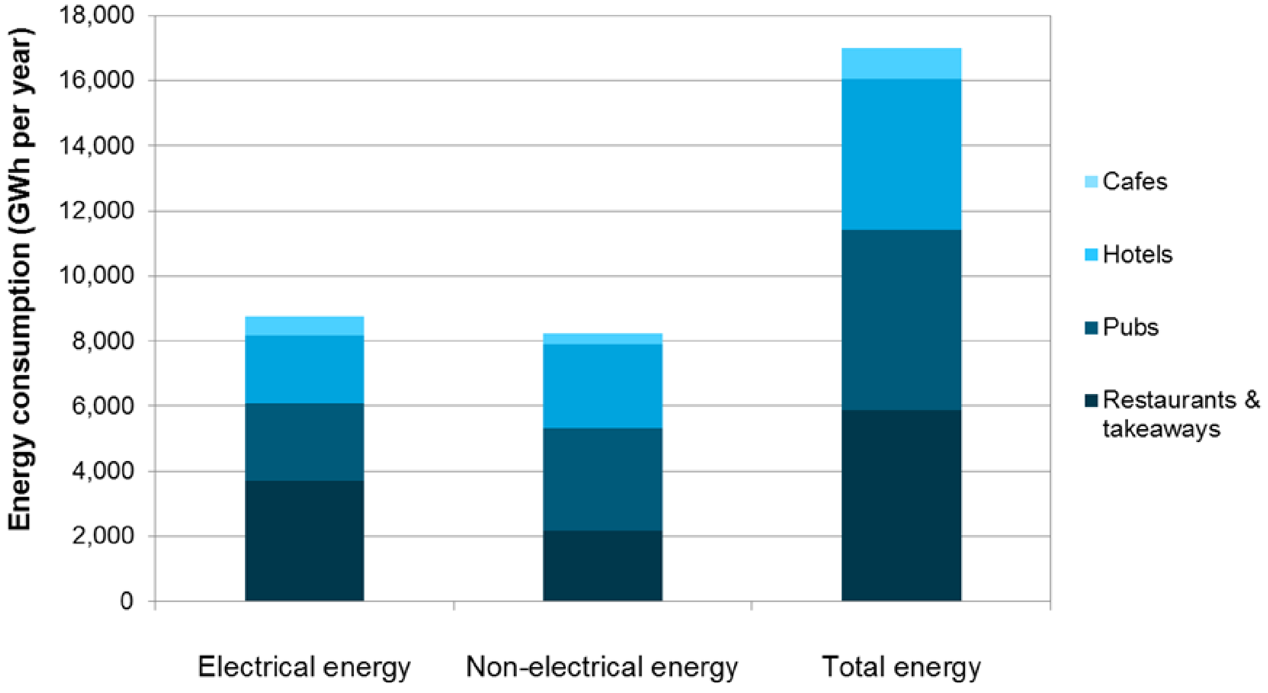
The findings in this report are based on data collected through 272 telephone surveys used in the energy use and abatement models and 30 site surveys in 2014–15.

Key findings

Energy consumption in the hospitality sector, 2014–15

- According to modelled data based on telephone survey responses, the sector consumed 16,980 GWh of energy. This included 8,760 GWh of electrical energy and 8,230 GWh of non-electrical energy per year (Figure 0.1).
- The largest energy consumer in this sector was restaurants & takeaways with 5,890 GWh total energy consumption (35 per cent of sector total). Pubs were the second largest consumers, with 5,520 GWh of total energy consumption (33 per cent of sector total).
- The difference in absolute consumption between the sub-sectors did not match with their overall size. Restaurants & takeaways were the largest consumers of energy of the four sub-sectors, but represented only 15 per cent (5 million m^2) of the total sector floor area. In contrast, both pubs and hotels represented a smaller portion of the sector's overall energy consumption despite each representing 40 per cent of the sector's total floor area.
- Restaurants & takeaways had the highest total median energy intensity (701 kWh/m^2), followed by cafes (578 kWh/m^2) and pubs (339 kWh/m^2).
- Restaurants & takeaways typically had the highest median energy intensities (429 kWh/m^2 for electrical energy and 244 kWh/m^2 for non-electrical energy). The second most energy intensive sub-sector was cafes (393 kWh/m^2 for electrical energy and 306 kWh/ m^2 for non-electrical energy). Cafes and restaurants & takeaways demonstrated the widest distribution in both electrical energy intensity and non-electrical energy intensity.
- The energy consumption of the hospitality sector was broken down into specific 'end uses'. The most significant end use was catering (8,620 GWh, 51 per cent of total energy consumption), followed by space heating (3,540 GWh, 21 per cent of total).

Figure 0.1: Energy consumption by energy type and hospitality sub-sector, 2014–15



Source: Energy use model results for the sector covering England and Wales

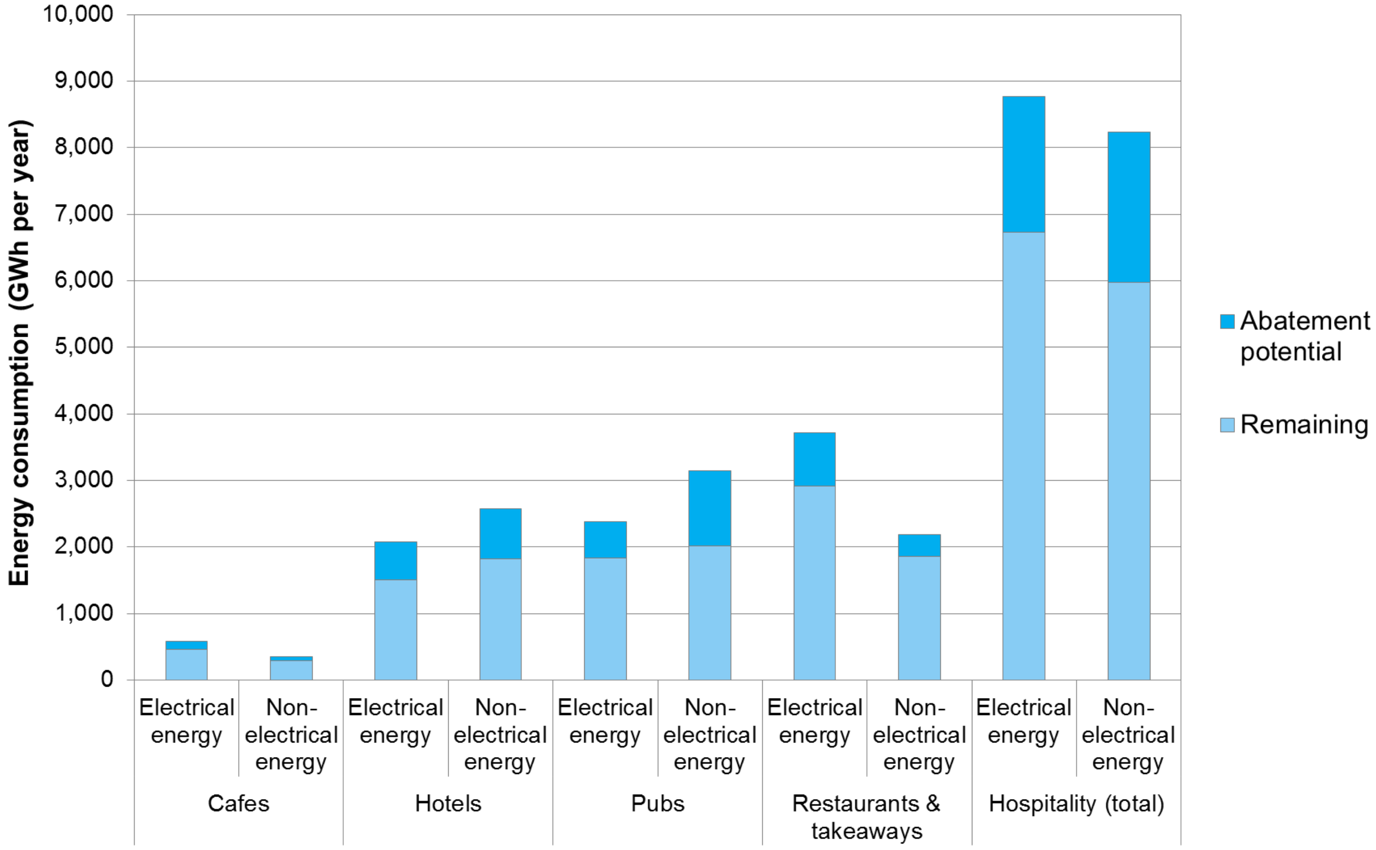
Abatement potential in the hospitality sector, 2014–15

- According to modelled data based on telephone survey responses, Figure 0.2 shows abatement potential for the sector, broken down by sub-sector and fuel type. This represents the total abatement potential that is technically available, which relates to the possible reductions in energy consumption following implementation of all applicable measures. The results include measures that are not cost-effective and the model applies a simple assessment of measure suitability. Building specific installation requirements that may impose additional costs are not accounted for.
- The total abatement potential in the hospitality sector was 4,300 GWh of total energy (25 per cent reduction on consumption). This was comprised of 2,040 GWh of electrical energy (a 23 per cent reduction on consumption) and 2,260 GWh of non-electrical energy (a 27 per cent reduction).
- This could be achieved at a capital cost of £1.8 billion. The socially cost effective potential was 1,060 GWh of total energy consumption, which consisted of 990 GWh of electrical energy consumption and 70 GWh of non-electrical energy consumption. Companies are more likely to be influenced by the payback period for improvement: overall there were 1,130 GWh of total energy savings with a private payback period[4] of 3 years or less (700 GWh of electrical energy abatement and 440 GWh of non-electrical energy abatement).

[4] Payback is calculated by dividing the total cost associated with a measure (the capital cost installation cost and annual operational costs) and dividing these by the annual financial savings achieved based on energy cost reductions.

- The sub-sector with the largest relative and absolute abatement potential was pubs, with 550 GWh of electrical energy (23 per cent of the baseline) and 1,130 GWh of non-electrical energy (36 per cent of the baseline).

Figure 0.2: Abatement potential by energy type and hospitality sub-sector, 2014–15



Source: Abatement model results by sub-sector, England and Wales

Table 0.1 shows the abatement potential by measure type. Definitions of measure type are included in Appendix D. The largest group of savings for the hospitality sector – in terms of reductions in energy consumption – relate to the implementation of building instrumentation & control measures, carbon & energy management and space heating measures. The largest group of savings – in terms of the potential energy bill savings – relate to the implementation of cooled storage upgrades.

Table 0.1: Abatement potential in the hospitality sector by measure type, 2014–15

Measure type	Savings: Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**
Air conditioning and cooling	6,500	20	70	-	70	85,500
Building fabric	24,200	110	120	480	600	461,400
Building instrumentation and control	34,200	180	170	680	850	149,300
Building services distribution systems	1,300	5	10	-	10	32,400
Carbon and energy management	40,400	180	300	440	730	68,700
Hot water	5,100	20	30	70	100	26,400
Humidification	-	-	-	-	-	-
Lighting	39,900	110	400	-	400	152,600
Cooled storage	54,700	160	550	-	550	213,700
Small appliances	4,200	20	30	50	80	64,300
Space heating	17,600	110	40	540	580	233,800
Swimming pools	500	3	2	10	20	7,800
Ventilation	31,200	100	310	-	310	259,300
Total	**259,800**	**1,020**	**2,040**	**2,260**	**4,300**	**1,755,200**

Source: Abatement model results for the sector, England and Wales

1. Hospitality sector

This report relates to the hospitality sector (one of ten sectors covered in the Building Energy Efficiency Survey (BEES)). This section provides definitions for the four hospitality sub-sectors (cafes, hotels, pubs and restaurants & takeaways). It then sets the hospitality sector in the wider non-domestic stock context in terms of both the number of premises and floor area it represents.

Table 1.1 sets out the definitions for each of the sub-sectors reported in the hospitality sector.

Table 1.1: Table of hospitality sub-sector definitions[5]

Sub-sector	Definition
Cafes	Refers to premises used for the preparation and sale of food and beverages; often with a focus on the provision of hot drinks and/or breakfasts and light meals. Gross Floor Area should include all space within the premises, including kitchens, sales areas, dining areas, staff break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported.
Hotels	Refers to premises used for renting overnight accommodation on a room/suite and nightly basis, and typically include a bath/shower and other facilities in guest rooms. Hotels typically have daily services available to guests including housekeeping/laundry and a front desk/concierge; food and drink services may be for non-guests too. Hotels should be majority-owned by a single entity and have rooms available on a nightly basis. Gross Floor Area should include all interior space within the premises, including guestrooms, halls, lobbies, atriums, food preparation and restaurant space, conference and banquet space, fitness centres/spas, indoor pool areas, laundry facilities, lift shafts, stairways, mechanical rooms, storage areas, employee break rooms, and back-of-house offices.
Public houses (pubs)	Refers to premises with a bar and one or more public room licensed for the sale and consumption of alcoholic drink. Gross Floor Area should include all internal spaces including public bars, corridors, toilets, offices, kitchens and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting.
Restaurants & Takeaway food	Restaurants refers to premises used for preparation and sale of ready-to-eat food and beverages, with a focus on the provision of sit-down meals.

[5] These definitions were originally based on those used for US Energy Star scheme and then were adapted for the UK context.

Sub-sector	Definition
outlets (restaurants & takeaways)	Examples of restaurants include fast casual, casual, and fine dining restaurants. Gross Floor Area should include all space within the premises, including kitchens, sales areas, dining areas, offices, staff break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting. The restaurant sub-sector includes premises which offer both a dining area and a take-away service. Takeaways refers to premises used for the preparation and sale of ready-to-eat food. Takeaways are characterised by a limited menu of food prepared quickly (often within a few minutes), and sometimes cooked in bulk in advance and kept hot. Gross Floor Area should include all space within the premises, including kitchens, sales areas, offices, staff break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting. Takeaways which also have dining areas are treated as restaurants. Restaurants & takeaways were originally separate sub-sectors but were combined to provide a robust sample size and in recognition that there was high variability in the share of food sold for consumption offsite in premises classed as restaurants.

Hospitality sector in the context of the wider non domestic stock

The hospitality sector accounts for 6 per cent of the non-domestic stock in terms of premises count (97,100) and 5 per cent in terms of floor area (36 million m^2 GIA[6]).[7]

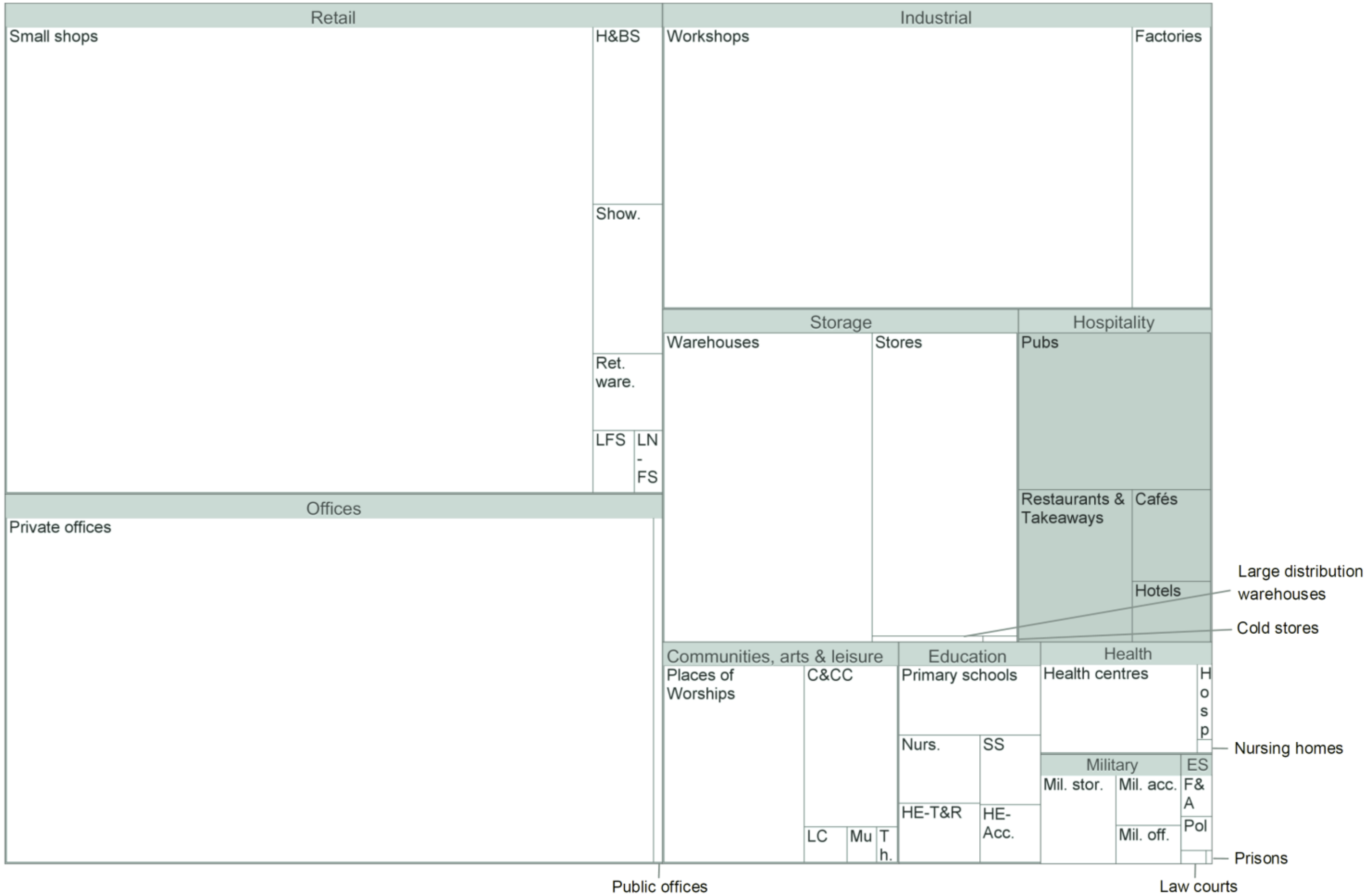
In terms of energy consumption the sector consumed 16,980 GWh of total energy per year. This comprised 8,760 GWh of electrical energy and 8,230 GWh of non-electrical energy, equivalent to 11 per cent and 11 per cent of non-domestic stock totals respectively. This information is set out in Figure 1.1 to Figure 1.3.

[6] GIA stands for Gross Internal Area: the area of a building measured to the internal face of the perimeter walls at each floor level.

[7] The sources for these statistics can be found in the technical annex (and are referred to collectively as the Population table).

Figure 1.1: Building frequency by sub-sector for the non-domestic stock covered by BEES 2014–15

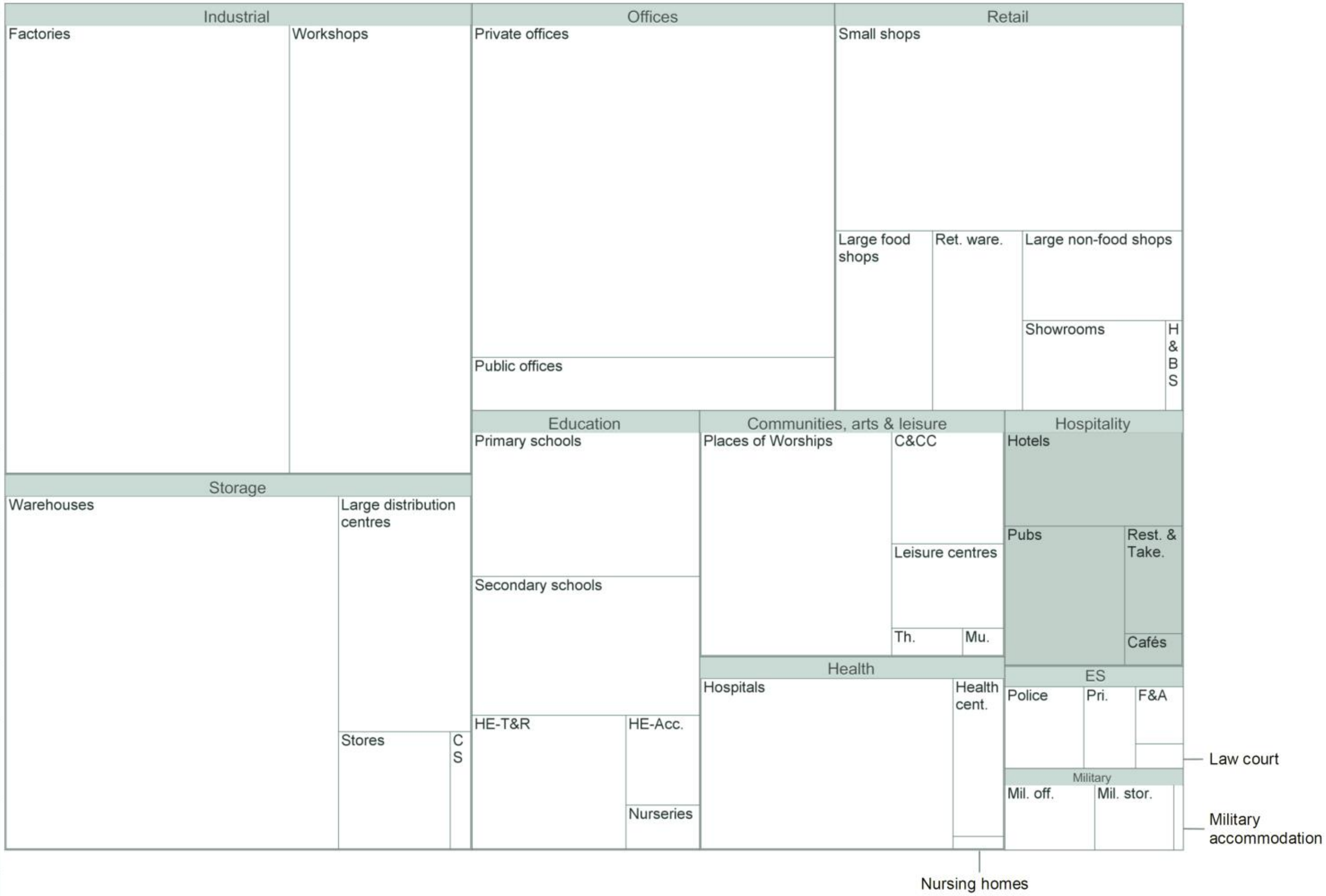
ID	Sub-sector
H&BS	Hairdressing & beauty salons
Show.	Showrooms
Ret. ware.	Retail warehouses
LFS	Large food shops
LN-FS	Large non-food shops
C&CC	Clubs & community centres
LC	Leisure centres
Mu.	Museums, Art galleries and Libraries
Th.	Theatres, cinemas and concert halls
Nurs.	Nurseries
SS	Secondary schools
HE-T&R	HE—Teaching and research
HE-Acc.	HE — Accommodation
Hosp.	Hospitals
Mil. stor.	Military storage
Mil. acc.	Military accommodation
Mil. off.	Military offices
F&A	Fire & ambulance stations
Pol.	Police stations



Source: Population table

Figure 1.2: Floor area by sub-sector for the non-domestic stock covered by BEES 2014–15

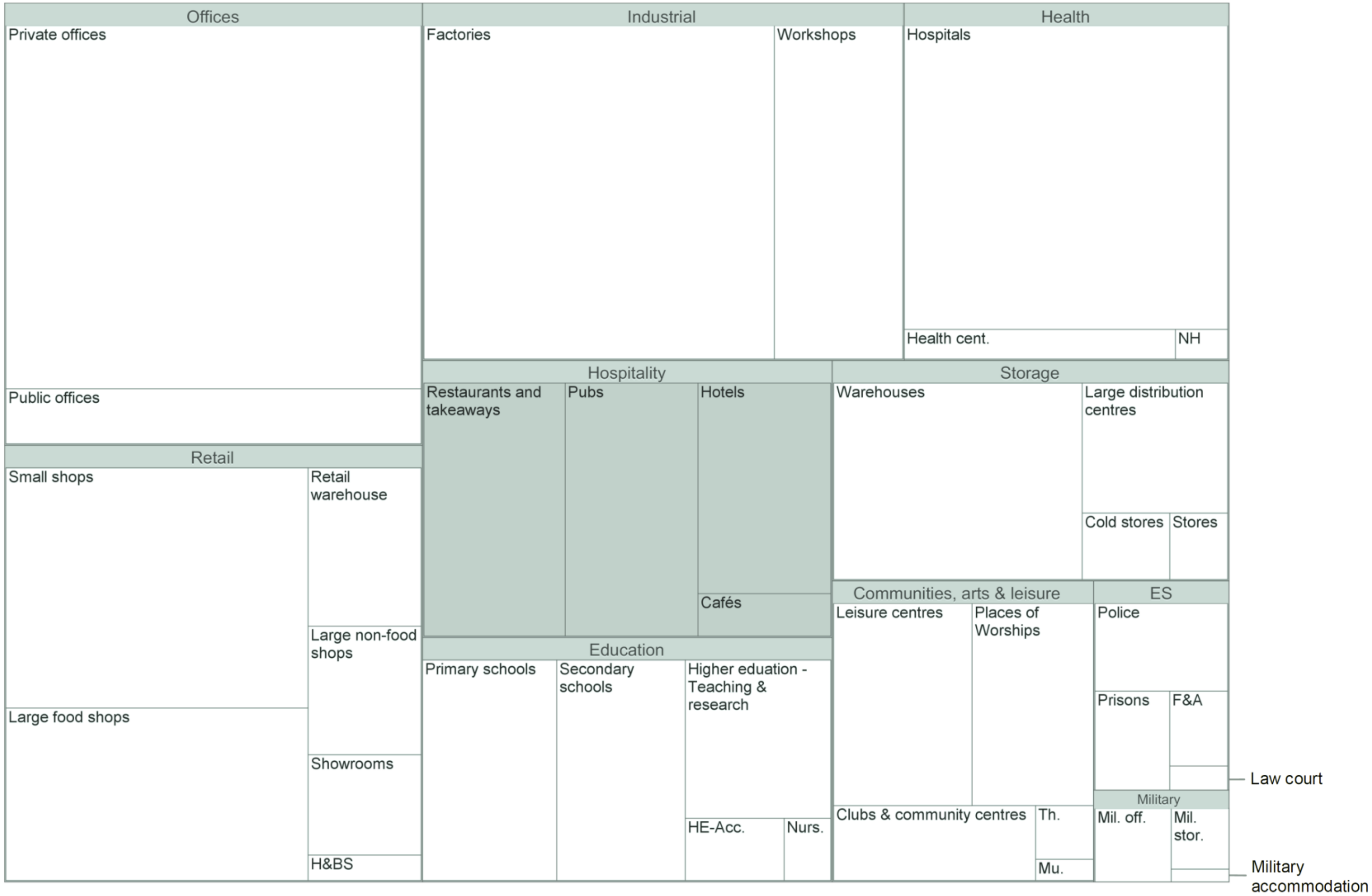
ID	Sub-sector
Ret. ware.	Retail warehouse
H&BS	Hairdressing & beauty salons
CS	Cold stores
HE-T&R	HE—Teaching and research
HE-Acc.	HE — Accommodation
C&CC	Clubs & community centres
LC	Leisure centres
Th.	Theatres, cinemas and concert halls
Mu.	Museums, Art galleries and Libraries
Health cent.	Health centre
Rest. & Take.	Restaurants & takeaways
Pri.	Prisons
F&A	Fire & ambulance stations
Mil. off.	Military office
Mil. Stor.	Military storage



Source: Population table

Figure 1.3: Energy consumption by sub-sector for the non-domestic stock covered by BEES 2014–15

ID	Sub-sector
Health cent.	Health centre
NH	Nursing homes
H&BS	Hairdressing & beauty salons
HE-Acc.	HE — Accommodation
Nurs.	Nurseries
Th.	Theatres, cinemas and concert halls
Mu.	Museums, Art galleries and Libraries
F&A	Fire & ambulance stations
Mil. off.	Military office
Mil. Stor.	Military storage



Source: Energy use model results for the sector, England and Wales

General characteristics of the hospitality sector

The survey records relate to a single premises within buildings predominantly classified as hospitality activities. In some cases the premises will be the whole building, in other cases just the area occupied by a single organisation.

Hospitality premises varied greatly in size and complexity from small cafes and takeaways with no heating or cooling plant to large city centre hotels with extensive mechanical ventilation and air conditioning, leisure and conference facilities. Individual premises ranged in organisational structure from owner occupied micro-businesses, local chains, franchises, and major national and international chains.

Within the sector there was a distinction between premises with accommodation (hotels) and those that focused predominantly on catering (restaurants & takeaways and cafes). The main activity found in most hospitality premises was eating and drinking space for customers although in hotels bedrooms were more important. Other activities commonly found in hospitality premises included significant kitchen facilities, bar facilities and cooled storage, customer and staff rest facilities and lifts. In those premises where accommodation was provided, additional activities were also common. These included music venues and corporate function suites. In some hotels there were also more energy intensive activities such as server rooms, gyms, swimming pools and saunas.

Summary statistics for the hospitality sector

A number of standard characteristics for the hospitality sector are set out in Table 1.2, Figure 1.4 and Figure 1.5; from premises and organisation size through to operating hours and premises tenure. These key characteristics for the hospitality sector and how these vary across the hospitality sub-sectors themselves are described.

Analysis of BEES has primarily been done to give a fair representation of floor area within sub-groups. Floor area has a strong association with energy use.

Based on the floor area weighted records, premises in the hospitality sector broadly split into two groups, with hotels having distinctly different attributes to the remaining sub-sectors:

- Hotel premises tended to operate 24 hours a day, have a floor area of greater than 1,000 m^2, be owner occupied and be operated by large organisations;
- Whilst there is variation between cafes, pubs and restaurants & takeaways, they were far more likely to be managed by a small to medium sized enterprise and occupy smaller leased premises.

Hospitality premises were occupied by a range of organisation sizes. Pubs and cafes tended to be occupied by small or micro businesses i.e. fewer than 50 employees (89 per cent and 80 per cent, respectively). In contrast, there were premises of all organisation sizes in restaurants & takeaways and hotels. 59 per cent of restaurants & takeaways and 46 per cent of hotels were large organisations, with a further 29 per cent of restaurants & takeaways and 26 per cent of hotels operated by small or micro-sized businesses.

Hotels were generally larger premises, with 82 per cent of hotels with a floor area of more than 1,000m^2. In contrast, the rest of the sub-sectors tended to occupy premises between 100m^2 and 500m^2 with 73 per cent of restaurants & takeaways, 66 per cent of cafes and 64 per cent of pubs in this banding.

With regards to tenure, the majority (71 per cent) of hotels were owned rather than leased by the occupiers. For all other sub-sectors, premises were typically leased: 79 per cent of restaurants & takeaways, 63 per cent of pubs and 61 per cent of cafes.

Organisations across the sector commonly described themselves as ‘actively seek[ing] new ways to reduce energy use’. For example, 69 per cent of hotels and 67 per cent of restaurants & takeaways indicated high interest levels for energy reduction. Cafes were the only exception, with around half of sites indicating that energy management was not a priority (55 per cent)[8].

In terms of building age, pubs and cafes tended to be based in older buildings and the other hospitality sub-sectors were in newer buildings. For instance, a large proportion of pubs (89 per cent) were constructed prior to 1900, along with 46 per cent of cafes. In comparison, hotels and restaurants & takeaways generally occupied more modern buildings, with 59 per cent and 33 per cent constructed after 1986.

The likelihood of a premises occupying a whole building, as opposed to part of a building, varied significantly across sub-sectors. Cafes typically occupied only part of a building (61 per cent of records). In contrast pubs, hotels and restaurants & takeaways consisted almost predominantly of premises occupying the whole building (95 per cent, 73 per cent and 72 per cent of floor area, respectively).

The usage pattern within hotels differed substantially from other sub-sectors, with 96 per cent of sites having peak operating hours of 24 hours per day (this is defined as hours when at least 50 per cent of the maximum number of staff on a typical day are present in the premises). Restaurants & takeaways and pubs had reasonably long peak operating hours, 85 per cent and 40 per cent had peak operating hours of between 8 – 15 hours a day. This could reflect the midday and evening meal time operating peaks. Cafes were the most likely to have peak operating hours for fewer than 8 hours a day (56 per cent).

[8] This means the respondent chose the option ‘We try to reduce energy use when we can but it is not an area of high importance” in response to the energy management attitudes question in the telephone survey.

Table 1.2: Range of building and premises characteristics by hospitality sub-sector by percentage of floor area, 2014–15

Column percentages

	Hospitality sub-sector				
	Cafes (%)	Hotels (%)	Pubs (%)	Restaurants & takeaways (%)	**Hospitality sector (%)**
Organisation size[9]					
Micro (0-9)	67	17	50	17	**33**
Small (10-49)	13	9	39	12	**22**
Medium (50-249)	6	27	3	11	**14**
Large (250+)	12	46	8	59	**31**
Don't know	2	1	0	2	**1**
Total floor area (m^2)					
Less than 50	10	-	0	2	**1**
50-99	24	-	0	5	**2**
100-249	59	1	3	37	**10**
250-499	7	13	61	36	**35**
500-999	-	4	35	20	**19**
1,000-4,999	-	27	-	-	**11**
5,000-9,999	-	33	-	-	**13**
10,000 or more	-	22	-	-	**9**
Tenure					
Owned	36	71	37	21	**48**
Leased	61	29	63	79	**52**
Don't know	2	-	0	-	**0**
Energy management ambition[10]					
Active	32	69	58	67	**63**
Passive	55	26	42	30	**34**
None	13	5	0	4	**3**
Don't know	-	-	-	-	**-**
Age of building					
Pre-1900	46	26	89	29	**53**
1900-1939	9	8	5	9	**7**
1940-1985	20	6	0	10	**5**
1986-1990	4	1	-	11	**2**
1991-2006	2	54	-	17	**25**
2007 or later	-	4	3	5	**4**
Don't know	19	-	3	18	**5**

[9] 'Large' relates to organisations employing 250+ staff, with further categories defined as: Medium (50-249), Small (10-49), Micro (1-9).

[10] 'Active' relates to respondents who indicated that they "actively seek new ways to reduce energy use"; 'Passive' relates to respondents who indicated that they "try to reduce energy use where possible, but it's not a priority", 'None' relates to respondents who indicated that they "have not considered ways to reduce energy use".

Table 1.2 continued.

	Hospitality sub-sector				
	Cafes (%)	Hotels (%)	Pubs (%)	Restaurants & takeaways (%)	**Hospitality sector (%)**
Building structure					
Whole building	39	73	95	72	**80**
Part of building	61	27	5	28	**20**
Multiple buildings	-	-	-	-	**-**
Peak operating hours[11]					
8 or less	56	-	10	18	**9**
9-15	41	3	85	40	**43**
16-23	-	1	3	26	**5**
24	-	96	3	15	**42**
Don't know	3	1	-	1	**1**
Opening hours[12]					
8 or less	23	-	3	10	**3**
9-15	68	2	68	35	**36**
16-23	4	2	21	34	**15**
24	2	96	8	20	**45**
Don't know	3	1	-	1	**1**
Unweighted base	*48*	*44*	*93*	*87*	***272***

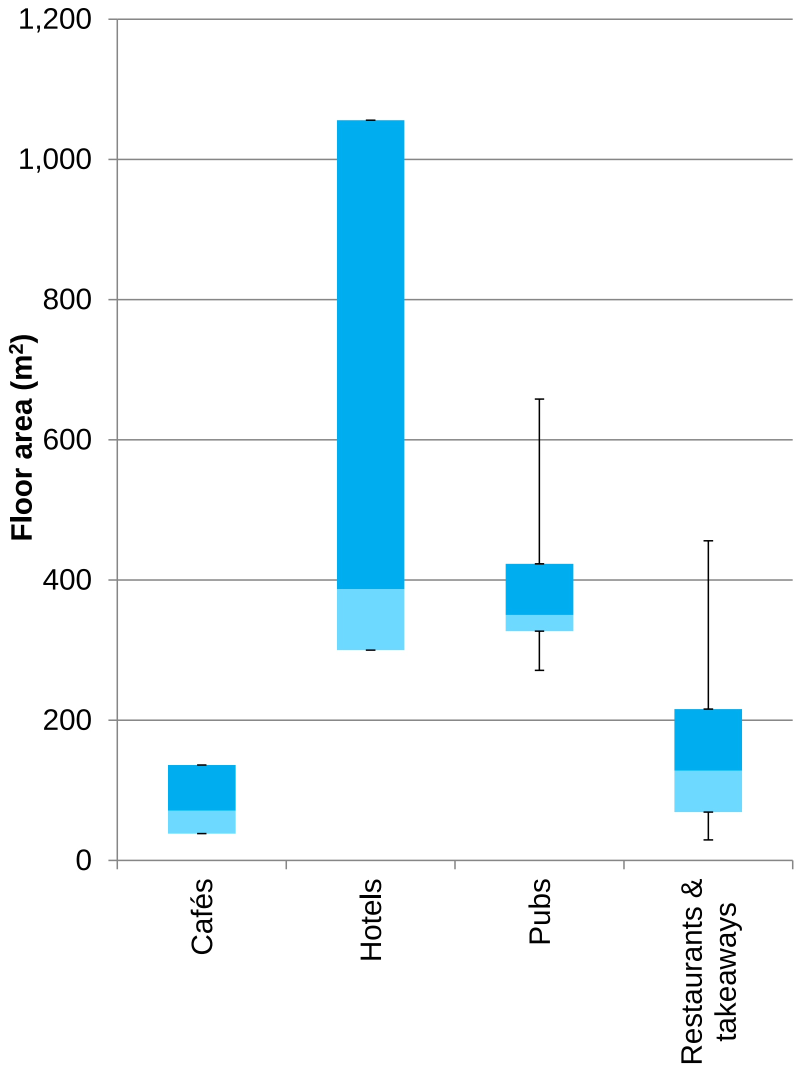
Source: Telephone survey or equivalent records for the sector, England and Wales

[11] Respondents were asked "How many hours in a typical working day is the premises reasonably fully occupied by your employees (at least 50% of staff present)?".

[12] This was defined as the total number of hours that the premises was at least partially occupied by staff (when at least 20 per cent of the maximum number of staff - on a typical working day - were present).

Figure 1.4 shows the distribution of premises sizes, in terms of floor area, by sub-sector. The plot shows that hotels had the largest median floor area in the hospitality sector at 390 m^2, followed by pubs (350 m^2), restaurants & takeaways (130 m^2) and cafes (70 m^2). The distribution of floor area sizes for hotels was also much wider than other sub-sectors, with the central 50 per cent of records having floor areas between 300 m^2 and 1,060 $m^{2;}$ compared with a range of 70 m^2 to 220 m^2 in restaurants & takeaways, 330 m^2 to 420 m^2 in pubs and 40 m^2 to 140 m^2 in cafes.

Figure 1.4: Premises size by hospitality sub-sector, 2014–15

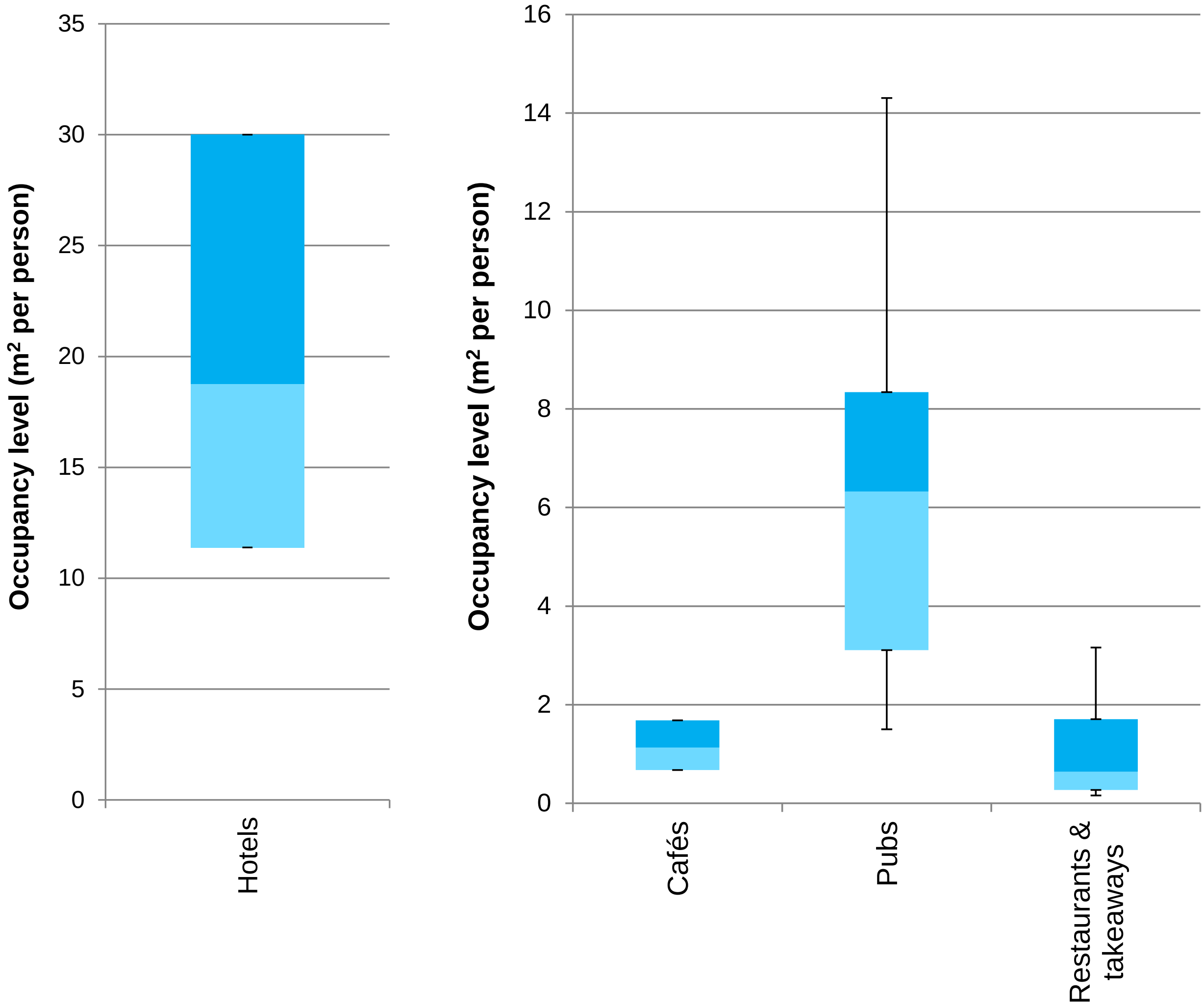


Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded.

Source: Telephone survey or equivalent records for the sector, England and Wales

Figure 1.5 shows the distribution of occupancy level (the floor area per staff and visitor number) based on the number of visitors present over a typical working day. Hotels show the widest distribution in occupancy level, and the lowest median occupancy level of 19 m^2 per person. This compares with a median of 6 m^2 per person in pubs and 1 m^2 in both cafes and restaurants & takeaways.

Figure 1.5: Occupancy level (floor area per staff and visitor number) by hospitality sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded.

Source: Telephone survey or equivalent records for the sector, England and Wales

2. Methods

This section provides a summary of the Building Energy Efficiency Survey (BEES) methodology describing the research objectives of this study, the standard approach to data collection, data screening and data processing; as well as the methodological challenges for the hospitality sector.

Greater detail on the BEES methodology in relation to the hospitality sector is presented in Appendices A, B and C, which cover statistics on the methodological quality and an explanation of how the approach was tailored for the hospitality sector.

A detailed technical annex for BEES has also been published alongside this report, which provides detailed coverage on sampling approaches, the study method and the models used. This can be found at www.gov.uk.

Research objectives

The Building Energy Efficiency Survey (BEES) was designed to meet the following research objectives:

- To update the Department's understanding of how energy is used, for a snap-shot in time, across the non-domestic building stock in more detail than is available at present;[13]
- To update the Department's understanding of how energy use can be abated across the non-domestic building stock in more detail than is available at present;
- To understand the barriers and enablers of energy abatement.[14]

The first two objectives are addressed in this and other sector reports. The third objective is addressed in the BEES overarching report.

Standard approach

A standard overall approach was designed to gather information on energy use in premises relying on telephone surveys and a limited number of site surveys. The non-domestic stock was broken down into 10 sectors and 38 sub-sectors.

The analysis for BEES was performed at sub-sector level with bespoke questionnaires and modelling assumptions used at this level.

The restaurants & takeaways sub-sector was originally two distinct sub-sectors for the two different building types – these were amalgamated retrospectively. The underlying analysis however is based on different questionnaires and modelling assumptions.

The study has generated a database of 3,690 records. Each record may represent an entire building or a premises within a larger building. The findings in this report are based on data collected for the hospitality sector through 272 telephone surveys and 30 site surveys during 2015.

The records include data on energy usage, information on the building itself (fabric, age etc.) and the occupant's organisation.

---

[13] The current non-domestic stock model (Pout, C (2000) NDEEM: the national non-domestic buildings energy and emissions model) is underpinned by field research conducted by Sheffield Hallam University in the 1990s.

[14] The detail on the barriers and enablers of energy abatement are addressed in the overarching report.

The survey asked respondents about the energy used within or associated with premises e.g. sports floodlighting, external security and car park lighting. Energy use activities which were not within the scope of the study included industrial process loads. It was not possible to capture all energy end uses that may be present in a premises.

The standard method is summarised in Figure 2.1 and set out in the bullet points below:

1. **Sample design** - BEES has been sampled and grossed primarily based on data from the Non-domestic National Energy Efficiency Data-framework (ND-NEED). This dataset uses the Valuation Office Agency's (VOA) property rating list. Where a sector was out of scope of the VOA database, alternative data sources were used. This gives a base record of address, floor area, building type, and energy use[15]. Using the Experian references in ND-NEED it was possible to add a contact telephone number. Analysis shows that the scope of BEES includes 89 per cent of building floor area in England & Wales. The number of surveys per sub-sector was determined based on their overall size with a minimum of 50 surveys sought where possible. Overall 1 per cent of floor area has been surveyed based on the sub-sectors in scope.
2. **Data collection** – A sub-sector tailored telephone survey, supplemented with data from a more detailed site survey in a subset of cases, was used to gather the information required to model the energy end uses within the premises.
    - The telephone survey involved a single stage and took around 25 minutes to complete. It gathered basic information on the premises, its servicing and usage. It also included sub-sector specific key questions to gather further data on the most significant energy end uses. These questions were designed with input from expert interviewers and, if necessary, trial site surveys at the design stage of the research programme. The survey was conducted with the person responsible for energy management, building management or another suitable manager.
    - A limited number of site surveys were undertaken on the telephone survey sample. The candidates were selected based on a range of characteristics such as energy intensity, location and floor area size. The site surveys gathered detailed information on the energy end use consumption, activities (extent and intensity), abatement potential and the barriers and enablers to implementing energy efficiency measures in the premises. The outputs were used to test the energy use and abatement models. Data collected on site was also used to correct and overwrite findings from the initial telephone survey. The data on barriers was collected via semi-structured face to face interviews.
3. **Data cleansing** - Prior to modelling, the data were cleansed firstly through record exclusion. Records were screened for outliers, then they were reviewed for quality. The outlier analysis was based on typical operating metrics, such as occupancy level (the number of square metres per person in a premises). Where extreme values were identified the record would be removed. The quality assurance process identified the proportion of questions for which a response was required to model energy use. Any records which failed to meet the minimum data quality thresholds, measured by the percentage of 'Don't know' responses were excluded. Exclusion of these records was deemed necessary on the grounds that a significant prevalence of 'Don't know' responses was considered indicative of a respondent who lacked engagement or had a poor understanding of their building's core services and equipment. Within the hospitality sector, a total of 317 telephone survey or equivalent records were collected – following the record exclusion process a total of 272 records were retained for analysis. In this

[15] The BEES sector and sub-sector classifications were based on a bespoke classification developed from VOA data of Special Category Code (SCAT) and Property Description.

sector the share of records excluded was low (14 per cent of total), as the available sample was considered to be generally of good quality.

4. Secondly, record amendment was conducted on the remaining data. The remaining records were reviewed and in some cases data amended to overcome isolated yet important instances of ‘Don’t know’. These amendments were applied to the telephone survey dataset. Where telephone survey records contained a ‘Don’t know’, the response was estimated where possible based on the most likely response based on what was typical for the premises, or was proxied based on other question responses[16].
5. **Data processing** – Two models were used to process the cleaned telephone survey outputs. The **energy use model** was used to estimate the energy use in each premises, and the **abatement model** was used to estimate the cost and abatement potential of different abatement measures if they were to be installed in that premises. These models are outlined below, for more details see the technical annex. It should be noted that all processed outputs relate to the time when the original data was collected.[17]
    - The energy use model used an energy calculator to estimate a premises energy consumption, split by end use and fuel type, based on the cleaned telephone survey responses. A calibration process was carried out for each sub-sector to map telephone survey responses to different values of parameters in the energy calculator. This calibration was based on alternative data sources, previous knowledge of the sub-sector and the site surveys. The energy use mode did not take dynamic effects or building geometry into account, given the nature of the telephone survey data.
    - The abatement model used the cleaned telephone survey outputs and a set of relatively simplistic measure applicability rules to assess whether or not different abatement measures were applicable to a particular premises. The effect of applicable measures was estimated by changing relevant parameters in the energy calculator and recalculating the energy consumption of the premises.
6. **Weighting** – All the data generated was weighted upwards to represent the sub-sector population, based on the likelihood the premises was selected and on the overall share of floor area in the achieved sample.

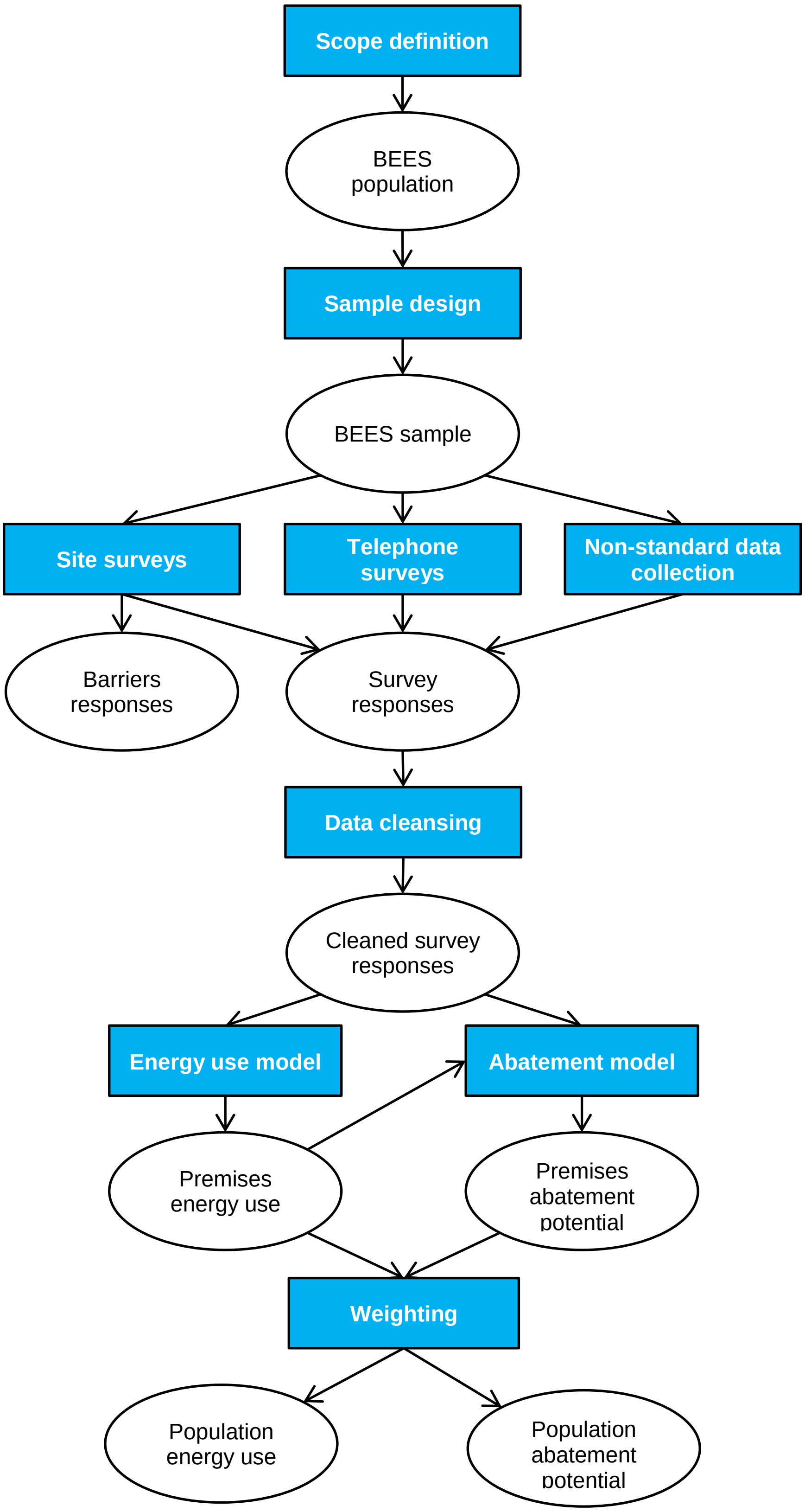
This approach was then tailored by sector. The impact of the change to the methodology within the hospitality sector is covered in “Methodology challenges in the hospitality sector”, which follows in this section, and in more detail in Appendix B.

All estimates shown in this report are point estimates and subject to uncertainty as they are based on survey findings. Confidence intervals are shown in Appendix A at sub-sector level for energy intensity for electrical and non-electrical uses.

[16] For example, in one sub-sector a small number of respondents gave a ‘Don’t know’ response to the question “Do you use electricity to heat tap water and/or showers and if so how much?”. The vast majority of responses to within the sub-sector were ‘None’, so this was used as a proxy as it was deemed to be suitably representative of the sample. The energy consumption for these sites was also checked in each instance for any evidence that water was heated with non-electrical fuel.

[17] Data collection for the Building Energy Efficiency Survey in its entirety occurred over 18 months from late 2013 to mid-2015.

Figure 2.1: Methodology flowchart



Methodology challenges in the hospitality sector

For hospitality sub-sectors the methodology was implemented as envisaged. There were however overarching complications, which needed to be accounted for during planning. These related primarily to accuracy of responses to key quantitative questions, the respondents' understanding of technical questions and their availability to answer the telephone survey. In this sector, for instance, the modelling was highly reliant on respondents providing accurate estimates of meals provided on a typical day, and in some case premises floor area. During the site surveys questions relating to the building servicing were generally found to be incorrect: respondents would correctly answer if air conditioning was present but would not know the type of system installed. Finally, particularly in cafes and restaurants & takeaways, being able to conduct a telephone survey when respondents were available was challenging.

A summary of further specific issues encountered is set out below and a full description is included in Appendix B:

- **Data collection** The uptake for site surveys through the telephone survey sample in the restaurants & takeaways sub-sectors was low. Organisations in the sub-sector were therefore directly contacted to invite them to participate in the programme. As a result there was a high reliance on data arising from one major restaurant chain. To compensate for this and increase the sample, findings from pub site surveys were used to calibrate the restaurants & takeaways energy use and abatement models. Originally, restaurants & takeaways were to be treated as separate sub-sectors, but as a result of the poor response rates, they were merged for reporting purposes reducing the granularity of results for these sub-sectors.
- **Data processing** Pub and hotel floor area is not included in VOA data. 27 out of 109 out of the original pub telephone surveys records required the use of an estimated floor area, based on the respondent's view of the equivalent house size, due to the absence of an EPC matched floor area or an area stated by the respondent. Similarly in hotels, respondents were asked to provide floor areas – 5 out of 44 provided a professionally measured floor area and 34 provided an estimate. The remaining floor areas were estimated based on the number of bedrooms stated in the telephone survey, unless a site survey was carried out on the premises (allowing a professional measurement). The accuracy of the estimates are not known, which could have lead to either under or over-estimating energy demands linked to floor area.
- **Data processing** Catering consumption was based on limited input data given the diversity of the load, which includes consumption associated with cooking appliances, warm and cold storage for all foodstuffs, dishwashing and kitchen uses of hot water, and any other specialist equipment relating to the provision of food for customers. In the energy use model, catering load was estimated based on a simple 'per meal' allowance as there was not time to collect further information in the telephone survey. A calibration process was undertaken within each sub-sector to derive a suitable 'per meal' benchmark for use in this study. In the pubs sub-sector this was based on site survey findings. In cafes and restaurants & takeaways, the site survey sample was insufficient and matched energy data from ND-NEED coupled with a wider literature review was used to derive an appropriate benchmark.

3. Energy consumption

This section presents a series of summary charts and tables detailing the results of the energy use modelling undertaken during the analysis of the hospitality sector.

Energy consumption and greenhouse gas emissions in the hospitality sector

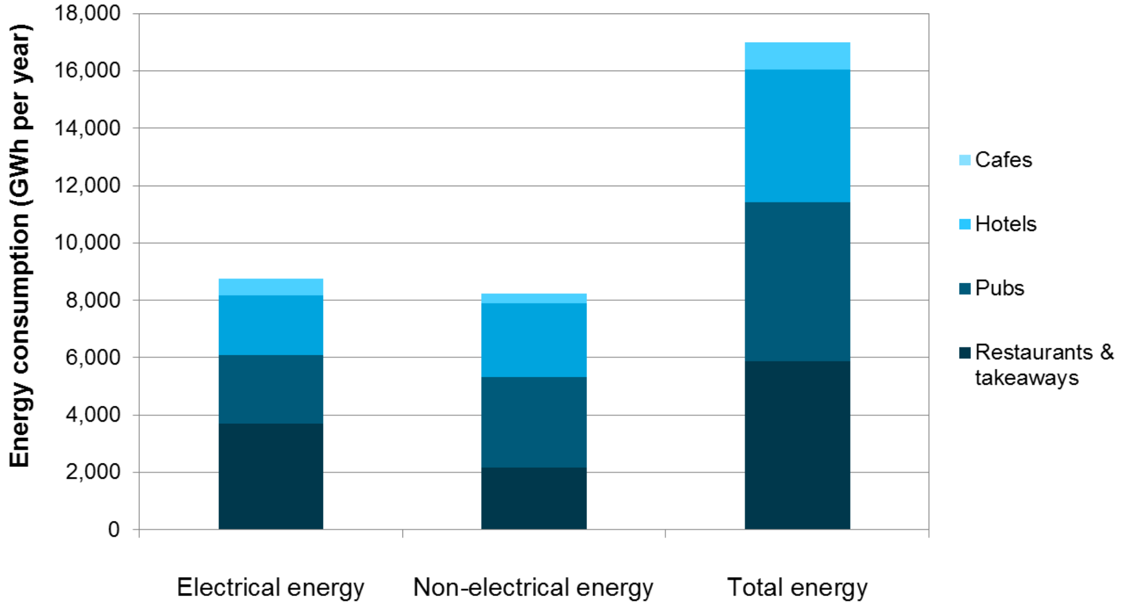
The electrical and non-electrical energy consumption of the hospitality sector is presented in Figure 3.1, broken down by the four hospitality sub-sectors (covering cafes, hotels, pubs and restaurants & takeaways).

The hospitality sector consumed 16,980 GWh of energy. This consisted of 8,760 GWh of electrical energy and 8,230 GWh of non-electrical energy per year (Figure 3.1).

The largest energy consumer in this sector was restaurants & takeaways with a consumption of 5,890 GWh of energy (35 per cent of total). This was split between 3,710 GWh of electrical energy (42 per cent of sector total) and 2,180 GWh of non-electrical energy (26 per cent of sector total). This was in spite of this sub-sector being one of the smallest in the hospitality sector (5 million m^2 for restaurants & takeaways compared with 15 million m^2 for pubs and 15 million m^2 for hotels).

Pubs were the second largest consumer in the sector, with a consumption of 5,520 GWh of energy (33 per cent of total). This consisted of 2,380 GWh of electrical energy consumption (27 per cent of sector total) and 3,140 GWh of non-electrical energy consumption (38 per cent of sector total). Hotels consumed 4,650 GWh of energy (27 per cent of total), which consisted of 2,080 GWh of electrical energy (24 per cent of sector total) and 2,570 GWh of non-electrical energy (31 per cent of sector total). Cafes were the smallest consumers in the sector with a consumption of 930 GWh of energy (5 per cent of total), which was split into 580 GWh of electrical energy (7 per cent of sector total) and 350 GWh of non-electrical energy (4 per cent of sector total).

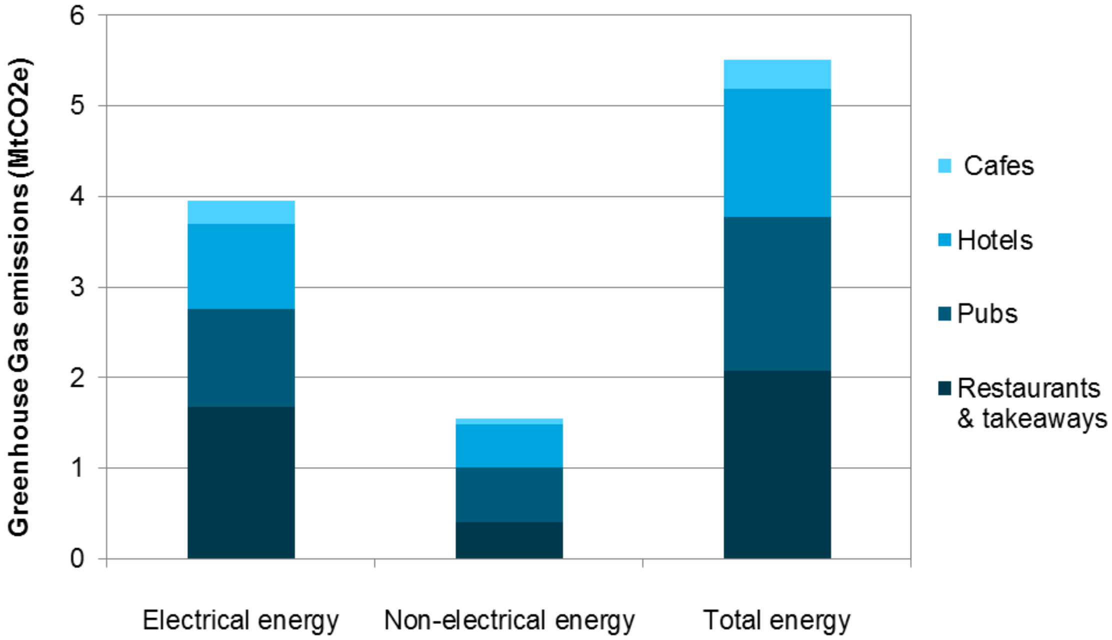
Figure 3.1: Electrical and non-electrical energy consumption by energy type and hospitality sub-sector, 2014–15



Source: Energy use model results for the sector, England and Wales

The greenhouse gas emissions for the hospitality sector are presented in Figure 3.2.[18] The total greenhouse gas emissions from the hospitality sector were calculated to be 5.5 $MtCO_2e$ per year. The annual emissions from electrical energy consumption were 4.0 $MtCO_2e$ and those from non-electrical energy consumption were 1.6 $MtCO_2e$.

Figure 3.2: Greenhouse gas emissions by energy type and by hospitality sub-sector, 2014–15



Source: Energy use model results by sub-sector, England and Wales

[18] Greenhouse gas emissions were estimated using energy consumption figures from the energy use model and grid average electricity and fuel emission factors from IAG guidance on valuing greenhouse gas emissions published by DECC, updated on 10 December 2015. See https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal for further information.

Energy consumption by end use

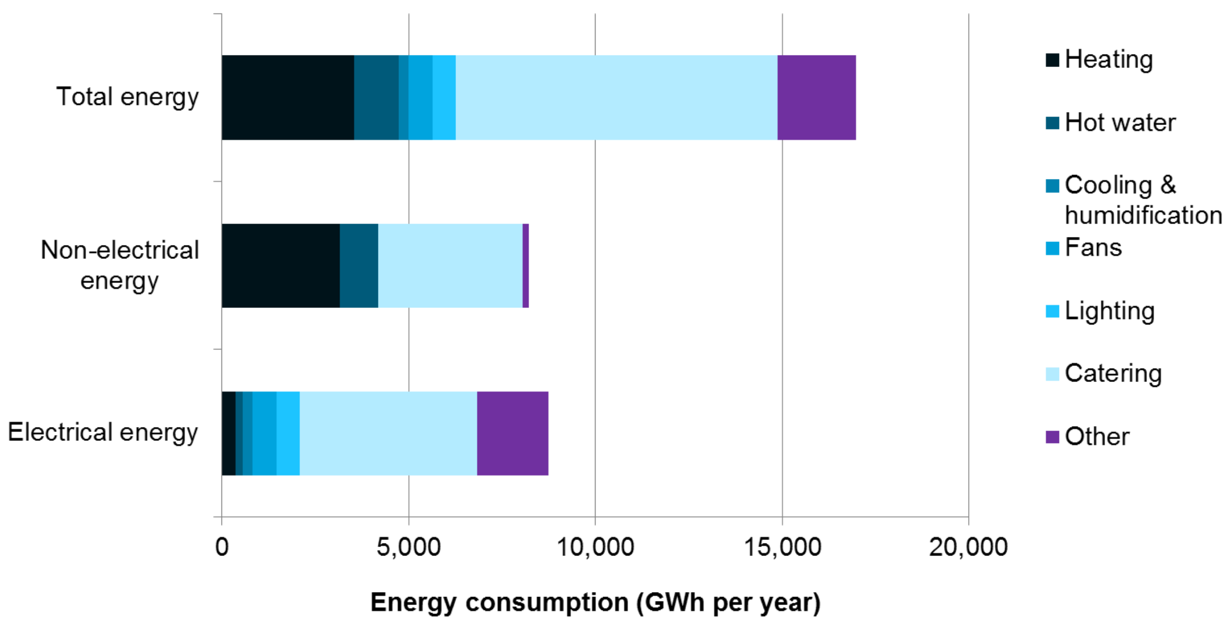
The distribution of total energy consumption by end use is presented in Figure 3.3 and Table 3.1.[19]

The energy use model defines 23 separate energy end uses in its analysis. These are derived by modelling the telephone survey inputs and calibrated using site survey data. For the purposes of presentation in Figure 3.3, the 23 uses have been simplified to six categories, covering key building services end uses (heating, hot water, lighting, fans, cooling & humidification and other) and one custom category relevant to the sector (catering). The simplified classification is shown against the more detailed classification results in Table 3.1.

Further detail can be found in Appendix C on the 23 end uses and how these are re-categorised to seven categories.

The total energy consumption for the hospitality sector was 16,980 GWh. The most significant end use was catering (8620 GWh, 51 per cent of total energy consumption), followed by space heating (3,540 GWh, 21 per cent of total consumption).

Figure 3.3: Energy consumption by simplified end use breakdown for the hospitality sector, 2014–15



Source: Energy use model results for the sector, England and Wales

[19] In the context of the BEES study, small power represents office equipment (comprising computers, printers and ancillary desktop equipment). Other plug-in loads are disaggregated into entertainment equipment, catering, pool/leisure equipment etc.

The most common end uses of electrical energy were catering at 3,870 GWh (54 per cent of total), followed by cooled storage (1,350 GWh, 15 per cent). The most significant non-electrical energy end uses were central catering at 3,870 GWh (47 per cent) followed by space heating (3,170 GWh, 39 per cent). Non-electrical energy consumption for heating was much higher than electrical energy consumption (3,170 GWh compared with 370 GWh).

Table 3.1: Energy consumption by energy type and energy end use for the hospitality sector, 2014–15

Energy end use category (Simplified)	BEES end use category[20]	Electrical energy consumption (GWh/year)	Non-electrical energy consumption (GWh/year)	Total energy consumption (GWh/year)
Heating	Space heating	370	3,170	3,540
Hot water	Hot water	170	1,010	1,190
Cooling & humidification	Space cooling	280	-	280
Fans	Fans	630	-	630
Lighting	Lighting - internal	630	-	630
Catering	Catering	4,750	3,870	8,620
Other	Pumps	60	-	60
	Controls	50	-	50
	Lighting - external	70	-	70
	Small power	40	-	40
	ICT equipment	-	-	-
	Vertical transport	170	-	170
	Cooled storage	1,350	-	1,350
	Entertainment equipment	130	-	130
	Pool/leisure	50	180	230
	Other	10	-	10
Total		**8,760**	**8,230**	**16,980**
Unweighted base		*272*	*236*	***272***

Source: Energy use results by sub-sector, England and Wales

20 The end uses are defined in Appendix C.

Hospitality sector energy intensity distributions

Energy intensity (energy use per m^2 floor area) enables activities across sectors to be compared, and is used for benchmarking in the building services industry.[21] Figure 3.4, Figure 3.5 and Figure 3.6 present the distribution of energy intensity for all modelled records in each sub-sector within the hospitality sector, in terms of total energy intensity, electrical energy intensity and non-electrical energy intensity respectively.[22] In this report all intensity figures (excluding box plots) have been calculated using the total sector or sub-sector floor area regardless or whether they have a particular energy source or end-use.

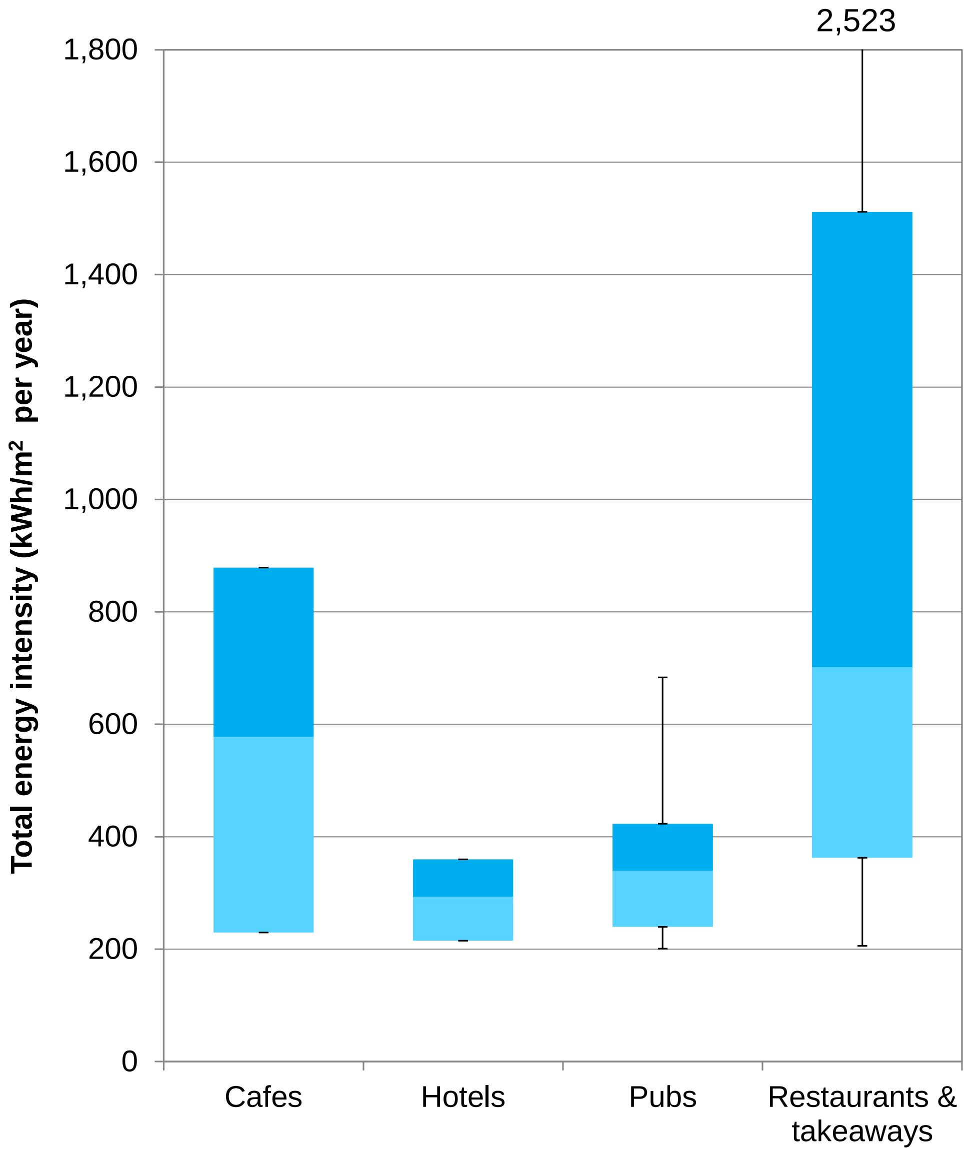
Figure 3.4 shows that restaurants & takeaways had the highest total median energy intensity (701 kWh/m^2), followed by cafes (578 kWh/m^2) and pubs (339 kWh/m^2). Figure 3.5 and Figure 3.6 show that restaurants & takeaways typically had the highest median energy intensities (429 kWh/m^2 for electrical energy and 244 kWh/m^2 for non-electrical energy). The second most energy intensive sub-sector was cafes (393 kWh/m^2 for electrical energy and 306 kWh/ m^2 for non-electrical energy). Cafes and restaurants & takeaways demonstrated the widest distribution in both electrical energy intensity and non-electrical energy intensity.

---

[21] As employed in CIBSE TM46 Energy Benchmarks (available at: http://www.cibse.org/knowledge/cibse-tm/tm46-energy-benchmarks), and others.

[22] Please note mean energy intensities are calculated by summing the total consumption associated with an end use and dividing it by the sub-sectors total floor area. The energy intensities for non-electrical uses are therefore based on the total population and do not make an allowance for where the main heating fuel is electricity.

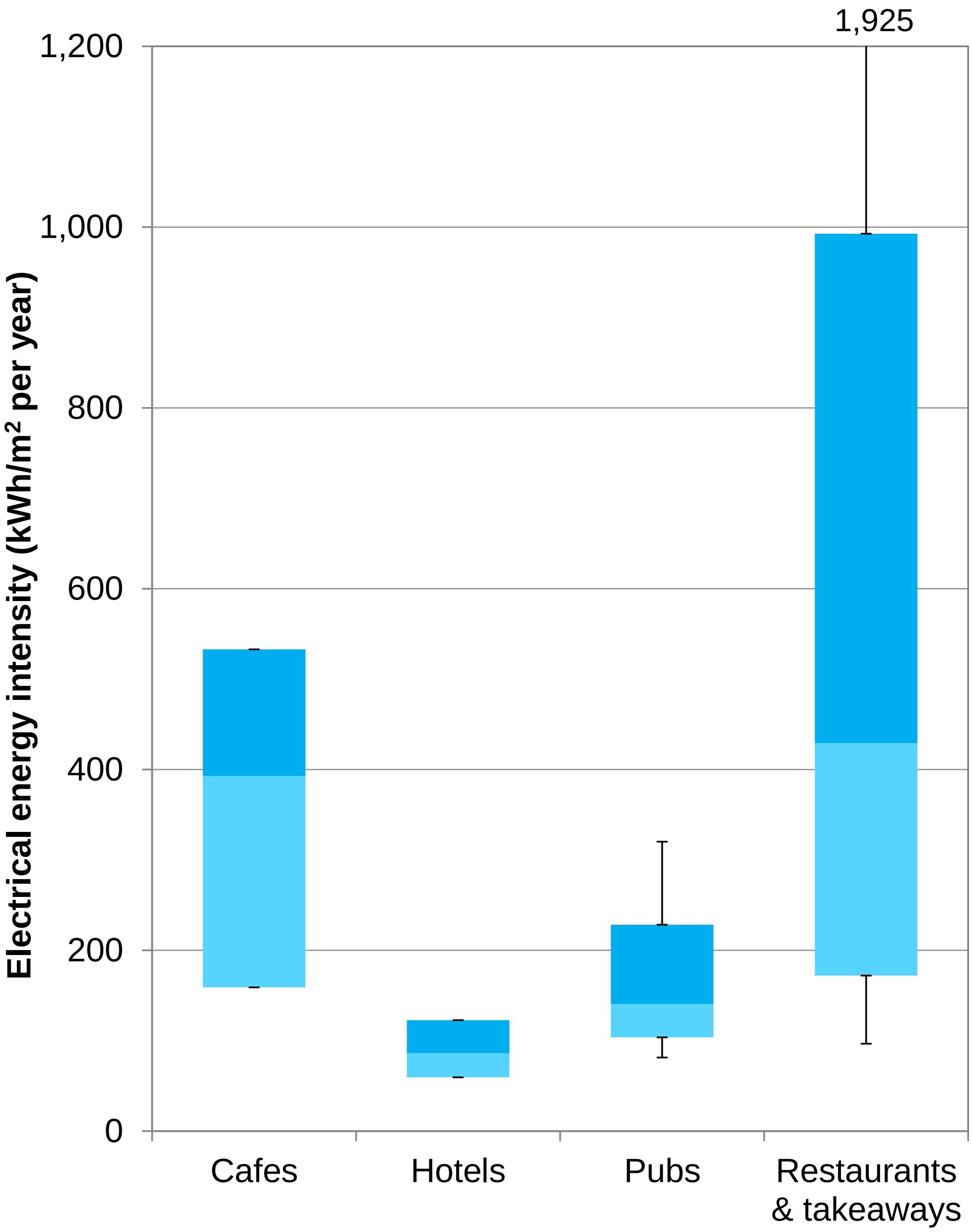
Figure 3.4: Distribution of total energy intensity by hospitality sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded.

Source: Energy use model results by sub-sector, England and Wales

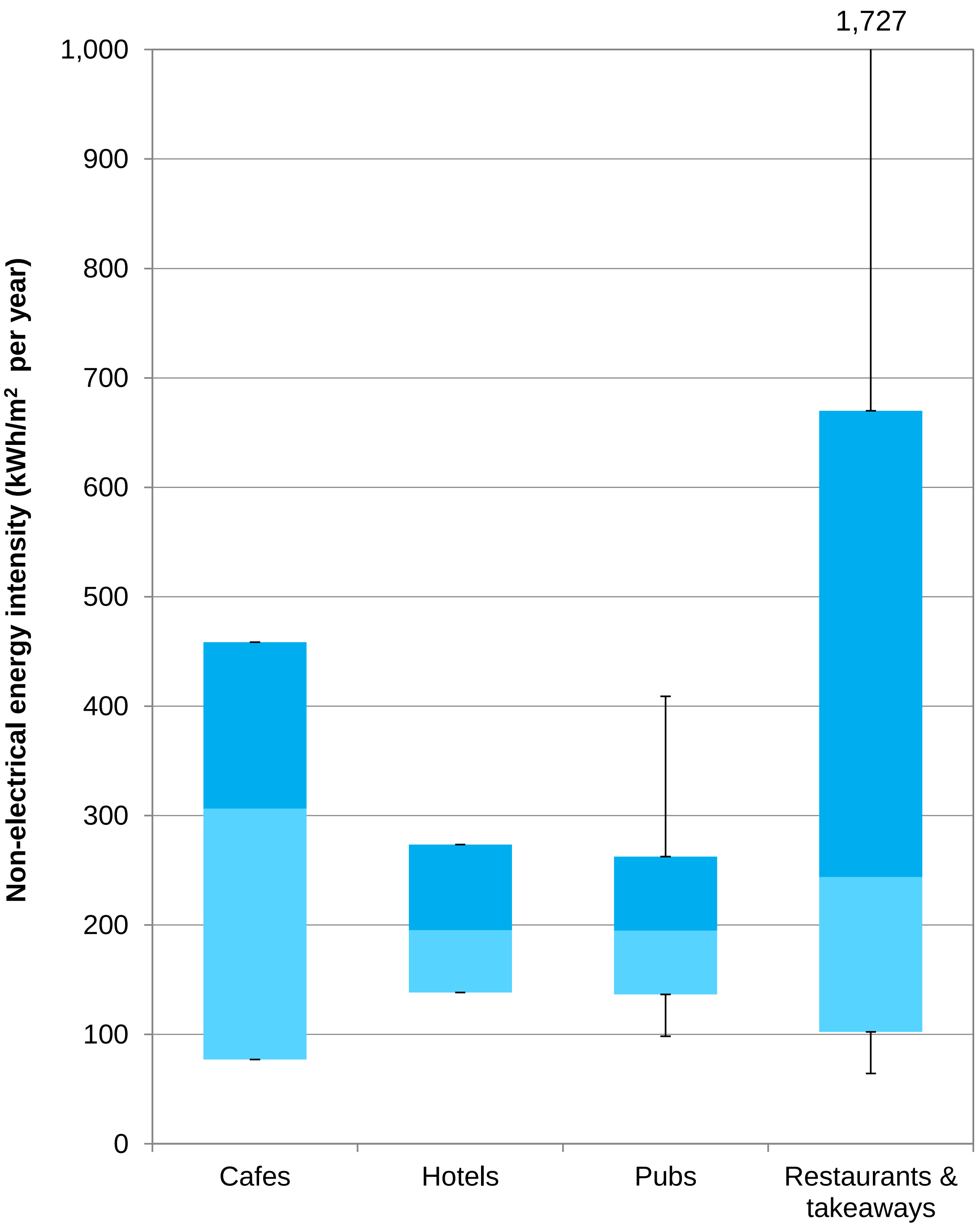
Figure 3.5: Distribution of electrical energy intensity by hospitality sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded.

Source: Energy use model results by sub-sector, England and Wales

Figure 3.6: Distribution of non-electrical energy intensity by hospitality sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded.

Source: Energy use model results by sub-sector, England and Wales

Hospitality sub-sector energy end use breakdowns

Figure 3.7 shows the mean modelled energy intensity by end use for each of the sub-sectors in the hospitality sector. Further data is provided in Appendix C where energy consumption and energy intensity is provided separately for electrical and non-electrical energy end use breakdowns by sub-sector.

Catering was the dominant end use within the hospitality sector (54 per cent of electrical energy consumption and 47 per cent of non-electrical energy consumption), and the largest end use in all sub-sectors with the exception of hotels. This end use included all cooking appliances, warm and cold storage for all foodstuffs, hot water for dishwashing and kitchen uses of hot water, and any other specialist equipment relating to the provision of food for customers. This high prevalence of catering loads was found to be consistent with other studies in the hospitality sector[23,24], and was also supported by site survey findings within the BEES study.

Restaurants & takeaways exhibited the highest energy intensity for catering. Cafés were also dominated by catering loads. In both these sub-sectors, the premises are normally dedicated to food provision only, so this result is as expected.

It was also noted in these premises that a significant number of premises had either no heating or cooling systems, or that these systems only served part of the premises. This is due to the high heat gains and general acceptance of high summer temperatures in kitchens, and the fact that in many smaller premises kitchens are not thermally separated from the customer area and heat gains from cooking can supply some or all of the heating to this space.

Heating energy intensity was highest in the pubs sub-sector, which had a high prevalence of older premises, as well as long operational hours and residential accommodation for landlords and/or guests. Hotels also exhibited significant heating energy intensity; while these premises often operate 24 hours a day, the trend was for these to be newer premises than pubs.

Significant energy use for fans was present in all sub-sectors. In catering establishments, kitchen extract ventilation contributed much of the energy intensity; in restaurants and hotels mechanical ventilation for customer areas was much more common than in cafes and takeaways. Cooling (air conditioning) was most common in hotels and restaurants, and rare in the remaining sub-sectors.

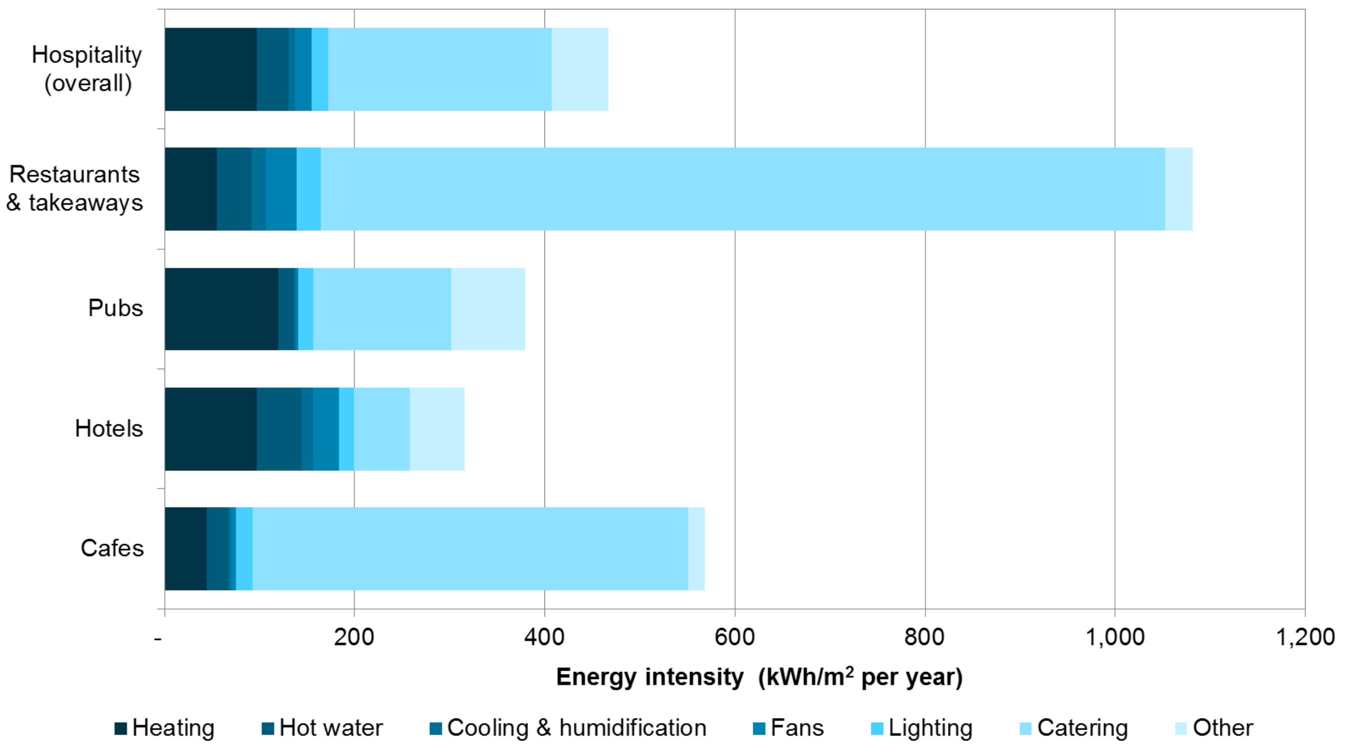
The "other" end use is particularly evident in pubs and hotels and to a lesser extent in restaurants & takeaways. The main contributor here was cooled storage for bar and cellar cooling, which made up a large part of the electricity demand in the pubs sub-sector in particular.

---

[23] For example "Food preparation and catering; Sector overview", Carbon Trust, 2012, Fig. 1: Of the energy breakdown presented, the BEES catering scope includes catering and refrigeration use (40% of total) and a significant share of water heating and ventilation (a further 22% of total). For more details see https://www.carbontrust.com/media/138492/j7895_ctv066_food_prep_and_catering_03.pdf

[24] "Energy Reduction and Benchmarking in Commercial Kitchens", Hearnshaw, S.A, et al, CIBSE conference paper identified typical operational vs. environment energy split of 66%/34% across a number of UK restaurant, food pub & carvery chains. The "operational energy" referred to here is a near identical scope to the BEES definition of catering.

Figure 3.7: Mean energy intensity simplified end use breakdowns by hospitality sub-sector, 2014–15



Source: Energy use model results by sub-sector, England and Wales

4. Abatement potential

In this section, abatement potential[25] for the hospitality sector is considered. Abatement potential is calculated on a sub-sector and sector level.

Abatement method

In order to determine the abatement potential for each premises record, the abatement model identified appropriate abatement measures based on the responses from the telephone survey, and then calculated the energy saved by the measure compared with existing equipment based on the energy end use energy consumption calculated in the energy use model. Appendix D provides more detail on the main groupings of abatement measures, and the technical annex sets out a detailed explanation of the abatement model. The abatement model calculates 95 individual measures, but these have been grouped into larger categories, within each group of measures there will be some measures that are more cost-effective than others for the sector and sub-sectors. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole.

The abatement potential was calculated on the basis of replacing current equipment with a more efficient alternative, regardless of the age or efficiency of this current equipment. This captured the entire technical potential available. It did not take into account the likelihood of equipment being replaced as part of a planned replacement cycle or whether take-up would be limited due to barriers or site-specific factors.

The costs were based on standardised absolute installation costs[26], while the benefits were only based on the incremental reduction in energy consumption[27]. Replacement of systems which were not at the end of their life were therefore included, but will be more expensive, as the impact on energy consumption is likely to be smaller for new equipment, while the full capital costs are taken into account. This means that a measure may be cost-effective if the system is replaced at the end of its life - especially as at the end of life the cost of the more energy efficient alternative would be compared to replacement with a less efficient alternative - but, the same measure may not be cost-effective if the system is replaced earlier in its life. Replacing measures at the end of life will be less costly for organisations, but it would take longer for the full potential to be realised. While the costs include an allowance for installation costs and hassle costs, this may not include all the wider disruption costs that may be faced by organisations upgrading equipment; for example it does not factor in the costs of relocating staff if it is not possible for staff to work on site while work is underway. The extent to which organisations face these costs will depend on whether upgrades are scheduled as part of a wider refurbishment.

To account for the impact of interactions between measures - for example if more efficient lights are installed the impact of using better lighting controls is smaller - the abatement measures in each premises were ordered by their return on investment. This way the impact of installing

[25] Abatement potential refers to the potential to improve the energy efficiency of the premises in a given sub-sector.

[26] The total cost consists of the capital cost, installation cost and annual operational costs. These costs were based on the costs of existing installations in non-domestic buildings.

[27] Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/483278/Valuation_of_energy_use_and_greenhouse_gas_emissions_for_appraisal.pdf

cheaper measures was taken into account first before calculating the impact of more expensive measures.

The calculated costs and energy savings were weighted to represent the whole sub-sector and hospitality sector throughout England and Wales.

Total technical abatement potential for hospitality sector

The abatement potential for each sub-sector where it is available is shown in Table 4.1 and Figure 4.1. The total abatement potential was between 19 and 30 per cent of total energy consumption[28]. Each sub-sector can achieve between 21 to 27 per cent savings in electrical energy consumption and 15 to 36 per cent savings in non-electrical energy consumption. This could be achieved at an overall capital expenditure of £1.8 billion.

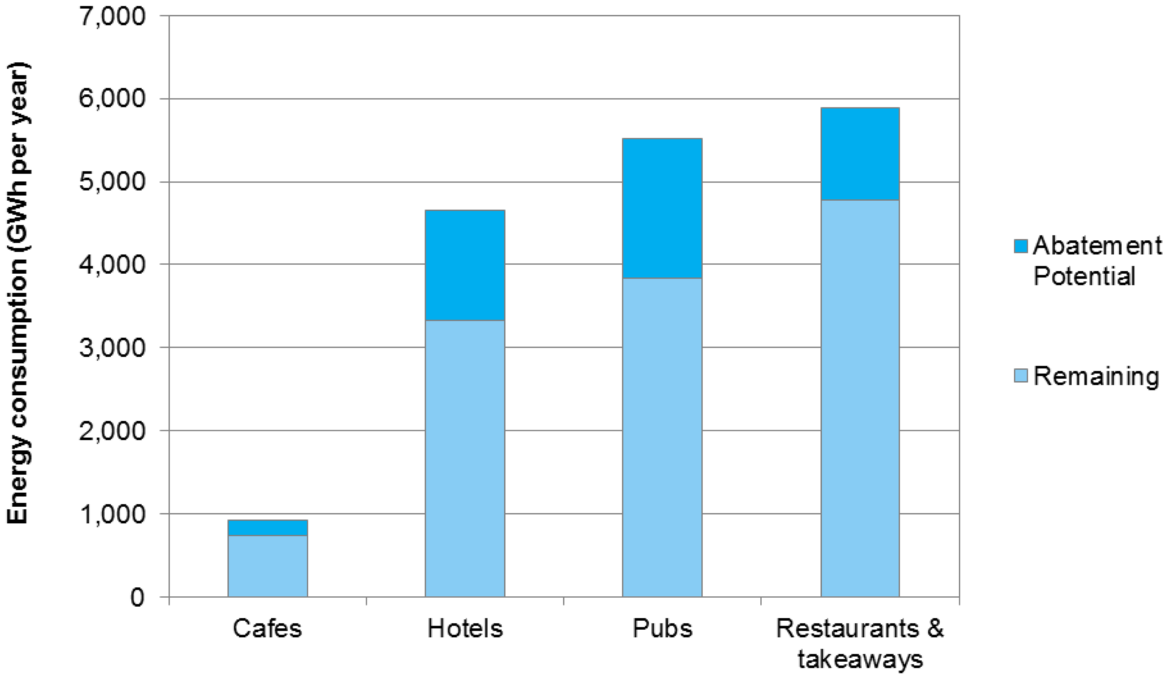
Table 4.1: Abatement potential by hospitality sub-sector, 2014–15

		Baseline		**Abatement potential**		
Sub-sector	**Capital Expenditure required to deliver abatement potential (£ thousands)**	Annual electrical energy consumption (GWh)	Annual non-electrical energy consumption (GWh)	Annual electrical energy savings (GWh)	Annual non-electrical energy savings (GWh)	Overall reduction (per cent)
Cafes	124,100	580	350	120	60	20
Hotels	535,600	2,080	2,570	570	750	28
Pubs	601,300	2,380	3,140	550	1,130	30
Restaurants & takeaways	494,400	3,710	2,180	790	320	19
Total	**1,755,300**	**8,760**	**8,230**	**2,040**	**2,260**	**25**

Source: Abatement model results for the sector by sub-sector, England and Wales

[28] All costs, energy and carbon savings are based on 2015 values and sourced from Interdepartmental Analysts' Group reference tables available at https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal. The costs presented are nominal.

Figure 4.1: Abatement potential by hospitality sub-sector, 2014–15

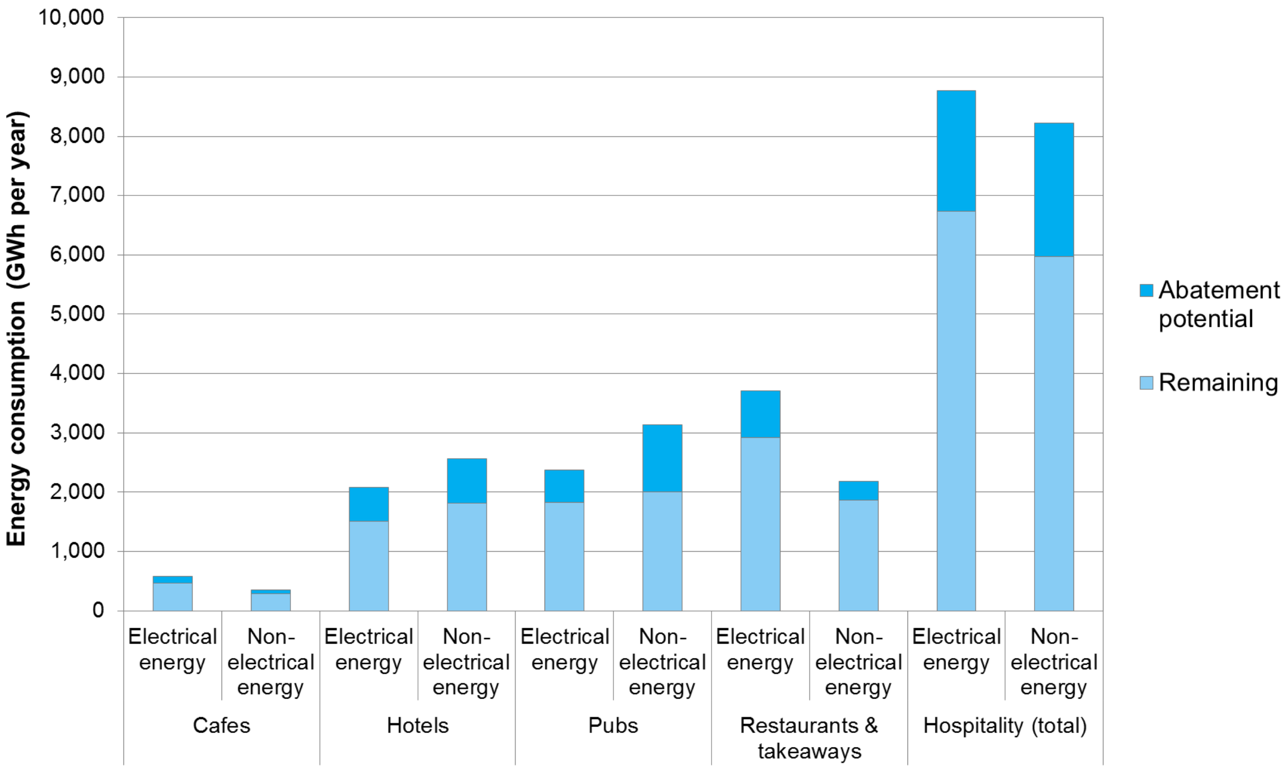


Source: Abatement model results by sub-sector, England and Wales

Figure 4.2 shows that the total technical abatement potential in 2014-15 varied by sub-sector: Pubs had the largest absolute and proportional scope for reduction (30 per cent of total energy consumption). This compared with 28 per cent in hotels, and 19 per cent in restaurants & takeaways. The relatively low reductions for cafe and restaurants & takeaways was due in part to the high level of catering energy use in these sub-sectors and the limitations in the abatement model relating to the calculation of catering energy abatement measures.

The results were separated into electrical and non-electrical energy. On percentage basis there was marginally more abatement potential associated from savings in non-electrical energy use. This is likely due to the high prevalence of non-electrical energy being used as a fuel for space heating and catering, and the associated savings from related abatement measures. Further detail of the abatement potential for each sub-sector is provided in Appendix D.

Figure 4.2: Total abatement potential by energy type and hospitality sub-sector, 2014–15



Source: Abatement model results by sub-sector, England and Wales

Marginal Abatement Cost Curve

As well as the total abatement potential and the costs of delivery, it is important to understand the overall cost-effectiveness of measures. Using the abatement model it was possible to assess the costs and benefits of measures from the point of view of society as a whole, by following Government guidance on the valuation of energy use and emissions.[29] This takes into account the capital expenditure, operational expenditure, social cost of energy, air quality impacts, and value of emissions, all discounted at the social discount rate. While this includes the main categories of costs, it was not possible to include the costs and benefits of all impacts on occupants: for example some measures may provide a potentially better occupant experience through improved illumination, or a potentially worse occupant experience through lack of control over light switches.

A measure is socially cost effective if the total social benefits outweigh the total social costs of the measure across the lifetime of the measure. This is a static measure of cost effectiveness based on current expected costs and benefits - for example this does not take into account potential reductions in capital costs that could result from more of that technology being installed. To enable groups of measures to be compared, a metric of social-cost effectiveness was calculated: Net Present Value of costs and benefits (NPV) divided by total energy savings over the lifetime of the measures in the group and plotted on a Marginal Abatement Cost Curve (MACC), which shows the level of abatement opportunity available and the costs associated with this opportunity if they were all implemented in 2014-15. The MACC in Figure 4.3 graphically represents each group of abatement opportunities as a block. The width of the block represents the total amount of abatement the measure can deliver in GWh and the height represents the cost-effectiveness. Because the measure groups are ranked by cost-effectiveness, the most cost-effective (delivering abatement at the least-cost per GWh) will be found on the left of the diagram. Moving to the right, measure groups become subsequently more costly.

As the MACC assesses cost from a societal perspective, we have supplemented this by providing the simple private payback periods for each measure group to help show how attractive these measures might be for individual organisations on the basis of how long it takes to recoup the costs of measures undertaken from the energy savings generated. Note that the payback period reflects the gross bill savings of the measure alone, rather than the bill savings that would be achieved by the measure if all other measures were installed.

The total abatement potential of the socially cost effective measure groups was 1,060 GWh, 990 GWh of which was electrical energy consumption and 70 GWh non-electrical consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 1,130 GWh, of which 700 GWh was electrical energy consumption and 440 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole. Similarly the aggregation of measure groups from the sub-sector level to the sector level may hide measure groups that are cost effective in a particular sub-sector, but not for the sector as a whole.

---

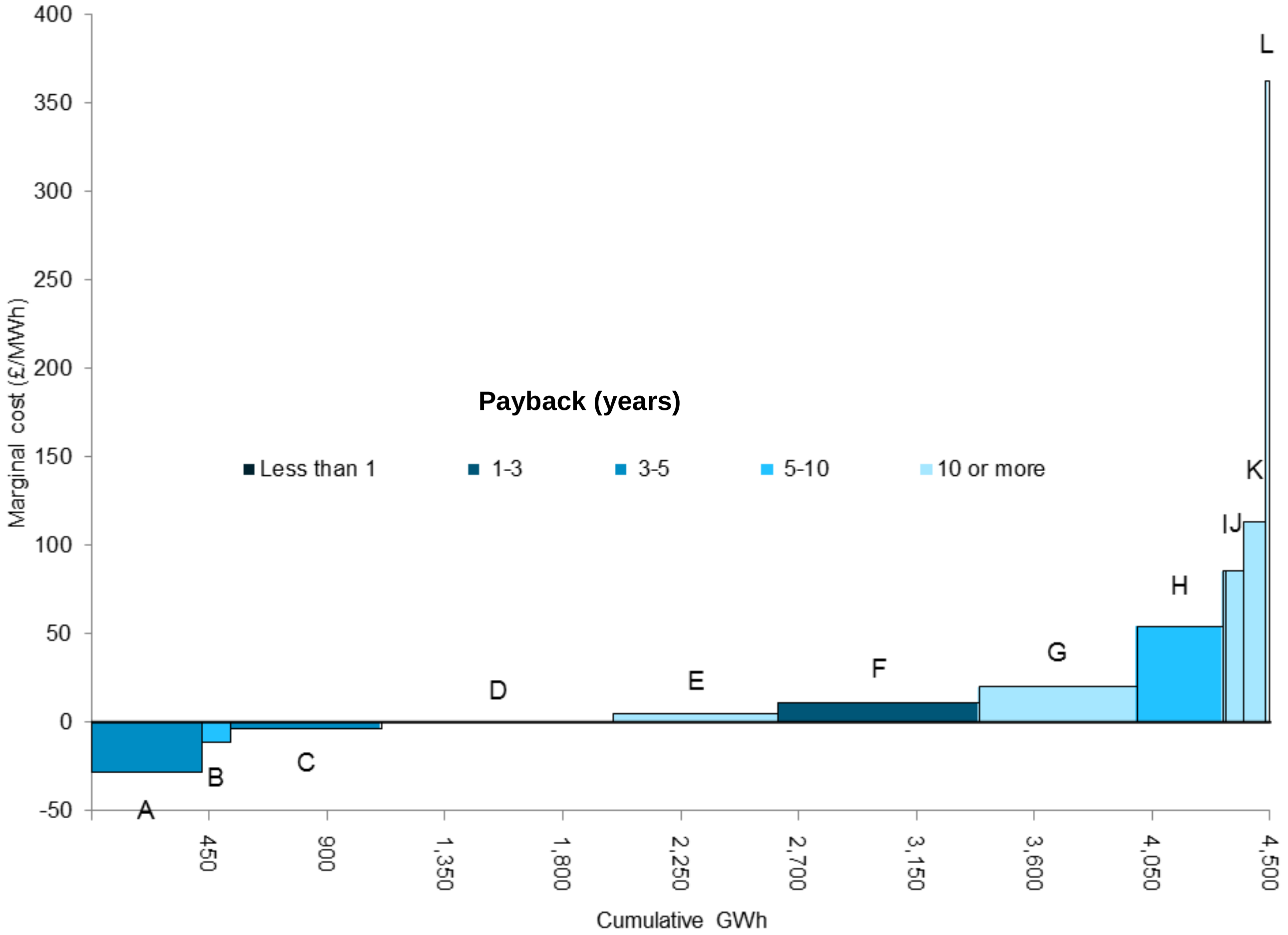
[29] Supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/483278/Valuation_of_energy_use_and_greenhouse_gas_emissions_for_appraisal.pdf

There were a number of measure groups that were socially cost-effective. If implemented, these measure groups provide more financial benefits to society than costs. The largest cost-effective opportunities were lighting upgrades, cooled storage and hot water plant upgrades. These measures also had relatively low payback periods, suggesting they may be more likely to get taken up, but recognising that take-up will also depend on the extent to which there are barriers. Interestingly, building instrumentation and control measures also had relatively low payback periods, but were not socially cost effective to implement.

These modelled findings corresponded broadly with opportunities identified in the site surveys. Typically site surveys identified potential savings associated with cooled storage, lighting upgrades and building instrumentation and controls. In pubs and hotels there were refrigeration opportunities associated with replacing highly energy intensive ‘flash’ coolers with ‘remote’ coolers. Lighting upgrades to LEDs were also regularly identified. Finally, the use of controls were not common place and therefore many premises would have benefited from thermostatic radiator valves (TRVs) being installed, and in larger hotels there was scope for additional controls to provide smaller individual heating zones in larger spaces, to avoid unnecessary heating in unoccupied areas. With regards to catering consumption the surveyors also only identified limited opportunities, beyond behavioural measures, as is consistent with the modelling.

In some cases site surveys identified additional potential to that calculated in the modelled output for a record. Typically this would be the case where an exceptional characteristic about the premises had been identified at the site visit, which related to information not collected as part of the telephone survey. These additional abatement opportunities were often in relation to building instrumentation & controls. There was for instance a general tendency to have set point temperatures for cellar cooling which were lower than necessary. In hotels many of the unoccupied hotel rooms had Thermostatic Radiator Valves (TVRs) turned up to the maximum possible temperature.

Figure 4.3: Marginal abatement cost curve by measure type, 2014–15



Note: the marginal abatement cost is calculated based on the social cost effectiveness, while the payback period is calculated from a private perspective.

A Lighting [MAC: £-28 per MWh. GWh: 400]
B Hot water [MAC: £-11 per MWh. GWh: 100]
C Cooled storage [MAC: £-4 per MWh. GWh: 550]
D Building instrumentation and control per MWh. GWh: 850]
E Building fabric [MAC: £5 per MWh. GWh: 600]
F Carbon and Energy Management [MAC: £11 per MWh. GWh: 730]
G Space heating [MAC: £20 per MWh. GWh: 580]
H Ventilation [MAC: £54 per MWh. GWh: 310]
I Swimming pools [MAC: £85 per MWh. GWh: 20]
J Air conditioning and cooling [MAC: £86 per MWh. GWh: 70]
K Small appliances [MAC: £113 per MWh. GWh: 80]
L Building services distribution systems [MAC: £362 per MWh. GWh: 10]

Source: Abatement model results for the sector, England and Wales

Table 4.2[30] shows the abatement potential by measure type. The most significant available savings – in terms of a reduction in overall energy consumption - were associated with building instrumentation and control, carbon and energy management and building fabric measures. The most significant available savings – in terms of annual energy bill savings - were associated with carbon and energy management, lighting and cooled storage measures.

Table 4.2: Abatement potential by measure type, 2014–15

Measure type	Savings					
	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**
Air conditioning and cooling	6,500	20	70	-	70	85,500
Building fabric	24,200	110	120	480	600	461,400
Building instrumentation and control	34,200	180	170	680	850	149,300
Building services distribution systems	1,300	5	10	-	10	32,400
Carbon and energy management	40,400	180	300	440	730	68,700
Hot water	5,100	20	30	70	100	26,400
Humidification	-	-	-	-	-	-
Lighting	39,900	110	400	-	400	152,600
Cooled storage	54,700	160	550	-	550	213,700
Small appliances	4,200	20	30	50	80	64,300
Space heating	17,600	110	40	540	580	233,800
Swimming pools	500	3	2	10	20	7,800
Ventilation	31,200	100	310	-	310	259,300
Total	**259,800**	**1,020**	**2,040**	**2,260**	**4,300**	**1,755,200**

Source: Abatement model results for the sector, England and Wales

[30] Annual greenhouse gas emissions were estimated using the energy savings from the abatement model and the long run marginal electricity and fuel emission factors from IAG guidance on valuing greenhouse gas emissions published by DECC, updated on 10 December 2015 (see https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal for further information). Measures were assumed to be installed in 2015 and the annual emissions savings averaged over the lifetime of the measure.

Appendix A: Sampling statistics

This appendix provides summary quality statistics for the sample. The confidence intervals by sector for electrical energy intensity and non-electrical energy intensity by sub-sector are provided, and the the telephone survey response rates by sub-sector.

Confidence intervals

Table A.1: Confidence intervals for electrical energy intensity

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Cafes	357	± 99
Hotels	141	± 26
Pubs	164	± 33
Restaurants & takeaways	681	± 205
Hospitality	**241**	**± 61**

Table A.2: Confidence intervals for non- electrical energy intensity

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Cafes	212	± 103
Hotels	174	± 40
Pubs	215	± 44
Restaurants & takeaways	400	± 201
Hospitality	**226**	**± 55**

Response rates

Table A.3: Telephone survey response rates for the hospitality sector

	Cafes (%)	Hotels (%)	Pubs (%)	Restaurants & takeaways (%)	**Hospitality sector (%)**
Completed interview	9	10	9	10	9
Still live[31]	54	61	68	59	62
Screening failure/other non-response[32]	1	0	0	0	0
Refusal	19	18	13	15	15
Other non-response	5	4	3	6	5
Invalid contact details	13	8	7	10	9

[31] This refers to sites which were prepared as part of the sample, but were not required. As such they may have been contacted to take part in a telephone survey but neither refused nor accepted (e.g. non answer, answer-phone, tried to make appointment).

[32] This refers to sites which were deemed out of quota during the sampling process, and also includes sites which did not pass the initial screening – this may have been due to a mismatch of sub-sector type between the sampling register and the response given during a telephone interview.

Appendix B: Hospitality method challenges and data collection

This appendix provides detail of any non-standard methodology used for the hospitality sector.

Hospitality sector methodology challenges

In the case of the hospitality sector it was not possible to adopt the standard approach to data collection described in the methodology section for all sub-sectors. The reasons are outlined in Table B.1.

Table B.1: Hospitality sector approach challenges

Stage	Challenge	Response	Impact
Data collection	The uptake for site surveys through the standard route in cafes, restaurants & takeaways was low, resulting in a small initial number of site survey bookings.	A non-standard approach was used. First, a number of additional, randomly selected records were contacted directly and offered site surveys without the completion of a telephone survey. This was successful with cafes (where the quota was achieved) but not in restaurants & takeaways. As a result targeted engagement activities were conducted with central contacts of a small number of large companies with extensive outlet chains to recruit further sites. This provided a further 4 site surveys for restaurants & takeaways. Finally, the team also boosted the number of site surveys in analogous sub-sectors. Additional site surveys were targeted at pubs with high daily catering requirements.	There was no significant impact on cafes for reporting. For restaurants, there was a high reliance on data from one organisation (where 2 site surveys were completed) and the analogous findings from pubs. As a result the site surveys provided useful information on typical consumption by equipment types but did not allow for the determination of differences between the premises occupied by smaller companies compared to those of larger companies, in terms of condition and barriers to energy efficiency. For takeaways, there was only a single site survey undertaken at a major chain; similar limitations to restaurants therefore

Stage	Challenge	Response	Impact
			apply. Unlike restaurants, with pubs it was not possible to identify an analogous sub-sector where additional site surveys could have been applied. As result of the response rate issues encountered in takeaways their results have been merged with restaurants to ensure the study findings are not disclosive.
Data processing	Pub floor area was not used by VOA for valuation and therefore is not in ND-NEED.	Telephone survey respondents were asked to estimate floor area in their telephone survey responses. Where estimates were not possible they were asked to provide an indication of premises extent by comparing the area to illustrative house sizes. Site surveys were increased for pubs, to provide an increased number of records where confidence was high in the accuracy of the input data. Pubs were also manually matched to the non-domestic Energy Performance Certificate database. This provided a more accurate floor area for those records that had been matched.	27 out of 109 pub records still required the use of an estimated floor area based on the respondent's view of the equivalent house size due to the absence of an EPC matched floor area or an area stated by the respondent. For these records the accuracy of the floor area is prone to significant error i.e. greater than +/-25 per cent in energy intensity kWh/m^2.
Data processing	Hotel floor area was not used by VOA for valuation and therefore was not in ND-NEED.	Telephone survey respondents were asked to estimate floor area in their telephone survey responses. Where estimates were not possible they were asked to provide an indication of premises extent by collecting data on the number and type (size) of bedrooms present.	This had a significant impact on confidence in the floor areas in this sub-sector and a subsequent effect on the energy intensities determined in the modelling process. Many end uses were calculated on a per m^2 basis, so an incorrect floor

Stage	Challenge	Response	Impact
		Site surveys were increased for hotels, to provide an increased number of records where confidence was high in the accuracy of input data.	area for the record directly impacted the gross energy consumption of the modelled result. Although the correlation between bedroom numbers and measured floor areas was reasonable (from those hotels which were site surveyed) the results are still likely to have had a significant impact.
Data processing	Modelling catering load (pubs and hotels). In the Energy use model, catering load was estimated based on a simple per meal allowance due to the limited time for data collection in the telephone survey. While the number of meals was known to be a relatively weak indicator of catering energy use, no alternative approach could be adopted within the data collection constraints.	A customised benchmark for the energy required per meal was derived for pubs by comparison of the Energy use model energy prediction with the energy consumption determined during site surveys. This benchmark was used to estimate the catering energy consumption in the remaining records which did not receive site surveys. The 'per meal' benchmark derived for pubs was also used in the hotels sub-sector.	For pubs, where catering made up a large proportion of the overall energy load, we have low confidence in the Energy use model estimate of energy consumption, and high degrees of variance at the individual record level have been observed. For hotels, acceptable model performance was achieved at record level using this method, but the estimated catering load was subject to the same limitations as in the pub sub-sector.
Data collection	Modelling catering load (restaurants, takeaways, cafes). In the Energy use model, catering load was estimated based on a simple per meal allowance due to the limited time for data collection in the telephone survey. While the number of meals was known to be a relatively weak indicator of catering energy use, no alternative approach could be adopted within the data	There were insufficient site surveys to derive custom catering benchmarks based on verified site survey data only. In light of this, the model was calibrated as best as possible for all other end uses, and the custom benchmarks for catering were derived from the difference between the modelled values and the matched data. In certain cases this still yielded a limited dataset to work from, and estimation was used where derived values did not yield good model performance. It was also not	Variance between modelled and matched data at individual record level was high in these sub-sectors, resulting in low confidence in estimation of total electricity and non-electrical energy consumption at individual record level.

Stage	Challenge	Response	Impact
	collection constraints.	possible to deploy different benchmarks for different types of establishment e.g. dependent on throughput (number of meals per day), type of meals served (e.g. reheated, freshly cooked) or number of courses per meal.	
Data collection	Minimum quotas were not achieved for site survey records in takeaways and restaurants.	Targeted engagement delivered a reduced number of site surveys within major chains only.	An acceptable net to gross ratio could not be derived from site survey data for takeaways, so the sub-sector was analysed based on NIA as stated in NEED (NIA refers to ‘Net Internal Area’, the usable area measured to the internal finish of the perimeter or party walls, ignoring skirting boards, at each floor level). This may have resulted in a relative exaggeration of hot water and catering loads as a share of the final total energy consumption. It was not possible to verify the range across which the model estimated energy consumption at end use level against site survey data. Confidence in end use level estimates was therefore poor compared to other sub-sectors.

Telephone survey and site survey data collection

Table B.2 shows that 272 telephone survey or equivalent records and 30 site surveys were completed in total.

Table B.2: Summary of data collection statistics, 2014–15

	Telephone survey						Site surveys	
Sub-sector	Target sample quota	Number of telephone surveys completed	Number of telephone survey equivalent records completed	Total telephone survey or equivalent records completed	Number of telephone survey records retained post-screening[33]	Average interview length (mins.)	Target sample size	Site surveys complet-ed
Cafes	50	49	5	54	48	21	6	6
Hotels	50	51	0	51	44	24	8	8
Pubs	109	109	0	109	93	23	11	11
Restaurants & takeaways	111	93	10	103	87	24	12	5
Hospitality sector	**320**	**317**	**15**	**317**	**272**	**23**	**37**	**30**

Source: Telephone survey or equivalent records, England and Wales

[33] See section 2: Method for details of the procedure for record screening on the grounds of data quality.

Appendix C: End use definitions and energy intensity end use breakdowns

This appendix provides definitions on the energy end uses and the energy intensity by end use category across each sub sector within the hospitality sector. This is split out between electrical energy and non-electrical energy use.

Energy end use definitions

The definitions for the adapted CIBSE energy end uses are set out in Table C.1.

Table C.1: Definitions for energy end uses

End use category		Description
1	**Space heating**	Energy consumption for space heating (including via ventilation), excluding hot water heating, process heating and unusual end-uses such as swimming pool heating and frost protection of ramps. Includes electricity input to heat pumps directly associated with space heating should be included.
2	**Hot water**	Energy used for hot water (e.g. hand washing and drying, showers, manual dish washing in kitchenettes) including electrical consumption of any heat recovery systems, but not pumps and controls. Excludes water heating associated with central catering.
3	**Space cooling**	Energy consumption for chillers, cooling towers, and air-cooled condensers for comfort cooling purposes, including the condenser and cooling tower fans, sump heaters and ancillaries except pumps. Excludes dedicated computer and telecommunication cooling systems. Includes local coolers and apportioned cooling load of reversible heat pumps.
4	**Fans**	Ventilation fans, including recirculation fans and mechanical plant room fans, excluding condenser and cooling tower fans
5	**Pumps**	All pumps excluding those specific to unusual end uses such as swimming pools. Includes pumps used for central heating, hot water, and boiler ancillaries such as burner fans, flue boost or dilution fans and gas pressure boosters, chilled water and condenser water, cold water booster pumps and sump pumps.
6	**Controls**	Controls for mechanical and electrical services, building energy management systems, security and alarm systems.
7	**Humidification**	All humidification plant used to provide humidification for general building services including ventilation and air conditioning but excluding special energy uses such as swimming pool de-humidification.
8	**Lighting – internal**	All general internal lighting including task lights and emergency lights.

End use category		Description
9	**Lighting – external**	All external lighting associated with the premises, including for dedicated car parks and street lighting for dedicated access routes
10	**Lighting – display**	All display lighting including retail/artwork display or demonstration lighting, decorative lighting in lobbies etc.
11	**Small power equipment**	Office equipment uses within the general premises space comprising computer workstations, printers, and desk based telecommunications equipment. Also includes electronic point of sale equipment.
12	**ICT equipment**	All servers, central computers, telecommunications equipment, transmitters, etc. Typically but not always found in a dedicated room. Includes dedicated computer and telecommunication cooling systems. Excludes control equipment.
13	**Vertical transport**	All vertical transport devices including lifts, escalators, travellators and any other powered means of vertical passenger transport associated with the premises. Includes dedicated vertical transport controls.
14	**Catering - central**	Kitchen (or café) catering preparation and servery equipment including dishwashers, and water heating associated with catering. Excludes restaurant lighting, ventilation and air conditioning.
15	**Catering - distributed**	Energy use for food and drink preparation in kitchenettes, rest rooms, etc. including kettles, coffee making machines, microwaves, fridges and hot water boilers for drink making; also all food and drink vending machines for premises occupants, including those located in café and restaurant areas.
16	**Cooled storage**	All energy uses for devices or facilities providing commercial cold food storage e.g. chilled cabinets, freezers, cold rooms. It includes lighting in display cabinets and trace heating in display cabinet doors.
17	**Entertainment lighting**	Stage or performance lighting.
18	**Entertainment equipment**	Audio-visual equipment, gaming machines, etc. Includes projectors, TV screens, sound systems in all premises types
19	**Laundry**	Fabric washing and drying machines
20	**Medical equipment**	Energy used for medical equipment or health services in hospitals, doctor's surgeries, dentists, vet centres, etc. Excludes equipment in laboratories.
21	**Laboratory equipment**	Energy used for equipment in laboratories.
22	**Pool/leisure**	All energy use associated with pool and sport leisure facilities within the premises. This should include heating, lighting, pumps, ventilation, humidification, and dedicated controls, alarms etc.
23	**Other**	Any other energy uses which fall outside categories 1 to 21, which are "normal" - i.e. are typical for the specific building type.

Source: Adapted from Upgrade of CIBSE TM22 from 2006 to 2012 version by Verco, March 2012

The energy end uses have been grouped for the purpose of presentation in the report. The groupings are set out in Table C.2 below.

Table C.2: Energy end use categories (detailed to reduced number) by energy type

Energy type	Detailed end use category	Reduced end use category
Electrical	Space heating	Heating
	Hot water	Hot water
	Space cooling	Cooling & humidification
	Fans	Fans
	Lighting - internal	Lighting
	Central catering	Catering
	Distributed catering	Catering
	Pumps	Other
	Controls	Other
	Lighting - display	Other
	Lighting - external	Other
	Small power	Other
	Vertical transport	Other
	Cooled storage	Other
	Entertainment equipment	Other
	Pool/leisure	Other
	Other - normal	Other
Non-electrical	Space heating	Heating
	Hot water	Hot water
	Catering	Catering
	Pool/leisure	Other

Note: The following sources were used to inform end use categories and how to simplify them: Definition of energy end uses in “Draft International Standard ISO/DIS 12655: Energy performance of buildings — Presentation of real energy use of buildings, 2011” (available at https://www.iso.org/obp/ui/#iso:std:iso:12655:ed-1:v1:en:term:3.6.5); and “Carbon Buzz reduced energy end uses, 2016” (available at http://www.carbonbuzz.org/index.jsp).

Tables C.3 and C.4 show energy consumption by end use for each hospitality sub-sector and for the sector combined. Tables C.5 and C.6 show energy intensity by end use for each hospitality sub-sector and for the sector combined.

Table C.3: Electrical energy consumption by energy end use category and hospitality sub-sector, 2014–15

Simplified end use category	**BEES end use category**	**Electrical energy consumption (GWh per year)**				
		Cafes	Hotels	Pubs	Restaurants & takeaways	**Hospitality sector**
Heating	Space heating	40	170	50	110	370
Hot water	Hot water	10	70	40	50	180
Cooling & humidification	Space cooling	4	180	20	80	280
Fans	Fans	8	400	50	180	630
Lighting	Lighting - internal	30	230	230	140	630
Catering	Catering	460	360	870	3,000	4,680
Other	Pumps	1	30	30	7	60
	Controls	2	20	20	9	50
	Lighting - display	-	-	-	-	-
	Lighting - external	0	10	40	20	70
	Small power	2	10	10	10	40
	Vertical transport	-	150	10	10	170
	Cooled storage	20	320	940	70	1,350
	Entertainment equipment	2	60	50	10	130
	Pool/leisure	-	50	-	-	50
	Other normal	0	-	4	2	7
Total		**580**	**2,080**	**2,380**	**3,710**	**8,760**
Unweighted base		*48*	*44*	*93*	*87*	*272*

Source: Energy use model results by sub-sector, England and Wales

Table C.4: Non-electrical energy consumption by energy end use category and hospitality sub-sector, 2014–15

Simplified end use category	BEES energy end use category	Non-electrical energy consumption (GWh per year)				
		Cafes	Hotels	Pubs	Restaurants & takeaways	**Hospitality sector**
Heating	Space heating	30	1,260	1,690	190	3,170
Hot water	Hot water	20	630	210	150	1,010
Catering	Catering	290	500	1,230	1,840	3,870
Other	Pool/leisure	-	180	-	-	180
	Humidification	-	-	-	-	-
Total		**350**	**2,570**	**3,140**	**2,180**	**8,230**
Unweighted base		*48*	*44*	*93*	*87*	*272*

Source: Energy use model results by sub-sector, England and Wales

Table C.5: Electrical energy intensity by energy end use category and hospitality sub-sector, 2014–15

Simplified end use category	BEES end use category	Electrical energy intensity (kWh/m^2 per year)				
		Cafes	Hotels	Pubs	Restaurants & takeaways	**Hospitality sector**
Heating	Space heating	30	10	3	20	10
Hot water	Hot water	8	5	2	10	5
Cooling & humidification	Space cooling	3	10	1	20	8
Fans	Fans	5	30	3	30	20
Lighting	Lighting - internal	20	20	20	30	20
Catering	Catering	280	30	60	550	130
Other	Small power	1	1	1	3	1
	Pumps	1	2	2	1	2
	Controls	1	1	1	2	1
	Lighting - display	-	-	-	-	-
	Lighting - external	0	1	2	3	2
	Vertical transport	-	10	1	2	5
	Cooled storage	10	20	70	10	40
	Entertainment equipment	1	4	3	2	4
	Pool/leisure	-	3	-	-	1
	Other normal	0	-	0	0	0
Total		**360**	**140**	**160**	**680**	**240**
Unweighted base		*48*	*44*	*93*	*87*	*272*

Source: Energy use model results by sub-sector, England and Wales

Table C.6: Non-electrical energy intensity by energy end use category and hospitality sub-sector, 2014–15

Simplified end use category	BEES energy end use category	Non-electrical energy intensity (kWh/m^2 per year)				
		Cafes	Hotels	Pubs	Restaurants & takeaways	**Hospitality sector**
Heating	Space Heating	20	90	120	30	90
Hot water	Hot water	10	40	20	30	30
Catering	Catering	180	30	90	340	110
Other	Pool/leisure	-	10	-	-	5
	Humidification	-	-	-	-	-
Total		**210**	**170**	**220**	**400**	**230**
Unweighted base[34]		*48*	*44*	*93*	*87*	*272*

Source: Energy use model results by sub-sector, England and Wales

[34] Unweighted bases are higher than in table C.4 due to the inclusion of the floor area for all records in the sector.

Appendix D: Abatement potential

The definitions for each measure type is included in this appendix as well as the abatement potential for each hospitality sub-sector. For each sub-sector a table on abatement potential by measure type is provided as well as a marginal abatement cost curve.

Measure type definitions

The measure type definitions are included in Table D.1. The research team determined these definitions based on their experience as energy specialists. The full list of abatement model measures, and their mapping into relevant measure groups, is also shown. Please note that this list contains the full set of abatement measures used across the project, including some which were not employed in this sector.

Table D.1: Measure type definitions

Measure type	Definition	Measure name
Air conditioning and cooling	Measures associated with air conditioning and cooling plant	Cooling time controls Cooling re-commissioning Cooling temperature control Cooling plant upgrade (0-8 years old) Cooling plant upgrade (8-15 years old) Cooling plant upgrade (more than 15 years old) Free cooling Cooling zone controls
Building fabric	Measures associated with the external building fabric	Flexible plastic curtains on loading bays High speed shutter doors to loading bays Interlocks between heating systems and loading bay or vehicle access doors Replace glazing Cavity wall insulation Loft insulation Clean windows Ground insulation Insulation maintenance Internal/external wall insulation Reflective coatings for windows Blinds Flat roof insulation Draught proofing Double glazing

Building instrumentation and control	Measures associated with improving the controls and monitoring on standard building services	BMS installation BMS re-commissioning BMS maintenance Energy meters for kitchen facilities Energy meters for lifts and escalators Heating zone controls Time controls on the heating system Weather compensator controls on heating Time control on hot water system Lift maintenance
Building services distribution systems	Measures associated with improving the efficiency of the building's distribution systems	Voltage optimisation
Carbon and energy management	Measures associated with organisational policy, users of the building and the capacity of the core delivery teams	Awareness campaign targeted at HVAC (heating, ventilation and air conditioning) HVAC maintenance Improve sub-metering Procurement Energy management Awareness campaign targeted at catering usage Awareness campaign targeted at lift usage 'Low hanging fruit' energy awareness campaign Cooled storage procurement Catering equipment procurement Keeping external doors shut (retail) Reduced use of air curtains (retail) 'Intensive' energy awareness campaign Minimise simultaneous operation of heating and cooling systems
Cooled storage	Measures which improve the efficiency of the refrigeration plant	Optimise refrigeration controls Relocate catering equipment Replace central catering refrigeration equipment Replace cooled storage refrigeration equipment
Hot water	Measures associated with improving the efficiency of hot water used for domestic services; such as hot tap water	Replacement of central generation of hot water with point of use Domestic hot water maintenance Hot water efficiency measures (low flow taps, showers & baths)
Humidification	Measures associated with the systems regulating building humidity	Humidification control maintenance

Lighting	Measures associated with lighting improvements	Automatic controls on lighting Localised lighting controls CFL to LED lighting retrofit T12 to LED lighting retrofit T5 to LED lighting retrofit T8 to LED lighting retrofit T8 to T5 lighting retrofit Lighting maintenance T12 to T5 lighting retrofit External lighting – HID to LED External lighting control Dsiplay lighting controls
Small applicances	Measures associated with small power usage, such as computer upgrades	Replace catering equipment Automated shutdown for ICT usage Computer upgrade LCD flat screens Server virtualisation Thin clients Doors on fridges (retail)
Space heating	Measures that improve the efficiency of heating the building	Replace heating boiler plant with high efficiency type (0-8 years old) Replace heating boiler plant with high efficiency type (8-15 years old) Replace heating boiler plant with high efficiency type (15 years old or more) Boiler maintenance Holiday season plant shutdown Optimise heat zoning Thermostatic radiator valve (TRV) Pipe work insulation
Swimming pools	Measures that improve the efficiency of energy used for swimming pools	Energy meters for the pool complex Swimming pool covers Draught proofing of pool Pool maintenance
Ventilation	Measures that improve the efficiency of the ventilation systems	Optimising ventilation time controls Optimising ventilation zoning Variable speed drives Ventilation plant upgrade (0-8 years old) Ventilation plant upgrade (8-15 years old) Ventilation plant upgrade (15 years old or more) Motor replacement Motor controls Motor resizing

Note: The following sources were used to inform end use categories and how to simplify them: Definition of energy end uses in "Draft International Standard ISO/DIS 12655: Energy performance of buildings — Presentation of real energy use of buildings, 2011" (available at https://www.iso.org/obp/ui/#iso:std:iso:12655:ed-1:v1:en:term:3.6.5); and "Carbon Buzz reduced energy end uses, 2016" (available at http://www.carbonbuzz.org/index.jsp).

Cafes

In cafes there was an annual abatement potential of 130 GWh of electrical energy and 60 GWh of non-electrical energy (equivalent to 50 $ktCO_2e$ combined). This equates to a 21 per cent and 18 per cent reduction on energy consumption respectively. The capital cost to achieve this is £124m. The annual savings delivered would be £14m.[35] These figures are grouped according to measure type in Table D.2. The total abatement potential of the socially cost effective measure groups was 60 GWh, all of which was electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 40 GWh, of which 20 GWh was electrical energy consumption and 20 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.1).

Table D.2: Abatement opportunity data for cafes, 2014–15

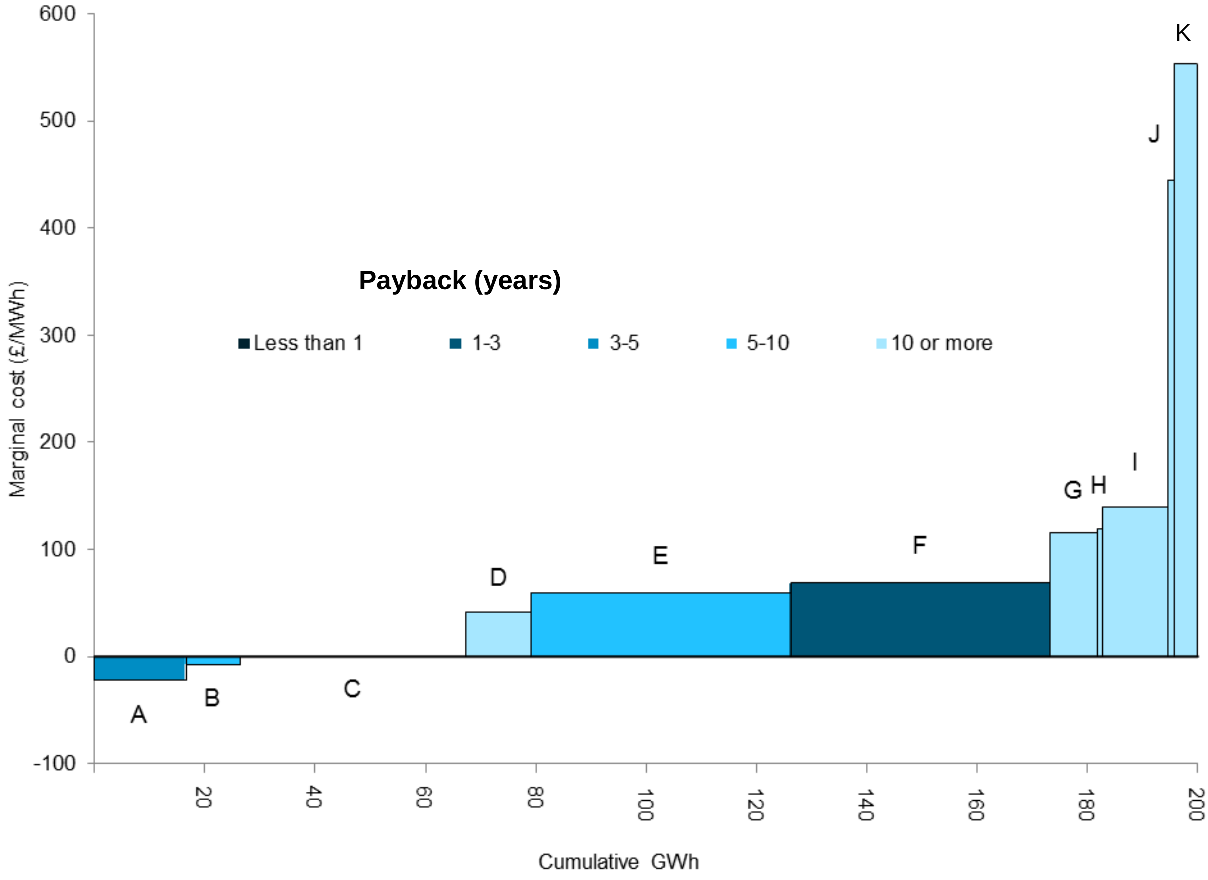
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	**Payback period (years)**[36]
Air conditioning and cooling	100	0	1	-	1	1,900	17
Building fabric	700	2	6	6	10	18,300	21
Building instrumentation and control	2,600	10	20	20	40	19,100	6
Building services distribution systems	100	1	1	-	1	3,700	16
Carbon and energy management	2,900	10	20	20	40	8,500	3
Hot water	600	2	5	4	9	3,500	6
Humidification	-	-	-	-	-	-	-
Lighting	1,600	5	20	-	20	7,200	4
Cooled storage	3,800	10	40	-	40	15,400	4
Small appliances	500	3	4	4	8	7,400	12
Space heating	700	2	5	6	10	23,200	25
Swimming pools	-	-	-	-	-	-	-
Ventilation	400	1	4	-	4	15,700	27
Total	**14,000**	**50**	**130**	**60**	**190**	**124,000**	‘’

Source: Abatement model results for sub-sector, England and Wales

[35] Annual savings relates to the financial savings associated solely with the reduced energy consumption.

[36] Payback relates to the duration of time after which the capital costs of a measure are recouped through the accumulated bill savings the measure delivers. Note that the payback period reflects the gross bill savings of the measure alone, rather than the bill savings that would be achieved by the measure if all other measures were installed.

Figure D.1: Marginal abatement cost curve for cafes, 2014–15



Note: the marginal abatement cost is calculated based on the social cost effectiveness, while the payback period is calculated from a private perspective.

A Lighting [MAC: £-22 per MWh. GWh: 20]
B Hot water [MAC: £-8 per MWh. GWh: 10]

C Cooled storage [MAC: £-1 per MWh. GWh: 40]

D Building fabric [MAC: £41 per MWh. GWh: 10]

E Building instrumentation and control [MAC: £60 per MWh. GWh: 40]

F Carbon and energy management [MAC: £68 per MWh. GWh: 40]

G Small appliances [MAC: £115 per MWh. GWh: 10]

H Air conditioning and cooling [MAC: £119 per MWh. GWh: 1]

I Space heating [MAC: £139 per MWh. GWh: 10]

J Building services distribution systems [MAC: £444 per MWh. GWh: 1]

K Ventilation [MAC: £553 per MWh. GWh: 4]

Source: Abatement model results for sub-sector, England and Wales

Hotels

In hotels there was an annual abatement potential of 570 GWh of electrical energy and 750 GWh of non-electrical energy (equivalent to 300 ktCO_2e combined). This equates to a 27 per cent and 29 per cent reduction on energy consumption respectively. The capital cost to achieve this is £536m. The annual savings delivered would be £76m.[37] These figures are grouped according to measure type in Table D.3. The total abatement potential of the socially cost effective measure groups was 410 GWh, of which 200 GWh was electrical energy consumption and 210 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 490 GWh, of which 230 GWh was electrical energy consumption and 260 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.2).

Table D.3: Abatement opportunity data for hotels, 2014–15

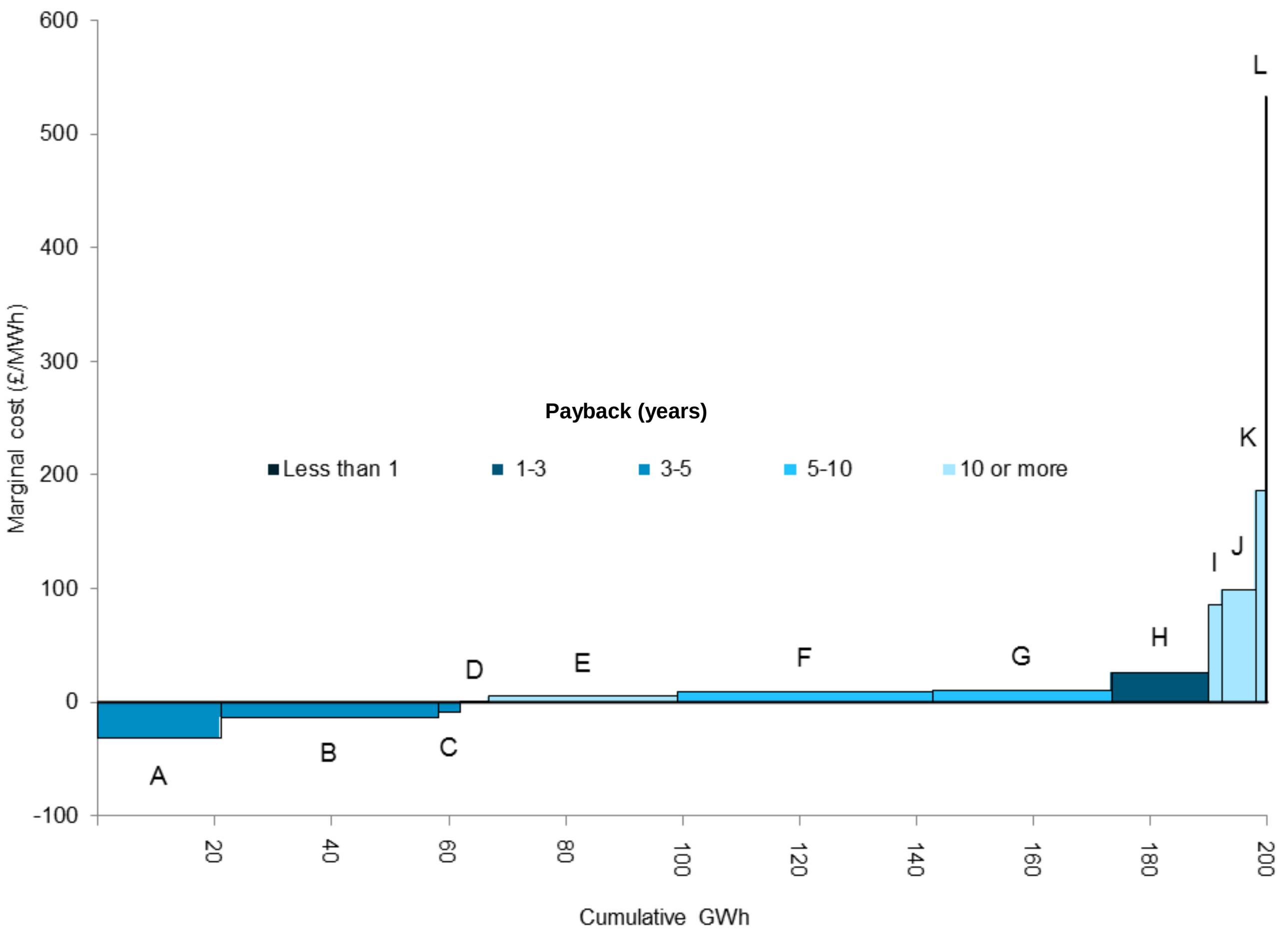
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving (ktCO_2e)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Pay-back period (years)[38]
Air conditioning and cooling	3,800	10	40	-	40	54,400	33
Building fabric	8,700	40	40	170	210	173,300	15
Building instrumentation and control	10,200	50	50	190	240	31,900	3
Building services distribution systems	200	1	2	-	2	5,300	8
Carbon and energy management	5,500	30	40	70	110	11,300	2
Hot water	900	5	4	20	20	4,300	4
Humidification	-	-	-	-	-	-	-
Lighting	13,800	40	140	-	140	46,600	3
Cooled storage	3,100	9	30	-	30	13,900	4
Small appliances	500	3	2	10	10	13,600	20
Space heating	8,500	50	20	270	290	71,800	13
Swimming pools	500	3	2	10	20	7,800	13
Ventilation	20,000	60	200	-	200	101,400	4
Total	**75,500**	**300**	**570**	**750**	**1,320**	**535,600**	‘’

Source: Abatement model results for sub-sector, England and Wales

[37] Annual savings relates to the financial savings associated solely with the reduced energy consumption.

[38] Payback relates to the duration of time after which the capital costs of a measure are recouped through the accumulated bill savings the measure delivers. Note that the payback period reflects the gross bill savings of the measure alone, rather than the bill savings that would be achieved by the measure if all other measures were installed.

Figure D.2: Marginal abatement cost curve for hotels, 2014–15



Note: the marginal abatement cost is calculated based on the social cost effectiveness, while the payback period is calculated from a private perspective.

A Lighting [MAC: £-32 per MWh. GWh: 140]
B Building instrumentation and control [MAC: £-14 per MWh. GWh: 240]
C Hot water [MAC: £-9 per MWh. GWh: 20]
D Cooled storage per MWh. GWh: 30]
E Building fabric [MAC: £5 per MWh. GWh: 210]
F Space heating [MAC: £9 per MWh. GWh: 290]
G Ventilation [MAC: £11 per MWh. GWh: 200]
H Carbon and energy management [MAC: £26 per MWh. GWh: 110]
I Swimming pools [MAC: £85 per MWh. GWh: 20]
J Air conditioning and cooling [MAC: £99 per MWh. GWh: 40]
K Small appliances [MAC: £186 per MWh. GWh: 10]
L Building services distribution systems [MAC: £533 per MWh. GWh: 2]

Source: Abatement model results for sub-sector, England and Wales

Pubs

In pubs there was an annual abatement potential of 550 GWh of electrical energy and 1,130 GWh of non-electrical energy (equivalent to 370 $ktCO_2e$ combined). This equates to a 23 per cent and 36 per cent reduction on energy consumption respectively. The capital cost to achieve this is £601m. The annual savings delivered would be £84m.[39] These figures are grouped according to measure type in Table D.4. The total abatement potential of the socially cost effective measure groups was 580 GWh, of which 220 GWh was electrical energy consumption and 360 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 570 GWh, of which 330 GWh was electrical energy consumption and 240 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.3).

Table D.4: Abatement opportunity data for pubs, 2014–15

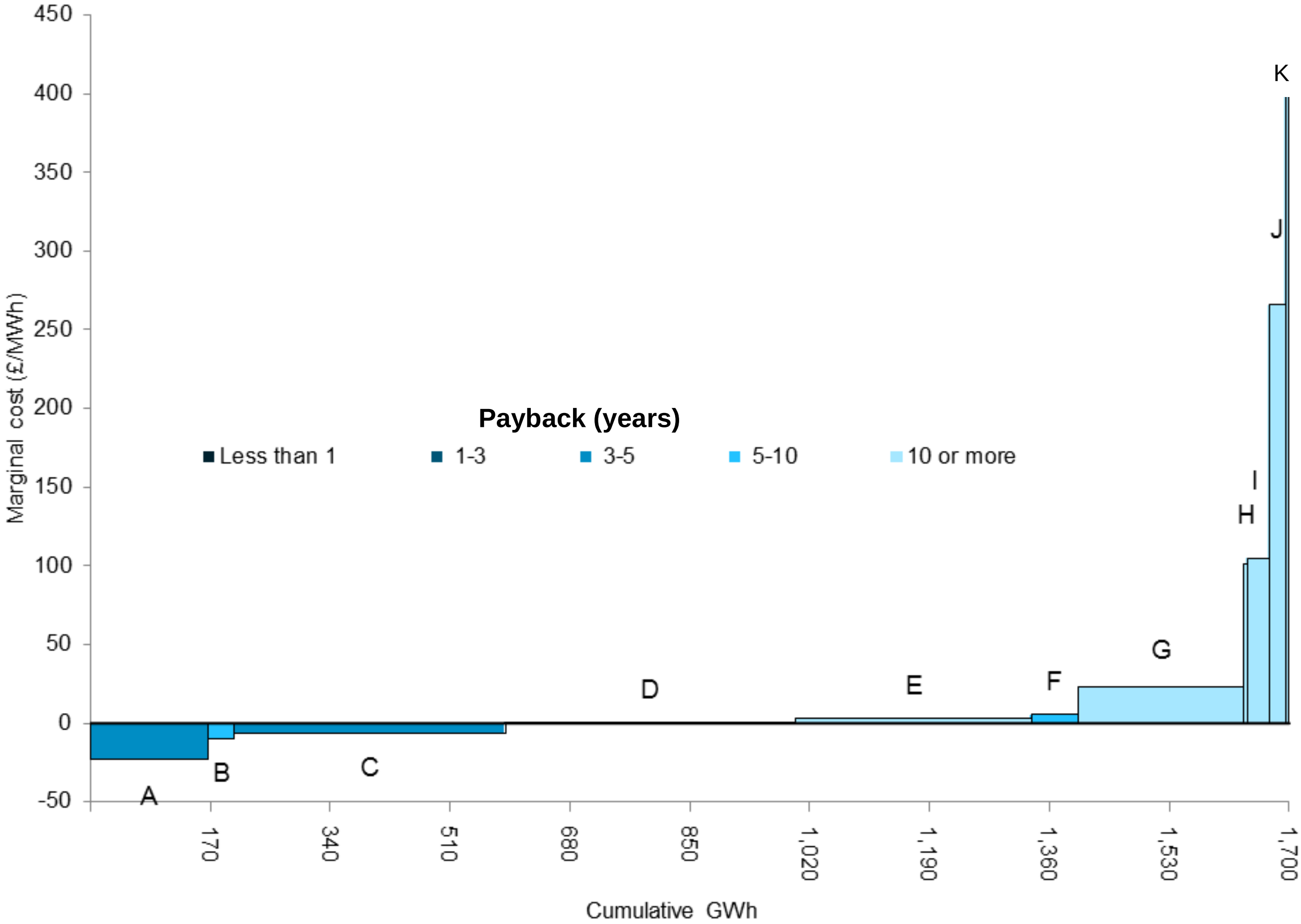
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electri-cal energy savings (GWh)	Total annual non-electri-cal energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Pay-back period (years)[40]
Air conditioning and cooling	400	1	5	-	5	5,400	14
Building fabric	12,200	60	50	280	330	224,900	13
Building instrumentation and control	12,700	80	40	340	380	45,700	3
Building services distribution systems	500	2	5	-	5	13,900	10
Carbon and energy management	22,500	100	160	240	410	31,600	1
Hot water	1,900	8	10	20	40	10,500	5
Humidification	-	-	-	-	-	-	-
Lighting	16,300	50	160	-	160	69,500	3
Cooled storage	6,600	20	70	-	70	33,000	4
Small appliances	1,600	7	10	20	30	22,200	10
Space heating	6,400	40	6	230	230	100,000	14
Swimming pools	-	-	-	-	-	-	-
Ventilation	2,300	7	20	-	20	44,600	14
Total	**83,500**	**370**	**550**	**1,130**	**1,680**	**601,300**	‘’

Source: Abatement model results for sub-sector, England and Wales

[39] Annual savings relates to the financial savings associated solely with the reduced energy consumption.

[40] Payback relates to the duration of time after which the capital costs of a measure are recouped through the accumulated bill savings the measure delivers. Note that the payback period reflects the gross bill savings of the measure alone, rather than the bill savings that would be achieved by the measure if all other measures were installed.

Figure D.3: Marginal abatement cost curve for pubs, 2014–15



Note: the marginal abatement cost is calculated based on the social cost effectiveness, while the payback period is calculated from a private perspective.

A Lighting [MAC: £-23 per MWh. GWh: 160]
B Hot water [MAC: £-10 per MWh. GWh: 40]

C Building instrumentation and control [MAC: £-7 per MWh. GWh: 380]

D Carbon and energy management per MWh. GWh: 410]

E Building fabric [MAC: £3 per MWh. GWh: 330]

F Cooled storage [MAC: £5 per MWh. GWh: 70]

G Space heating [MAC: £23 per MWh. GWh: 230]

H Air conditioning and cooling [MAC: £101 per MWh. GWh: 5]

I Small appliances [MAC: £105 per MWh. GWh: 30]

J Ventilation [MAC: £266 per MWh. GWh: 20]

K Building services distribution systems [MAC: £416 per MWh. GWh: 5]

Restaurants & takeaways

In restaurants & takeaways there was an annual abatement potential of 790 GWh of electrical energy and 320 GWh of non-electrical energy (equivalent to 300 $ktCO_2e$ combined). This equates to a 21 per cent and 15 per cent reduction on energy consumption respectively. The capital cost to achieve this is £494m. The annual savings delivered would be £87m.[41] These figures are grouped according to measure type in Table D.5. The total abatement potential of the socially cost effective measure groups was 530 GWh, of which 510 GWh was electrical energy consumption and 20 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 170 GWh, of which 70 GWh was electrical energy consumption and 100 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.4).

Table D.5: Abatement opportunity data for restaurants & takeaways, 2014–15

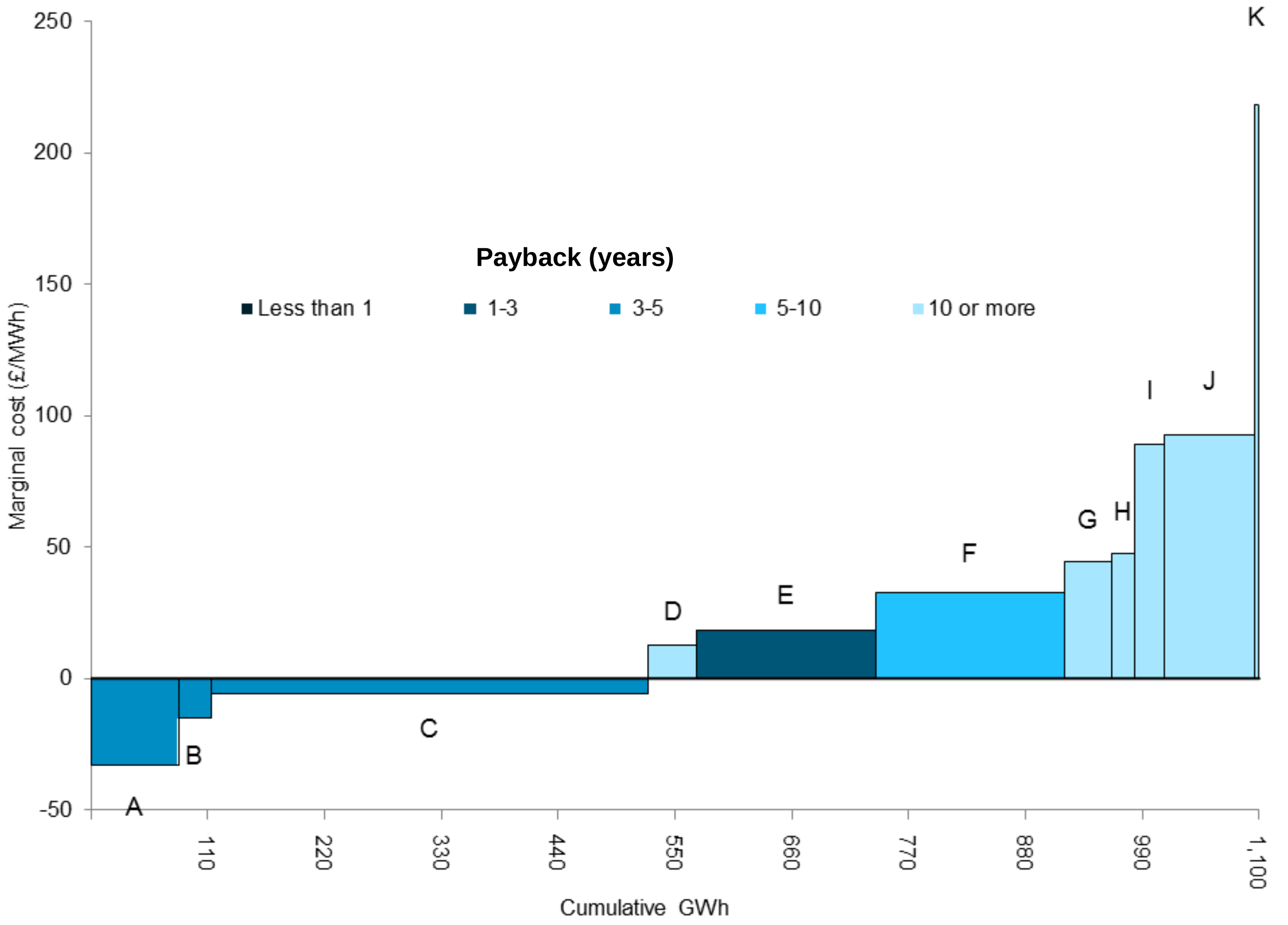
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[42]
Air conditioning and cooling	2,200	8	20	-	20	23,800	10
Building fabric	2,600	10	20	30	50	44,800	13
Building instrumentation and control	8,600	40	60	120	180	52,700	5
Building services distribution systems	500	2	5	-	5	9,500	12
Carbon and energy management	9,600	40	70	100	170	17,300	2
Hot water	1,700	7	10	20	30	8,000	4
Humidification	-	-	-	-	-	-	-
Lighting	8,300	20	80	-	80	29,300	3
Cooled storage	41,200	120	420	-	420	151,400	4
Small appliances	1,500	9	10	20	30	21,100	12
Space heating	2,100	10	10	30	50	38,800	14
Swimming pools	-	-	-	-	-	-	-
Ventilation	8,500	30	90	-	90	97,700	8
Total	**86,700**	**300**	**790**	**320**	**1,110**	**494,300**	‘’

Source: Abatement model results for sub-sector, England and Wales

[41] Annual savings relates to the financial savings associated solely with the reduced energy consumption.

[42] Payback relates to the duration of time after which the capital costs of a measure are recouped through the accumulated bill savings the measure delivers. Note that the payback period reflects the gross bill savings of the measure alone, rather than the bill savings that would be achieved by the measure if all other measures were installed.

Figure D.4: Marginal abatement cost curve for restaurants & takeaways, 2014–15



Note: the marginal abatement cost is calculated based on the social cost effectiveness, while the payback period is calculated from a private perspective.

A Lighting [MAC: £-33 per MWh. GWh: 80]
B Hot water [MAC: £-15 per MWh. GWh: 30]
C Cooled storage [MAC: £-6 per MWh. GWh: 420]
D Building fabric [MAC: £12 per MWh. GWh: 50]
E Carbon and energy management [MAC: £18 per MWh. GWh: 170]
F Building instrumentation and control [MAC: £32 per MWh. GWh: 180]
G Space heating [MAC: £44 per MWh. GWh: 50]
H Air conditioning and cooling [MAC: £47 per MWh. GWh: 20]
I Small appliances [MAC: £89 per MWh. GWh: 30]
J Ventilation [MAC: £93 per MWh. GWh: 90]
K Building services distribution systems [MAC: £218 per MWh. GWh: 5]

Source: Abatement model results for sub-sector, England and Wales

Department for Business, Energy & Industrial Strategy
3 Whitehall Place
London SW1A 2AW
www.gov.uk/beis