Department for
Business, Energy
& Industrial Strategy

Building Energy Efficiency Survey: Retail sector, 2014–15

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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 retail 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 facilitators 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.

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[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.

Retail sector overview

The retail sector consisted of large food shops, large non-food shops, retail warehouses, showrooms, small shops and hairdressers & beauty salons. For the purpose of this study, it did not include retail premises that were present in other building types. The retail sector had a total floor area of 113 million m^2 (14 per cent of the total non-domestic stock) across 487,400 premises (31 per cent of the total non-domestic stock). The retail sector's total energy consumption was 27,340 GWh. The sector's electrical energy consumption was 21,670 GWh (26 per cent of the total non-domestic stock) and non-electrical energy consumption was 5,670 GWh (7 per cent of total non-domestic stock).

The findings in this report are based on data collected through 1,033 records gathered through telephone surveys or other equivalent means and 48 site surveys in 2014–15. These were used in the energy use and abatement models. Of the 1,033 records, 100 were mystery shopper surveys.

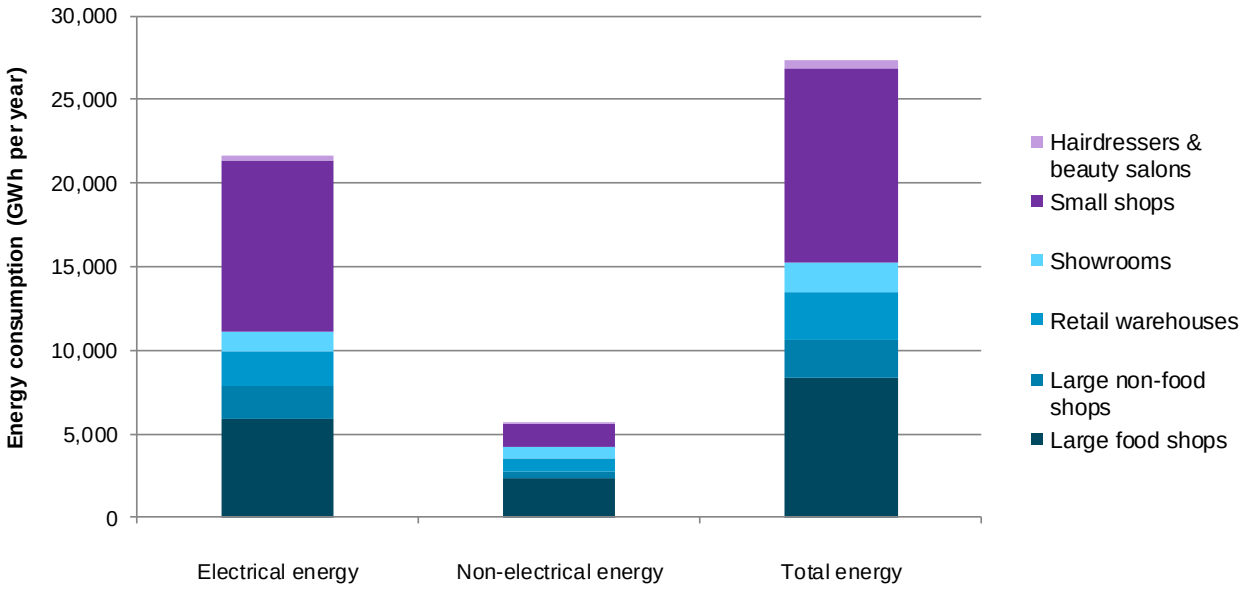
Key findings

Energy consumption in the retail sector, 2014–15

- According to modelled data based on telephone survey responses, the sector consumed 27,340 GWh of energy. This included 21,670 GWh of electrical energy and 5,670 GWh of non-electrical energy per year (Figure 0.1).
- The largest energy consumer in this sector was small shops with 11,600 GWh total energy consumption (42 per cent of sector total). Large food shops were the second largest consumer in the sector, with 8,310 GWh of total energy consumption (30 per cent of sector total). Hairdressers & beauty salons were the smallest consumer in the sector, with 450 GWh of total energy consumption (2 per cent of sector total).
- The difference in absolute consumption between the sub-sectors matched to some extent with their overall size. Small shops were the largest sub-sector in the retail sector in terms of energy consumption, while also representing 53 per cent of the sector's overall floor area (60 million m^2). Large food shops and retail warehouses were the next largest sub-sectors in terms of floor area (15 million m^2 and 14 million m^2, respectively).
- Large food shops had the highest total median energy intensity (581 kWh/m^2), followed by hairdressers & beauty salons (379 kWh/m^2).
- Large food shops premises typically displayed the highest median electrical energy intensity (387 kWh/m^2 for electrical energy). The second most energy intensive sub-sector in terms of electrical energy was hairdressers & beauty salons (278kWh/m^2). Hairdressers & beauty salons displayed the highest median non-electrical energy intensity of 212 kWh/m^2, followed by large food shops (180 kWh/m^2).

- The energy consumption of the retail sector was broken down into specific ‘end uses’. The most significant end use was space heating (8,740 GWh, 32 per cent of total energy consumption), followed by cooled storage (6,960 GWh, 25 per cent of total).

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



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

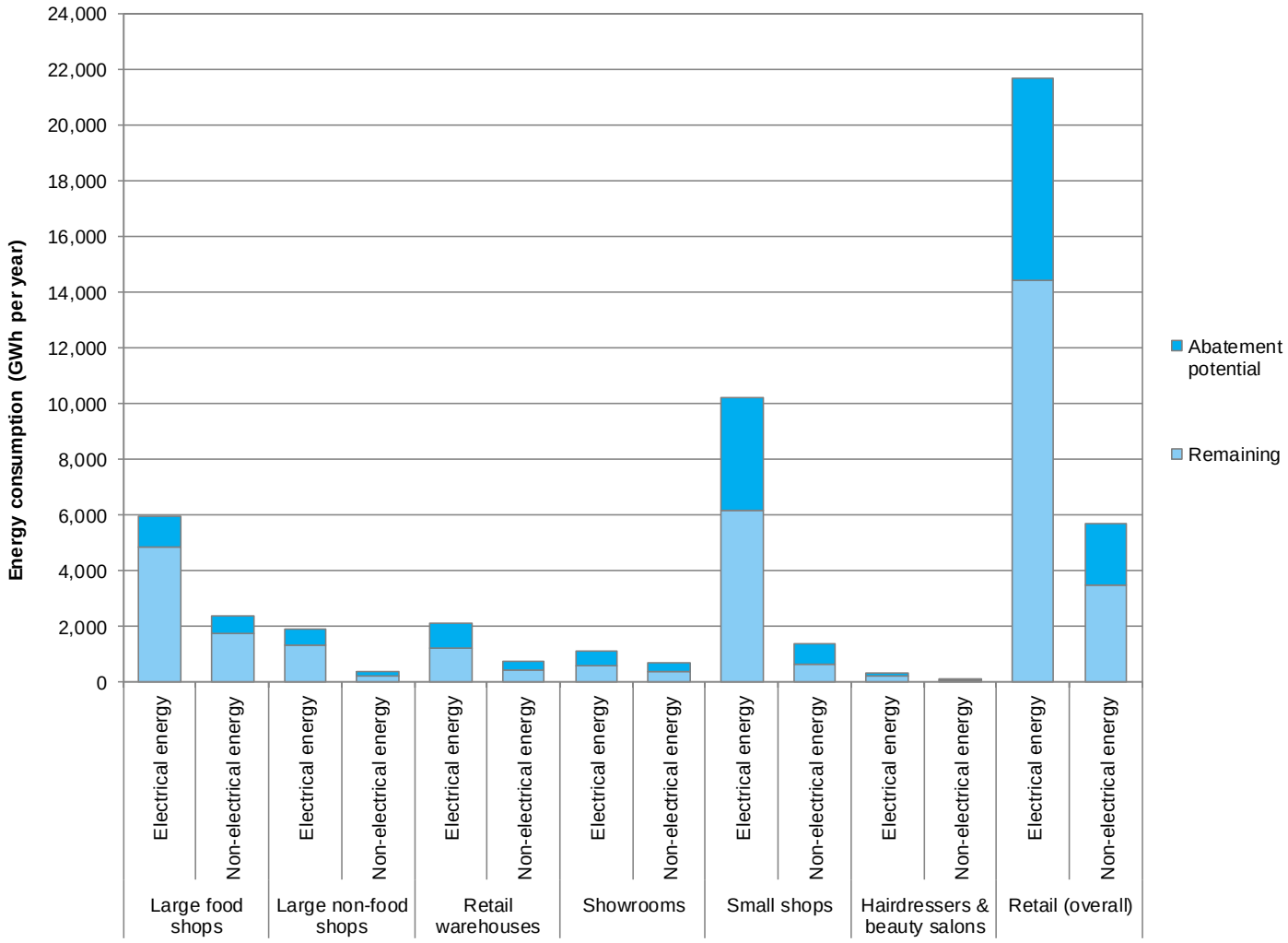
Abatement potential in the retail sector, 2014–15

- 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 retail sector was 9,420 GWh of total energy (34 per cent reduction on consumption). This comprised of 7,250 GWh of electrical energy (a 33 per cent reduction on consumption) and 2,180 GWh of non-electrical energy (a 38 per cent reduction on consumption).
- This could be achieved at a capital cost of £5.83 billion. The socially cost effective potential was 2,820 GWh of electrical energy consumption, and no non-electrical energy consumption. Companies are more likely to be influenced by the payback period[4] for improvement: overall there were 1,360 GWh of total energy savings with a private payback period of 3 years or less (1,070 GWh of electrical energy abatement and 290 GWh of non-electrical energy abatement).
- The sub-sector with the largest absolute abatement potential was small shops, which could reduce total consumption by 4,810 GWh which spilts between with a reduction on

[4] Payback 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.

consumption of 4,080 GWh of electrical energy and 730 GWh of non-electrical energy. The sub-sector with the largest relative abatement potential was showrooms, with a 47 per cent reduction on electrical and non-electrical energy consumption.

Figure 0.2: Abatement potential by energy type and retail 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 retail sector – in terms of reductions in energy consumption – relate to the implementation of lighting upgrades, carbon & energy management measures, building instrumentation & control and lighting measures. The largest group of savings – in terms of the potential energy bill savings – relate to the implementation of lighting upgrades.

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

Measure type	Savings	Total

	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)	**capital cost of measure (£ thousands)**
Air conditioning and cooling	22,300	60	220	-	220	241,300
Building fabric	59,900	180	500	400	900	1,197,100
Building instrumentation and control	77,200	310	610	660	1,270	519,200
Building services distribution systems	8,600	30	90	-	90	222,400
Carbon and energy management	113,400	400	1,070	290	1,360	352,700
Hot water	1,900	10	7	50	50	72,700
Humidification	-	-	-	-	-	-
Lighting	280,100	800	2,820	-	2,820	1,231,700
Cooled storage	110,900	330	1,120	-	1,120	711,100
Small appliances	6,700	20	70	2	70	82,900
Space heating	45,000	220	250	790	1,040	685,700
Swimming pools	-	-	-	-	-	-
Ventilation	49,000	150	490	1	490	516,400
Total	**775,000**	**2,500**	**7,250**	**2,180**	**9,420**	**5,833,200**

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

1. Retail sector

This report relates to the retail sector (one of 10 sectors covered in the Building Energy Efficiency Survey (BEES)). This section provides definitions for the six retail sub-sectors; large food shops, large non-food shops, retail warehouses, showrooms, small shops and hairdressers & beauty salons. It then sets the retail 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 retail sector.

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

Sub-sector	Definition
Large food shops	Refers to premises used for the retail sale of food products and items, with a total floor area exceeding 750m^2.
Large non-food shops	Refers to premises used to conduct the retail sale of non-food consumer goods, including 'large non-food shops' and 'department stores'. 'Large non-food shops' refers to individual stores, surveyed as separate premises, which sell consumer goods such as clothing, books, toys, sporting goods, office supplies, hardware, and electronics. 'Department stores' refers to premises used for large scale retail activity, providing a variety and range of goods organised into separate departments. These can include clothing, furniture, home appliances, toys, cosmetics, gardening, toiletries and hardware. Gross Floor Area should include all space within the premises, including sales areas, storage areas, offices staff break rooms, lift shafts, and stairwells. 'Large non-food shops' and 'department stores' were originally separate sub-sectors, but were combined to provide a robust sample size.
Retail warehouses	Refers to retail outlets located in warehouse-style buildings (i.e. large individual buildings, with high-celling, open plan interiors, often displaying goods on an industrial rack rather than conventional retail shelving) . Often offering a limited variety of merchandise sold in bulk at a discount to customers. Generally located outside town centres and often in dedicated retail parks.
Showrooms	Refers to premises used for the display of goods for sale. This includes 'vehicle showrooms' and 'non-vehicle showrooms'. 'Vehicle showrooms' refer to premises used for the sale of new or used cars and light trucks. Gross Floor Area should include all space within the premises, including sales floors, offices, conference rooms, vehicle

[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
	service centres, parts storage areas, waiting rooms, staff break rooms, hallways, and stairwells. Gross Floor Area should not include any exterior spaces such as vehicle parking areas and an adjustment has been made to overall population data to ensure this is the case[6]. 'Non-vehicle showrooms' refer to premises used for the sale of goods, such as appliances, or furniture. Gross Floor Area should include all internal areas including sales areas, storage areas, offices staff break rooms, lift shafts, and stairwells. 'Vehicle showrooms' and 'non-vehicle showrooms' were originally separate sub-sectors but were combined to provide a robust sample size.
Small shops	Refers to small premises used for betting shops, or for conducting the retail sale of both food and non-food consumer goods such as clothing, books, toys, sporting goods, office supplies, hardware, and electronics. 'Small food shops', 'small non-food shops' and 'betting shops' were modelled as separate sub-sectors but were combined for reporting purposes.
Hairdressing & beauty salons	Refers to premises used for the provision of cosmetic treatments and hairdressing services. This may include skin health, facial aesthetic, foot care, aromatherapy, oxygen therapy and mud baths.

Retail sector in the context of the wider non domestic stock

The retail sector is a large segment of the non-domestic stock. It accounts for 31 per cent of the non-domestic stock in terms of premises count (487,400) and 14 per cent in terms of floor area (113 million m^2 GIA[7]).[8]

In terms of energy consumption the sector consumed 27,340 GWh of total energy per year. This comprised 21,670 GWh of electrical energy and 5,670 GWh of non-electrical energy per year, this is equivalent to 17 per cent of the non-domestic total (26 per cent of electrical and 7 per cent of non-electrical energy). This information is set out in Figure 1.1, Figure 1.2 and Figure 1.3.

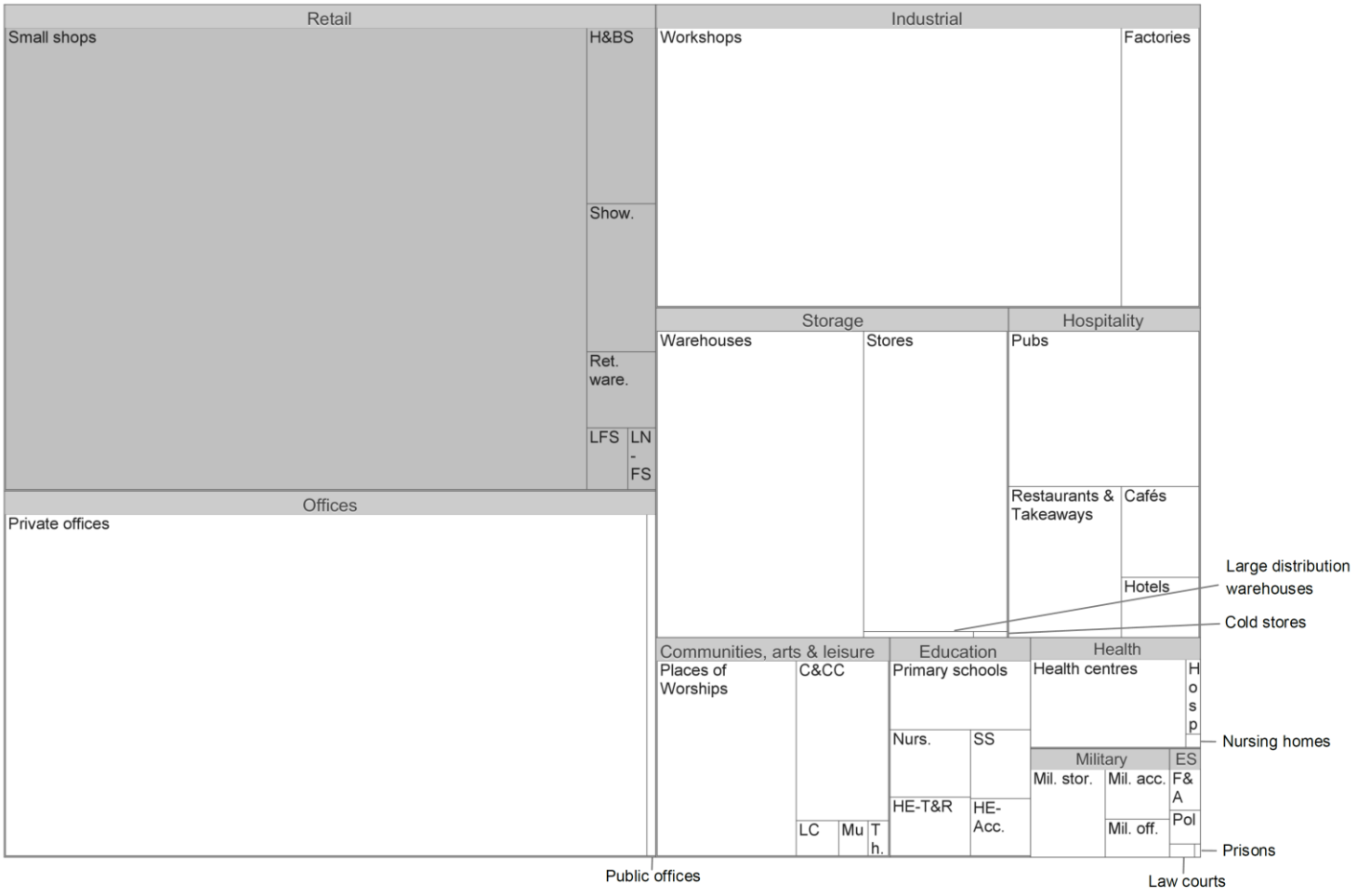
[6] UCL undertook an analysis of the Valuation Office Agency data to determine what proportion of a sub-sector's total floor area is associated with non-building area i.e. external parking. This analysis was used to exclude external areas in reporting.

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

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

Figure 1.1: Premises frequency by sub-sector for the non-domestic stock, 2014–15

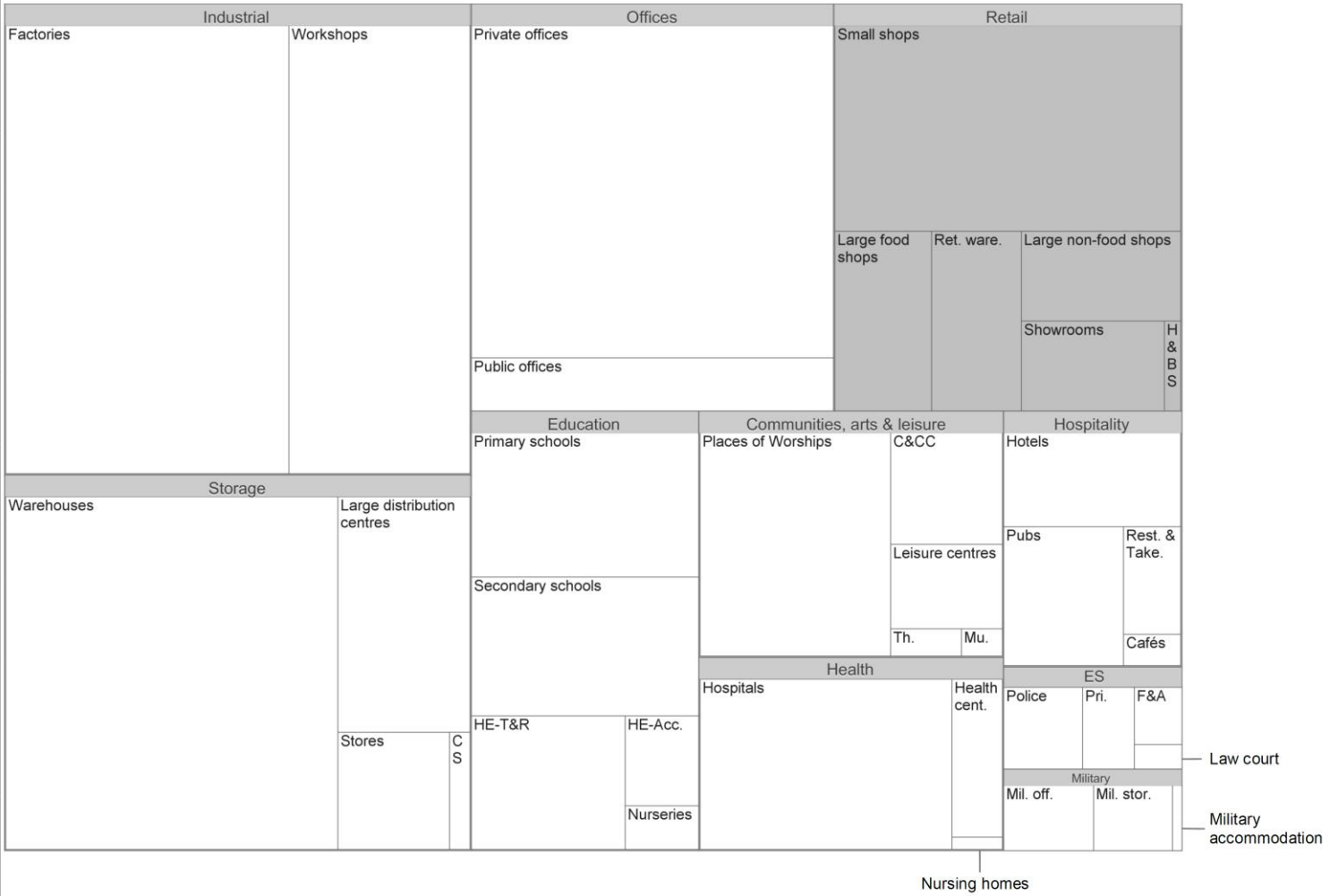
ID	Sub-sector
H&BS	Hairdressing & beauty salons
Show.	Showrooms
Ret. ware.	Retail warehouses
LFS	Large food shops
LN-FS	Large non-food shops
C&CC	Clubs & community centres
LC	Leisure centres
Mu.	Museums, Art gal-leries and Libraries
Th.	Theatres, cinemas and concert halls
Nurs.	Nurseries
SS	Secondary 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, 2014–15

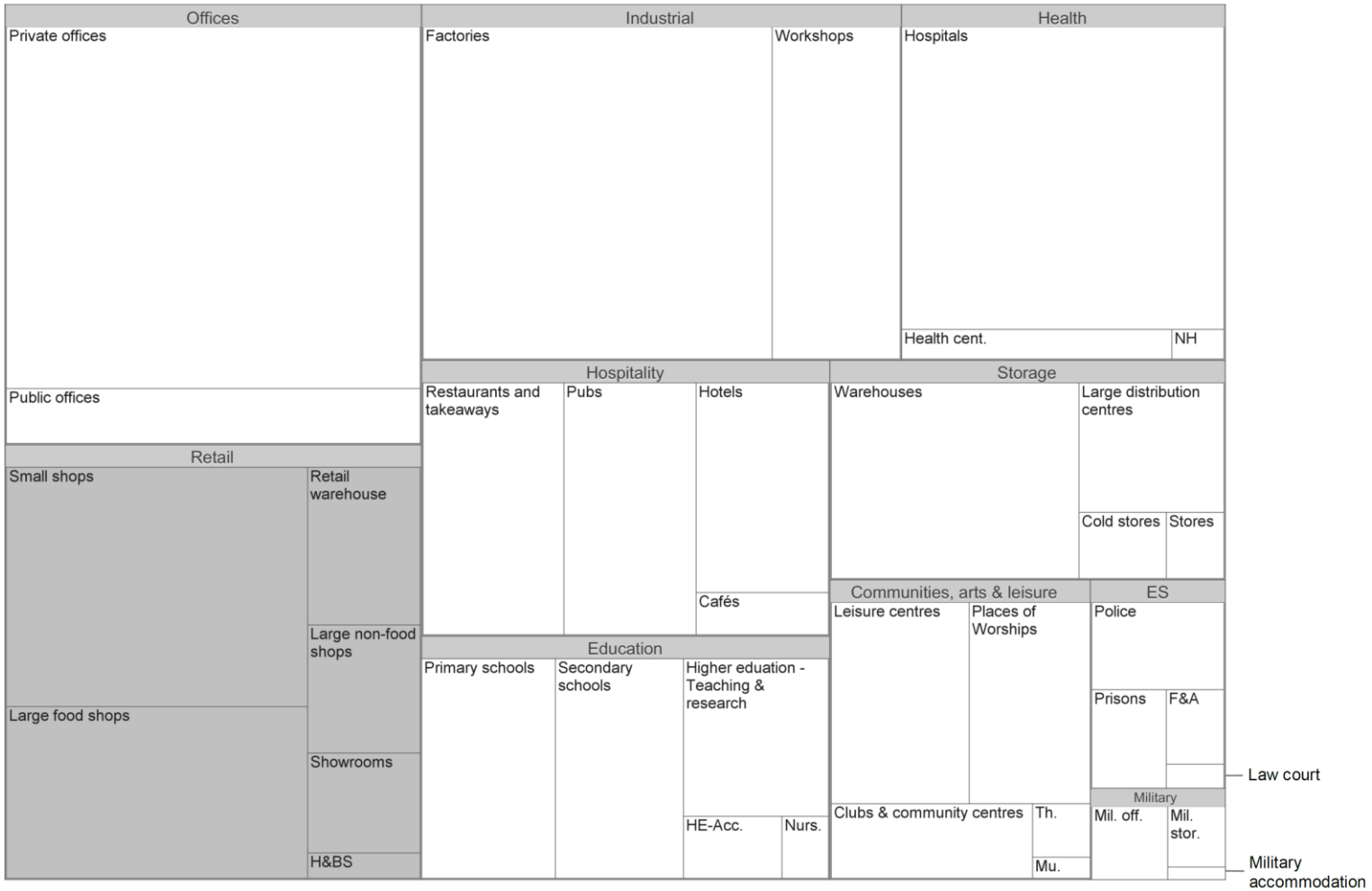
ID	Sub-sector
Ret. ware.	Retail warehouse
H&BS	Hairdressing & beauty salons
CS	Cold stores
HE-T&R	HE—Teaching and research
HE-Acc.	HE — Accommodation
C&CC	Clubs & community centres
LC	Leisure centres
Th.	Theatres, cinemas and concert halls
Mu.	Museums, Art galleries and Libraries
Health cent.	Health 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, 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 by sub-sector, England and Wales

General characteristics of the retail sector

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

The retail sector varied greatly in size and complexity from small shops and hairdressers & beauty salons, through to large supermarkets, vehicle showrooms and flagship high street retail stores. The sector included premises with very low servicing provision (e.g. a builder's merchant with basic heating only) through to flagship retail stores with extensive ventilation, air conditioning and display lighting.

Individual premises ranged in organisational structure from sole traders in rented units, to local, national and global retail chains and franchises.

Within the sector, both product type and target market had a material impact on the design and energy performance of retail premises, especially the impact of the sale of chilled and frozen food. As did electrical items on display (e.g. TVs, computers, lighting), sale of high value goods and certain other specialisms such as the sale of animals.

Across the sector, most premises were dominated by retail space for the sale of goods and services. Other common activity areas included customer cafés and toilets. In non-customer areas, rest areas and storage space were present in almost all cases. Delivery areas, offices and server rooms were often found in larger premises and refrigerated storage and food preparation areas were common in food shops.

Summary statistics for the retail sector

A number of standard characteristics for the retail sector are set out in Table 1.2, Figure 1.4 and Figure 1.5; from premises and organisation size through to peak 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 retail sector broadly fit into three categories:

- Large food shops, large non-food shops and retail warehouses which were occupied by large organisations, generally based in premises with a floor area more than 1,000 m^2, with active engagement on energy management and 9 to 15 peak operating hours a day;
- Small shops and hairdressers & beauty salons which were occupied by micro organisations, based in a premises with a floor area below 250 m^2, where energy management was not a priority and with peak operating hours that were fewer than 8 hours a day;
- Showrooms that had a mix of organisation sizes, with a floor area greater than 500 m^2, energy management was unlikely to be seen as a priority and with peak operating hours between 9 to 15 hours a day.

It should be noted that due to the reliance on mystery shopper records for some sub-sectors (this was a non-standard form of data collection, which is discussed in greater detail in the methods section), it has not been possible to gather information on all standard sector characteristics in each sub-sector. Where this is the case, 'not asked' indicates the weighted floor area of the records where data gaps exist.

There were clear groupings in terms of organisation size. Almost all retail warehouses (100 per cent), large non-food shops (97 per cent) and large food shops (96 per cent) were occupied by large organisations employing 250 or more people. In comparison, hairdressers & beauty salons and small shops were typically occupied by micro organisations employing fewer than 10 people (73 per cent and 66 per cent, respectively). Showrooms had the most diverse range of organisation sizes, occupied predominantly by small or micro organisations (60 per cent), with 21 per cent of premises area occupied by large organisations.

In terms of premises size, the majority of large food shops, large non-food shops and retail warehouses had a floor area of greater than 1,000 m^2 (97 per cent, 98 per cent and 82 per cent, respectively). In contrast, floor space in small shops and hairdressers & beauty salon premises tended have a floor area of fewer than 250 m^2 (73 per cent and 93 per cent, respectively). Showroom premises had floor areas across all size ranges, with 48 per cent greater than 1,000 m^2 and 12 per cent fewer than 250 m^2.

For the sample where data has been gathered, the majority of retail floor space was leased. This was the case for retail warehouses (51 per cent) and small shops (60 per cent), for instance. The only sub-sector in which owner occupancy was more prevalent was showrooms (75 per cent). Floor space in hairdressers & beauty salons was split evenly between owned and leased (50 per cent, respectively).

Where information on energy management practices was available, the extent to which an organisation proactively managed energy appeared linked to the organisation's size. Those sub-sectors which were dominated by large organisations were also more likely to 'actively seek new ways to reduce energy use'. This was the case for 50 per cent of large food shops and the majority of retail warehouses at 54 per cent. In comparison, showrooms, small shops, and hairdressers & beauty salons tended to be more passive in their energy management[9] (54 per cent, 56 per cent and 53 per cent, respectively).

The sub-sectors differed quite substantially between one another in terms of building age. Small shops, hairdressers & beauty salons and showrooms were primarily based in premises that were constructed prior to 1985 (79 per cent, 66 per cent, and 52 per cent respectively). In comparison, large food shops and retail warehouses were predominantly located in premises constructed after 1991 (70 per cent and 44 per cent, respectively).

Premises in all retail sub-sectors were most likely to occupy a building in its entirety (whole building). In small shops, hairdressers & beauty salons and large non-food shops however there were a large number of premises that occupied only part of a building (48 per cent, 42 per cent and 38 per cent, respectively).

The majority of retail warehouses (96 per cent), large non-food shops (77per cent), large food shops (80 per cent) and showrooms (71 per cent) had peak operating hours of between 9 to 15 hours (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 building). 18 per cent of large food shops also had peak operating hours of between 16 to 24 hours. In comparison, peak operating hours in hairdressers & beauty salons and small shops tended to be fewer than 8 hours a day (72 per cent and 57 per cent, respectively). For the majority of sub-sectors, patterns of opening hours matched those of peak operating hours, although there were a small number of premises in all sub-sectors opening for 16 to 23 hours. Large food shops however showed a different pattern, with 75 per cent of floor area in this sub-sector opening for 24 hours per day.

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[9] 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 retail sub-sector by percentage of floor area, 2014–15 *Column percentages*

	Retail sub-sector						
	Large food shops (%)	Large non-food shops (%)	Retail warehouses (%)	Showrooms (%)	Small shops (%)	Hairdres-sers & beauty salons (%)	**Retail sector (%)**
Organisation size							
Micro (0-9)	-	-	-	28	66	73	39
Small (10-49)	3	3	-	32	15	21	12
Medium (50-249)	1	-	-	17	6	2	5
Large (250+)	96	97	100	21	11	1	43
Don't know	-	-	-	1	2	4	1
Total floor area (m^2)							
Less than 50	-	-	-	0	7	28	4
50-99	-	-	-	1	25	41	14
100-249	-	-	-	11	40	24	23
250-499	-	-	3	14	13	7	9
500-999	3	2	15	25	7	-	9
1,000-4,999	43	45	59	33	7	-	24
5,000-9,999	47	20	23	5	-	-	12
10,000 or more	7	33	-	10	-	-	5
Tenure							
Owned	13	6	19	75	37	50	32
Leased	-	19	51	25	60	50	45
Don't know	36	-	-	-	3	-	0
Not asked	50	75	31	-	-	-	23
Energy management ambition [10]							
Active	50	16	54	38	31	34	35
Passive	0	11	13	54	56	53	38
None	-	2	2	8	13	13	9
Do not know	-	-	-	-	-	-	-
Not asked	50	71	31	-	-	-	18
Age of building							
Pre-1900	1	3	-	10	38	31	22
1900-1939	1	12	-	11	23	22	15
1940-1985	2	9	13	31	18	13	16
1986-1990	2	3	6	8	2	-	3
1991-2006	29	3	25	16	5	1	11
2007 or later	41	10	19	6	2	1	10
Don't know	13	11	23	19	14	29	15
Not asked	11	49	14	-	-	3	8

[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

	Retail sub-sector						
	Large food shops (%)	Large non-food shops (%)	Retail warehouses (%)	Showrooms (%)	Small shops (%)	Hairdressers & beauty salons (%)	**Retail sector (%)**
Building structure							
Part of building	6	38	14	9	48	42	33
Whole building	94	62	86	85	52	58	66
Multiple buildings	-	-	-	6	0	-	1
Not asked	-	-	-	-	-	-	-
Peak operating hours[11]							
8 or less	2	11	4	29	57	72	36
9-15	80	77	96	71	41	28	59
16-23	10	-	-	-	1	-	2
24	8	-	-	-	-	-	1
Don't know	-	13	-	-	0	-	2
Opening hours[12]							
8 or less	-	8	2	20	41	50	26
9-15	21	77	90	73	53	47	58
16-23	3	3	8	7	6	3	5
24	75	-	-	-	-	-	10
Don't know	-	13	-	-	0	-	2
Unweighted base	*57*	*55*	*49*	*45*	*701*	*44*	*1,033*

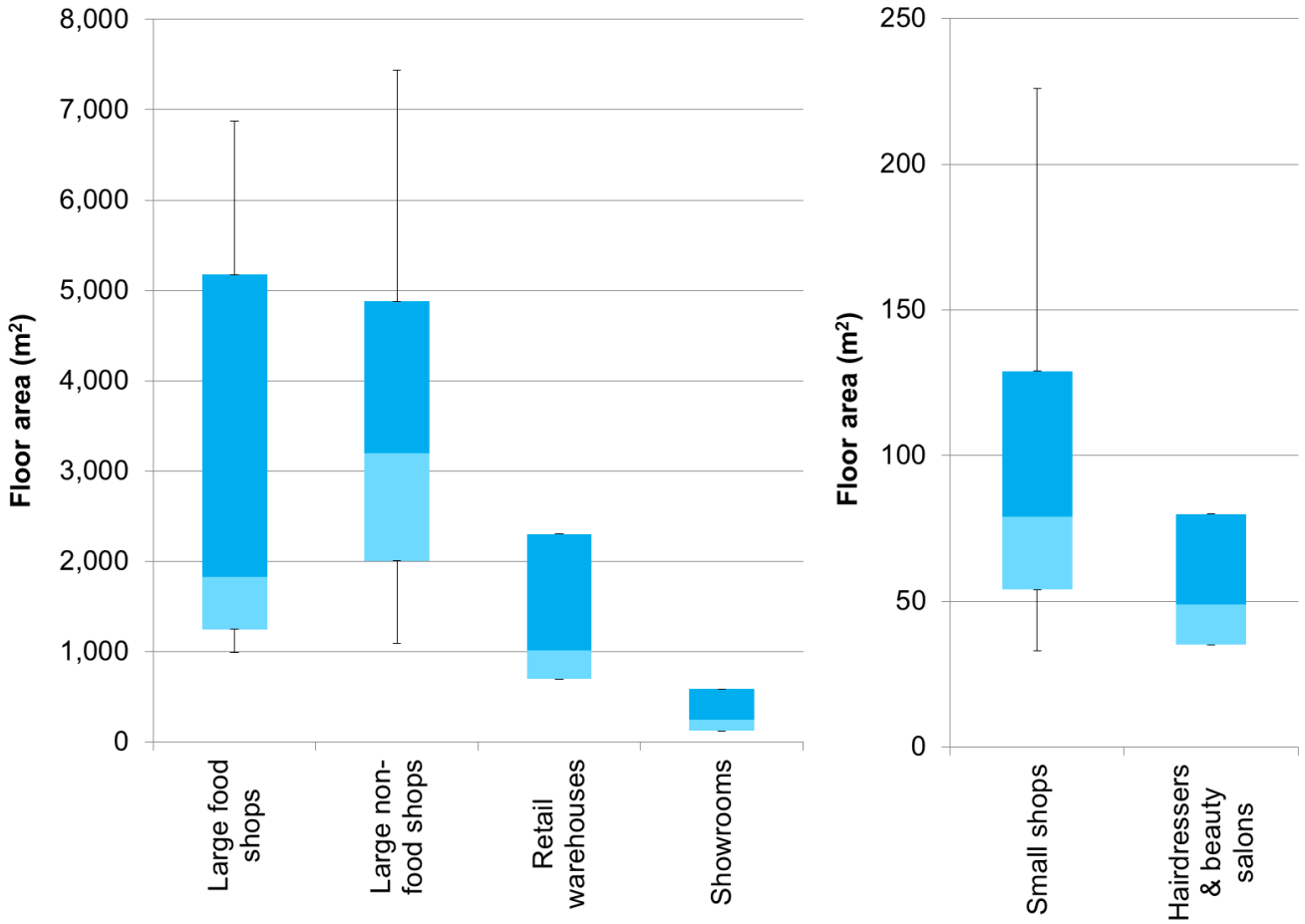
Source: Telephone survey or equivalent records for the sector, England and Wales

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

Figure 1.4 shows the distribution of premises sizes, in terms of floor area, by sub-sector. The plot shows that large non-food shops had the largest median floor area of the retail sector (3,190 m^2), followed by large food shops (1,830 m^2), retail warehouses (1,020 m^2) and showrooms (240 m^2). The distribution of floor area sizes for large food shops was the widest of the sector, with the central 50 per cent of records having a distribution of floor areasbetween 1,250 m^2 and 5,180 m^2.

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

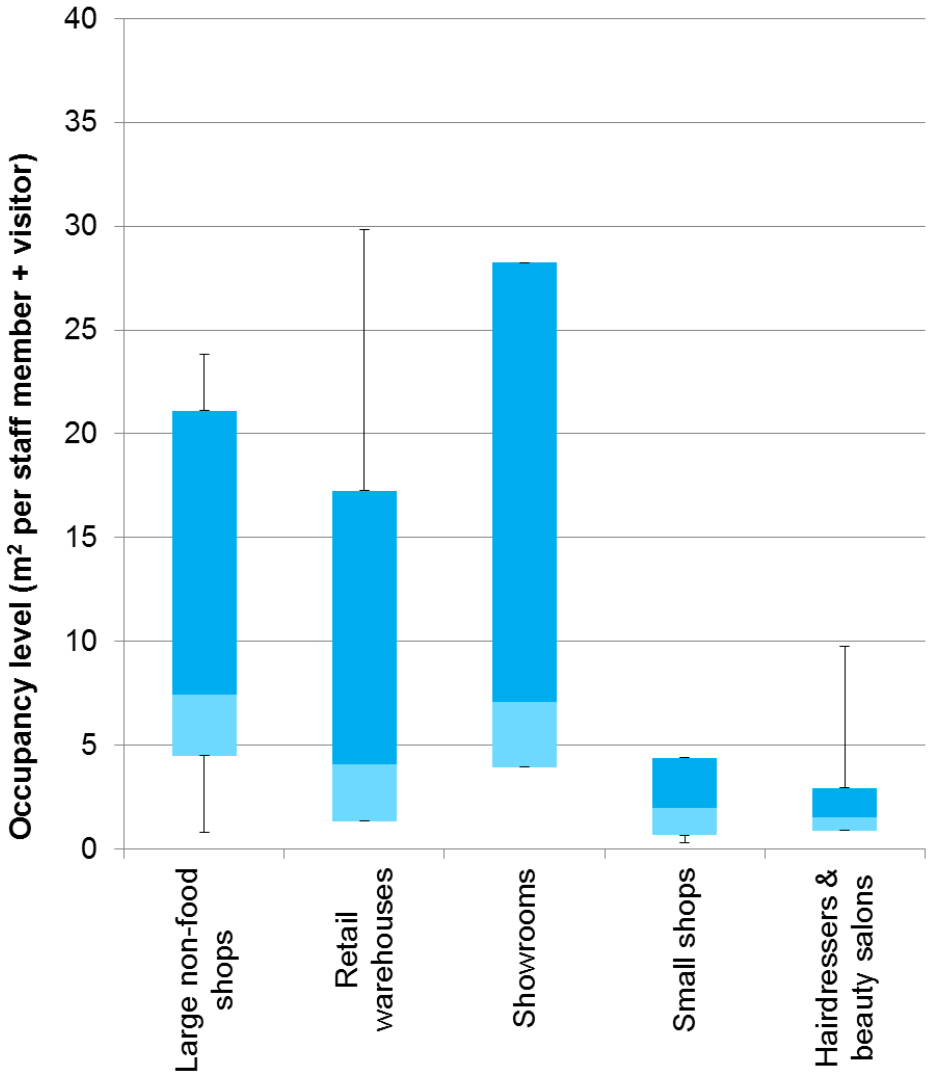


Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. 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 staff and visitors typically present at any one time during a typical working day. Large food shops showed the lowest median occupancy level of 13 m^2 per person[13]. This compared with a median of 7 m^2 per person in large non-food shops and showrooms.

Figure 1.5: Occupancy level by retail sub-sector, 2014–15



Note: Large food shops not included due to high not asked responses to the staff / visitor question in the survey due to Mystery shopper records.

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

[13] Commonly, in sectors where this metric is reported, staff density would be based on Net Lettable Floor Area (NLA). This is the area of a building that is let to tenants and excludes common areas e.g. walkways. A typical ratio from GIA to NLA is 0.7.

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 retail sector.

Greater detail on the BEES methodology in relation to the retail 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 retail 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;[14]
- 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.[15]

The first two objectives are addressed in this and other sectors 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 is performed at sub-sector level with bespoke questionnaires and modelling assumptions used at this level.

During the analysis process a number of sub-sectors were retrospectively merged, as it became apparent that some sub-sectors shared common characteristics in terms of building type and energy profile. The large food shops sub-sector originally consisted of large food shops and supermarkets - these were amalgamated retrospectively. Similarly, the small shops sub-sector originally existed as three separate sub-sectors: small food shops, small non-food shops, and betting shops. Department stores and large non-food shops were merged together in the large non-food shops sub-sector, and vehicle and non-vehicle showrooms were merged together to form the showrooms sub-sector. In the case of each sub-sector, the underlying analysis was based on different questionnaires and a different set of 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

[14] 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.

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

collected for the retail sector through through 1,033 records gathered through telephone surveys or other equivalent means and 48 site surveys during 2015. These were used in the energy use and abatement models. Of the 1,033 records, 100 were mystery shopper surveys. [16]

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

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[17]. 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 premises 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 these 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 facilitators 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

[16] Mystery shopper surveys involved a trained team entering premises and recording relevant observable information in relation to the premises. This was only used where there was no alternative means of gathering BEES data

[17] 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.

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 premises' core services and equipment. Within the health sector, a total of 192 telephone survey or equivalent records were collected – following the record exclusion process a total of 166 records were retained for analysis. In this sector the share of records excluded was moderately low (14 per cent of total), as many of the records in the available sample yielded a low proportion of 'Don't know' responses, considered to indicate poor record reliability, while others did not have a reliable matched floor area.

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[18].
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.[19]
    - 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 retail sector is covered in "Methodology challenges in the retail sector", which follows in this section, and in more detail in Appendix B.

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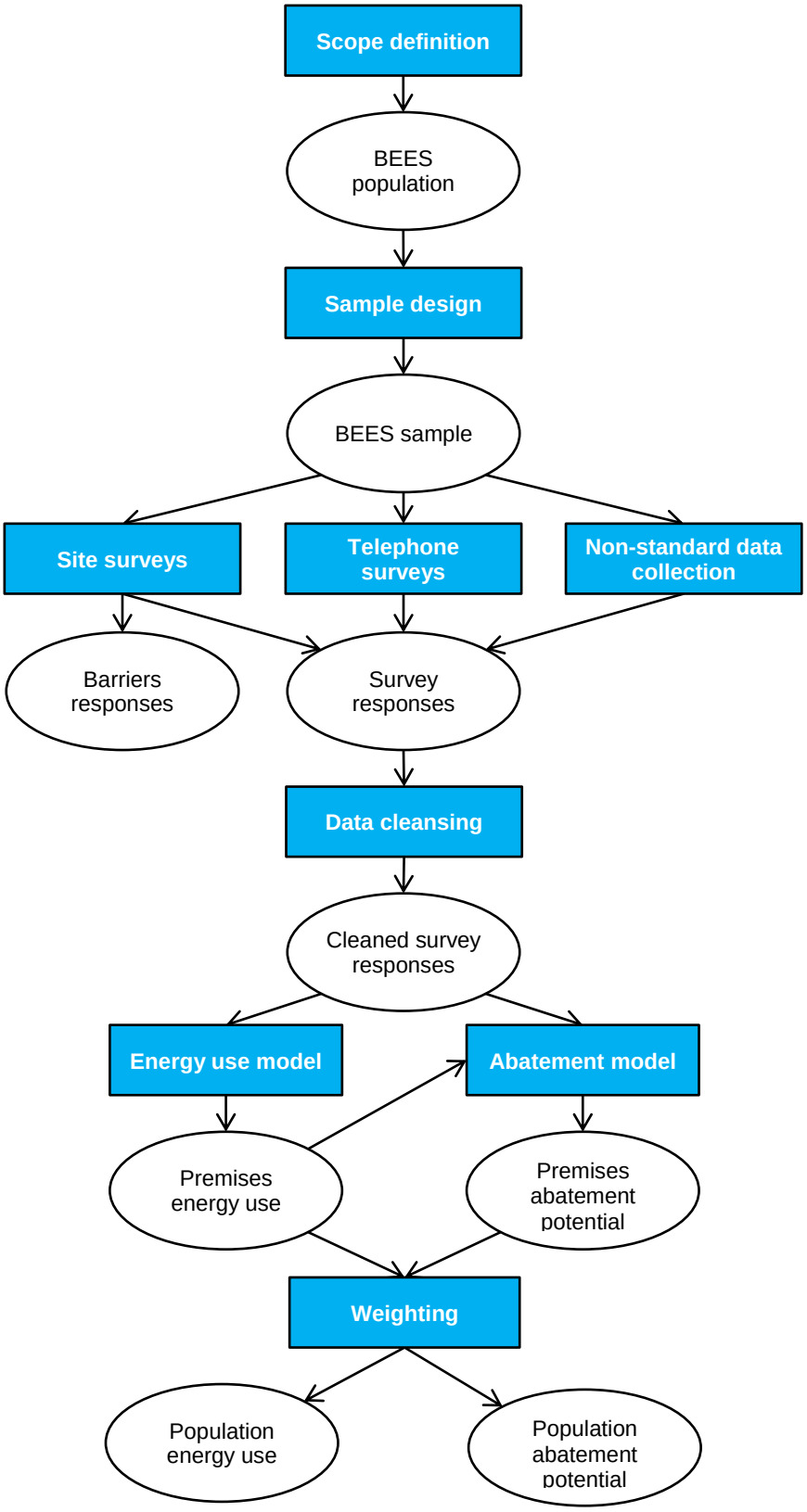
[18] For example, in one sub-sector a small number of respondents gave a 'Don't know' response to the question "Do you use electricity to heat tap water and/or showers and if so how much?". The vast majority of responses to within the sub-sector were 'None', so this was used as a proxy as it was deemed 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.

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

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.

Figure 2.1: Methodology flowchart



Methodology challenges in the retail sector

For retail sub-sectors the BEES methodology was amended due to low participation levels from major retailers who were unwilling to participate. As a result data needed to be gathered through both a sub-set of engaged companies and through mystery shoppers visiting premises to ensure a reasonable spread of premises were surveyed. A summary of further specific issues encountered is set out below and a full description is included in Appendix B.

- **Design -** Many large retailers declined to participate in the survey via the direct telephone survey approach targeted at stores. In order to gather data, two parallel approaches were pursued: retailers were contacted at head office level and asked to participate directly; and a "Mystery shopper" approach[20] was used (where it was not possible to elicit sufficient participation through direct contact). Where direct contact with retailers was used, this created a significant selection bias. This was compensated in part through the use of mystery shopper records to provide greater diversity of store types. However, where the mystery shopper approach was used a limited amount of data could only be collected and so confidence in the modelling results is weaker. This has a major impact of sub-sectors such as department stores, where there is a high reliance on this method of data collection.
- **Design** - The retail sector was very diverse, and the Valuation Office Agency's classifications were based primarily on size and form (e.g. large, small, department store) rather than the classification of products sold. This made targeting telephone survey questions challenging as a very wide range of activities needed to be covered. This means that the modelled results are based on simplified data inputs relative to other sub-sectors and therefore the outputs will be less accurate.
- **Reporting** –Sub-sectors have been merged in the Retail sector, to ensure that the findings are not disclosive and that sub-sectors are of an adequate size to ensure reliable estimates. It was not possible to achieve satisfactory participation levels for all sub-sectors in this sector via the standard methodology or alternatives used. Data for these sub-sectors was included in other analogous sub-sectors to ensure anonymity and to avoid disclosing sensitive information on respondents..These mergers only reduce the granularity of results, not the robustness.The mergers were:
    - Small shops - this contains small food shops, small non-food shops and betting shops;
    - Large food shops - this contains supermarkets and large food shops;
    - Large non-food shops - This contains large non-food shops and department stores;
    - Showrooms - this contains vehicle and non-vehicle showrooms.

[20] Mystery shopper surveys involved a trained team entering premises and recording relevant observable information in relation to the premises. This was only used where there was no alternative means of gathering BEES data

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 retail sector.

Energy consumption and greenhouse gas emissions in the retail sector

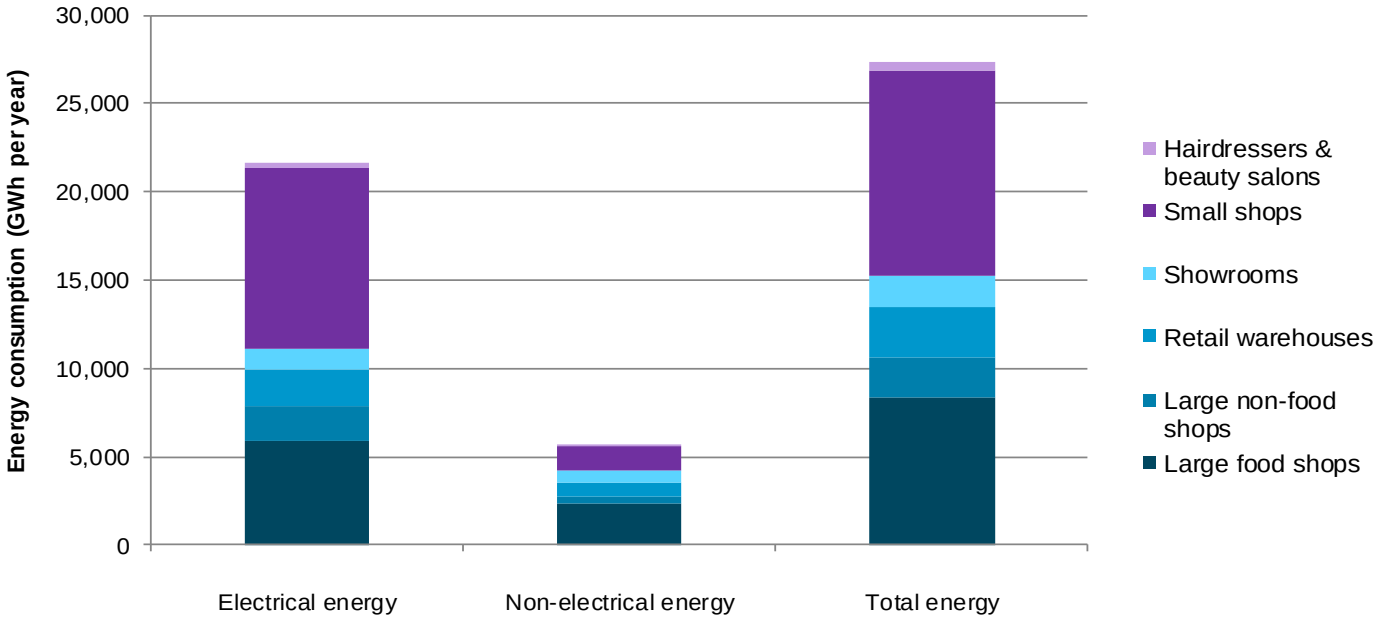
The total energy consumption, electrical and non-electrical energy consumption of the retail sector are presented in Figure 3.1, broken down by the six retail sub-sectors (covering large food shops, large non-food shops, retail warehouses, showrooms, small shops and hairdressers & beauty salons).

The retail sector consumed 27,340 GWh of energy. This consisted of 21,670 GWh of electrical energy and 5,670 GWh of non-electrical energy per year (Figure 3.1).

The largest energy consumer was small shops with a consumption of 11,600 GWh (42 per cent of total). This was split between 10,230 GWh of electrical energy (47 per cent of sector total) and 1,370 GWh of non-electrical energy (24 per cent of sector total). This was partly due to this sub-sector being the largest in the retail sector (60 million m^2 total floor area compared with 15 million m^2 for large food shops and 14 million m^2 for retail warehouses).

Large food shops were the second largest consumers in the sector, with a consumption of 8,310 GWh of energy (30 per cent of total). This consisted of 5,940 GWh of electrical energy consumption (27 per cent of sector total) and 2,380 GWh of non-electrical energy consumption (42 per cent of sector total). Hairdressers & beauty salons were the smallest consumers in the sector with a consumption of 450 GWh (2 per cent of total), which was split into 350 GWh of electrical energy (2 per cent of sector total) and 100 GWh of non-electrical energy (2 per cent of sector total).

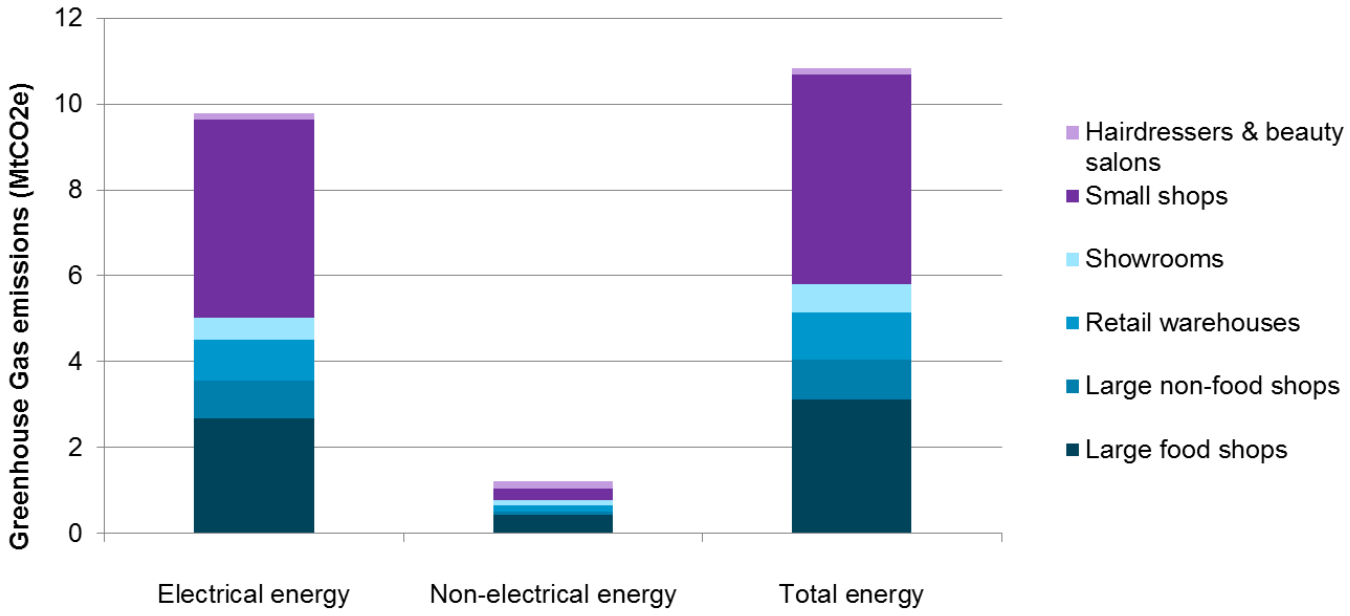
Figure 3.1: Electrical and non-electrical energy consumption by energy type and retail sub-sector, 2014–15



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

The greenhouse gas emissions for the retail sector are presented in Figure 3.2.[21] The total greenhouse gas emissions from the retail sector were estimated to be 10.9 $MtCO_2e$ per year. The annual emissions from electrical energy consumption were 9.8 $MtCO_2e$ and those from non-electrical energy consumption were 1.1 $MtCO_2e$.

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



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

Energy consumption by end use

The distribution of total energy consumption by end use is presented in Figure 3.3 and Table 3.1.[22]

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 (cooled storage). The simplified classification is shown against the more detailed classification results in Table 3.1.

Note that in this sector, due to the inherent difficulty of segregating display lighting and normal internal lighting, the two end uses have been merged. Further detail can be found in Appendix D on the 23 end uses and how these are re-categorised.

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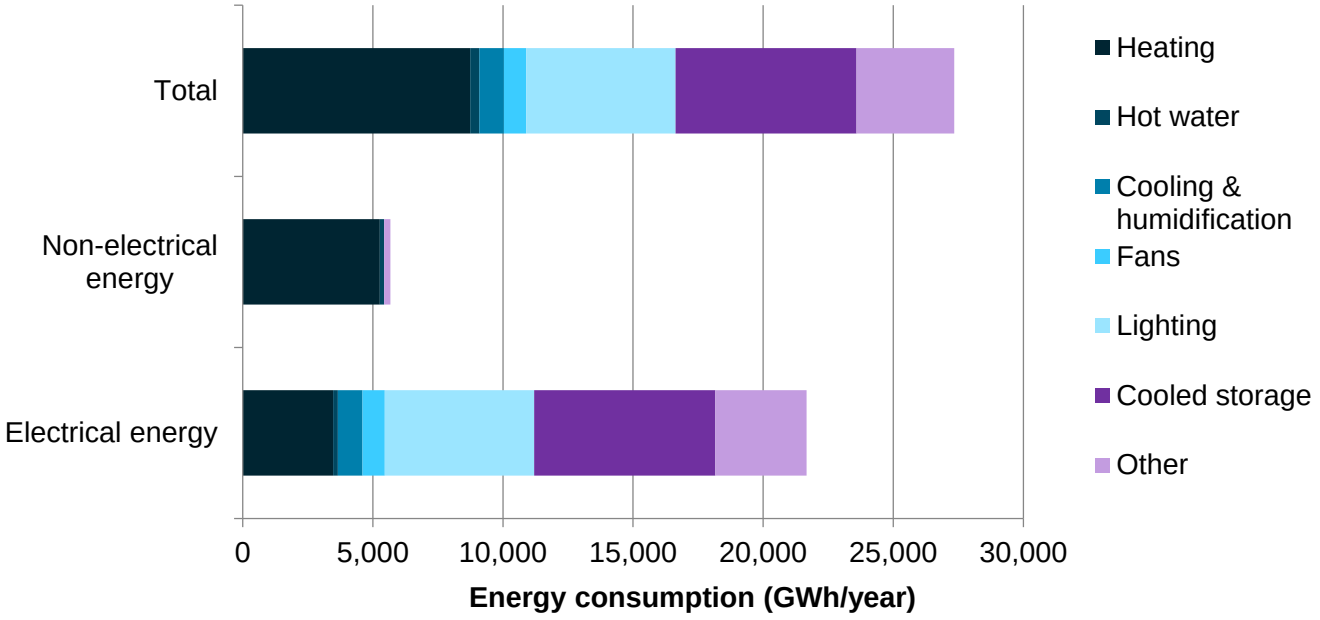
[21] Greenhouse gas emissions were estimated using energy consumption figures from the energy use model and electricity and grid average fuel emission factors from IAG guidance on valuing greenhouse gas emissions published by DECC, updated on 10 December 2015. See https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for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

[22] 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 total energy consumption for the retail sector was 27,340 GWh. The most significant end use was space heating (8,740 GWh, 32 per cent of total consumption), followed by cooled storage (6,960 GWh, 25 per cent of total consumption). The most common end uses of electrical energy were cooled storage at 6,960 GWh (32 per cent of total), followed by lighting (internal lighting and display lighting combined – 5,730 GWh, 26 per cent). The next major end uses included space heating (3,470 GWh, 16 per cent), other (2,970 GWh, 14 per cent), space cooling (950 GWh, 4 per cent) and fans (860 GWh, 4 per cent). The most significant non-electrical energy end uses were space heating at 5,270 GWh (93 per cent) followed by catering (240 GWh, 4 per cent). Non-electrical energy consumption for heating was slightly higher than electrical energy consumption (5,270 GWh compared with 3,470 GWh).

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



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

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

Energy end use category (Simplified)	BEES end use category[23]	Electrical energy consumption (GWh/year)	Non-electrical energy consumption (GWh/year)	Total energy consumption (GWh/year)
Heating	Space heating	3,470	5,270	8,740
Hot water	Hot water	180	160	350
Cooling & humidification	Cooling & humidification	950	-	950
Fans	Fans	860	-	860
Lighting	Lighting - internal	4,700	-	4,700
	Lighting - display	1,030	-	1,030
Catering	Catering	540	240	780
Cooled storage	Cooled storage	6,960	-	6,960
Other	Pumps	160	-	160
	Controls	140	-	140
	Lighting - external	230	-	230
	Vertical transport	20	-	20
	Entertainment equipment	690	-	690
	Pool/leisure	-	-	-
	Small power	530	-	530
	ICT equipment	90	-	90
	Other	1,110	-	1,110
Total		**21,670**	**5,670**	**27,340**
Unweighted base		*1,033*	*613*	*1,033*

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

Retail 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.[24] Figure 3.4 to Figure 3.6 present the distribution of energy intensity for all modelled records in each sub-sector within the retail sector, in terms of energy intensity, electrical energy intensity and non-electrical energy intensity respectively.[25] 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.

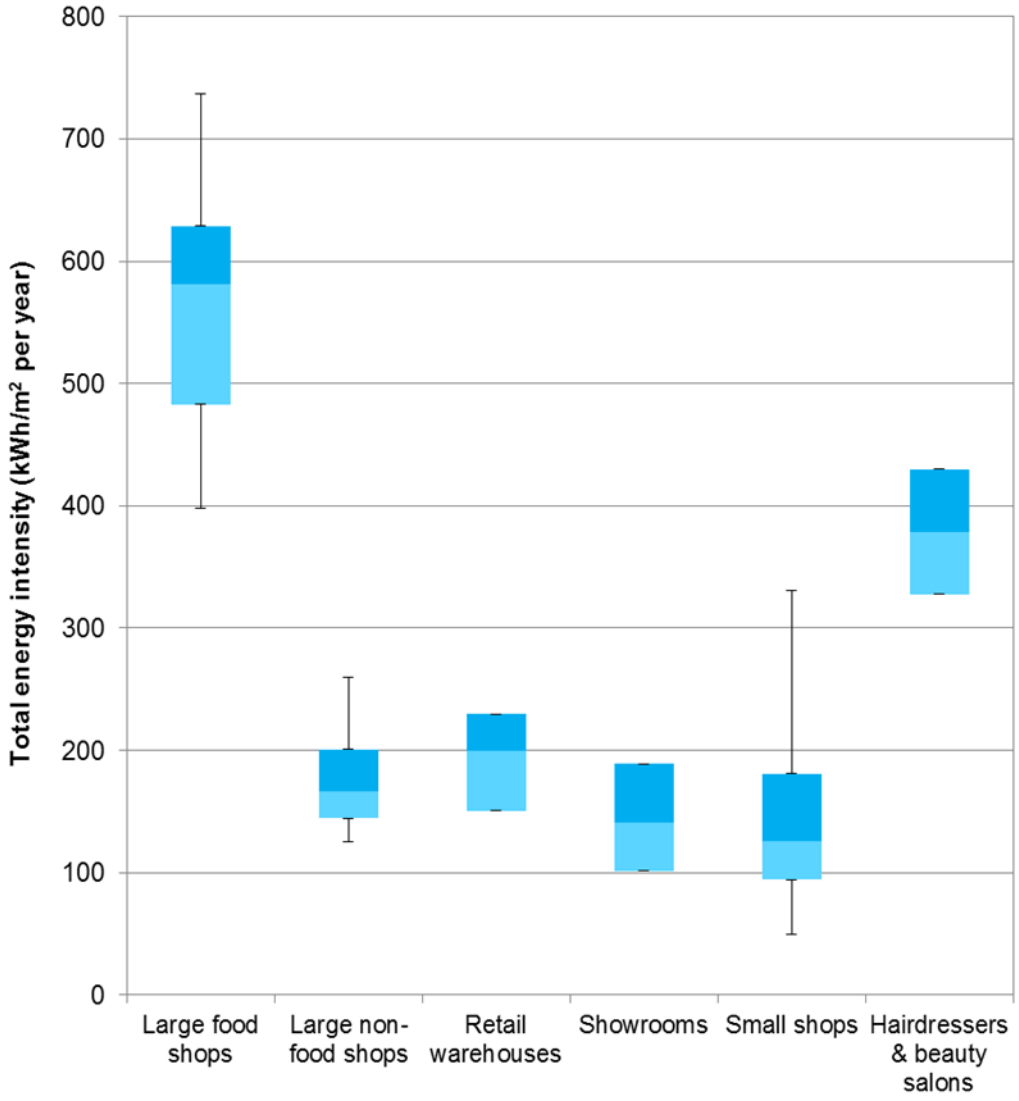
[23] The end uses are defined in Appendix C.

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

[25] 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 shows that large food shops had the highest total median energy intensity (581 kWh/m^2), followed by hairdressers & beauty salons (379 kWh/m^2). Figure 3.5 and Figure 3.6 show that large food shops premises typically displayed the highest median electrical energy intensity (387 kWh/m^2 for electrical energy). The second most energy intensive sub-sector in terms of electrical energy was hairdressers & beauty salons (278 kWh/m^2). Hairdressers & beauty salons displayed the highest median non-electrical energy intensity of 212 kWh/m^2, followed by large food shops (180 kWh/m^2). The high clustering of low non-electrical energy intensities in figure 3.6 for large non-food shops and small shops is due to their being a number of premises in these sectors where the electricity is the dominant source of heating and cooling but a small proportion of non-electrical is present.

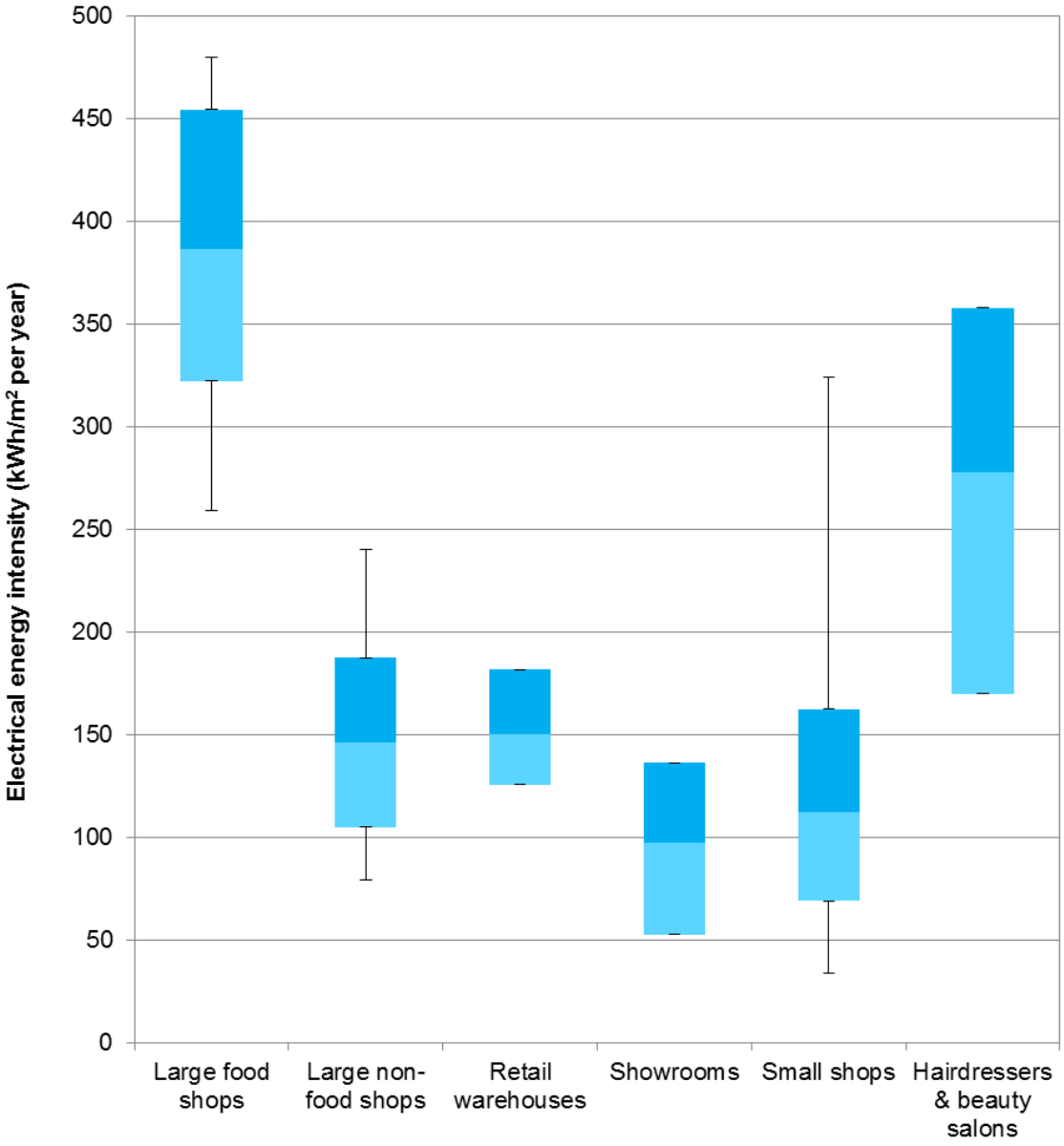
Figure 3.4: Distribution of total energy intensity by retail sub-sector, 2014–15



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

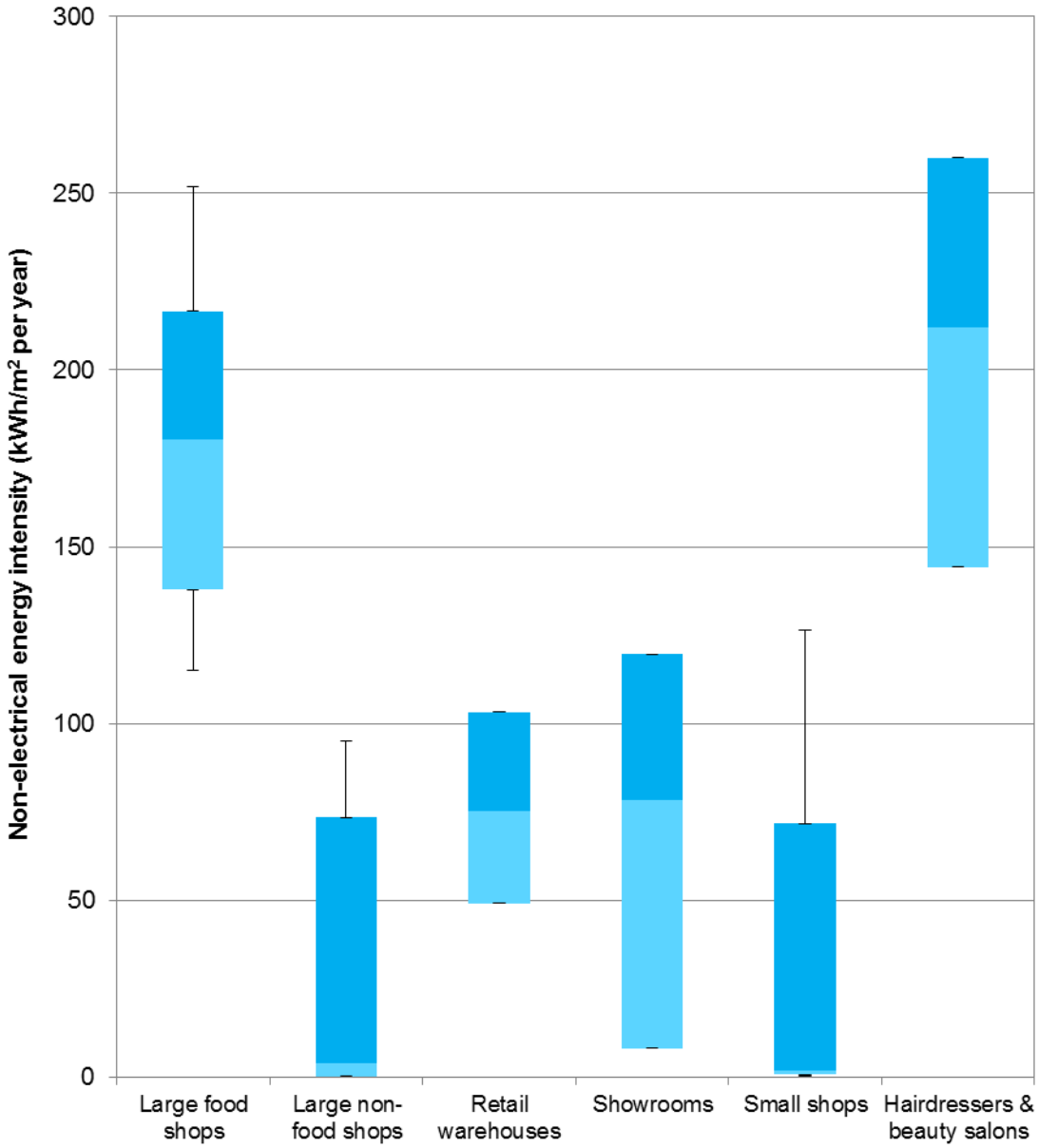
Figure 3.5: Distribution of electrical energy intensity by retail sub-sector, 2014–15



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 retail sub-sector, 2014–15



Notes: 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.

BEES reveals a high share of cases for small shops and large non-food shops with very low non-electrical intensity. These estimates are subject to high uncertainty and could be zeros.

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

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Retail 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 retail sector. Further data is provided in Appendix C where energy intensity is provided separately for electrical and non-electrical energy end use breakdowns by sub-sector.

Space heating was the largest end use, with regard to total energy consumption, for the retail sector. This was followed by cooled storage, lighting and "other". Hot water, cooling & humidification and fans contributed relatively small proportions of the total.

The high heating energy intensity in large food shops was closely linked to the presence of chilled and frozen food retail areas. Heat supplied to the customer area was absorbed by the refrigerated food cabinets. Increased levels of heating were therefore required, to combat the conflict between cooled storage and heating requirements for customers. The high cooled storage intensity in large food shops may also be partly attributed to this. It was noted during site surveys that this process negated the need for space cooling in large food shops, despite the high heat gains from lighting systems. These effects can be managed through the use of either 'curtains' or doors on cabinets, which then limits the amount of additional cooling or heating required to compensate for this.

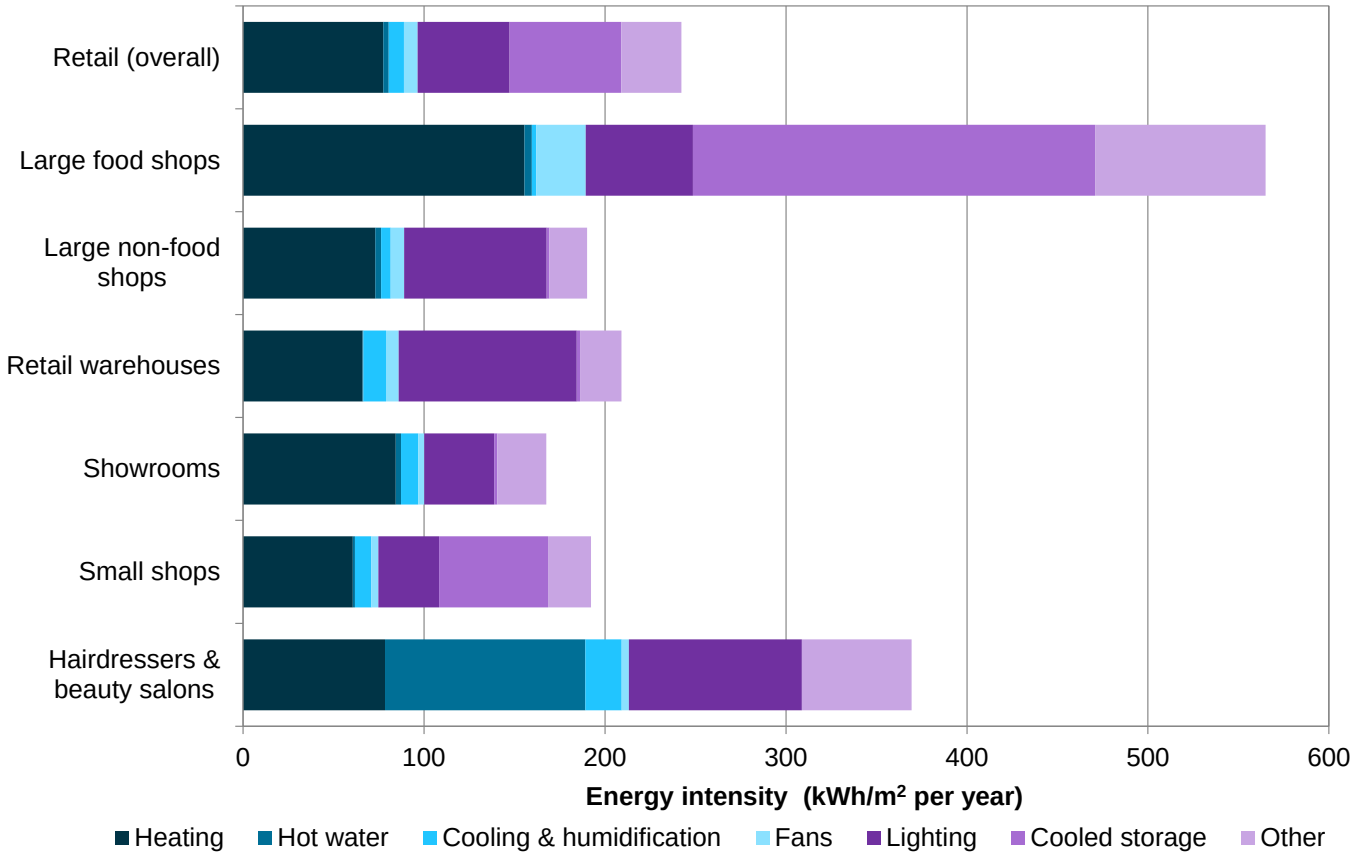
Showrooms also demonstrated a relatively high heating intensity, where high ceilings and extensive windows increased the heat loss of the premises. It was noted during site surveys for large non-food shops and retail warehouses that high heat gains from lighting reduced heating demand, resulting in comparatively low values for heating energy intensity with regard to the wider non-domestic buildings stock.

Cooled storage is concentrated in large food shops and small shops. In large food shops, it was by far the most energy intensive end use, and made this one of the most energy intensive sub-sectors in the non-domestic stock more widely. This was corroborated by sub-metering data collected in the site surveys, and other research in the sector. Small shops also exhibited high cooled storage intensities, as a result of refrigerated food cabinets in relevant shops in this sub-sector.

Lighting consumption across the retail sector was high compared to most other non-domestic sectors types, at 51 kWh/m^2 per year. This was linked to high lighting levels in many sub-sectors, particularly retail warehouses and large non-food shops. Large food shops also displayed similarly high lighting levels, but in this sub-sector site surveys and telephone surveys indicated that energy efficient lighting such as LEDs were commonplace, reducing the energy intensity. Small shops and showrooms tended towards lower lighting levels, and also shorter hours of use compared to large shops, which reduced their lighting consumption. In hairdressers & beauty salons, the use of non-essential decorative lighting, using inefficient fittings (e.g. halogen spotlights), contributed to the high lighting energy intensity in this sub-sector.

Cooling & humidification and fans were present in all sub-sectors. Fans were most significant in large food shops where long hours of use and food odours increased demand for ventilation. Cooling intensity was most significant in hairdressers & beauty salons, where heat gains from lighting and salon equipment meant many premises were air conditioned.

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



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

4. Abatement potential

In this section, abatement potential[26] for the retail 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[27], while the benefits were only based on the incremental reduction in energy consumption[28]. 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

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

[27] 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.

[28] 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 retail sector throughout England and Wales.

Total technical abatement potential for retail 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 20 and 47 per cent of total energy consumption[29]. Each sub-sector can achieve between 18 to 48 per cent savings in electrical energy consumption and 26 to 53 per cent savings in non-electrical energy consumption. This could be achieved at an overall capital expenditure of £5.83 billion.

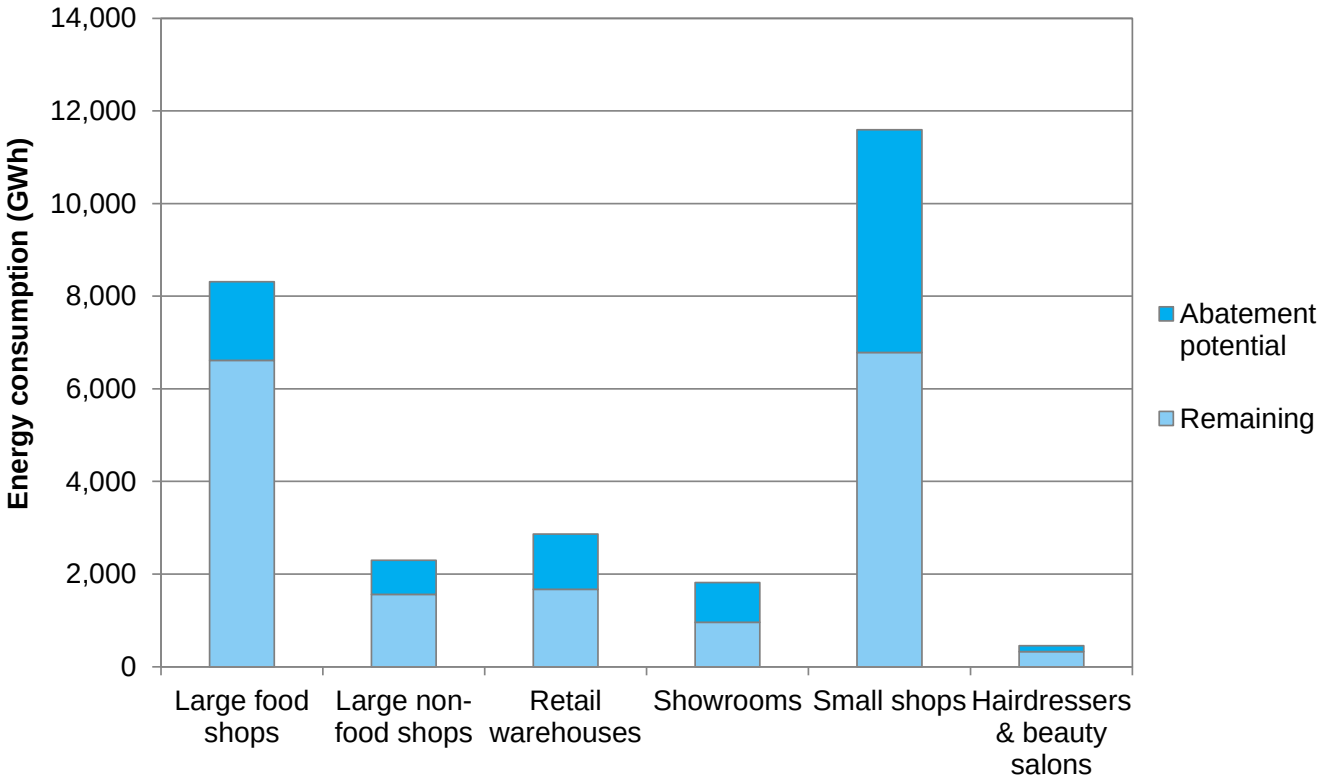
Table 4.1: Abatement potential by retail sub-sector, 2014–15

		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)
Hairdressers & beauty salons	185,800	350	100	100	30	27
Large food shops	614,300	5,940	2,380	1,070	630	20
Large non-food shops	321,200	1,910	390	590	150	32
Retail warehouses	491,400	2,130	740	880	310	42
Showrooms	373,600	1,110	700	530	330	47
Small shops	3,846,900	10,230	1,370	4,080	730	41
Total	**5,833,200**	**21,670**	**5,670**	**7,250**	**2,180**	**34**

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

[29] 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 retail sub-sector, 2014–15

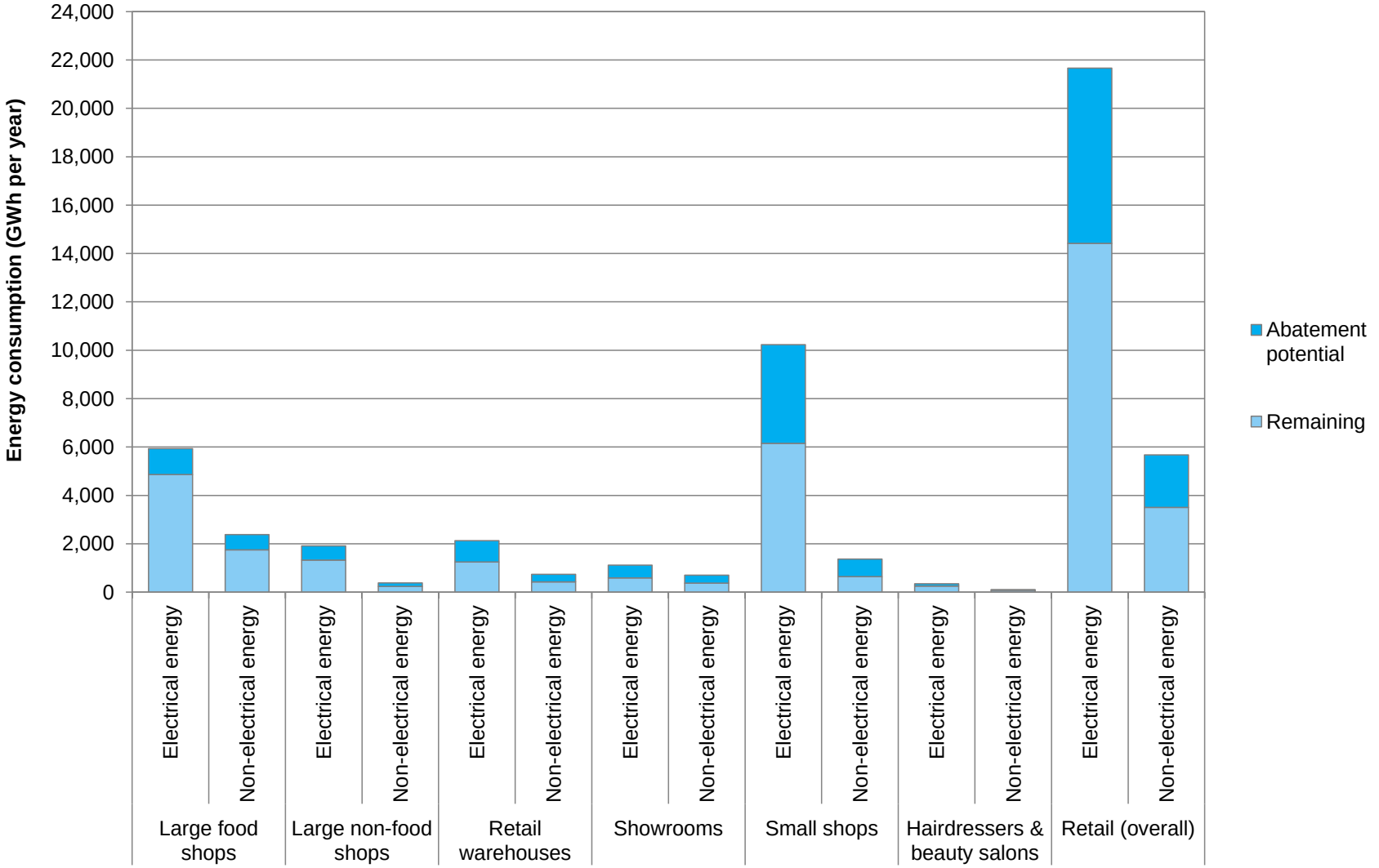


Source: Abatement model results by sub-sector, England and Wales

Figure 4.2 shows that the total technical abatement potential in 2014-15 varied by sub-sector: showrooms had the largest scope for reduction (47 per cent of total energy consumption). This compared with 42 per cent in retail warehouses, 41 per cent in small shops and 32 per cent in large non-food shops.

The results were separated into electrical and non-electrical energy. On a percentage basis there was marginally more abatement potential associated with 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 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 retail 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.[30] 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 2,820 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 1,360 GWh, of which 1,070 GWh was electrical energy consumption and 290 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.

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[30] 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

Only the lighting measure group was socially cost-effective when measure groups were considered at the sector level. If implemented, this measure group provides more financial benefits to society than costs. The lighting measure group also had relatively low payback periods, suggesting it may be more likely to get taken up, but recognising that take-up will also depend on the extent to which there are barriers.

These modelled findings corresponded broadly with opportunities identified in the site surveys. Typically site surveys identified potential savings associated with building instrumentation and controls, ventilation plant and lighting upgrades.

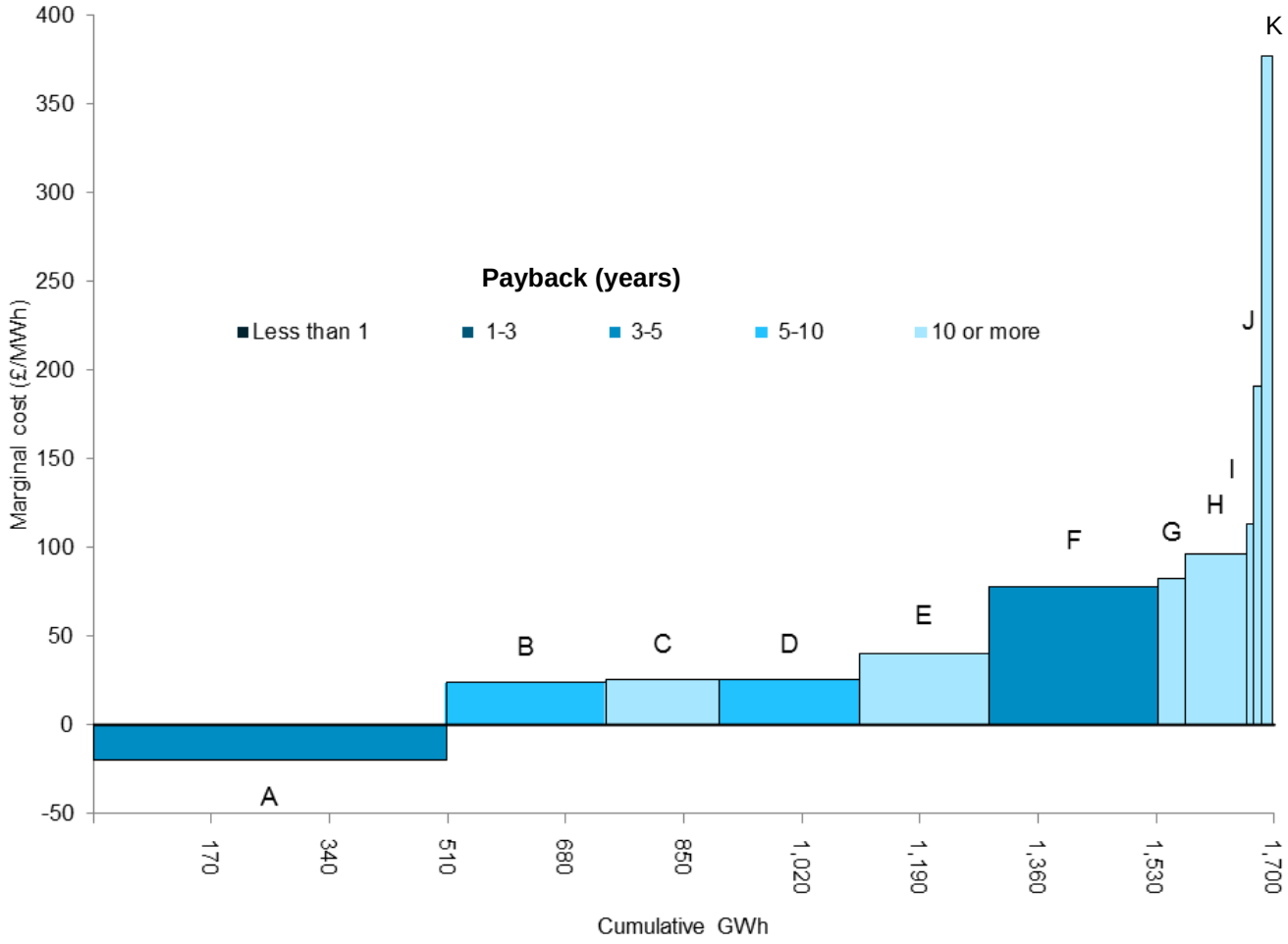
In several premises lighting upgrades to LEDs were identified. There was extensive use of halogen and standard fluorescent lights, which are more inefficient lamps than LEDs. There was also scope for motion sensors to be installed in the non-public access areas.

There were opportunities to improve the efficiency of the ventilation plant. There was scope to install variable speed drives and also to replace belt driven fans with ‘direct drive’ Electronically Commutated fans.

There was also evidence from the site surveys that energy is being wasted in areas that could be prevented, if the management and wider staff were better equipped to understand the nature of the heating, cooling and ventilation systems on site, and the best means to operate these. For example, on one such site the managers were unaware of the existence of a supply and extract ventilation system in place and that the fans were running continuously during occupied hours unnecessarily. In another site survey, one of the AC unit controllers had been set to target a temperature of 22°C whilst locked in ‘cooling only’ mode. Because the ambient temperature was above 22°C at the time it meant that the plant delivered little or no cooling or heating and yet consumed a reasonable amount of energy.

These examples were not uncommon practice for staff based on site for whom energy management is not necessarily a priority. However with relatively low investment, cost savings could be achieved through additional training and through monitoring of out of hours consumption.

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: £-20 per MWh. GWh: 2,820]
B Building instrumentation and control [MAC: £24 per MWh. GWh: 1,270]
C Building fabric [MAC: £25 per MWh. GWh: 900]
D Cooled storage [MAC: £25 per MWh. GWh: 1,120]
E Space heating [MAC: £40 per MWh. GWh: 1,040]
F Carbon and Energy Management [MAC: £78 per MWh. GWh: 1,350]
G Air conditioning and cooling [MAC: £83 per MWh. GWh: 220]
H Ventilation [MAC: £96 per MWh. GWh: 490]
I Hot water [MAC: £113 per MWh. GWh: 50]
J Small appliances [MAC: £191 per MWh. GWh: 70]
K Building services distribution systems [MAC: £377 per MWh. GWh: 90]

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

Table 4.2[31] shows the abatement potential by measure type. The most significant available savings were associated with lighting upgrades, carbon & energy management measures and building instrumentation & control measures. The most significant available savings – in terms of annual energy bill savings - were associated with lighting, carbon & energy management and building instrumentation & controls. It is worth noting that the opportunities associated with cooled storage are restricted to those sub-sectors where cooled storage is a substantial end use i.e. typically the food retailers where food is being preserved under chilled or frozen temperatures.

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

Measure type	Savings					Total capital cost of measure (£ thousands)
	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)	
Air conditioning and cooling	22,300	60	220	-	220	241,300
Building fabric	59,900	180	500	400	900	1,197,100
Building instrumentation and control	77,200	310	610	660	1,270	519,200
Building services distribution systems	8,600	30	90	-	90	222,400
Carbon and energy management	113,400	400	1,070	290	1,360	352,700
Hot water	1,900	10	7	50	50	72,700
Humidification	-	-	-	-	-	-
Lighting	280,100	800	2,820	-	2,820	1,231,700
Cooled storage	110,900	330	1,120	-	1,120	711,100
Small appliances	6,700	20	70	2	70	82,900
Space heating	45,000	220	250	790	1,040	685,700
Swimming pools	-	-	-	-	-	-
Ventilation	49,000	150	490	1	490	516,400
Total	**775,000**	**2,500**	**7,250**	**2,180**	**9,420**	**5,833,200**

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

[31] 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)
Hairdressing & beauty salons	285	± 38
Large food shops	403	± 27
Large non-food shops	158	± 14
Retail warehouses	155	± 20
Showrooms	103	± 20
Small shops	170	± 20
Retail	**192**	**± 17**

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

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Hairdressing & beauty salons	84	± 34
Large food shops	162	± 15
Large non-food shops	32	± 12
Retail warehouses	54	± 16
Showrooms	65	± 16
Small shops	23	± 5
Retail	**50**	**± 7**

Response rates

Due to the use of mystery shopper records in large food shops, large non-food shops and retail warehouses it was not possible to calculate response rates for these sub-sectors.

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

	Large food shops (%)	Large non-food shops (%)	Retail warehouses (%)	Showrooms (%)	Small shops (%)	Hairdressers & beauty salons (%)
Completed interview	N/A	N/A	N/A	10	16	17
Still live[32]	N/A	N/A	N/A	48	46	26
Screening failure/other non-response[33]	N/A	N/A	N/A	7	5	7
Refusal	N/A	N/A	N/A	22	24	40
Invalid contact details	N/A	N/A	N/A	13	10	9

N/A – not applicable

[32] 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).

[33] 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: Retail method challenges and data collection

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

Retail sector methodology challenges

In the case of the retail 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: Retail sector approach challenges

Stage	Challenge	Response	Impact
Design	The retail sector was very diverse, and the Valuation Office Agency's SCAT.PD classifications were based primarily on size and form (e.g. large, small, department store) rather than the product classifications sold. This made targeting telephone survey questions challenging as a very wide range of activities must be covered.	Within small shops, the respondent was required to confirm whether they were a food or non-food shop in order to identify the correct telephone survey questions. In other sub-sectors, simple indicators such as proportion of floor area were used to determine the extent of energy intensive sales activities e.g. food and electrical sales areas.	The primary impact of this issue was increased modelling challenges, due to the diversity of activities which needed to be covered within the sector. The limitations inherent within the telephone survey mean that certain unusual energy uses would not have been captured.
Data collection	Many large retailers declined to participate in the survey via the direct telephone survey approach targeted at stores.	Multiple responses were required: 1. Retailers were contacted at head office level and asked to participate directly. This required a pragmatic approach to populating telesurvey records and identifying site survey records, resulting in a reduced variety of premises in the records used in the study. Sub-sectors affected were small shops, hairdressers & beauty salons, large	Where direct contact with retailers was used, this created a significant selection bias within the telesurvey and site survey records, but also improved the quality of some of the telephone survey data as a consequence of the methods of data collection used. Site survey results were also improved due to easier access to technical information and energy data with support from head office. Where the mystery shopper

Stage	Challenge	Response	Impact
		non-food shops, large food shops and retail warehouses. 2. A “mystery shopper” approach was used where it was not possible to elicit sufficient participation through direct contact. This approach used public access visits to the retail premises to collect a limited subset of the intended telephone survey data for each premises. This method was used in large food, large non-food and retail warehouse sub-sectors. All records for department stores (included in large non-food shops) were mystery shopper records.	approach was used, confidence in the modelling results was weaker. A significant proportion of the questions in the telesurvey could not be answered using this method and many assumptions were required; including some relating to critical fields relating to basic building services. No information was collected on non-customer areas so energy intensive activities may have been missed entirely.
Data collection	It was not possible to achieve satisfactory participation levels in the study via standard means for all the of the original sub-sector groups. Instead organisations needed to be directly recruited to participate in the programme. As a result, the original sub-sectors could not be reported separately because they could disclose commercial sensitive data about the participants. Instead the data for these sub-sectors was included in another analogous sub-sector to ensure anonymity.	To avoid disclosing sensitive information sub-sectors have been merged for reporting purposes. The mergers were: - Small shops: This contains small food shops, small non-food shops and betting shops - Large food shops: This contains supermarkets and large food shops - Large non-food shops: This contains large non-food shops and department stores. - Showrooms: This contains vehicle and non-vehicle showrooms.	The results for merged sub-sectors may obscure underlying more distinct energy related characteristics associated with the original sub-sector allocation.
Data collection	Analysis of mystery shopper data suggested a tendency to exaggerate the share of a store which was dedicated to refrigerated or frozen produce (when compared to site survey results for similar but different premises).	No further action could be taken in this case, it is an inherent accuracy limitation of the method; the suspected error could not be conclusively verified within the limitations of the study.	Cooled storage in large food shops may be exaggerated by a modest amount as a consequence of this data collection method.

Stage	Challenge	Response	Impact
Data collection	Complexity of large food shop premises limited site survey detail. For example in large food shops, it was not possible to collect an inventory of all equipment within the timescales, and unaccounted energy use of up to 20% of total was noted.	The surveyors focussed on the most significant end uses where the greatest consumption and abatement potential is found. Energy modelling was calibrated to match known energy consumption from end uses surveyed, and energy uses where loads were not accounted for were excluded.	Energy consumption estimates may be lower than actual data in these cases. In terms of major energy uses and abatement potential the impact is expected to be small.
Data processing	Exceptionally broad range of retail activities within the BEES sub-sectors presents a considerable modelling challenge. Limited sample size and participation issues prevented the study from collecting detailed data around the type of products sold.	Modelling approach distinguished between general retail, electrical retail, chilled and frozen retail and then sought to account for as many non-standard activities (e.g. display screens) as possible. However, product specific issues would not be captured unless they affected responses to generic questions in the telephone survey.	Variation between model predictions and matched data was notably higher in very mixed sub-sectors such as small shops, large non-food shops and retail warehouses. Certain significant end uses such as food preparation in small shops could not be quantified due to data collection limitations, and shortfalls were noted in BEES estimates in sub-sectors where these uses were more common.
Data processing	Differentiation of display lighting and general lighting was not possible in many site surveys, as lighting installations were often designed as a whole rather than in two separate elements.	Energy model calibration was undertaken based on the combined total for these two end uses and this combined total is presented in this report.	The end use level data for these end uses should not be analysed or used separately, but the total lighting consumption estimates are considered robust.
Data processing	Heat gains and cooled storage have significant knock on effects on end use consumption in some sub-sectors. This is notable in large non-food stores and retail warehouses where heat gains from lighting offset heating; hairdressers & beauty salons where lighting and equipment gains increase cooling demand, small shops where gains from display screens in some premises types offset heating demand, and large food	The energy model used in the study is not a dynamic model, so it was necessary to make standard adjustments to the energy end use demands in certain retail spaces to account for these issues where they were identified.	These adjustments were only made where they could be corroborated against site survey data. They adjusted the relevant end use energy consumption for all records, so while the results across all the records produce a robust average, increased variation at individual record level is expected where these issues occur.

Stage	Challenge	Response	Impact
	stores where refrigerated storage results in increased heating demand.		

Telephone survey and site survey data collection

Table B.2 shows that 1,033 telephone survey or equivalent records and 48 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[34]	Average interview length (mins.)[35]	Target sample size	Site surveys completed
Hairdressers & beauty salons	50	50	10	60	56	20	6	0
Large food shops	100	8	55	63	63	27	14	8
Large non-food shops	70	20	58	78	74	22	14	6
Retail warehouses	50	24	26	50	49	22	7	7
Showrooms	100	96	0	96	89	21	6	5
Small shops	1,025	731	29	760	702	22	22	22
Retail sector	**1,395**	**929**	**178**	**1,107**	**1,033**	**22**	**69**	**48**

Source: Telephone survey or equivalent records, England and Wales

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

[35] Average interview length applies only to those records collected through the standard telephone survey route.

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 retail 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 below

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.

End use category		Description
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.
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**	Energy used for equipment in laboratories.

End use category		Description
	equipment	
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.

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	Other
	Distributed catering	Other
	Small power	Other
	Pumps	Other
	Controls	Other
	Lighting - display	Lighting
	Lighting - external	Other
	Vertical transport	Other
	Cooled storage	Cooled storage
	Entertainment equipment	Other
	Pool/leisure	Other
	Laundry	Other
	ICT equipment	Other
	Lab equipment	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 retail sub-sector and for the sector combined. Tables C.5 and C.6 show energy intensity by end use for each retail sub-sector and for the sector combined.

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

Simplified end use category	BEES energy end use category	Electrical energy consumption (GWh per year)						
		Large food shops	Large non-food shops	Retail warehouses	Showrooms	Small shops	Hairdressers & beauty salons	**Retail sector**
Heating	Space heating	90	530	170	240	2,390	60	3,470
Hot water	Hot water	40	10	4	10	40	70	180
Cooling & umidification	Space cooling	40	60	170	100	550	20	950
Fans	Fans	400	90	100	40	230	5	860
Lighting	Lighting - internal	590	640	1,040	410	1,930	100	4,700
	Lighting - display	280	310	310	10	100	20	1,030
Cooled storage	Cooled storage	3,270	20	30	20	3,630	-	6,960
Other	ICT equipment	2	3	10	4	70	0	90
	Small power	30	70	40	30	360	10	530
	Pumps	40	10	20	20	70	2	160
	Controls	20	20	20	10	70	2	140
	Humidification	-	-	-	-	-	-	-
	Laundry	-	-	-	-	-	10	10
	Lighting - external	40	10	20	90	80	0	230
	Entertainment lighting	-	-	-	-	-	-	-
	Vertical transport	-	10	1	1	10	-	20
	Medical equipment	-	-	-	-	-	-	-
	Distributed catering	30	20	10	10	50	1	120
	Central catering	380	2	-	3	30	-	420
	Entertainment equipment	40	60	120	60	400	10	690
	Lab equipment	-	-	-	-	-	-	-
	Pool/leisure	-	-	-	-	-	-	-
	Other	640	50	70	70	230	40	1,100
Total		**5,940**	**1,910**	**2,130**	**1,110**	**10,230**	**350**	**21,670**
Unweighted base		*63*	*74*	*49*	*89*	*701*	*57*	*1,033*

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

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

Simplified end use category	BEES energy end use category	Non-electrical energy consumption (GWh per year)						
		Large food shops	Large non-food shops	Retail warehouses	Showrooms	Small shops	Hairdressers & beauty salons	**Retail sector**
Heating	Space heating	2,200	360	740	680	1,260	40	5,270
Hot water	Hot water	20	30	2	20	30	60	160
Catering	Catering	160	3	-	10	70	-	240
Other	Pool/leisure	-	-	-	-	-	-	**-**
	Humidification	-	-	-	-	-	-	**-**
Total		**2,380**	**390**	**740**	**700**	**1,370**	**100**	**5,670**
Unweighted base		*63*	*66*	*36*	*68*	*352*	*28*	*613*

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

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

Simplified end use category	BEES energy end use category	Electrical energy intensity (kWh/m^2 per year)						
		Large food shops	Large non-food shops	Retail warehouses	Showrooms	Small shops	Hairdressers & beauty salons	**Retail sector**
Heating	Space heating	6	44	12	22	40	45	31
Hot water	Hot water	3	1	0	1	1	60	2
Cooling & humidification	Space cooling	3	5	12	10	9	20	8
Fans	Fans	27	7	7	3	4	4	8
Lighting	Lighting - internal	40	53	76	37	32	82	42
	Lighting - display	19	26	23	1	2	13	9
Cooled storage	Cooled storage	222	2	2	2	60	0	62
Other	ICT equipment	0	0	0	0	1	0	1
	Small power	2	5	3	3	6	6	5
	Pumps	2	1	1	2	1	2	1
	Controls	1	1	1	1	1	1	1
	Humidification	-	-	-	-	-	-	-
	Laundry	-	-	-	-	-	7	0
	Lighting - external	3	1	2	8	1	0	2
	Entertainment lighting	-	-	-	-	-	-	-
	Vertical transport	0	1	0	0	0	-	0
	Medical equipment	-	-	-	-	-	-	-
	Distributed catering	2	1	1	1	1	0	1
	Central catering	26	0	-	0	1	-	4
	Entertainment equipment	3	5	9	5	7	8	6
	Lab equipment	-	-	-	-	-	-	-
	Pool/leisure	-	-	-	-	-	-	-
	Other	44	4	5	6	4	36	10
Total		**403**	**158**	**155**	**103**	**170**	**285**	**192**
Unweighted base		*63*	*74*	*49*	*89*	*701*	*57*	*1,033*

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

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

Simplified end use category	BEES energy end use category	Non-electrical energy intensity (kWh/m^2 per year)						
		Large food shops	Large non-food shops	Retail warehouses	Showrooms	Small shops	Hairdressers & beauty salons	**Retail sector**
Heating	Space heating	149	29	54	62	21	33	47
Hot water	Hot water	1	2	0	2	1	51	1
Catering	Catering	11	0	-	1	1	-	2
Other	Pool/leisure	-	-	-	-	-	-	-
	Humidification	-	-	-	-	-	-	-
Total		**162**	**32**	**54**	**65**	**23**	**84**	**50**
Unweighted base		*63*	*74*	*49*	*89*	*701*	*57*	*1033*

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

Appendix D: Abatement potential

The definitions for each measure type are included in this appendix as well as the abatement potential for each retail 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.

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).

Large food shops

In large food shops there was an annual abatement potential of 1,070 GWh of electrical energy and 630 GWh of non-electrical energy (equivalent to 430 $ktCO_2e$ combined). This equates to a 18 per cent and 26 per cent reduction on energy consumption respectively. The capital cost to achieve this is £614m. The annual savings delivered would be £122m[36]. These figures are grouped according to measure type in Table D.2. The total abatement potential of the socially cost effective measure groups was 630 GWh, of which 360 GWh was electrical energy consumption and 260 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 260 GWh, of which 50 GWh was electrical energy consumption and 210 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 large food shops, 2014–15

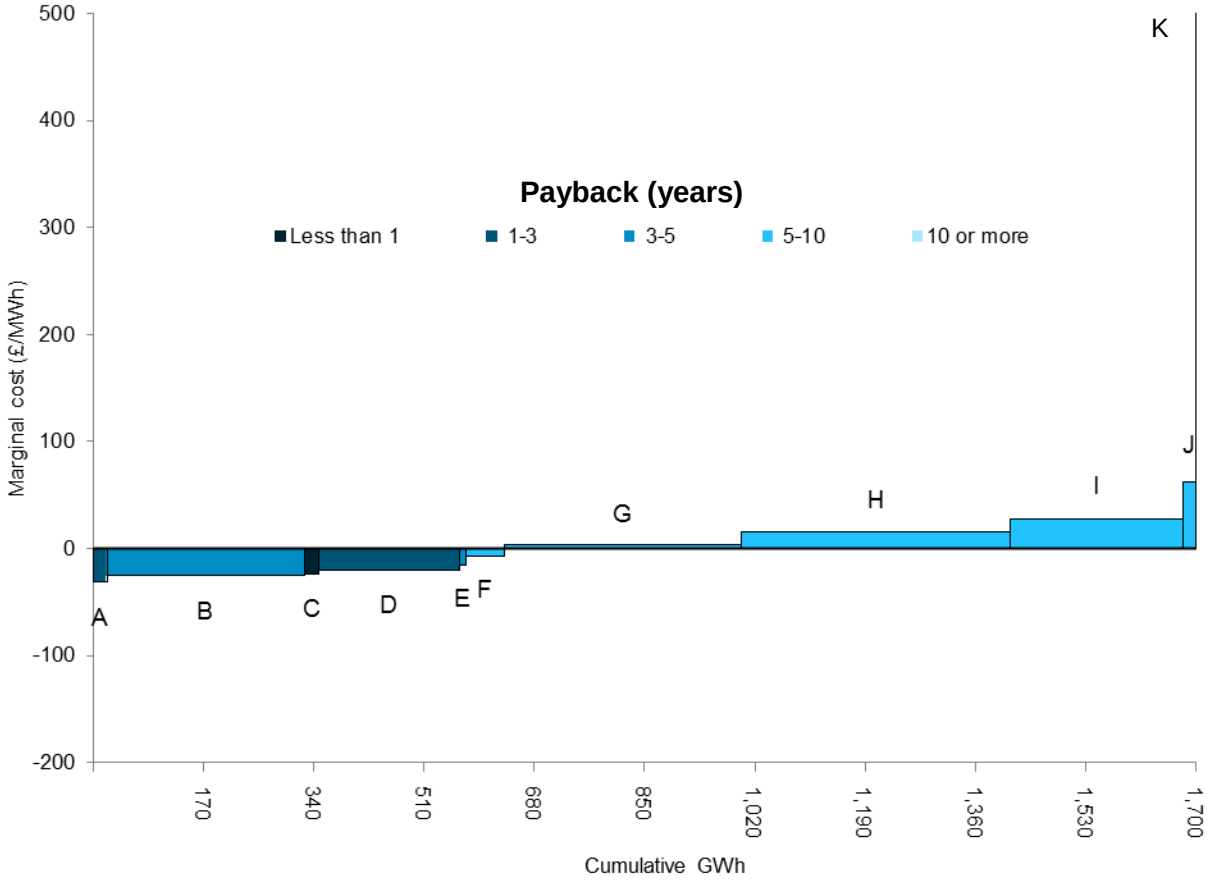
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[37]
Air conditioning and cooling	1,600	5	20	-	20	10,900	8
Building fabric	2,100	10	9	50	60	19,100	8
Building instrumentation and control	7,200	40	20	190	220	12,800	2
Building services distribution systems	0	0	0	-	0	700	30
Carbon and energy management	800	4	4	20	20	400	1
Hot water	200	1	1	5	5	900	5
Humidification	-	-	-	-	-	-	-
Lighting	30,600	90	310	-	310	111,800	3
Cooled storage	41,900	130	420	-	420	240,800	6
Small appliances	1,800	6	20	0	20	3,000	2
Space heating	9,800	70	6	360	370	62,100	9
Swimming pools	-	-	-	-	-	-	-
Ventilation	26,300	80	270	-	270	151,700	4
Total	**122,300**	**430**	**1,070**	**630**	**1,700**	**614,300**	‘’

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

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

[37] 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 large food shops, 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. Note also that series 'K' are not visible as the y-axis has been capped for presentation purposes .

A Small appliances [MAC: £-31 per MWh. GWh: 20]
B Lighting [MAC: £-25 per MWh. GWh: 310]
C Carbon and energy management [MAC: £-24 per MWh. GWh: 20]
D Building instrumentation and control [MAC: £-21 per MWh. GWh: 220]
E Hot water [MAC: £-15 per MWh. GWh: 10]
F Building fabric [MAC: £-7 per MWh. GWh: 60]
G Space heating [MAC: £3 per MWh. GWh: 370]
H Cooled storage [MAC: £16 per MWh. GWh: 420]
I Ventilation [MAC: £27 per MWh. GWh: 270]
J Air conditioning and cooling [MAC: £62 per MWh. GWh: 20]
K Building services distribution systems [MAC: £639 per MWh. GWh: 1]

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

Large non-food shops

In large non-food shops there was an annual abatement potential of 590 GWh of electrical energy and 150 GWh of non-electrical energy (equivalent to 200 $ktCO_2e$ combined). This equates to a 31 per cent and 38 per cent reduction on energy consumption respectively. The capital cost to achieve this is £321m. The annual savings delivered would be £62m[38]. These figures are grouped according to measure type in Table D.3. The total abatement potential of the socially cost effective measure groups was 570 GWh, of which 470 GWh was electrical energy consumption and 90 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 160 GWh, of which 90 GWh was electrical energy consumption and 70 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 large non-food shops, 2014–15

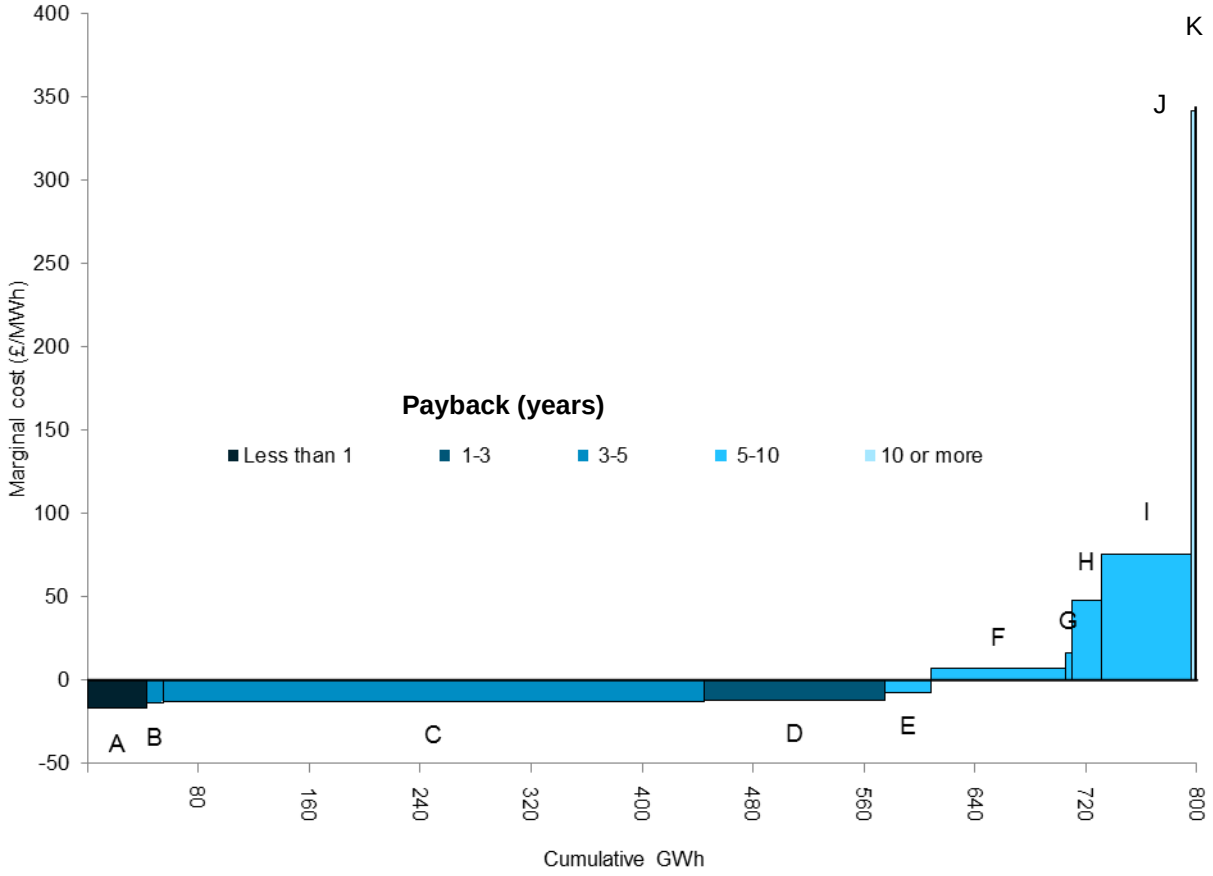
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[39]
Air conditioning and cooling	1,600	5	20	-	20	10,200	7
Building fabric	2,200	8	20	20	30	15,300	5
Building instrumentation and control	7,300	30	60	60	120	20,100	3
Building services distribution systems	200	1	2	-	2	5,400	13
Carbon and energy management	3,400	10	30	8	40	2,500	1
Hot water	200	1	1	7	7	1,100	4
Humidification	-	-	-	-	-	-	-
Lighting	36,100	100	360	-	360	176,600	4
Cooled storage	400	1	4	-	4	2,400	6
Small appliances	100	0	1	0	1	2,400	15
Space heating	4,400	20	30	60	90	27,100	7
Swimming pools	-	-	-	-	-	-	-
Ventilation	6,200	20	60	-	60	58,000	7
Total	**62,200**	**200**	**590**	**150**	**740**	**321,200**	‘’

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

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

[39] 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 large non-food shops, 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 Carbon and energy management [MAC: £-17 per MWh. GWh: 40]
B Hot water [MAC: £-14 per MWh. GWh: 10]
C Lighting [MAC: £-13 per MWh. GWh: 360]
D Building instrumentation and control [MAC: £-12 per MWh. GWh: 120]
E Building fabric [MAC: £-7 per MWh. GWh: 30]
F Space heating [MAC: £7 per MWh. GWh: 90]
G Cooled storage [MAC: £16 per MWh. GWh: 4]
H Air conditioning and cooling [MAC: £48 per MWh. GWh: 20]
I Ventilation [MAC: £75 per MWh. GWh: 60]
J Building services distribution systems [MAC: £342 per MWh. GWh: 2]
K Small appliances [MAC: £344 per MWh. GWh: 1]

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

Retail warehouses

In retail warehouses there was an annual abatement potential of 880 GWh of electrical energy and 310 GWh of non-electrical energy (equivalent to 320 $ktCO_2e$ combined). This equates to a 41 per cent and 42 per cent reduction on energy consumption respectively. The capital cost to achieve this is £491m. The annual savings delivered would be £95m[40]. These figures are grouped according to measure type in Table D.4. The total abatement potential of the socially cost effective measure groups was 900 GWh, of which 730 GWh was electrical energy consumption and 170 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 340 GWh, of which 170 GWh was electrical energy consumption and 170 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 retail warehouses, 2014–15

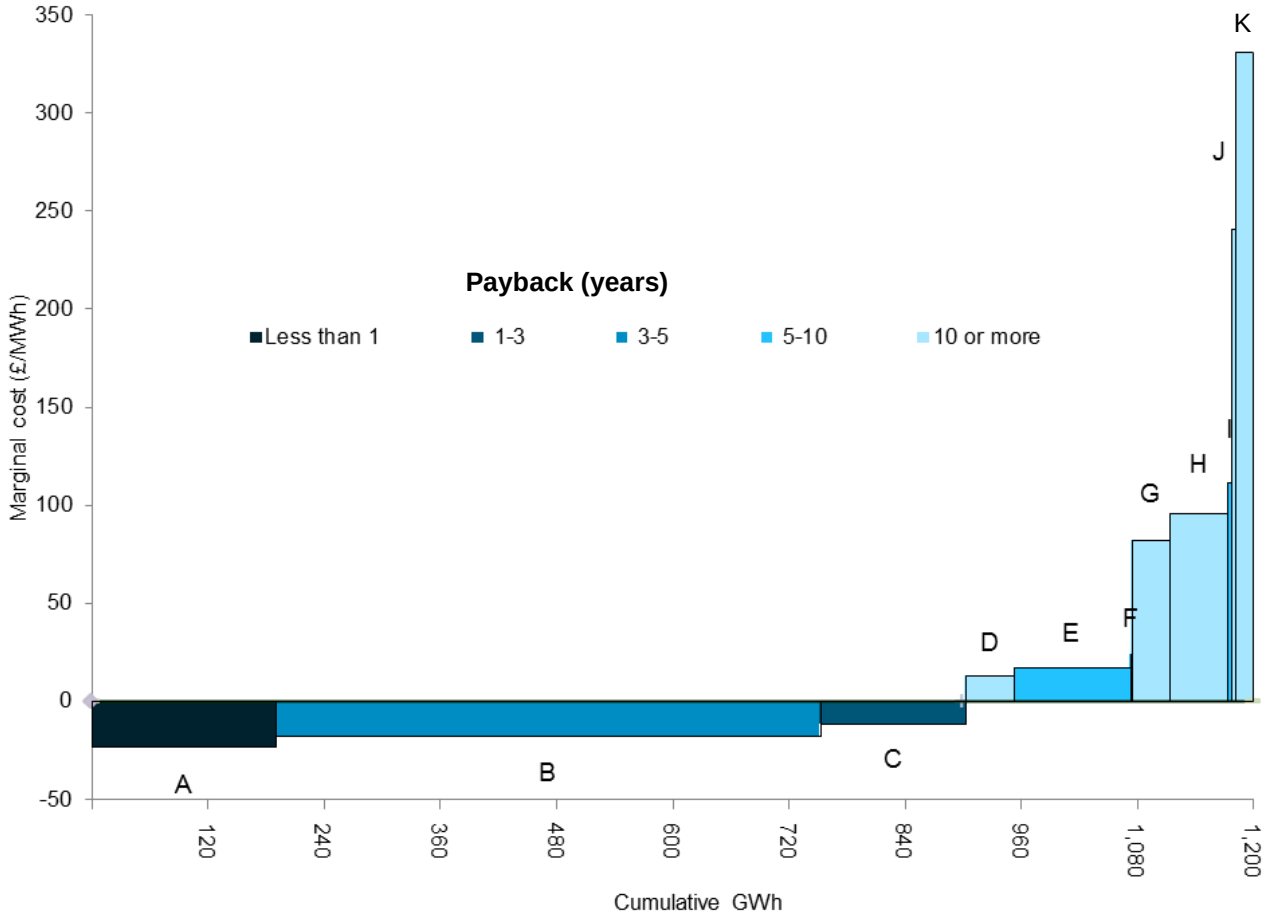
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[41]
Air conditioning and cooling	3,900	10	40	-	40	39,900	13
Building fabric	2,100	10	10	40	50	28,100	8
Building instrumentation and control	6,100	30	30	110	150	18,200	3
Building services distribution systems	2,200	7	20	-	20	47,200	11
Carbon and energy management	14,600	50	130	60	190	8,700	1
Hot water	0	0	0	0	1	1,100	37
Humidification	-	-	-	-	-	-	-
Lighting	56,000	160	560	-	560	243,900	4
Cooled storage	300	1	3	-	3	2,100	6
Small appliances	300	1	3	0	3	2,400	7
Space heating	4,000	20	10	100	120	37,000	10
Swimming pools	-	-	-	-	-	-	-
Ventilation	5,900	20	60	-	60	62,700	7
Total	**95,300**	**320**	**880**	**310**	**1,190**	**491,400**	‘’

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

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

[41] 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 retail warehouses, 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 Carbon and energy management [MAC: £-23 per MWh. GWh: 190]
B Lighting [MAC: £-18 per MWh. GWh: 560]
C Building instrumentation and control [MAC: £-12 per MWh. GWh: 150]
D Building fabric [MAC: £13 per MWh. GWh: 50]
E Space heating [MAC: £17 per MWh. GWh: 120]
F Cooled storage [MAC: £24 per MWh. GWh: 1]
G Air conditioning and cooling [MAC: £82 per MWh. GWh: 40]
H Ventilation [MAC: £96 per MWh. GWh: 60]
I Small appliances [MAC: £112 per MWh. GWh: 3]
J Hot water [MAC: £241 per MWh. GWh: 3]
K Building services distribution systems [MAC: £331 per MWh. GWh: 20]

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

Showrooms

In showrooms there was an annual abatement potential of 530 GWh of electrical energy and 330 GWh of non-electrical energy (equivalent to 220 $ktCO_2e$ combined). This equates to a 47 per cent and 47 per cent reduction on energy consumption respectively. The capital cost to achieve this is £374m. The annual savings delivered would be £61m[42]. These figures are grouped according to measure type in Table D.5. The total abatement potential of the socially cost effective measure groups was 420 GWh, of which 330 GWh was electrical energy consumption and 100 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 440 GWh, of which 380 GWh was electrical energy consumption and 60 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 showrooms, 2014–15

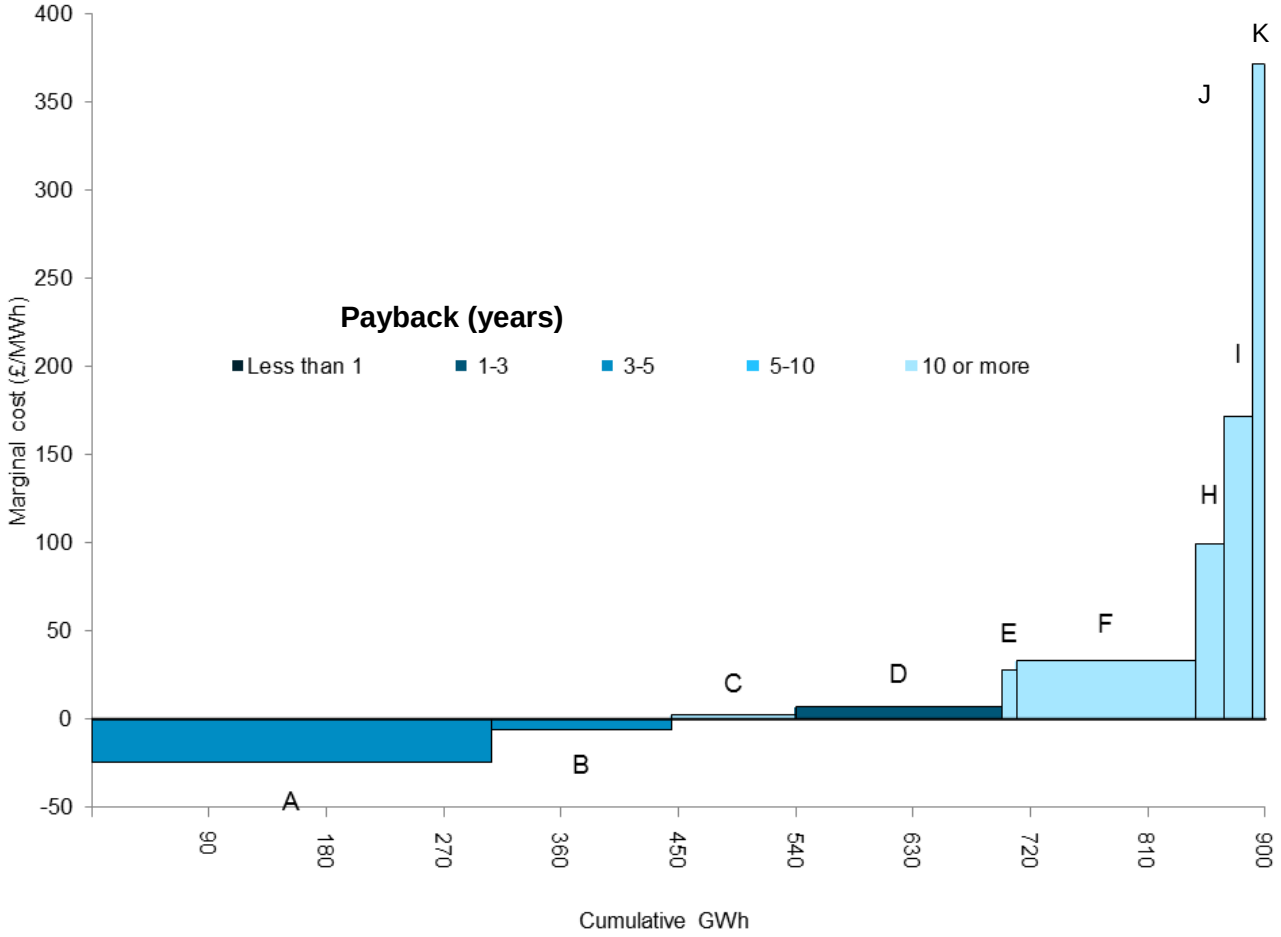
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[43]
Air conditioning and cooling	2,400	7	20	-	20	24,100	13
Building fabric	4,400	20	30	70	90	70,200	10
Building instrumentation and control	6,300	30	40	100	140	24,500	3
Building services distribution systems	900	3	10	-	10	22,600	10
Carbon and energy management	10,700	40	90	60	150	16,300	1
Hot water	200	2	1	7	8	4,200	15
Humidification	-	-	-	-	-	-	-
Lighting	28,500	80	290	-	290	112,300	3
Cooled storage	400	1	4	-	4	3,200	8
Small appliances	300	1	3	0	3	5,000	14
Space heating	5,200	30	30	110	130	63,100	11
Swimming pools	-	-	-	-	-	-	-
Ventilation	1,700	5	20	1	20	28,300	11
Total	**61,000**	**220**	**530**	**330**	**860**	**373,600**	‘’

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

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

[43] 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 showrooms, 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: £-25 per MWh. GWh: 290]

B Building instrumentation and control [MAC: £-6 per MWh. GWh: 130]

C Building fabric [MAC: £2 per MWh. GWh: 90]

D Carbon and energy management [MAC: £7 per MWh. GWh: 150]

E Hot water [MAC: £28 per MWh. GWh: 10]

F Space heating [MAC: £33 per MWh. GWh: 130]

G Cooled storage [MAC: £62 per MWh. GWh: 0]

H Air conditioning and cooling [MAC: £100 per MWh. GWh: 20]

I Ventilation [MAC: £172 per MWh. GWh: 20]

J Small appliances [MAC: £269 per MWh. GWh: 0]

K Building services distribution systems [MAC: £372 per MWh. GWh: 10]

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

Small shops

In small shops there was an annual abatement potential of 4,080 GWh of electrical energy and 730 GWh of non-electrical energy (equivalent to 1,320 $ktCO_2e$ combined). This equates to a 40 per cent and 53 per cent reduction on energy consumption respectively. The capital cost to achieve this is £3.85bn. The annual savings delivered would be £424m[44]. These figures are grouped according to measure type in Table D.6. The total abatement potential of the socially cost effective measure groups was 1,240 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 940 GWh, of which 800 GWh was electrical energy consumption and 140 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.5).

Table D.6: Abatement opportunity data for small shops, 2014–15

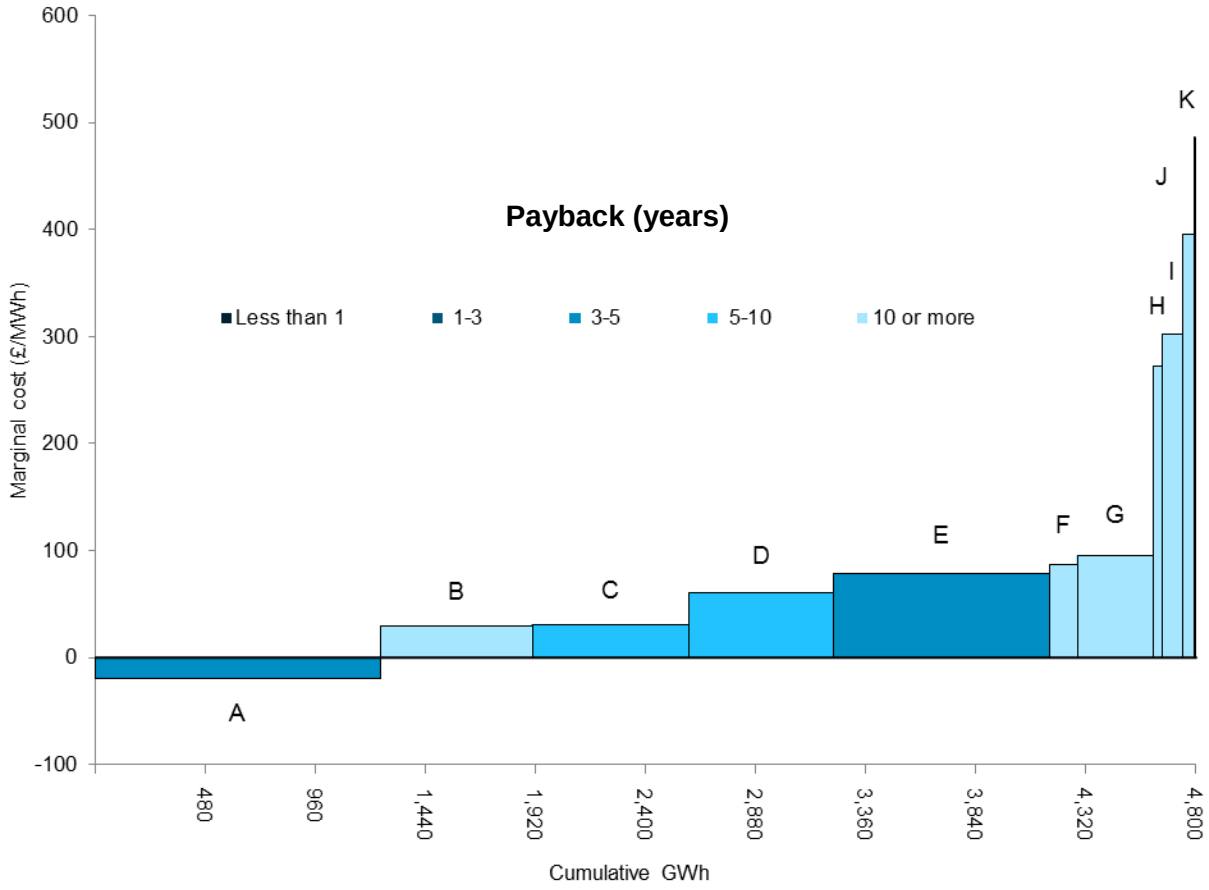
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years)[45]
Air conditioning and cooling	12,400	40	130	-	130	150,400	12
Building fabric	49,000	140	440	230	660	1,037,800	14
Building instrumentation and control	48,800	170	440	190	630	426,100	7
Building services distribution systems	5,100	20	50	-	50	142,400	11
Carbon and energy management	82,600	280	800	140	940	250,400	2
Hot water	500	3	3	10	10	61,200	97
Humidification	-	-	-	-	-	-	-
Lighting	123,300	350	1,240	-	1,240	569,400	3
Cooled storage	67,900	200	680	-	680	462,500	6
Small appliances	4,200	10	40	2	40	67,200	14
Space heating	21,300	80	170	160	330	468,300	14
Swimming pools	-	-	-	-	-	-	-
Ventilation	8,900	30	90	0	90	211,100	16
Total	**424,100**	**1,320**	**4,080**	**730**	**4,810**	**3,846,900**	‘’

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

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

[45] 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.5: Marginal abatement cost curve for small shops, 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. Note also that series 'K' are not visible as the y-axis has been capped for presentation purposes .

A Lighting [MAC: £-20 per MWh. GWh: 1,240]
B Building fabric [MAC: £30 per MWh. GWh: 660]
C Colled storage [MAC: £31 per MWh. GWh: 680]
D Building instrumentation and control [MAC: £60 per MWh. GWh: 630]
E Carbon and energy management [MAC: £78 per MWh. GWh: 940]
F Air conditioning and cooling [MAC: £86 per MWh. GWh: 120]
G Space heating [MAC: £96 per MWh. GWh: 330]
H Small appliances [MAC: £272 per MWh. GWh: 40]
I Ventilation [MAC: £302 per MWh. GWh: 90]
J Building services distribution systems [MAC: £396 per MWh. GWh: 50]
K Hot water [MAC: £486 per MWh. GWh: 10]

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

Hairdressers & beauty salons

In hairdressers & beauty salons there was an annual abatement potential of 100 GWh of electrical energy and 30 GWh of non-electrical energy (equivalent to 30 $ktCO_2e$ combined). This equates to a 27 per cent and 28 per cent reduction on energy consumption respectively. The capital cost to achieve this is £186m. The annual savings delivered would be £10m[46]. These figures are grouped according to measure type in Table D.7. The total abatement potential of the socially cost effective measure groups was 80 GWh, of which 60 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 70 GWh, all of which was 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.6).

Table D.7: Abatement opportunity data for hairdressers & beauty salons, 2014–15

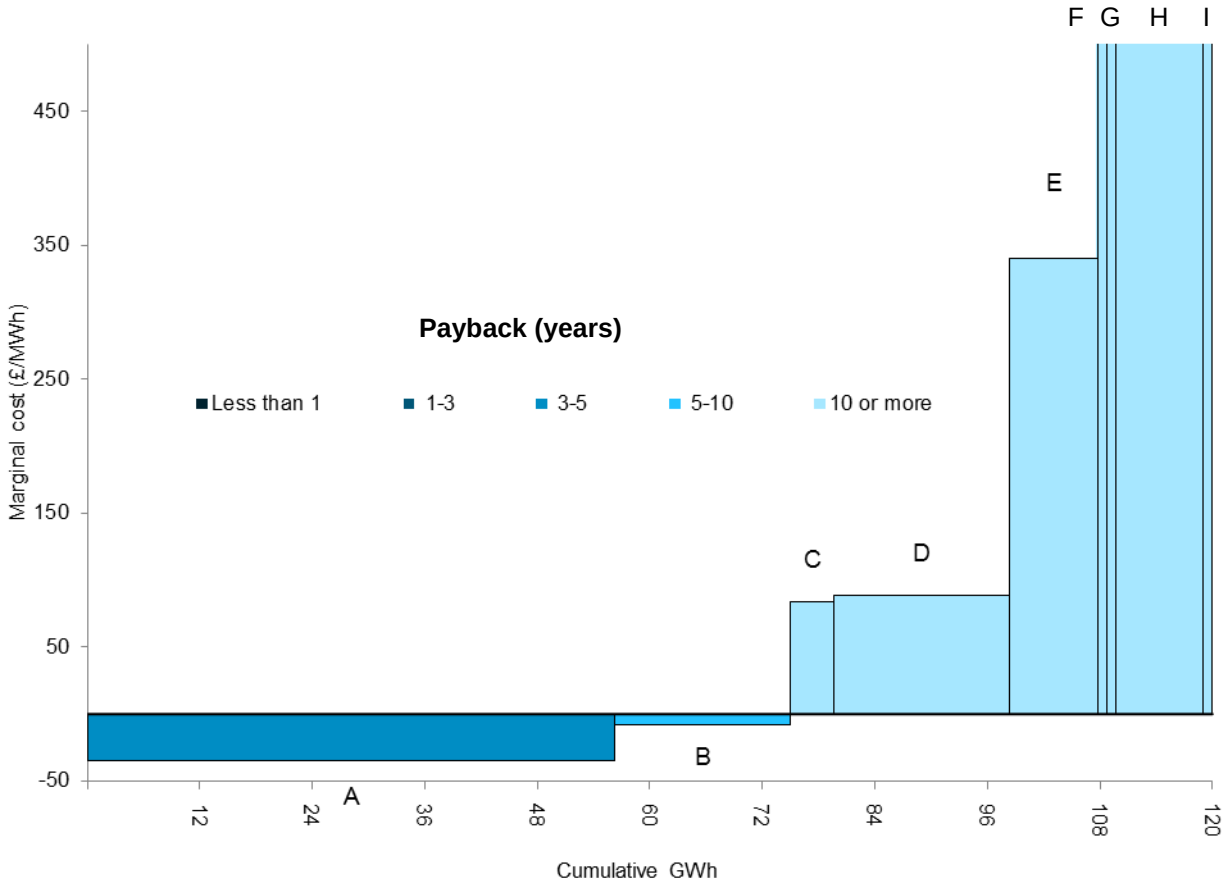
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	Payback period (years) [47]
Air conditioning and cooling	500	1	5	-	5	5,900	12
Building fabric	100	0	1	-	1	26,600	18
Building instrumentation and control	1,500	5	10	7	20	17,400	7
Building services distribution systems	100	0	1	-	1	4,100	7
Carbon and energy management	1,300	5	10	2	20	74,400	2
Hot water	700	4	2	20	20	4,200	5
Humidification	-	-	-	-	-	-	-
Lighting	5,600	20	60	-	60	17,700	2
Cooled storage	-	-	-	-	-	-	-
Small appliances	0	0	0	-	0	2,900	11
Space heating	400	1	3	3	5	28,000	24
Swimming pools	-	-	-	-	-	-	-
Ventilation	100	0	1	-	1	4,600	23
Total	**10,200**	**30**	**100**	**30**	**120**	**185,800**	‘’

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

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

[47] 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.6: Marginal abatement cost curve for hairdressers & beauty salons, 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.
Note also that series 'F','G','H' and 'J' are not visible as the y-axis has been capped for presentation purposes .

A Lighting [MAC: £-35 per MWh. GWh: 60]
B Hot water [MAC: £-8 per MWh. GWh: 20]
C Air conditioning and cooling [MAC: £84 per MWh. GWh: 5]
D Building instrumentation and control [MAC: £89 per MWh. GWh: 20]
E Space heating [MAC: £340 per MWh. GWh: 10]
F Building services distribution systems [MAC: £511 per MWh. GWh: 1]
G Ventilation [MAC: £588 per MWh. GWh: 1]
H Carbon and energy management [MAC: £2,643 per MWh. GWh: 10]
I Building fabric [MAC: £7,021 per MWh. GWh: 1]

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

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