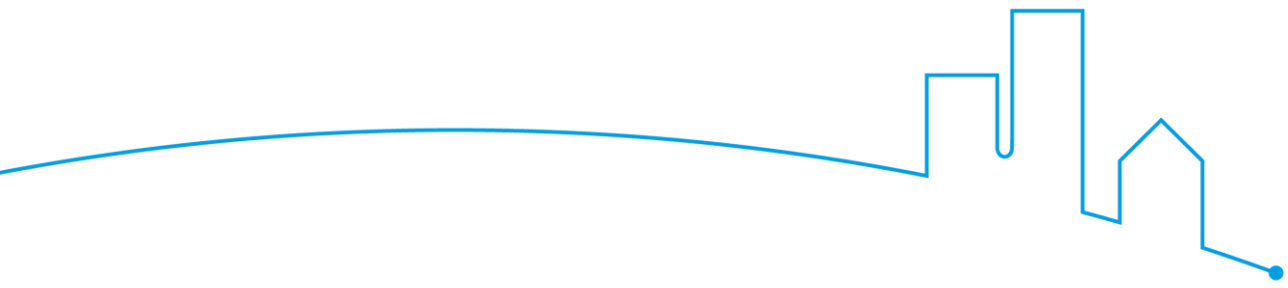
Department for
Business, Energy
& Industrial Strategy

BUILDING ENERGY EFFICIENCY SURVEY, 2014–15: OVERARCHING REPORT



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Acknowledgements

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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 the reports are point estimates and subject to uncertainty as they are based on survey findings. Confidence intervals are shown in Appendix A and sector reports 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 kilo-tonnes 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 mega-tonnes 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 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. ‘-’;

[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.

- 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).

Executive summary

Introduction

The Building Energy Efficiency Survey (BEES) reports on the non-domestic building stock in England and Wales in 2014–15. Within this overall scope the stock is split into 10 sectors. These are in turn made up of 38 sub-sectors, each of which was analysed separately. This overarching report describes the results from across the 10 sectors, whilst more detail is provided in 10 separate sector-specific reports. BEES was designed to meet the following research objectives:

- To update understanding of how energy is used, for a snap-shot in time, across the non-domestic building stock in England and Wales in more detail than is currently available;
- To update understanding of how energy use can be reduced across the non-domestic building stock in more detail than is currently available at present;
- To understand the barriers and facilitators of energy abatement.

Key findings

- The total stock consumed 161,060 GWh/year of total energy (of which electrical energy consumption comprised 53 per cent and non-electrical consumption 47 per cent). The five largest sectors in terms of energy consumption accounted for 71 per cent of total non-domestic energy consumption: these were offices, retail, industrial, health and hospitality.
- The most common end uses were space heating (66,940 GWh/year), internal lighting (21,260 GWh/year), catering (13,270 GWh/year) and cooled storage (for storage of food and drink) (10,790 GWh/year).
- There was 63,160 GWh/year (or 14,630 ktCO2e/year) total energy efficiency abatement potential, representing a 39 per cent reduction from current energy consumption. Over a third of the total abatement potential (22,080 GWh/year) came from measures with a private investment payback of three years or less. The bill savings from measures with a private payback of less than three years was £1.3bn a year.

- The measures with the largest potential savings were carbon & energy management, lighting replacement & control and building services instrumentation & control measures, together representing 55 per cent of the total abatement potential.

- Unsurprisingly the most commonly perceived barriers to energy efficiency were economic ones (e.g. low capital availability, investment costs and interventions not sufficiently profitable). The following were also common: organisational barriers (e.g. complex decision chains, divergent interests); barriers related to competencies (e.g. identifying the inefficiencies, implementing the interventions); and, behavioural barriers (e.g. lack of interest in energy efficiency, inertia).

Method

The study collected data through a large sample of telephone surveys (3,690) across all ten sectors, tailored to each of the 38 sub-sectors reported here. The telephone survey respondents were randomly selected from National-level datasets for England and Wales. A smaller subset of site surveys (214) across all sub-sectors was conducted to validate the telephone surveys and give insight into barriers and facilitators of energy efficiency.

The telephone survey responses were the primary input into two models: an energy use model, tailored to each sub-sector, calculated each premises' annual energy use, broken down by end use; and an abatement model calculated the energy saving potential.

Non-domestic stock

The non-domestic stock in England and Wales comprises 1.83 million premises, of which 1.57 million were within the scope of BEES[2] with a gross internal area (GIA) of 784 million m^2. The total energy consumed by the non-domestic building stock is a function of the specific activities within the premises, their duration and intensity, organisational factors such as size, and energy management maturity, and the size, form, age, fabric and services of the buildings. The stock can be characterised as follows:

- Small premises are far more common in terms of frequency: 92 per cent of premises were smaller than 1,000 m^2. However, large premises dominated: 68 per cent of the overall floor area was in the largest 10 per cent of buildings.

[2] Known exclusions were sub-sectors deemed 'de minimis' (53 million m^2) plus: Agricultural buildings/horticultural glasshouses (24 million m^2), Bank/ insurance/ building society branches (4 million m^2), Data centres (1 million m^2) and Post Office sorting centres (1 million m^2).

- Large organisations occupied 48 per cent of the total floor area compared with 44 per cent for SMEs.[3]
- Owner occupancy was slightly more common than renting on the whole at 58 per cent of the total floor area but was much higher in the public sector; renting was more common in the office, hospitality and storage sectors.
- Just over half (53 per cent) of the total floor area was found within premises without any energy management resource.
- 65 per cent of the stock was constructed pre-1991 with 24 per cent before 1940.
- Natural gas was used to heat 65 per cent of premises total floor area. There was significant variation in the heating fuel used for hot water across sectors with natural gas dominant in some and electricity in others.

Energy consumption

- The total stock consumed 161,060 GWh/year of energy, of which electricity was 84,820 GWh/year (53 per cent of total) and non-electrical energy consumption was 76,240 GWh/year (47 per cent of total).

- The five largest sectors in terms of energy consumption were offices (27,620 GWh/year, 17 per cent), retail (17 per cent), industrial (16 per cent), health (11 per cent) and hospitality (11 per cent). Together these accounted for 71 per cent of total non-domestic energy consumption.

- The four largest energy end uses were space heating, internal lighting, catering and cooled storage (for storage of food and drink), which accounted for 70 per cent of total consumption. The three most common end uses of electrical energy were internal lighting (21,260 GWh/year), followed by cooled storage (10,790 GWh/year), and ICT equipment (7,910 GWh/year). The three most common non-electrical energy end uses were space heating (59,300 GWh/year), hot water (6,300 GWh/year) and catering (6,040 GWh/year).

- Electricity use was dominant in four sectors: retail (79 per cent), offices (68 per cent), storage (57 per cent) and hospitality (52 per cent). In the other six sectors, non-electrical energy dominated, especially in these three: emergency services (70 per cent), community, arts & leisure (69 per cent) and education (67 per cent).

[3] The remaining floor area (9 per cent) is associated with premises where organisation size was not asked and or where respondents did not know their organisation size.

- 67 per cent of energy consumption was used to provide building services (heating, ventilation, cooling, hot water and lighting). The remaining 33 per cent of energy consumption related to sector-specific activity end uses.
- Median total annual energy intensity was highest for premises in hospitality (387kWh/m^2), followed by emergency services (325 kWh/m^2) and health (201 kWh/m^2).
- Owner occupied premises account for over half of total energy consumption (56 per cent, 90,890 GWh/year): 80 per cent of public sector consumption and 49 per cent in the private sector. In the offices, retail and hospitality sectors energy was predominantly consumed in rented premises.
- Large enterprises accounted for 53 per cent of total energy consumption. However, in the community, arts & leisure, industrial and hospitality sectors, a majority of energy consumption is from premises occupied by Small to Medium-sized Enterprises (SMEs).

Abatement potential

- 89,740 GWh/year (56 per cent of energy was used in premises where respondents indicated that they "actively seek new ways to reduce energy use" (active energy management). 55,090 GWh/year (34 per cent) of energy was used in premises where they "try to reduce energy use where possible, but it's not a priority" (passive energy management) and the remainder in premises where respondents "have not considered ways to reduce energy use" (no energy management).
- In terms of resources available to manage energy, 80,830 GWh/year (50 per cent) of energy used was in premises that had specialist energy management resources available. 49,900 GWh/year (31 per cent) of energy used was in premises with non-specialist energy management resources while 23,400 GWh/year (15 per cent) was in premises which had no energy management resources.
- Organisations in the public sector and other large organisations were more likely to have active energy management policies and specialist resources to manage energy than those in the private sector.
- There was 63,160 GWh/year (or 14,630 ktCO_2e/year) total abatement potential. This represents a 39 per cent reduction from current energy consumption. Almost half of this total abatement potential (22,080 GWh/year) came from measures with a private investment payback of three years or less, of which 55 per cent is from non-electrical measures. The bill savings from measures with a private payback of less than three years was £1.3bn a year.

- The measures with the largest potential savings were carbon & energy management, lighting replacement & control and building services instrumentation & control measures, together representing 55 per cent of the total abatement potential.
- This included 27,890 GWh/year of socially cost-effective abatement. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society.

Barriers and facilitators

- The most commonly perceived barriers to energy efficiency were economic ones (low capital availability, investment costs, hidden costs, intervention-related risks, external risks, and interventions not sufficiently profitable).
- The following barriers were also perceived to be common:
    - organisational barriers (complex decision chains, divergent interests, lack of internal control, lack of time, and low status of energy efficiency);
    - barriers related to competencies (identifying the inefficiencies, and opportunities, and implementing the interventions);
    - behavioural barriers (imperfect evaluation criteria, inertia, lack of interest in energy efficiency, lack of sharing the objectives, other priorities and split incentives).
- The most commonly cited enablers – respondents said that they believed would help them implement energy efficiency measures on site - were: improved energy management knowledge; increased availability of funding; and, greater buy in from key internal and external stakeholders.
- For major capital expenditure measures low capital availability was perceived to be the key barrier. Linked to this was also the issue that in many cases measures were not sufficiently profitable to meet internal investment requirements. Beyond financial barriers, respondents commonly cited inertia as being a major behavioural barrier to investment.
- In the hospitality, industrial, retail, education and emergency services sectors, the key barrier to energy efficiency was perceived to be that key internal stakeholders had ‘other priorities’ or that there were perceptions that energy efficiency conflicted with central organisational priorities. In the community, arts & leisure, hospitality, education and military sectors, complex decision chains - arising either through burdensome

external or internal approval processes – were perceived to be a major barrier to energy efficiency.

1. Methods

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

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

1.1 Research objectives

BEES was designed to meet the following research objectives:

- To update 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[4];
- To update 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 facilitators of energy abatement.

1.2 Introduction

The non-domestic building stock is very diverse, predominantly due to three defining characteristics:

- **Building type:** the purpose of a premises, its age, the way it is serviced[5] and the degree to which both fabric and services have been updated.
- **Scale:** the size of a premises and whether it constitutes a whole building, a part of a building or a collection of related buildings.

[4] 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 and the Open University in the 1990s.
[5] Servicing refers to the provision of heating, ventilation, cooling, hot water and lighting.

- **Activities:** the types of activities and processes that are carried out inside premises (or in their associated surroundings), the intensity of such use and its duration.

Additional diversity arises from differences between the organisations that own, operate and occupy the stock: premises can be owner occupied or rented by a tenant. The occupiers can be micro businesses, SMEs or large organisations with multiple premises. The owners can be investors, small or large landlords or the occupying organisation. Another key differentiator of premises is whether they are professionally managed by on-site staff and/or benefit from a remotely implemented formal energy management regime.

To successfully measure this diversity and produce a robust evidence base that can provide the evidence for future policy development and statistical publications covering non-domestic buildings, BEES has taken advantage of the Non-domestic National Energy Efficiency Data framework (ND-NEED)[6]. This framework enables different premises-level data to be matched using a common address spine derived primarily from the Valuation Office Agency (VOA) Rating List. Other linked databases include those with information about the organisations that occupy the premises and a database of the annual energy use recorded by all non-domestic electricity and gas meters[7]. These data sources can provide a robust overview of the premises in England & Wales, their activities and their total electricity and gas use.

BEES has been able to model a more detailed assessment of energy use in premises and thereby answer the research questions more completely by deploying a methodology which allowed this overview to be enhanced with granular data obtained at the premises level for 3,690 premises, carefully sampled from across the stock.

There were a number of challenges in the BEES method, which were addressed throughout the study. For example, several types of premises are not recorded on the VOA Rating List because they are not subject to business rates (e.g. prisons and military premises, nursing homes and places of worship). Additionally, the valuation of some types of premises is not based on the floor area[8] e.g. the records for premises providing accommodation, such as hotels, might record their size as the number of bedrooms, whilst for pubs it could be the quantity of beer sold.

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[6] https://www.gov.uk/government/statistics/non-domestic-national-energy-efficiency-data-framework-energy-statistics-2006-12

[7] The process conducted to validate the BEES energy modelling used annual gas and electricity data from meters with a postal address matched with the address of the premises. For the BEES sample, at the time of the study, about 60 per cent had matched electricity data and 30 per cent had matched gas data.

[8] In the VOA, floor area data is recorded using a mixture or gross and net internal area. BEES has been based on gross internal area with conversions applied to sectors which use net internal area, for example the office sector. Most retail premises record size as sales floor area. Industrial buildings and warehouses tend to record gross internal area.

1.3 Approach

An approach was designed to gather information on energy use in premises using telephone surveys of approximately 25 minutes and a limited number of site surveys. Each survey record may represent a premises comprising an entire building or a premises within a larger building.

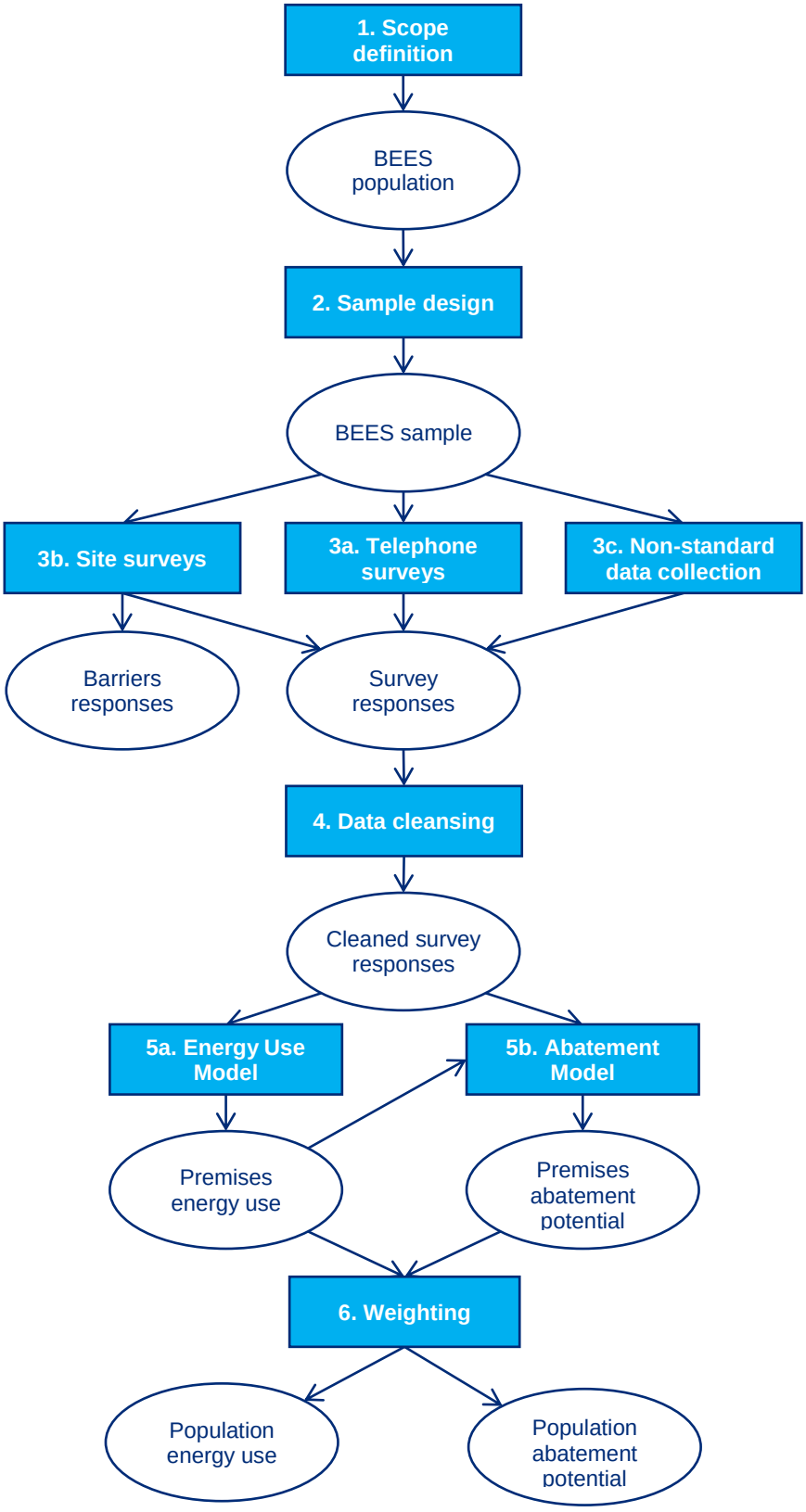
The findings in this report are based on all of the data collected through 3,690 telephone surveys and 214 site surveys in 2014–15.

The records include data on energy usage by different activities, information on the building itself (fabric, age, servicing, etc.) and the occupier's organisation.

The approach is summarised in Figure 1.1.[9]

[9] The paragraph numbers below relate to box numbers in the flow chart.

Figure 1.1: Methodology flowchart (boxes represent activities that correspond to the approach description above, and ovals represent outputs)



1. **Scope definition:** BEES started by breaking down the England and Wales non-domestic building stock population into different sub-sectors according to the purpose(s) of each premises (school, hospital, office, shop, hotel, factory, etc.). The survey covers the energy use of building sectors covering around 90 per cent of the total floor area of non-domestic buildings in England and Wales. Some sectors were excluded because they represented a tiny fraction of total energy use: for example buildings in the transport sector (e.g. bus & train stations). Other sectors chose not to take part in the survey including financial services (normally included in the retail sector) and dedicated data centres (normally included in the office sector)[10]. In addition, industrial processes were excluded from the scope of the survey, but industrial building services (e.g. heating, cooling and lighting) were included[11]. For reporting and study management, the sub-sectors were grouped into 10 sectors based on the granular data for 38 consolidated sub-sectors[12].

2. **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 VOA's property rating list. This gives a base record of address, floor area, premises type, and energy use[13]. Where a sector was out of scope of the VOA database, alternative data sources were used. Using the Experian references in ND-NEED it was possible to add a contact telephone number. Analysis shows that the coverage of BEES includes 89 per cent of building floor area in England & Wales. The number of telephone surveys per sub-sector was determined based on its overall size, with a minimum of 50 surveys sought where possible. Overall 1 per cent of floor area has been surveyed for the sub-sectors in scope.

3. **Data collection** - A sub-sector tailored telephone survey, supplemented with data from more detailed site surveys in a subset of cases, was used to gather the information required to model the energy end uses within these buildings.

   The telephone survey (**3a**) involved a single interview of around 25 minutes. It gathered basic information on the building, its servicing and usage. It also included sub-sector specific key questions to gather further data on the most significant

[10] The following sub-sectors were not considered de minimis but did not form part of the BEES research due to data access difficulties: Agricultural buildings/horticultural glasshouses, Bank/ insurance/ building society branches, Data centres, Post Office sorting centres. In addition, there are some 100 'de minimis' sub-sectors each of which represent a tiny percentage (less than 0.5%) of the population.
[11] To avoid overlap with the Department's research into energy use by industry, the scope of BEES excluded the energy used by industrial processes in industrial premises and all energy use on very large industrial sites such as steel and chemical works. Ministry of Defence premises associated with national security were also excluded.
[12] The BEES modelling was based on 48 sub-sectors. These were consolidated to 38 sub-sectors for reporting purposes.
[13] The BEES sector and sub-sector classifications are based on a bespoke classification developed from VOA data of Special Category Code (SCAT) and Property Description.

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 subset of 214 site surveys (**3b**) was undertaken on premises chosen from the telephone survey sample. The candidates were selected based on a range of characteristics such as energy intensity, location and floor area size. The site surveys gathered detailed information on the energy end use consumption, activities (extent and intensity), abatement potential and the barriers and enablers to implementing energy efficiency measures in the building. The outputs were used to test and moderate the energy use and abatement models (see step 5 for a description of these models). Data collected on site was also used to verify and, if necessary, correct and overwrite findings from the initial telephone survey. The data on barriers and enablers of energy efficiency was collected via 126 semi-structured face to face interviews.

As part of each site survey, respondents took part in a semi-structured interview to identify factors affecting their ability to implement energy efficiency measures on site. The target respondent was the individual accompanying the site surveyor, although in some cases it was necessary to contact and include other staff members based off site.

There were three parts to the interview process. The first reviewed the barriers to implementing energy efficiency measures. The respondent was presented with three potential energy efficiency measures identified on site and asked to name any factors impacting their ability to implement them, past or present. The second part of the interview focussed on the energy management practises conducted on site. This consisted of a structured interview of 15 questions. The third part of the interview considered the potential ‘enablers’ which might allow the respondent to better implement energy efficiency measures on site. These were also classified according to type and the likelihood of implementation.

In certain sectors or sub-sectors, limited engagement by respondents resulted in an insufficient sample size for telephone surveys or site surveys via the standard method (**3c**). Where this occurred alternative methods were used, which are described in more detail in the technical annex and individual sector reports. These alternative methods ranged from using data from existing research programmes, specially arranged site surveys on a given sub-sector through to the

adoption of mystery shoppers[14] to gather data on observable energy characteristics. An alternative method was used to gather data on 317 records (9 per cent) (see 'Appendix B: Method challenges and data collection', in each relevant sector report).

4. **Data cleansing -** Prior to modelling, the data was 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 person density (the number of square metres per person in a building). Where extreme values were identified the record would be removed. The quality analysis identified the proportion of questions for which no response was provided ('don't know' responses). The number of 'don't know' responses was monitored record by record across the full question set including sub-groups of questions critical to the generation of energy predictions. 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 knows' was considered indicative of a respondent who was less engaged in the interview or had a poor understanding of their building's core services and equipment.

   Across the non-domestic stock, a total of 4,179 telephone survey or equivalent records were collected – following the record exclusion process a total of 3,690 records were retained for analysis.

   Secondly, record amendment was conducted on the remaining data. The remaining records were reviewed and in some cases data was 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 on what was typical from similar premises, or based on other question responses from that premises.

   Where non-standard methods were used to collect telephone survey data, the same data cleansing process was used. In certain cases however, such as when data was collected through mystery shopper methods, the non-standard approach resulted in a higher proportion of 'don't know' or un-answered questions than in the standard method. In these cases, a higher threshold for 'don't know' was set, along with an increased level of assumptions or substitutions applied to the data.

[14] The mystery shopper methodology involved a site surveyor visiting a premises posing as a casual shopper to collect basic information.

5. **Data processing** – Two models were used to process the cleaned telephone survey responses. 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 suitable to be installed in that premises. These models are outlined below, with more details in the technical annex. It should be noted that all processed outputs relate to the time when the original data was collected[15].

   The energy use model (**5a**) used an energy calculator to estimate a premises' energy consumption, split by end use and fuel type. The cleaned telephone survey responses were interpreted to set different values for related parameters in the energy use model for each energy end use. This moderation was influenced by prior knowledge of the sub-sector, interviews with sub-sector experts and findings from the site surveys. The energy use model for heating and cooling did not take dynamic effects (e.g. internal or solar gains) into account. It was also blind to building geometry, given the limitations of a telephone survey to capture robust data about building form and fabric. The uncertainties created by these approximations were quantified as acceptable through a peer review exercise of the energy use model in which results were compared with those from a model using full dynamic simulation.[16]

   The energy model was not intended to be capable of predicting accurately the energy end use breakdown or even the total energy use of each record, given the known limitations of the model and the insufficiency and potential unreliability of the data available from the telephone survey. However, the model is considered capable of producing a plausible energy prediction for each premises record, justified by the survey responses. Furthermore, the model was calibrated at the aggregate level for each sub-sector. This meant that over or under predictions at individual premises level can be considered to balance themselves out, so that it is believed that the overall energy end use predictions for each sub-sector are reasonable. The energy model calibration process was applied at the sub-sector level and focused on the aggregated totals for the annual use of electricity and gas for all the premises which had matched energy supply data: each sub-sector model was adjusted, in ways suggested by the evidence of the site surveys, to achieve reasonable consistency between the model's aggregated predictions and the aggregated meter data for annual gas and electricity use at these premises.

[15] Data collection for the Building Energy Efficiency Survey in its entirety occurred over 18 months from mid-2014 to late 2015.

[16] Business, Energy and Industrial Strategy (2016). Peer review of the Building Energy Efficiency Survey energy use model.

The abatement model (**5b**) used the cleaned telephone survey data 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. Individual weighting factors were calculated for each premises based on the estimated prevalence of premises of that floor area in the overall population. The overall sector population statistics were compiled from a range of published sources and have been collated in a population table. This table can be found in the technical annex.

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

1.4 Challenges faced during research

Across each stage of the study, the main challenges and limitations, are viewed by the research team to have been:

- **Method Design:** Information requested in the telephone survey had to take a form that respondents could answer immediately without having to refer to documentation. As a consequence, the telephone survey was not suited to asking for detailed accurate numerical data or complex technical detail so a simpler, multiple choice question format was used which allowed us to determine the most appropriate inputs for subsequent modelling activities.

  It is worth noting that prior to commencing BEES a pilot of a variety of data collection methods was conducted in the retail sector.[17] This pilot study concluded that the use of telephone surveys was the most appropriate approach to deliver economically the size of sample that was being targeted. The BEES telephone survey was also extensively piloted in the first six months of the programme, testing a variety of options. This included trialling a range of different question options with varying technical complexity and length as well as the use of altenative forms of data collection, such as online

[17] BEIS 2013, BEIS Non-domestic building energy use project phase I, Pilot study of the food and mixed retail sector available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/207319/DECC_Non_-_domestic_building_energy_use_project_phase_I.pdf

surveys. The team also tailored sections of the telephone survey to sub-sectors, and worked with sub-sector experts, to ensure that key energy characteristics were explored and that questions were suitably designed.

- **Sampling:** In some cases the sample population for a sub-sector was low. This would mainly be because the overall population for that sub-sector was low across England and Wales. Where this was the case the team would aim to achieve 30 completed telephone survey records but this would not always be possible based on standard non-response rates. This increases the risk of sampling bias in these sub-sectors.

  There were a number of sub-sectors where the VOA only held partial or no data for sample design. Where sub-sectors were incomplete on the VOA often it was due to the method of valuation not being floor area. For these sub-sectors the sample design could not use floor area as a sample quota.

  Other sub-sectors were not included in VOA at all, such as prisons and military premises. In these instances alternative sample databases were used with certain compromises such as incomplete information on floor area or sample population numbers relative to the overall population, and in some instances known biases, such as being restricted to premises above certain floor area thresholds.

  Due to limitations on how the source datasets could be split for sampling, certain sub-sectors included a very diverse range of activities and energy characteristics. Ensuring the sample design captured the heterogeneity of a given sub-sector could only be managed using simple design quotas based on ensuring ranges in company size, premises energy intensity and premises floor area were met.

  Finally, Gross Internal Area (GIA) was used as the primary basis for describing the non-domestic stock. Within the VOA and other datasets used for sampling purposes, other measurement conventions such as Sales Floor Area or Net Lettable Area are used. There are also cases where VOA premise floor areas included outdoor spaces, or had applied unusual exclusions (e.g. squash courts were not included in floor areas). This introduced complexity in ensuring the sample design quotas were based on a correct understanding of the premises floor areas.

  The research team were advised by a team from University College London (UCL), who have worked with the VOA data extensively, on how best to overcome these issues. They were able to help identify those sub-sectors most affected by a high diversity of building types, for example, to inform our sample design. They also provided statistics on the proportion of land associated with VOA record types to allow us to assess the sub-sectors most affected by the issue and determine how the sample design and subsequent data analysis should be adapated accordingly.

- **Data collection:** The use of a telephone survey approach may have introduced some bias into the results. To address the issues, the telephone surveyors used for the research were highly experienced and the same core team were used throughout the programme. This improved the likelihood of achieving responses from a wider range of respondents, as experienced interviewers were more familiar with the telephone survey script and the study objectives and explaining these to potential respondents.

  The site survey time allowance was set based on the size and complexity of premises. Premises ranged from very small cafés to very large industrial and storage buildings of over 50,000m^2. In large premises, in particular, the site surveyors would often rely on documented estimation techniques to record data on how the premises operated. Finally, when carrying out site surveys, the quality of data available onsite was highly variable as was the capacity of site teams to provide support when escorting surveyors. As a result, site surveys varied substantially in the extent of analysis that could be undertaken, reducing in some cases the quality of the site survey reports signficiantly.

  To improve efficiency and consistency while on site, the team used a site surveying tool. This facilitated rapid building energy use and abatement calculation and semi-automated the write-up of audit reports.

  Barrier interviews could only be conducted with premises that had had a site visit. Furthermore, in some cases where one organisation provided a number of site surveys only one interview would be undertaken for the set of site surveys. This meant that findings were restricted to a small sample size of 126 records. The time for the interview on barriers was also restricted to one hour.

  All the site surveyors were briefed on the research objectives of BEES and trained in social research techniques to improve the way in which they handled these interviews and the quality of the information they recorded.

- **Data processing: Energy use model** - In order to process the telephone survey data collected in the BEES study, the energy model involved a number of simplifications and assumptions. For a number of end uses, such as catering, medical equipment and ICT consumption the modelling parameters were highly simplified.

- **Data processing: Abatement model** - A key challenge for the abatement modelling task was a limitation in the robustness of pre-existing data on the costs and effectiveness of abatement measures. The cost of implementing abatement measures is often dependent on the size of the project and the characteristics of the site where the measure is being applied (economies of scale can be achieved in larger buildings for certain measures). In order to account for this, cost/capacity curves and minimum costs were used in the abatement model for certain measures. In the absence of any alternative methods, a measure cost would be calculated using a payback methodology

where indicative costs are calculated using typical paybacks and applying these to the savings achieved.

1.5 Non-standard approaches used in the BEES study

While every effort was made in order to maximise the applicability of the standard method to all sub-sectors in the study, challenges were encountered during the research which required the development of non-standard approaches in order to deliver the project outcomes. Table 1.1 lists the non-standard approaches used and to which stage of the study they were applied in different sectors.

Table 1.1: Non-standard sector approaches

Stage of study	Non-standard approach	Sectors affected									
		Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency services	Military	Community, arts & leisure
Data collection	Telephone survey recruitment via direct contact with respondent organisations	●					●	●	●	●	
Data collection	Estimation of floor area obtained during telephone survey			●							●
Data collection	Mystery shoppers were used for data collection to capture data on observable energy characteristics	●									
Data collection	Site survey recruitment through direct contact with respondent organisations	●		●	●			●	●	●	●
Data collection	Site survey recruitment from outside telephone survey sample			●							
Sampling	Use of non-NEED datasets which were subject to bias						●	●	●	●	●
Energy Modelling	Simplified modelling approach to key end uses	●	●	●			●				●
Energy modelling	Restricted calibration process due to a lack of extensive matched energy data				●	●	●		●	●	

Stage of study	Non-standard approach	Sectors affected									
		Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency services	Military	Community, arts & leisure
Design / data collection / modelling	Estimation of input data for energy modelling	●			●		●		●	●	●
Site surveys	Industrial barrier interviews were not as applicable because the building related consumption is often minimal compared to the process load				●						

Further detail on each of the non-standard methods or methodological issues encountered are presented in the technical annex.

2 Non-domestic stock

The Building Energy Efficiency Survey (BEES) reports on the non-domestic building stock for England and Wales. Within this overall scope the stock was split into 10 sectors. These were in turn made up of 38 sub-sectors, each of which was analysed separately.

This section provides a list of sub-sectors in each of the 10 sectors. It then sets out the key characteristics of the non-domestic stock in terms of the number of premises and floor area it represents.

Table 2.1 shows the sub-sectors included in each of the sectors. For a full list of sub-sector definitions please refer to Appendix D.

Table 2.1: Table of sector definitions

Sector	Sub-sectors
Retail	Hairdressers & beauty salons
	Large food shops
	Large non-food shops
	Showrooms
	Small shops
	Retail warehouses
Office	Private sector offices
	Public sector offices
Hospitality	Pubs
	Hotels
	Restaurants & takeaways
	Cafes
Industrial	Factories[18]
	Workshops

[18] As discussed in the Methods section, industrial premises such as factories and workshops were assessed only for non-industrial process energy loads.

Sector	Sub-sectors
Storage	Cold stores
	Large distribution warehouses
	Stores
	Warehouses
Health	Health centres
	Hospitals
	Nursing homes
Education	Nurseries
	Primary schools
	Secondary schools
	Higher education – teaching and research
	Higher education – residential
Emergency services	Fire/ambulance stations
	Law courts
	Police stations
	Prisons
Military	Military offices
	Military storage
	Military accommodation
Community, arts & leisure	Clubs & community centres
	Places of worship
	Museums, art galleries & libraries
	Theatres, concert halls & cinemas
	Leisure centres

2.1 An overview of the non-domestic stock

The data in this report relates to a population of premises comprising the portion of the whole non-domestic stock covered by BEES. The total floor area in this population is 784 million m^2 gross internal area (GIA). Prior to BEES, the most complete model of the overall non-domestic building stock in England & Wales, CARB2[19], quantified the total floor area as 1,036 million m^2 GIA. The 241 million m^2 difference between these values is caused both by the known exclusions[20] of some premises types from BEES and a general updating in BEES of the CARB2 data with more recent information[21]. Please refer to the overarching technical annex for further information on the sources for these statistics.

The size of each sector and associated sub-sectors is set out in Figure 2.1, Figure 2.2 and Figure 2.3 on the basis of their premises count, floor area[22] and energy consumption.

Figure 2.1 shows how the 4 largest sectors (storage, industrial, retail and offices) account for 69 per cent of the total floor area.

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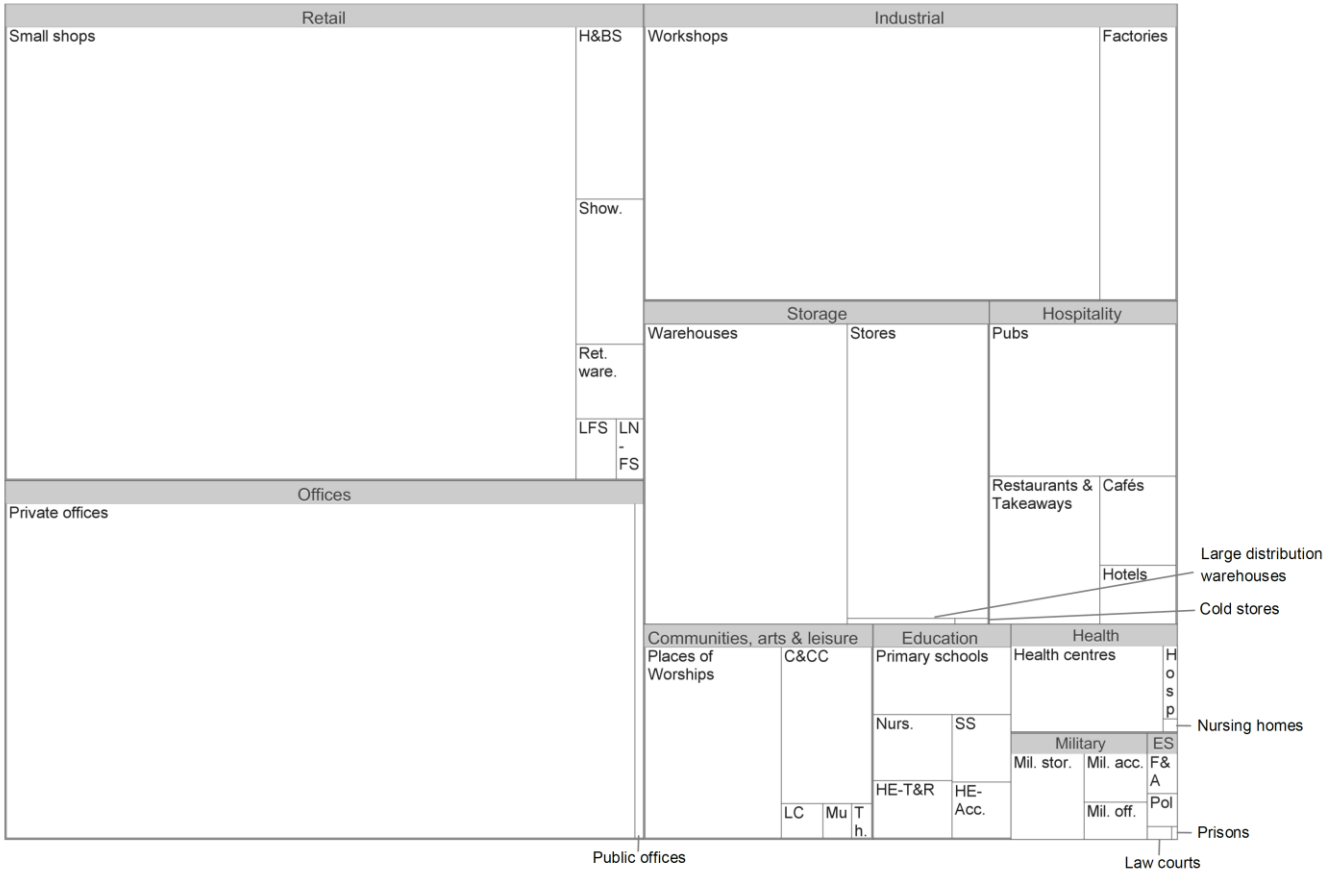
[19] https://www.ucl.ac.uk/energy-models/models/carb2
[20] The floor area of all the sub-sectors originally deemed 'de minimus' (53 million m^2) plus those that dropped out as BEES progressed: Agricultural buildings/horticultural glasshouses (24 million m^2), Bank/ insurance/ building society branches (4 million m^2), Data centres (1 million m^2) and Post Office sorting centres (1 million m^2).
[21] For example, CARB2 has the size of the military sub-sector as 84 million m^2, whilst BEES counts only 11.5 million m^2 based on evidence provided from the Ministry of Defence.
[22] Following analysis of the data on individual premises as part of BEES, the record results were weighted in order to produce results representative of all non-domestic buildings in England and Wales in each sector.

Figure 2.1: Premises frequency by sub-sector for the non-domestic stock, 2014–15

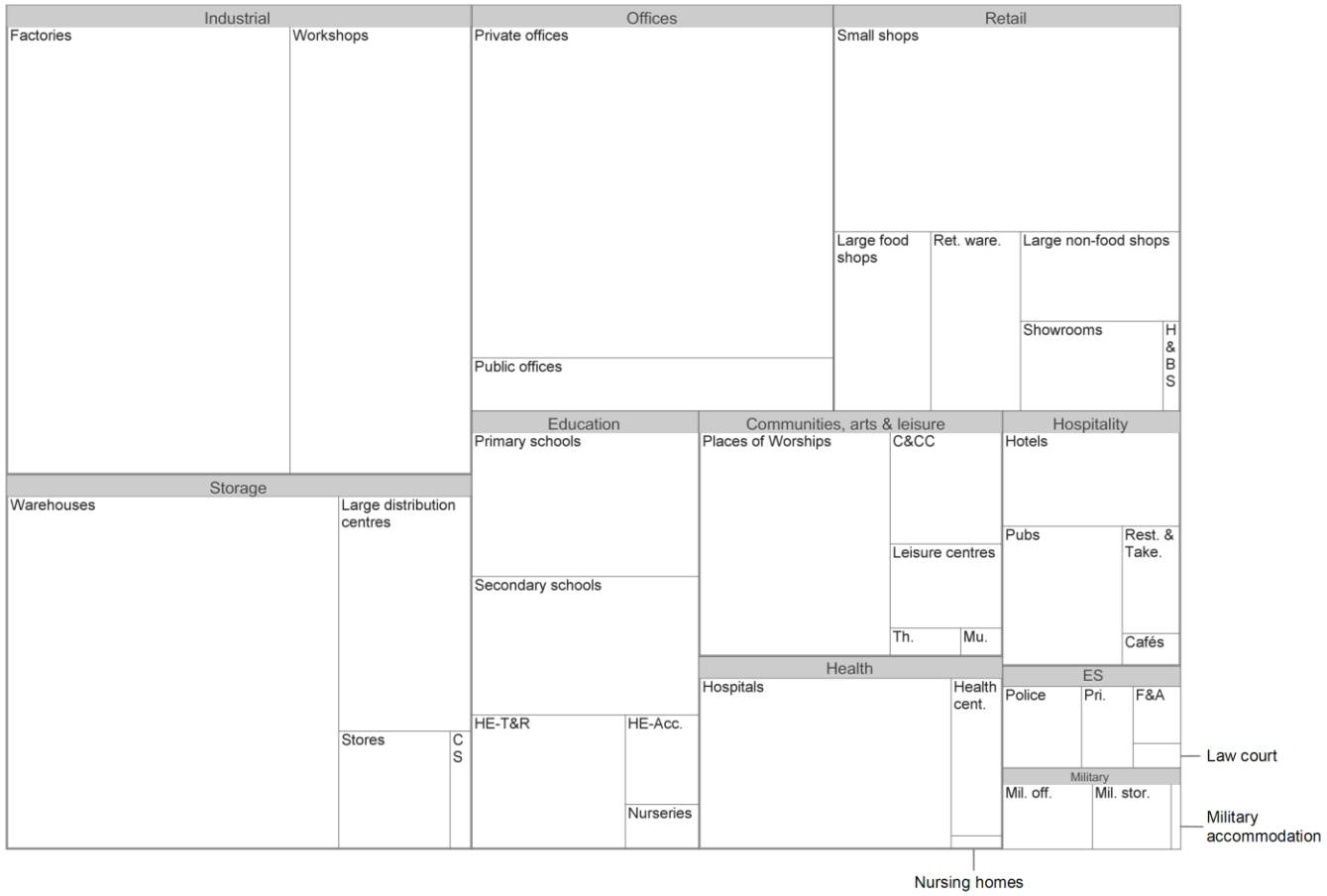
ID	Sub-sector
H&BS	Hairdressing & beauty salons
Show.	Showrooms
Ret. ware.	Retail warehouses
LFS	Large food shops
LN-FS	Large non-food shops
C&CC	Clubs & community centres
LC	Leisure centres
Mu.	Museums, Art galleries and Libraries
Th.	Theatres, cinemas
Nurs.	Nurseries
SS	Secondary schools
HE-T&R	HE—Teaching 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 2.2: Floor area by sub-sector for the non-domestic stock, 2014–15

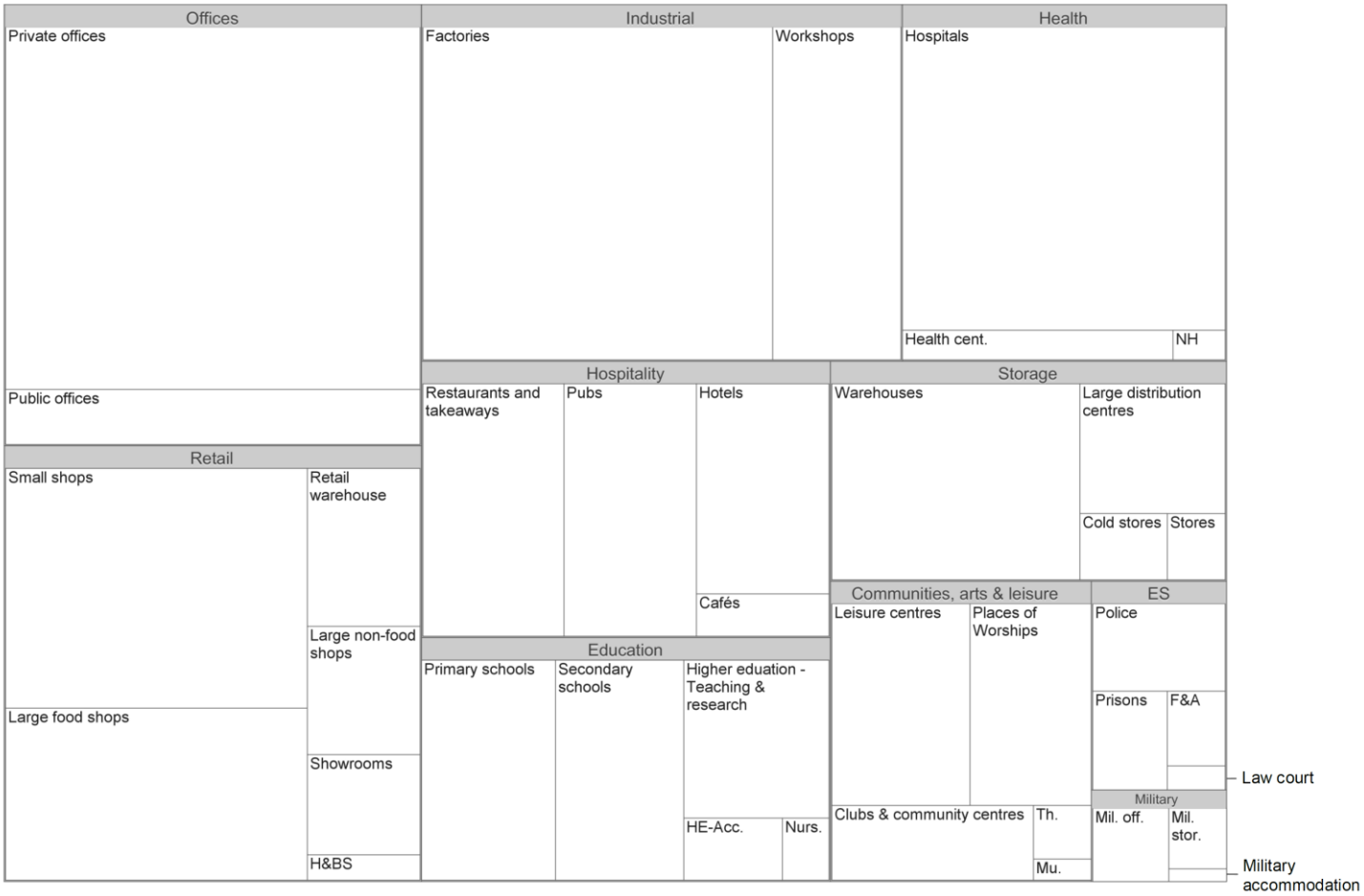
ID	Sub-sector
Ret. ware.	Retail warehouse
H&BS	Hairdressing & beauty salons
CS	Cold stores
HE-T&R	HE—Teaching and research
HE-Acc.	HE — Accommodation
C&CC	Clubs & community centres
LC	Leisure centres
Th.	Theatres, cinemas and concert halls
Mu.	Museums, Art gal-leries and Libraries
Health cent.	Health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



Source: Population table

Figure 2.3: 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

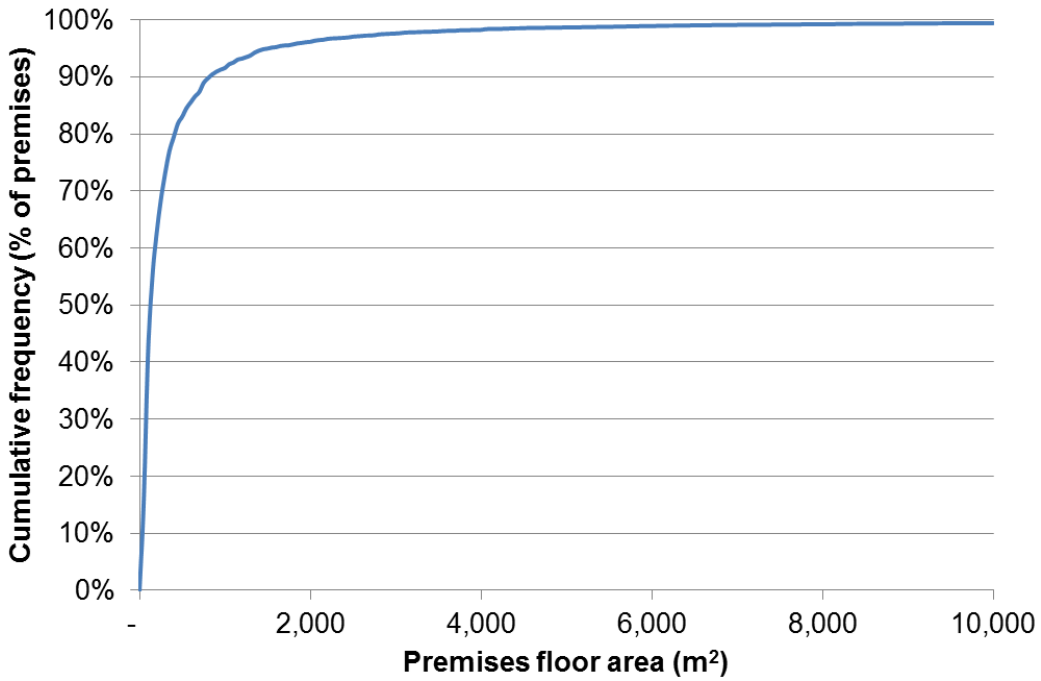


Source: Energy use model results by sub-sector, England and Wales

2.2 General characteristics of the non-domestic stock

The non-domestic stock in England and Wales comprises 1.83 million premises, of which 1.57 million were within the scope of BEES analysis. As shown in Figure 2.4, small premises are the most common in terms of frequency in BEES: 92% of premises were smaller than 1,000 m^2.

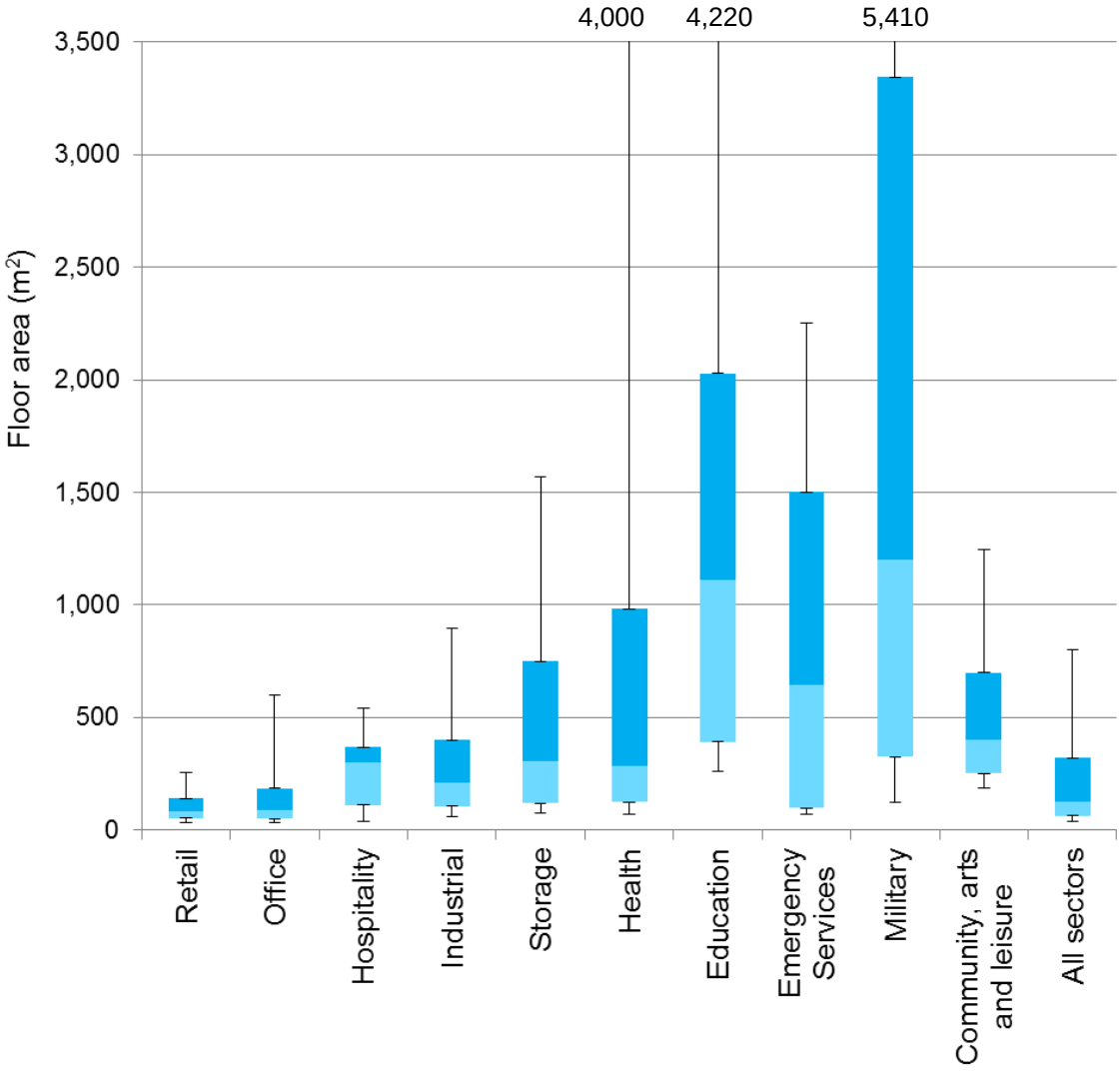
Figure 2.4: Plot of cumulative premises frequency against premises floor area, 2014–15



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

Figure 2.5 shows the distribution of premises sizes in each sector. Retail, offices, industrial and hospitality premises tended to be smaller with median floor areas of 80 m^2, 90 m^2, 210 m^2 and 300 m^2 respectively. Military (1,200 m^2), education (1,110 m^2), community, arts & leisure (400 m^2), storage (310 m^2) and health (280 m^2) had larger median premises sizes. The interquartile range of premises sizes (indicated by the two blue boxes of each series in Figure 2.5) were largest in the military, education, and emergency service sectors (3,020 m^2, 1,640 m^2 and 1,400 m^2 respectively). In contrast the retail and office sectors demonstrated the smallest distributions of premises sizes (90 m^2, and 140 m^2 respectively).

Figure 2.5: Premises floor area size by 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 sector, 80 per cent of the total number of data points are displayed.

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

Even though there are generally far greater numbers of smaller premises, the proportion of a sector's total floor area that exists in smaller premises is usually relatively small. This effect is shown in Table 2.2 which, for each sector, shows the per cent of the total weighted premises floor area within BEES covered by each quartile of the population ordered by size (the top quartile is split into two parts: 75-90 and 90-100 percentiles). However, large premises dominated: 68 per cent of the overall floor area was in the largest 10 per cent of buildings.

For example, in the retail sector, using the data from Figure 2.5 and Table 2.2 shows that 5 per cent of the total sector floor area is within premises in the lowest quartile (all retail premises under circa 80 m^2) and 14 per cent by half of all premises (those under 140 m^2). 75 per cent of retail premises are under 500 m^2, accounting for 27 per cent of total floor area. The largest 10 per cent of premises (all those over 2,900 m^2) accounts for 58 per cent of the total retail sector floor area.

Hospitality is the sector where the total floor area is most dominated by small premises: in this case, 90 per cent of all premises are under 700 m^2 and these account for 55 per cent of the total sector floor area. Half of all premises in the community, arts & leisure sector are under 800 m^2 but they account for only 19 per cent of total floor area.

50 per cent of premises in the offices sector are small (under 290 m^2) and contribute only 9% of total floor area. The decile of largest office premises (those with a floor area over 4,200 m^2) contribute almost two thirds of total floor area (64 per cent). The health sector is particularly dominated by larger buildings, with the quartile of largest premises (all those over 3,100 m^2) forming 89 per cent of total floor area.

Table 2.2: Proportion of total sector floor area covered by each quartile of the population ordered by size (the top quartile is split into two parts: 75-90 and 90-100 percentiles), 2014–15

Sector	Quartiles and decile ranges of premises count in floor area order (percentage of floor area in each banding) [23]				
	0 - 24%	25 - 49%	50 - 74%	75 - 89%	90 -100%
Retail	5	9	13	15	58
Offices	3	6	11	16	64
Hospitality	4	12	22	17	45
Industrial	2	5	10	12	71
Storage	2	5	14	14	65
Health	1	2	8	16	73
Education	4	10	19	22	45
Emergency Services	2	8	22	26	42
Military	2	10	21	67	
Community, arts & leisure	7	12	19	20	42
All sectors	2	5	10	15	68

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

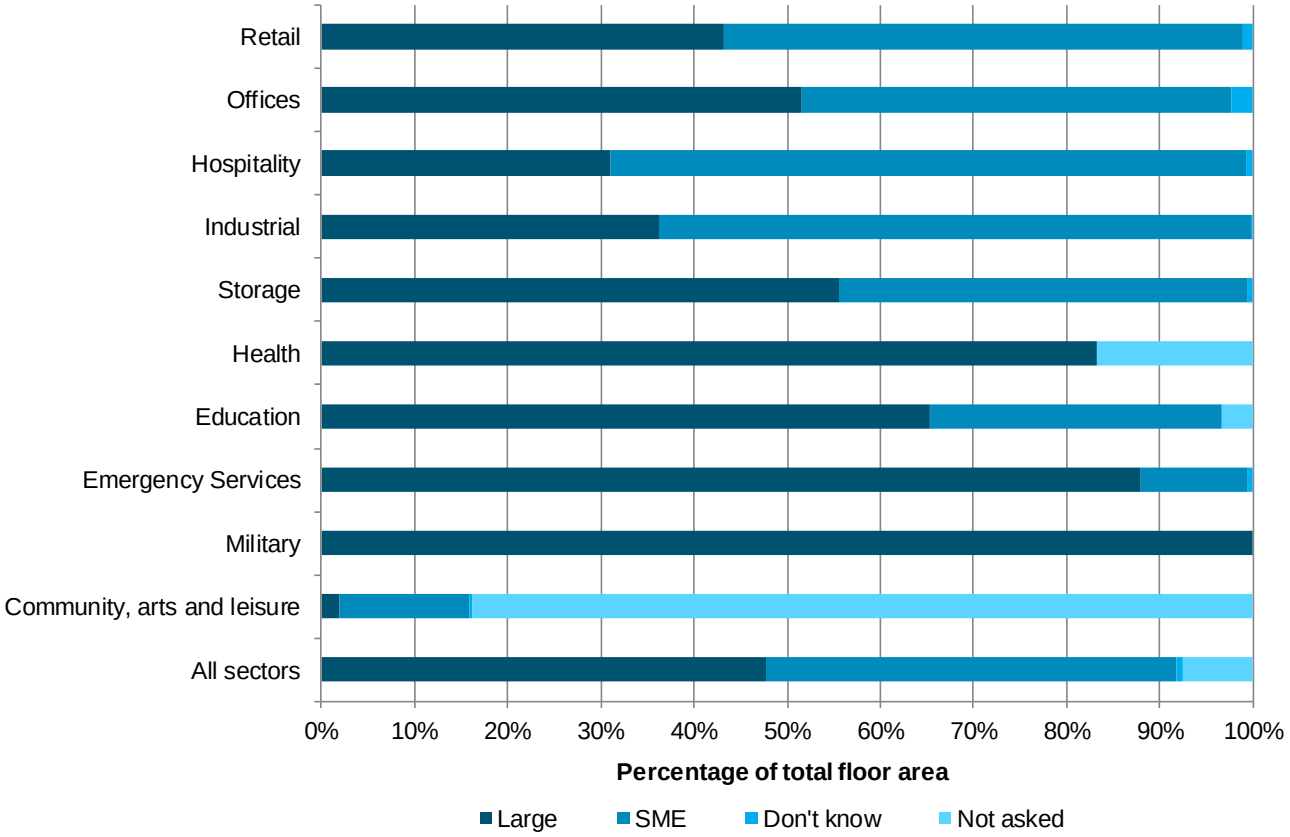
[23] The military floor area in the top decile cannot be provided because it is disclosive, the floor area for the upper quartile as a whole is therefore presented for this sector.

2.3 Summary statistics for the non-domestic stock

A number of standard characteristics for the non-domestic stock are set out by sector in Figure 2.6 to Figure 2.11 and Table 2.3; from premises and organisation size through to operating hours and premises tenure. The distributions of these characteristics are based on weighted floor area, and are accompanied by commentary on the most significant attributes.

Figure 2.6 shows the distribution of organisation size for each sector on a floor area basis. Organisation size was self-reported by respondents, so may not match with approaches to defining organisation size found in other studies. Overall, within BEES, the floor area for premises occupied by SMEs and large organisations is fairly similar (44 per cent and 48 per cent, respectively). Hospitality and industrial premises tended to be more occupied by SMEs (68 per cent and 63 per cent respectively of total floor area). In contrast, military (100 per cent), emergency services (88 per cent), health (83 per cent) and education premises (65 per cent) were all occupied predominantly by large organisations. Retail and offices were reasonably equally split whilst community, arts & leisure had a substantial number of premises where organisation size was not asked.

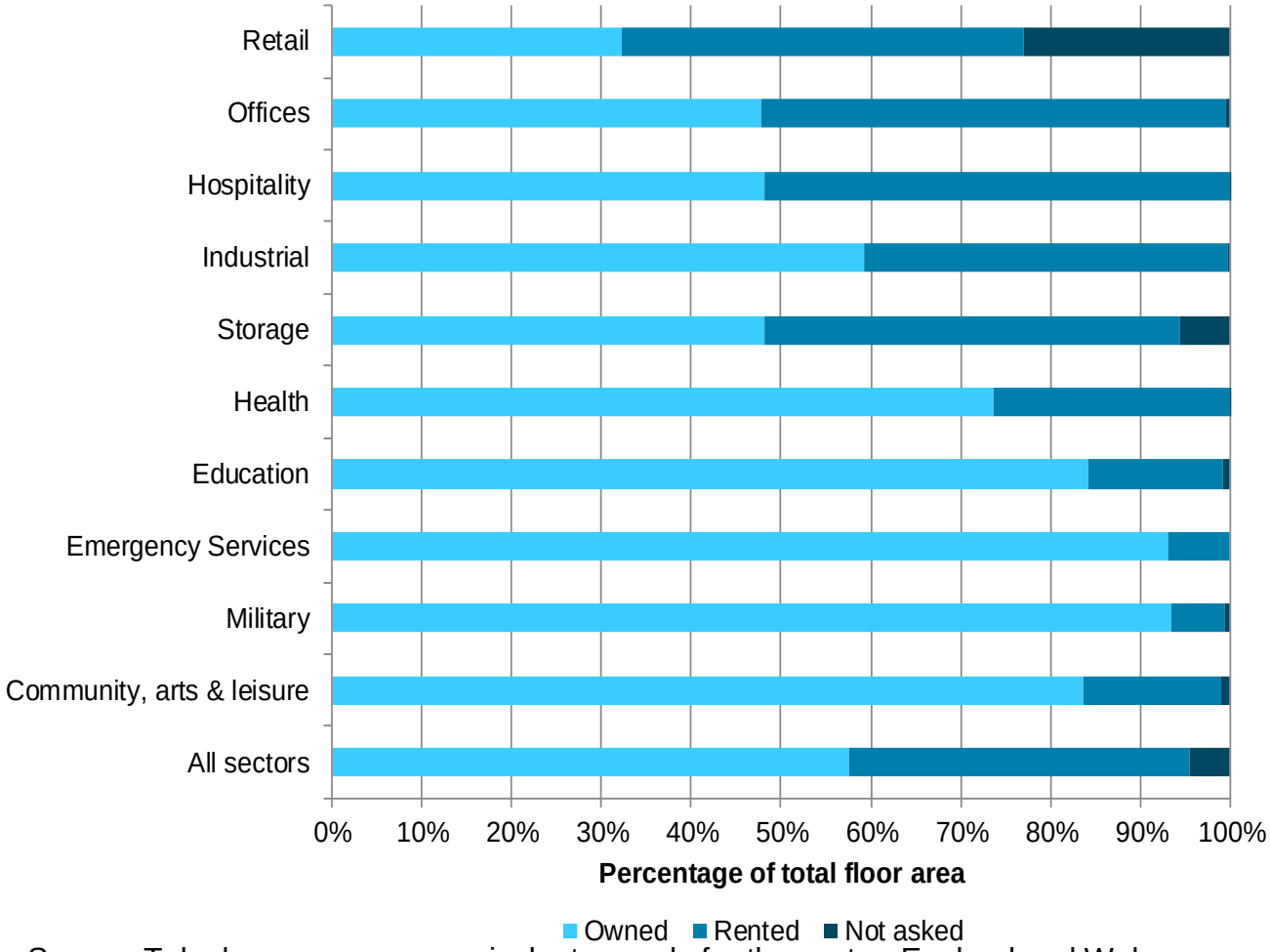
Figure 2.6: Distribution of floor area by organisation size and sector, 2014–15



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

Figure 2.7 shows the distribution of tenure for each sector on a floor area basis. Overall, 58 per cent of the non-domestic stock was owner occupied. In a number of sectors, especially those associated with the public sector, owner occupancy was highly prevalent: military, emergency services, education, community, arts and leisure and health had owner occupancy respectively at 93 per cent, 93 per cent, 84 per cent, 84 per cent and 74 per cent of floor area. Industrial premises also had high owner occupancy at 59 per cent of floor area. In offices, hospitality and storage it was more common to rent, with owner occupancy being circa 48 per cent of floor area for each of the sectors. This also may be the case for retail, although there was a large proportion not asked for this sector (23 per cent).

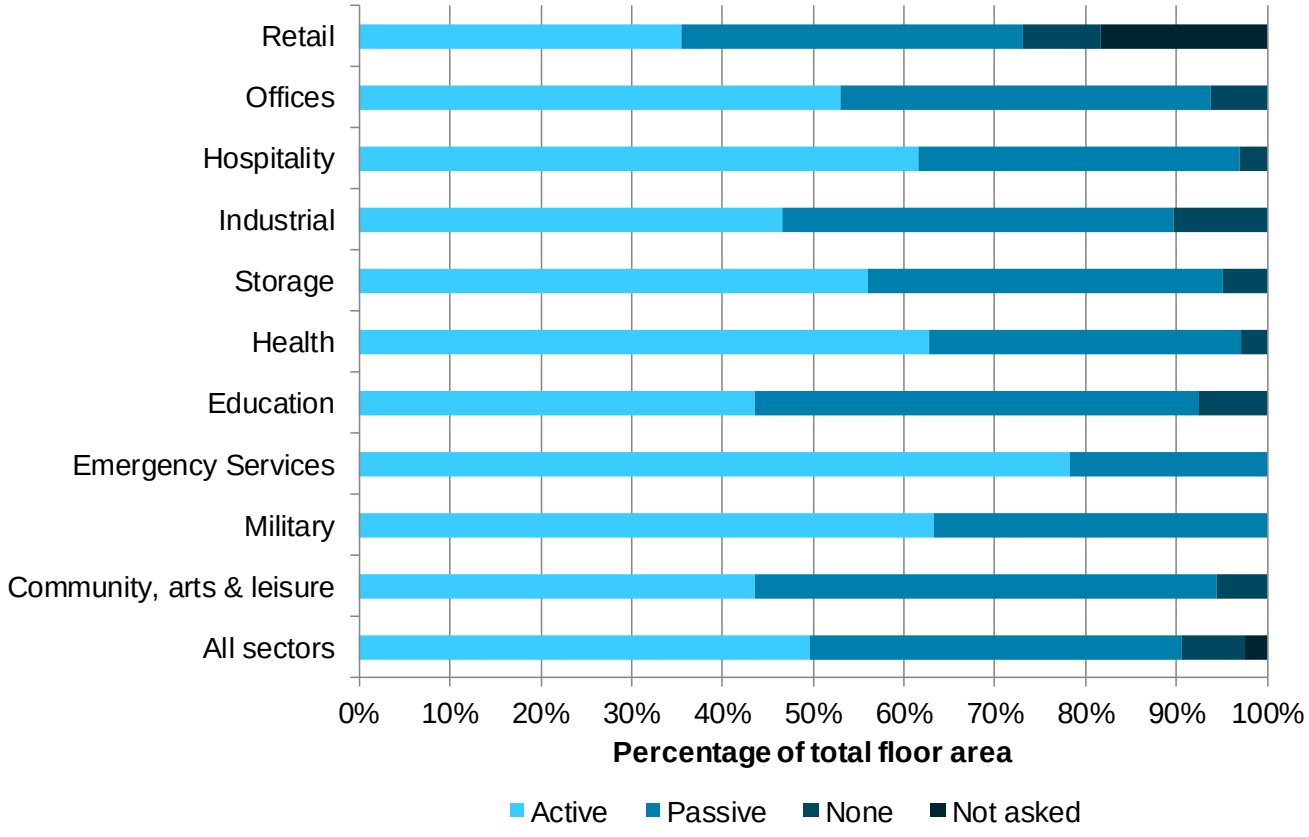
Figure 2.7: Distribution of floor area by tenure and sector, 2014–15



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

Figure 2.8 shows the distribution of energy management ambition[24] across sectors on a floor area basis. Overall the majority of premises had either active (50 per cent) or passive energy management ambitions (41 per cent) with only a very small number of premises having no energy management policies in place (7 per cent). Emergency services, military, health and hospitality were most likely to have active energy management policies in place at 78 per cent, 63 per cent, 63 per cent and 62 per cent respectively. Somewhat surprisingly, the sector with the highest proportion of no energy management ambition was industrial with 10 per cent, which could be associated with the large number of small workshops where the focus on energy management may be limited.

Figure 2.8 Distribution of floor area by energy management ambition and sector, 2014–15



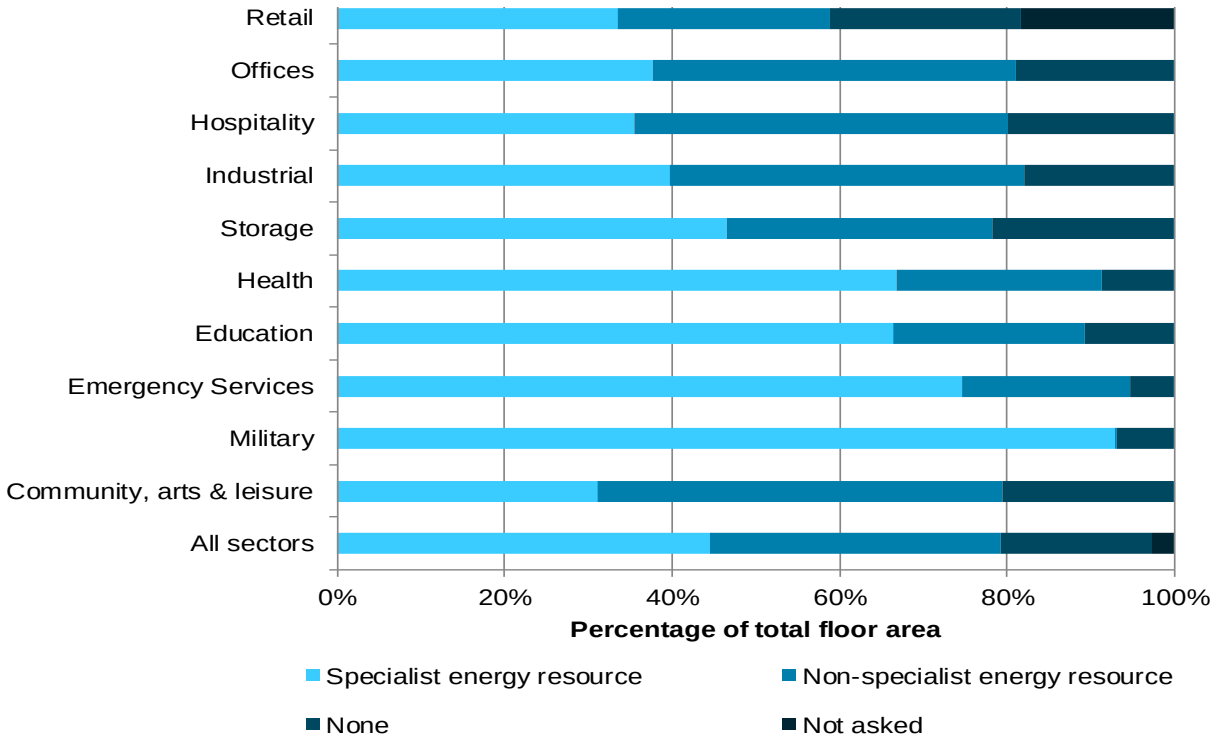
Source: Telephone survey or equivalent records for the sector, England and Wales

[24] '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".

The ability of owners or occupiers to implement abatement opportunities, and the success of doing so, is strongly affected by the availability of any energy management resource, either as a presence in the premises itself or, for organisations occupying a portfolio of premises, through a centralised energy management function. Figure 2.9 shows the distribution of floor area by sector and overall, according to the level of on energy management resource (on site or remote). Premises occupied or owned by organisations with more energy management resource would be expected to be more able to implement energy efficiency measures and therefore realise greater abatement potential.

Overall, just over half (53 per cent) of the total floor area was found within premises without active, professional energy management capability (those who responded with ‘managed by someone who is not a full time energy manager’, ‘managed by an enthusiast or energy champion’ or ‘no energy management’). The sector with the highest proportion of floor area in premises with specialist energy management included the military (93 per cent of total floor area), emergency services (75 per cent), health (67 per cent) and education (66 per cent). In contrast, the capability for energy management in the community arts & leisure, hospitality and office sectors was lower, with only 31 per cent, 35 per cent and 38 per cent respectively of floor area in sites with access to professional energy managers. The reason why these sectors have lower coverage in terms of specialised energy management resource may be due to a high propotion of SMEs occupying premises which are not that complex from an energy management perspective.

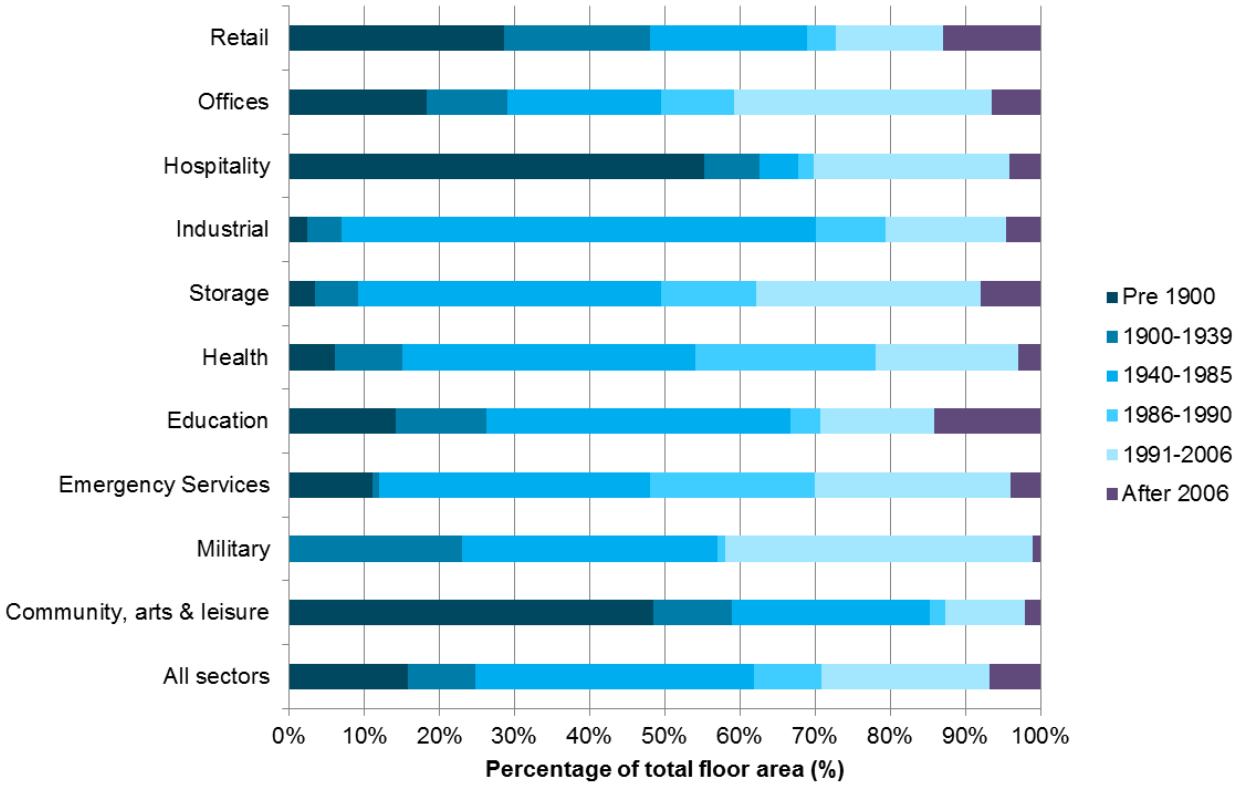
Figure 2.9: Energy management resource by sector, 2014–15



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

Figure 2.10 shows the distribution of premises by building age for each sector. The distribution is based on the floor areas for each premises record. The plot shows that the hospitality, community, arts & leisure and retail sectors featured a greater proportion of older buildings, which can be associated with the potential for energy efficiency savings. In these sectors, 60 per cent, 49 per cent and 33 per cent respectively of floor area was in premises constructed before 1940. In contrast, 42 per cent floor area in military premises, 38 per cent in offices and 36 per cent in storage premises was in premises constructed after 1991.

Figure 2.10: Percentage distribution of floor area by sector and premises age, 2014–15

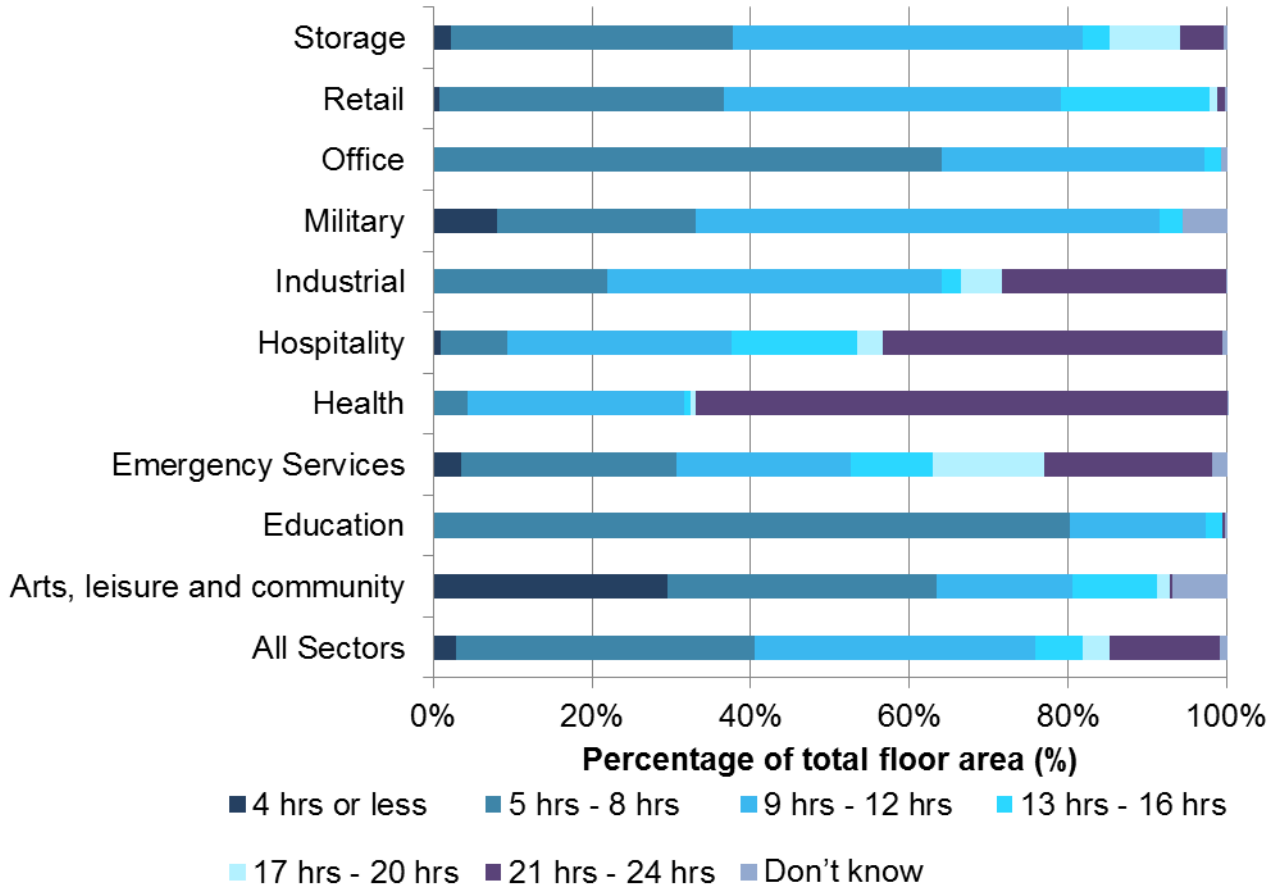


Source: Telephone survey or equivalent records for the sector, England and Wales

In addition to premises age, a key determinant of energy use and abatement potential is the amount of time a building is being used. Figure 2.11 shows the distribution of premises by the number of peak occupancy hours per day for each sector.

The chart shows variation in the usage patterns of premises within sectors. In the health, hospitality and emergency services sectors there was a greater proportion of premises operating in excess of 20 hours per day (66, 43 and 21 per cent of floor area respectively). In premises which are occupied for longer, energy efficiency measures would be expected to have shorter payback periods, as energy savings are realised more quickly. In contrast, the education, office and community, arts & leisure sectors contained premises with shorter hours of use – 74, 64 and 58 per cent of floor area in these sectors were within premises operating with peak occupancy hours of fewer than 8 hours per day.

Figure 2.11: Percentage of floor area by number of peak occupancy hours per day and sector, 2014–15



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

Table 2.3: Range of building and premises characteristics by sector and percentage of floor area, 2014–15 *Column percentages*

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	Community, arts & leisure (%)	**All sectors (%)**
Organisation size											
Micro (0-9)	39	15	33	20	11	-	1	-	-	8	**16**
Small (10-49)	12	19	22	22	18	-	10	4	-	4	**15**
Medium (50-249)	5	13	14	22	16	-	20	7	-	2	**13**
Large (250+)	43	52	31	36	56	83	65	88	100	2	**48**
Don't know	1	2	1	-	1	-	-	1	-	-	**1**
Not Asked	-	-	-	-	-	17	3	-	-	84	**8**
Total floor area (m^2)											
Less than 50	4	3	1	-	-	-	-	-	-	-	**1**
50-99	14	7	2	2	1	-	-	2	-	-	**4**
100-249	23	14	10	7	4	2	1	1	1	6	**9**
250-499	9	10	35	11	7	3	4	4	1	19	**10**
500-999	9	14	19	10	14	6	6	9	5	23	**12**
1,000-4,999	24	34	11	16	27	20	46	62	42	36	**27**
5,000-9,999	12	14	13	3	7	17	22	10	32	3	**10**
10,000 or more	5	4	9	51	40	52	22	12	19	12	**27**
Don't know	4	3	1	-	-	-	-	-	-	-	**1**
Tenure											
Owned	32	48	48	59	48	74	84	93	93	84	**58**
Leased	45	52	52	41	46	26	15	7	6	15	**38**
Not asked	23	-	-	-	6	-	1	-	1	1	**5**

Table 2.3 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	Community, arts & leisure (%)	**All sectors (%)**
Energy management ambition[25]											
Active	35	54	63	41	45	63	44	78	63	43	**46**
Passive	38	40	34	49	48	34	49	22	37	51	**44**
None	9	6	3	10	8	3	8	-	-	6	**7**
Do not know											
Not asked	18	-	-	-	-	-	-	-	-	-	**3**
Age of building											
Pre-1900	22	17	53	2	3	6	14	11	0	46	**14**
1900-1939	15	10	7	4	5	9	12	1	23	10	**8**
1940-1985	16	19	5	55	35	39	40	36	34	25	**33**
1986-1990	3	9	2	8	11	24	4	22	1	2	**8**
1991-2006	11	32	25	14	26	19	15	26	41	10	**20**
2007 or later	10	6	4	4	7	3	14	4	1	2	**6**
Don’t know	15	8	5	12	13	1	1	-	1	5	**9**
Not asked	8	-	-	-	-	-	-	-	-	-	**1**

[25] ‘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 2.3 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	Community, arts & leisure (%)	All sectors (%)
Premises relationship to building											
Whole building	66	76	80	73	78	67	69	70	61	92	**74**
Part of building	33	21	20	9	8	2	0	1	1	7	**15**
Multiple buildings	1	3	-	17	14	31	31	29	38	1	**9**
Peak operating hours[26]											
8 or less	36	64	9	22	37	4	80	30	32	61	**40**
9-15	59	34	43	43	46	28	19	32	58	23	**40**
16-23	2	1	5	7	10	1	-	14	2	5	**5**
24	1	-	42	28	5	66	-	21	-	-	**14**
Don’t know	2	1	1	-	1	1	-	3	8	11	**2**

[26] Respondents in most sub-sectors 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)?”. See sector reports for not standard uses of this question.

Table 2.3 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	Community, arts & leisure (%)	All sectors (%)
Opening hours[27]											
8 or less	26	18	3	14	23	1	8	3	20	38	**17**
9-15	58	75	36	43	50	16	78	10	47	34	**51**
16-23	5	6	15	8	7	6	5	3	4	16	**7**
24	10	1	45	35	19	77	9	81	21	2	**22**
Don't know	2	1	1	-	1	1	-	3	8	11	**2**
Unweighted base	*1,033*	*637*	*272*	*475*	*398*	*166*	*165*	*129*	*64*	*351*	***3,690***

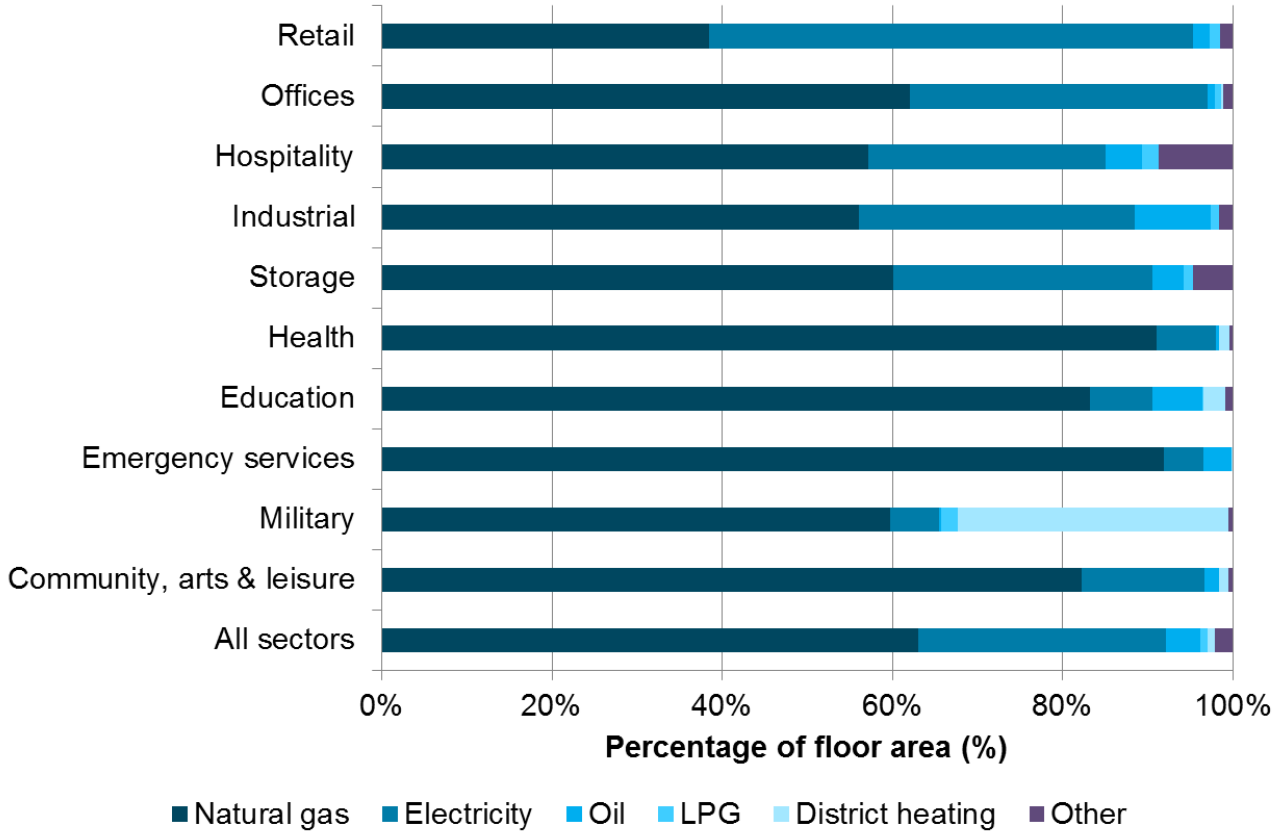
Source: Telephone survey or equivalent records for the sector, England and Wales

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

2.4 Type and condition of building services equipment

Most buildings were heated using gas boilers. Figure 2.12 shows the distribution of total floor area by the energy type of each premises' main heating fuel, by sector. Natural gas is used to heat 63 per cent of premises area. In contrast, 57 per cent of premises in the retail sector and 35 per cent of premises in offices used electricity as the main heating fuel. The military sector had 29 per cent of premises provided with heat from district heating systems.

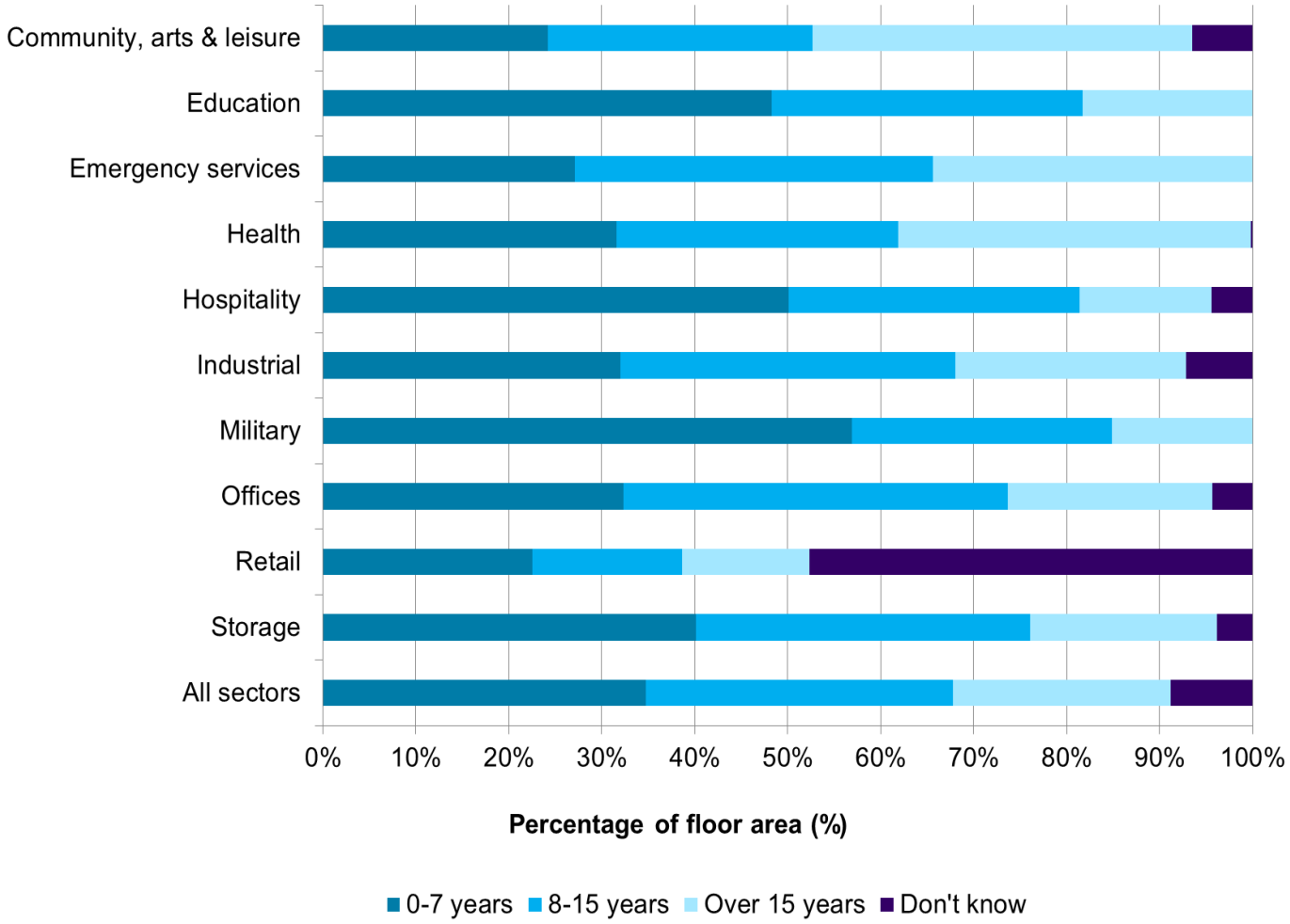
Figure 2.12: Percentage of floor area by sector and heating fuel, 2014–15



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

A large proportion of space heating across the stock is produced by gas boilers. Replacement of gas boilers can be a relatively simple energy reduction measure to achieve, where recommended. It is therefore important to know the age distribution of gas boiler plant used for space heating across the non-domestic stock (Figure 2.3)[28]. The chart shows that premises in the community, arts & leisure sector, health sector and emergency services sector had the greatest proportion of older heating plant, with 39 per cent, 38 per cent and 32 per cent of floor area respectively in premises with boilers over 15 years old. In contrast, the sectors with the greatest proportion of floor area in premises with boilers less than 7 years old were hospitality (48 per cent of total) and education (47 per cent of total) and military (36 per cent of total).

Figure 2.13: Percentage of floor area by sector and age of heating boiler, 2014–15

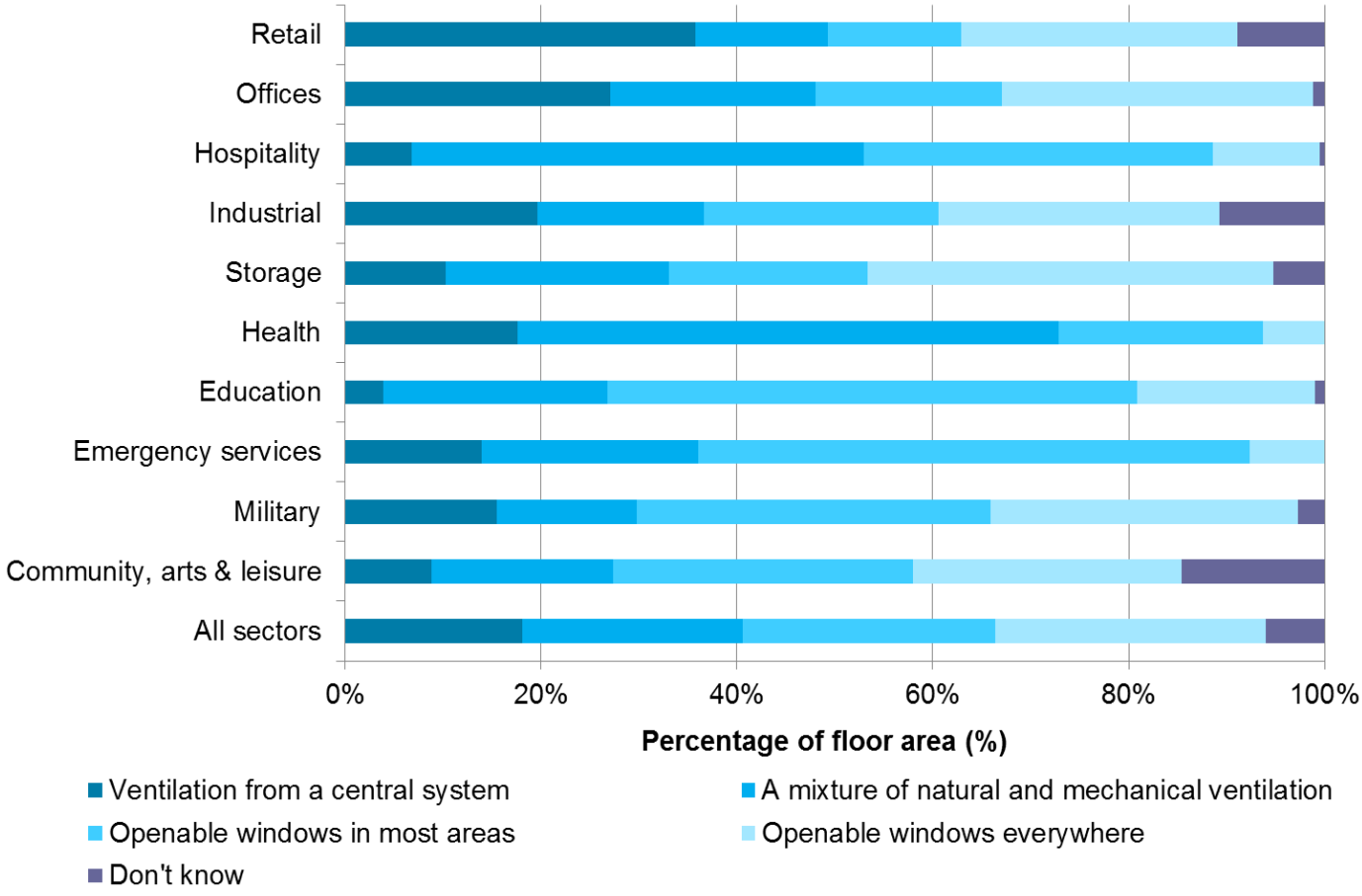


Source: Telephone survey or equivalent records for the sector, England and Wales

[28] The chart shows the age of heating boilers for those premises where the main heating fuel was natural gas, and where boilers were present.

Another key determinant of the energy use of a premises is whether it has mechanical services to provide ventilation (fresh air) and cooling. Figure 2.4 shows the proportion of total area with different degrees of mechanical servicing. 53 per cent of the floor area was found in premises with natural ventilation, 22 per cent with a mix of natural and mechanical and 18 per cent with full mechanical ventilation from a central system. Sectors which showed a different distribution to this general pattern included the retail and office sectors, in which 36 per cent and 27 per of the floor area respectively was in premises ventilated via a central system. The education sector, the military sector and the emergency services sector displayed the lowest levels of mechanical ventilation, with 72 per cent, 67 per cent and 64 per cent of floor area in premises with ventilation mainly by openable windows.

Figure 2.14: Percentage of floor area by sector and ventilation type, 2014–15

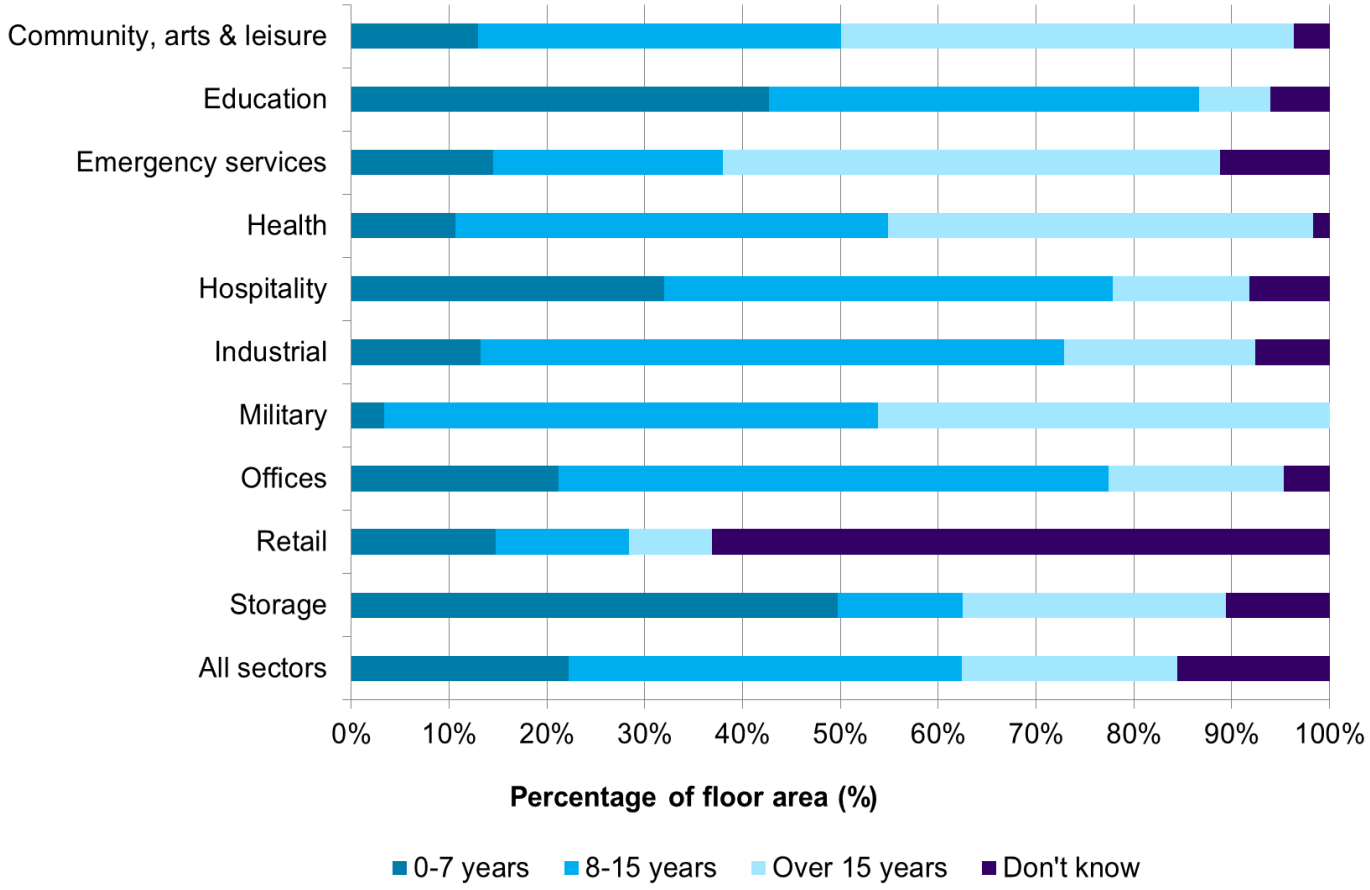


Source: Telephone survey or equivalent records for the sector, England and Wales

Replacement of central heating, ventilation and cooling mechanical services plant represents a significant opportunity for energy reduction. It is therefore important to understand the age of such plant across the non-domestic stock. Figure 2.15 and Figure 2.16 show the age distribution of ventilation plant and cooling plant, for those premises where these were present.

Figure 2.15 shows 40 per cent of the floor area with ventilation plant was found in premises with a plant age of between 8 and 15 years. Exceptions to this general pattern included the emergency services, military and community, arts & leisure sectors, where 51, 46 and 46 per cent of floor area was found in premises with ventilation plant more than 15 years old.

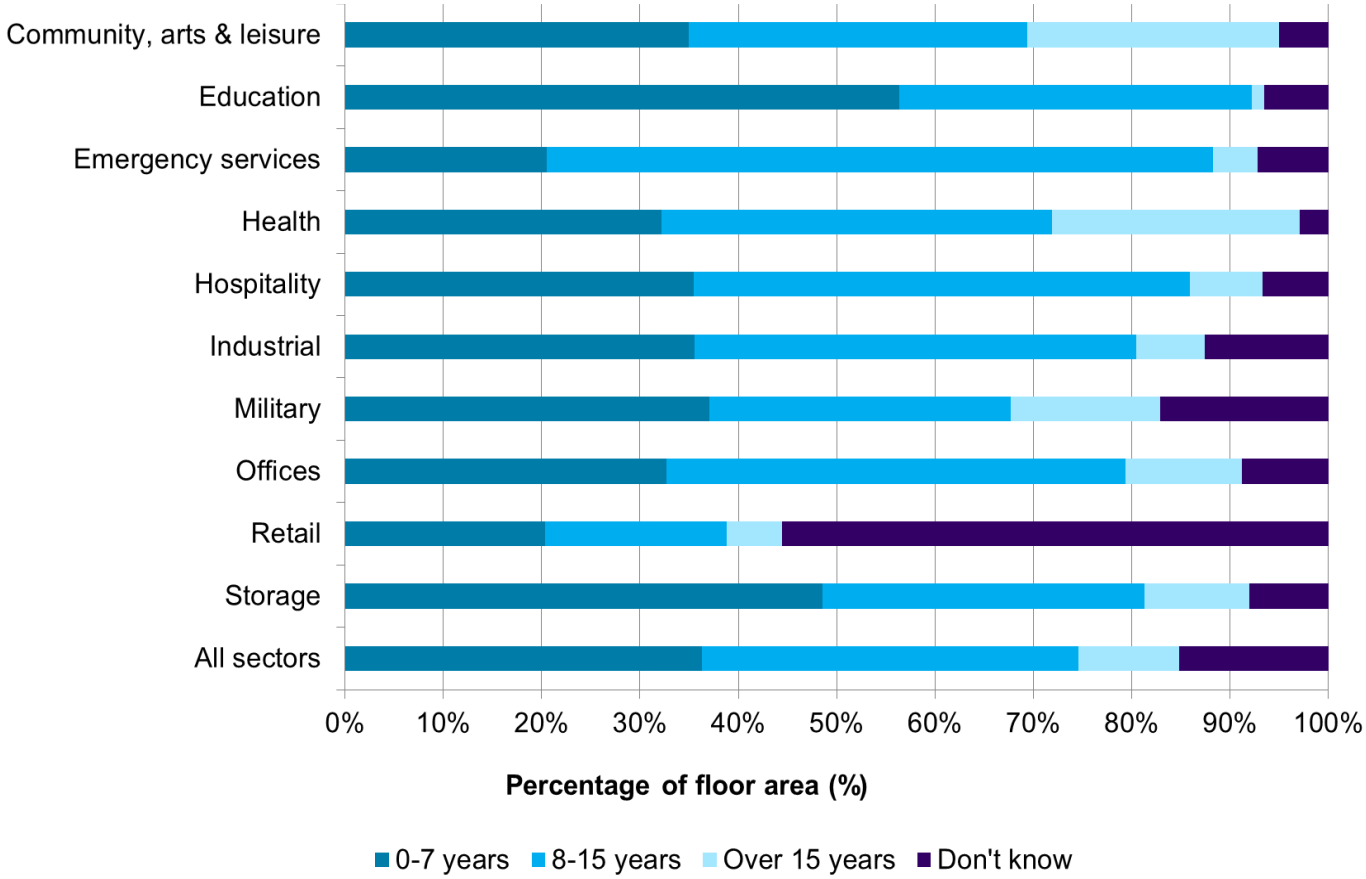
Figure 2.15: Percentage of floor area by sector and age of ventilation plant, 2014–15



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

Figure 2.16 shows that 90 per cent of premises floor area, where cooling plant was present, was found in sites with cooling plant less than 15 years old. In contrast, the community, arts & leisure and health sectors featured a greater proportion of cooling plant older than 15 years (26 per cent and 25 per cent of total floor area respectively).

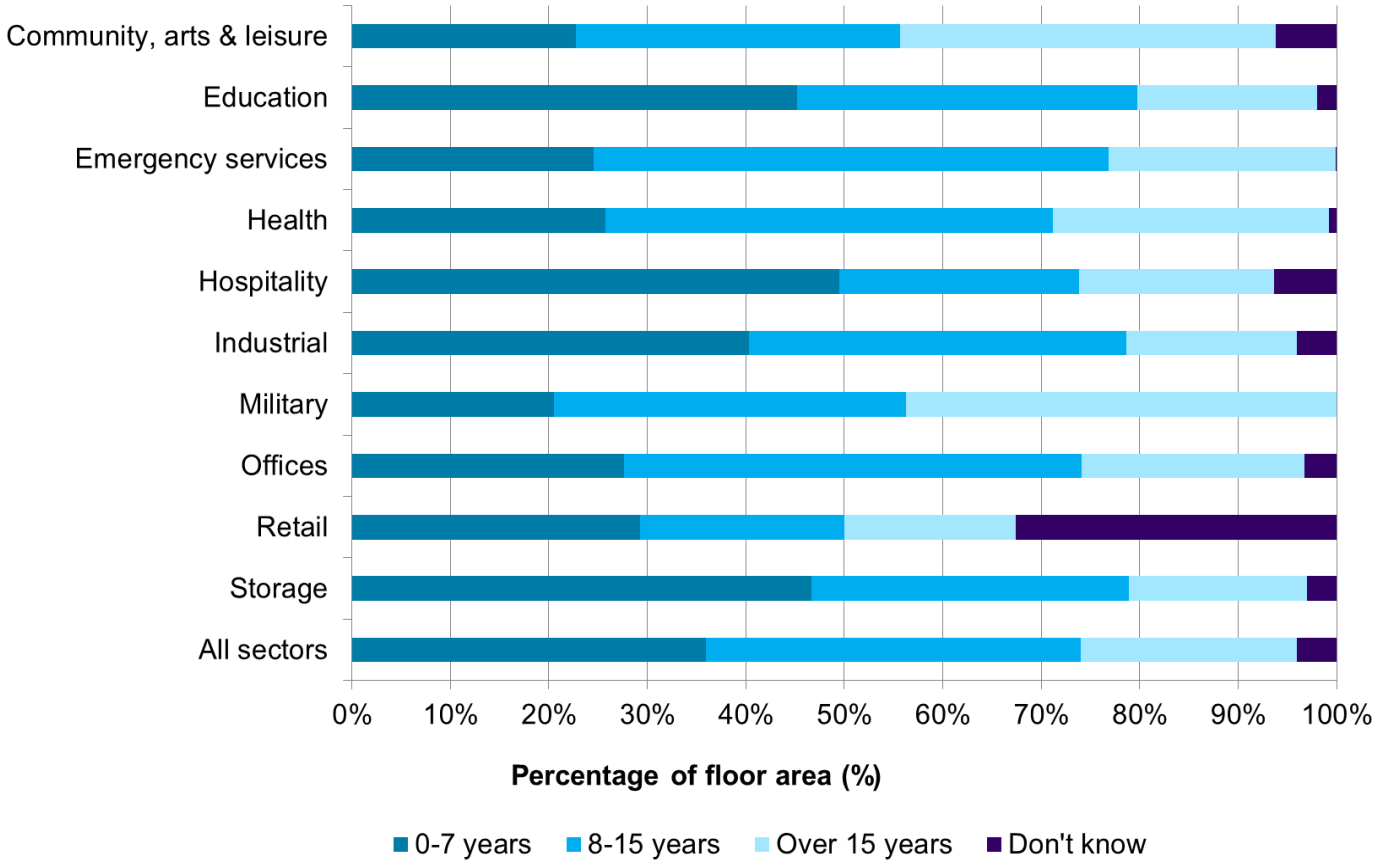
Figure 2.16: Percentage of floor area by sector and age of cooling plant, 2014–15



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

The other main category of building services is lighting. Interventions to upgrade lighting are usually easier than with central heating, ventilation and cooling plant, and with rapidly improving lighting technology, lighting replacement is increasingly popular and cost-effective. Figure 2.17 shows the age distribution for lighting across the stock. The sectors with the greatest proportion of floor area in premises with lighting plant over 15 years old included community, arts & leisure (38 per cent of total floor area), military (44 per cent) and health (28 per cent). In contrast, 49 per cent of floor area in the hospitality sector was found in premises with lighting fitted less than 7 years ago, which was marginally higher than the storage sector (47 per cent) and the education sector (45 per cent).

Figure 2.17: Percentage of floor area by sector and age of lighting plant, 2014–15



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

3 Energy Consumption

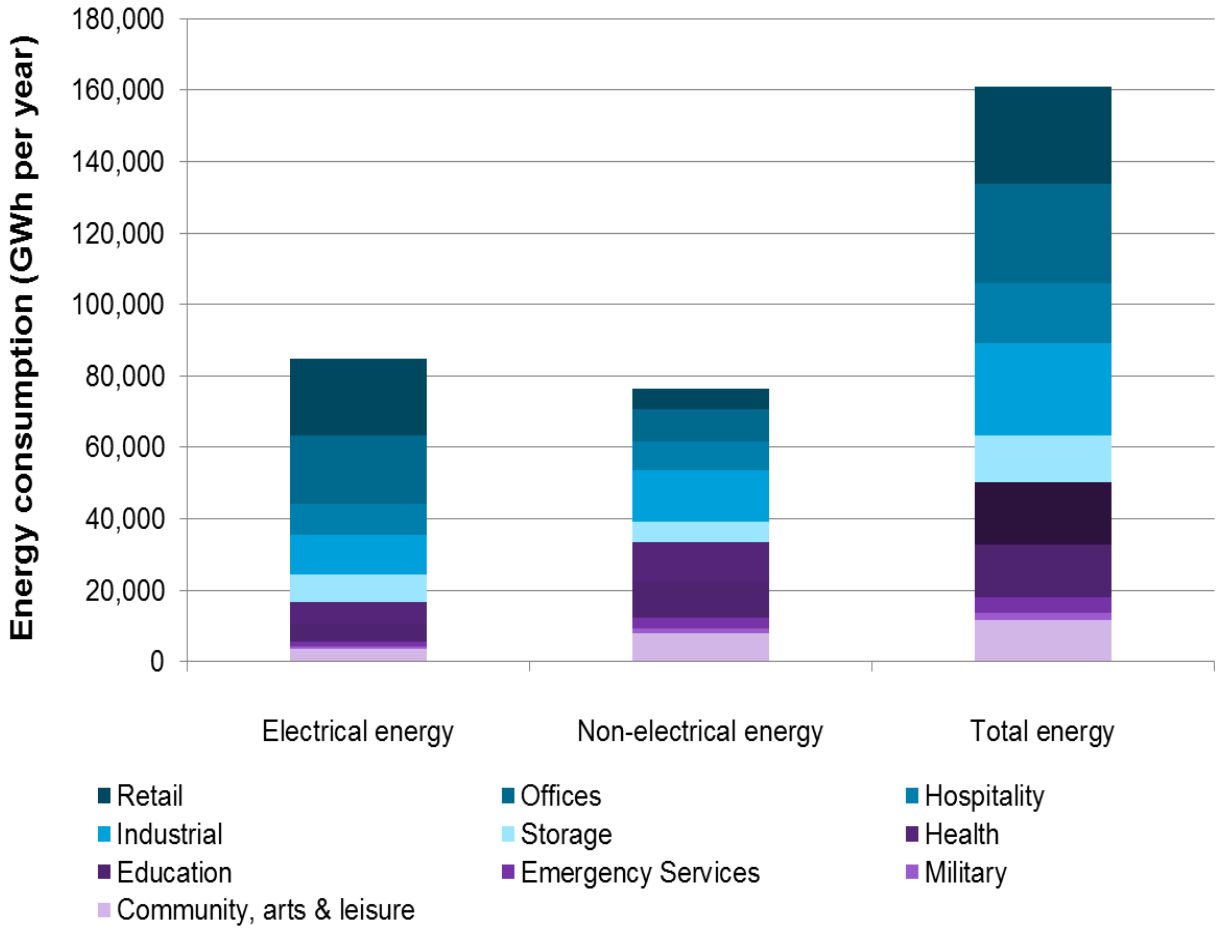
This section presents a series of summary charts and tables of the energy use modelling undertaken during the analysis of the non-domestic building stock.

3.1 Energy consumption and greenhouse gas emissions in non-domestic premises

The electrical and non-electrical energy consumption of the non-domestic stock is presented in Figure 3.1, broken down by the ten sectors.

The total stock consumed 161,060 GWh of total energy consumption, with electrical energy consumption of 84,820 GWh (53 per cent of total) and non-electrical energy consumption 76,240 GWh (47 per cent). The five largest sectors in terms of energy consumption accounted for 71 per cent of the non-domestic energy consumption. These were offices (27,620 GWh, 17 per cent), retail (27,340 GWh, 17 per cent), industrial (25,740 GWh, 16 per cent), hospitality (16,980 GWh, 11 per cent) and health (17,380 GWh, 11 per cent).

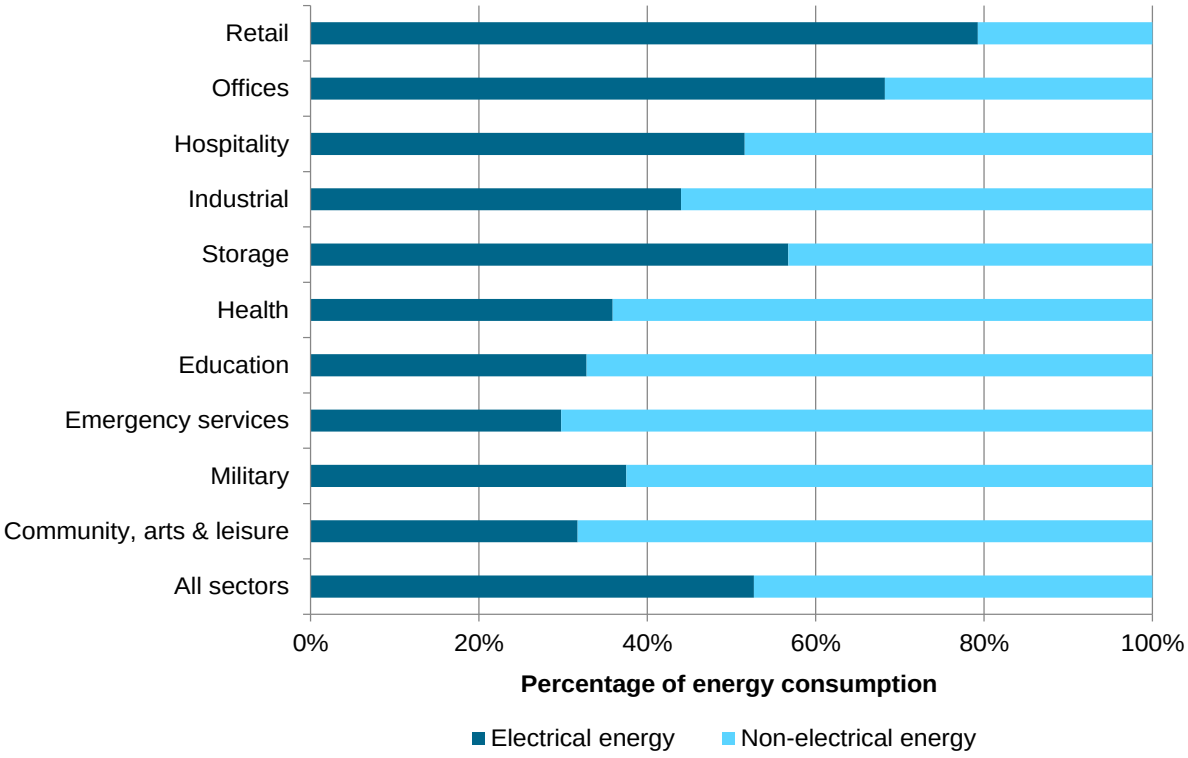
Figure 3.1: Energy consumption by energy type and sector, 2014–15



Source: Energy use model results, England and Wales

The electricity to non-electrical energy split for each sector and for the full non-domestic stock is shown in Figure 3.2. In 4 sectors electricity use is dominant: retail (79 per cent), offices (68 per cent), storage (57 per cent) and hospitality (52 per cent). In all the others, non-electrical energy was a greater proportion of overall energy consumption, especially emergency services, community, arts & leisure and education (70, 69 and 67 per cent of sector total consumption respectively).

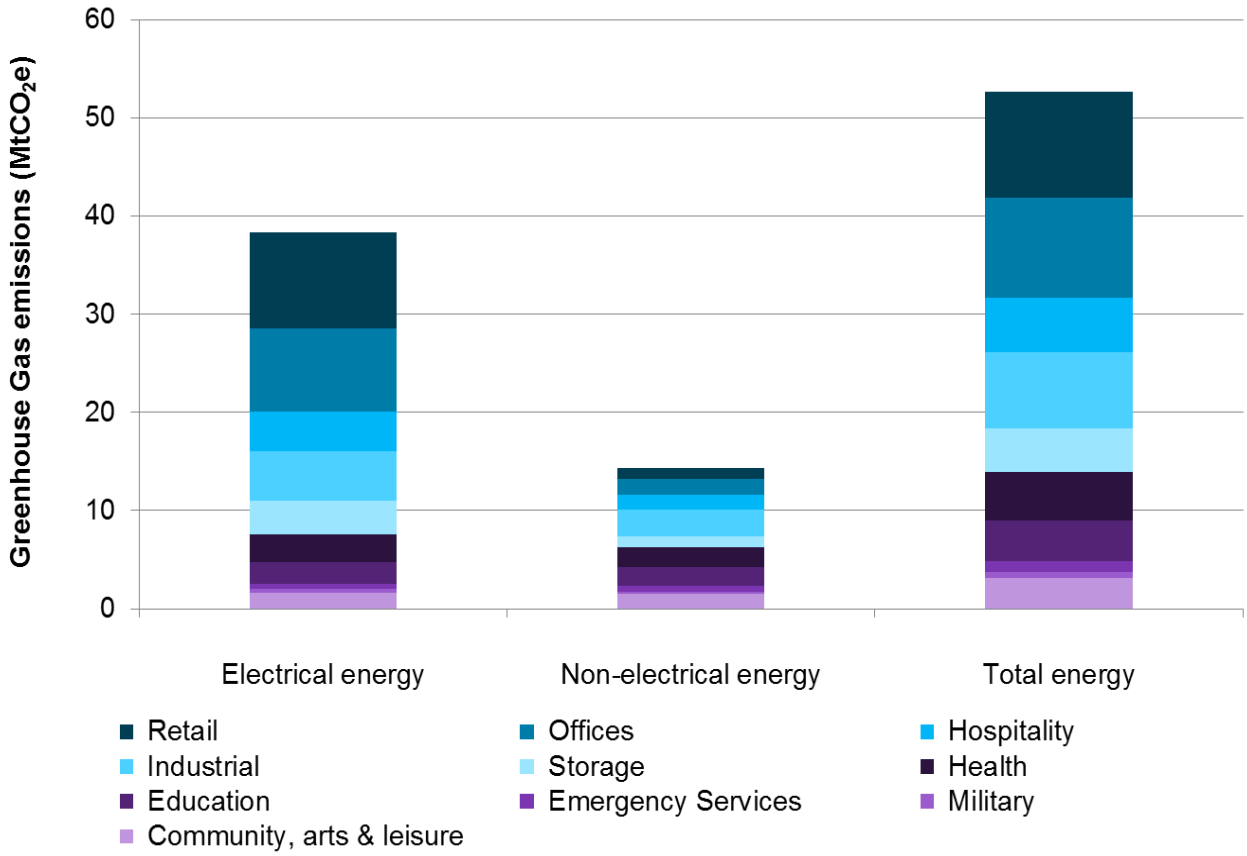
Figure 3.2: Energy consumption distribution by energy type and sector, 2014–15



Source: Energy use model results, England and Wales

The greenhouse gas emissions for the non-domestic stock are presented in Figure 3.3[29]. The total greenhouse gas emissions from the stock were 53 $MtCO_2e$ per year. The annual emissions from electrical energy consumption were 38$MtCO_2e$ and those from non-electrical energy consumption were 14 $MtCO_2e$.

Figure 3.3: Greenhouse gas emissions by energy type and sector, 2014–15

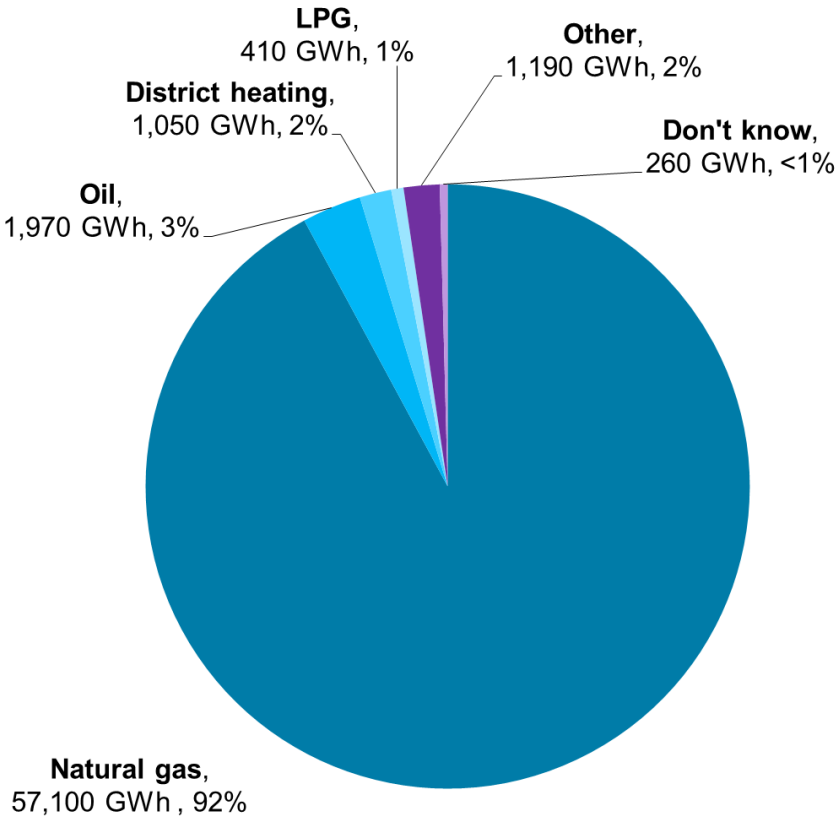


Source: Energy use model results, England and Wales

[29] Greenhouse Gas emissions were estimated using energy consumption figures from the energy use model and grid average electricity and fuel emission factors from IAG guidance on valuing greenhouse gas emissions published by BEIS, 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.

Non-electrical energy was made up of a number of different energy sources. A large part (around 78%) is for space heating and hot water provision. It was not possible to robustly model the breakdown of consumption by energy source for non-electrical consumption for all uses. It was however possible to model non-electrical consumption by different energy sources for space heating and hot water provision (Figure 3.4). 57,100 GWh (92 per cent) of non-electrical energy consumption was natural gas usage, followed by 1,970 GWh (3 per cent) for oil and 1,190 GWh (2 per cent) for 'other', which includes all forms of non-electrical renewable heat.

Figure 3.4 : Non- electrical energy consumption for space heating and hot water by energy source, 2014–15



Note: LPG – liquefied petroleum gas

Source: Energy use model results, England and Wales

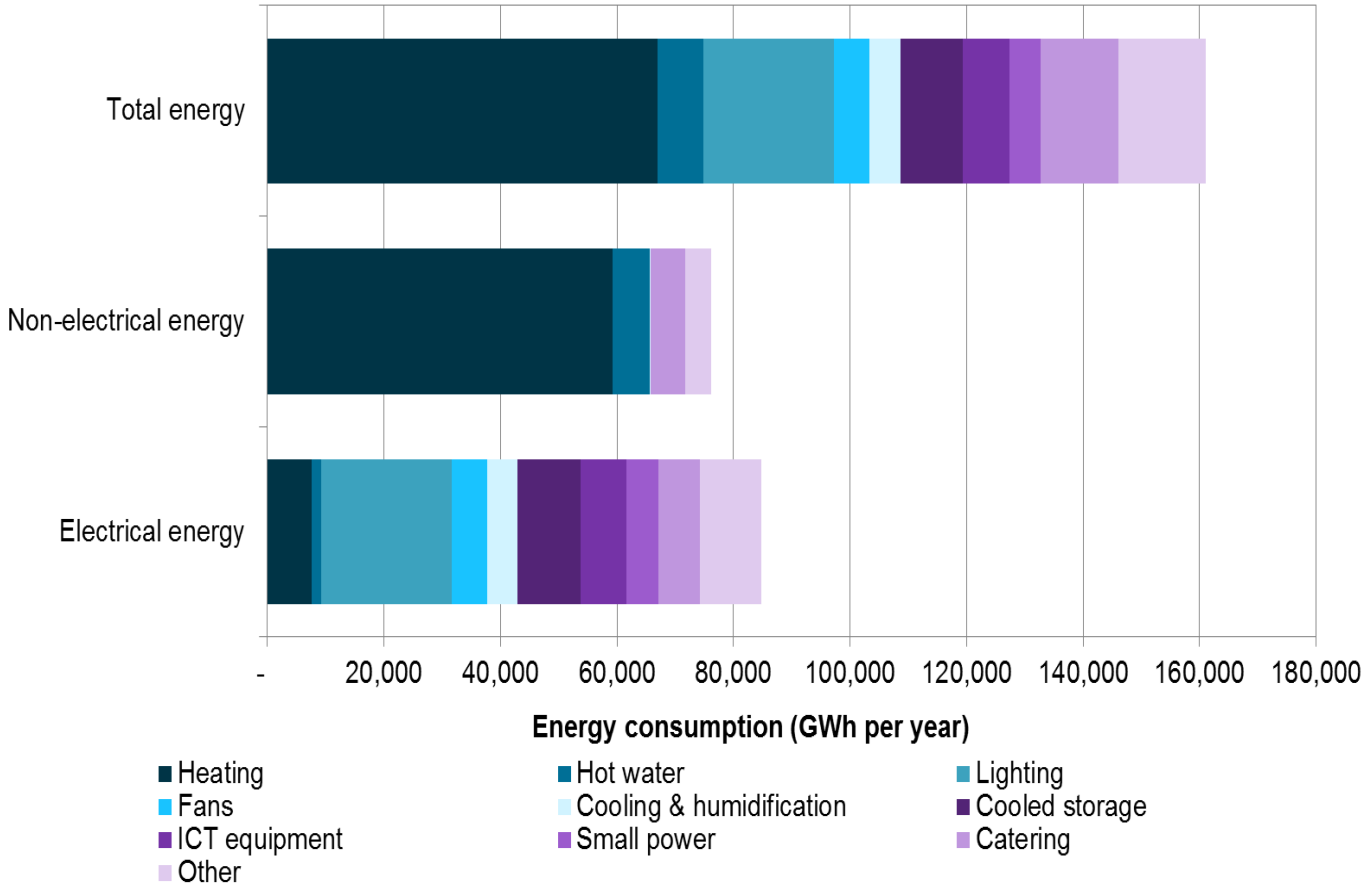
3.2 Energy consumption by end use

The distribution of energy consumption by end use is presented in Figure 3.5 and Table 3.1.[30]

The energy use model defined 23 separate energy end uses in its analysis. For the purposes of presentation in Figure 3.5, the 23 uses have been condensed into ten categories covering key building services end uses (heating, hot water, fans for ventilation, cooling & humidification and lighting), and other end uses more linked to how the building is used (cooled storage, ICT equipment, small power, catering and other. The simplified classification is shown against the more detailed classification results in Table 3.1.

Further detail is given in Appendix B on the 23 end uses and how these are aggregated to ten categories.

Figure 3.5: Energy consumption by energy type and energy end use, 2014–15



Source: Energy use model results, England and Wales

[30] 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 and other.

109,780 GWh (68 per cent) of energy c**o**nsumption (78 per cent of non-electrical energy and 52 per cent of electrical energy) was used for conditioning and lighting the non-domestic building stock i.e. heating and cooling to provide a comfortable working environment and other facilities needed to use a premises[31]. The five main building services end uses shown individually in Table 3.1 account for 108,618 GWh (67 per cent) of this total.

The remaining 52,430 GWh (33 per cent) of energy consumption (14 per cent of non-electrical energy and 49 per cent of electricity) was used by the activities taking place in the premises. Catering (13,270 GWh) and cooled storage i.e. food and drink refrigeration (10,790 GWh) were the most significant activity related end uses, followed by ICT loads (data centres and server rooms, 7,910 GWh) and small power (e.g. office equipment, 5,440 GWh).

The most common end uses of electrical energy were internal lighting at 21,260 GWh (25 per cent of total electrical energy), followed by cooled storage (10,790 GWh, 13 per cent), ICT equipment (7,910 GWh, 9 per cent), space heating (7,650 GWh, 9 per cent), catering (7,230 GWh, 8 per cent), fans (6,030 GWh, 7 per cent), small power (5,440, 6 per cent) and cooling (5,090 GWh, 6 per cent). The most significant non-electrical energy end uses were space heating at 59,300 GWh (86 per cent of total non-electrical energy) followed by hot water (6,300 GWh, 8 per cent) and catering (6,040 GWh, 8 per cent).

[31] The end use categories included in this calculation were space heating, hot water, space cooling, humidification, fans, internal lighting, pumps, controls and vertical transport.

Table 3.1: Energy consumption by energy type and energy end use, 2014–15

Energy end use category (Simplified)	BEES end use category	Electrical energy consumption (GWh/year)	Non-electrical energy consumption (GWh/year)	Total energy consumption (GWh/year)
Heating	Space heating	7,650	59,300	**66,940**
Hot water	Hot water	1,640	6,300	**7,940**
Cooling & humidification	Space cooling	5,090	-	**5,090**
	Humidification	130	130	**260**
Fans	Fans	6,030	-	**6,030**
Lighting	Lighting - internal	21,260	-	**21,260**
	Lighting - display	1,110	-	**1,110**
Catering	Catering	7,230	6,040	**13,270**
Cooled storage	Cooled storage	10,790	-	**10,790**
Other	Pumps	1,100	-	**1,100**
	Controls	720	-	**720**
	Lighting - external	2,160	-	**2,160**
	Vertical transport	440	-	**440**
	Entertainment equipment	1,460	-	**1,460**
	Entertainment lighting	20	-	**20**
	Pool/leisure	560	2,450	**3,000**
	Small power	5,440	-	**5,440**
	ICT equipment	7,910	-	**7,910**
	Laundry	130	70	**200**
	Lab equipment	290	-	**290**
	Medical equipment	1,440	1,960	**3,410**
	Other	2,220	-	**2,220**
Total		**84,820**	**76,240**	**161,060**
Unweighted base		*3,690*	*2,873*	*3,690*

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

3.3 Non-domestic energy intensity distributions

Energy intensity (energy use per m^2 floor area) enables the energy efficiency of premises and end uses to be compared across sectors, and is used for benchmarking in the building services and energy management industries[32]. Figure 3.6 to Figure 3.9 present the distribution of energy intensity for all modelled records in each non-domestic sector.

Figure 3.6 shows the total energy intensity for all premises in each sector. Taking all premises into account, hospitality had the highest median total energy intensity (387 kWh/m^2) followed by emergency services (325 kWh/m^2) and health (201 kWh/m^2) (Figure 3.6).

Figure 3.7 and Figure 3.8 show the electrical energy intensities for premises. The two charts are used to show separately the electrical energy intensity for premises that also use non-electrical energy and the intensity of electric only buildings. This is important to distinguish since the electrical intensity is expected to be significantly higher where electricity is used for end uses such as heating.

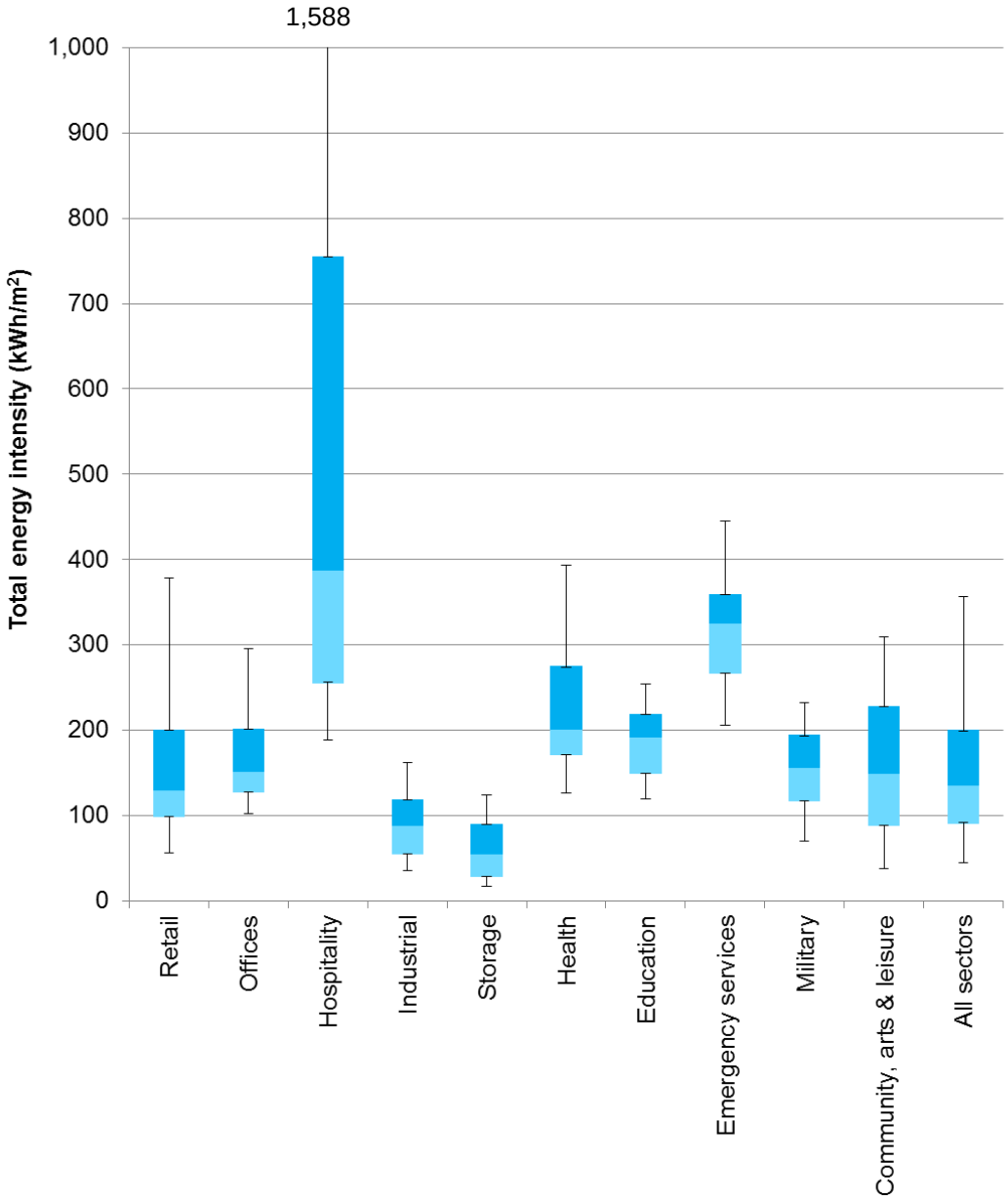
Within premises with non-electrical consumption (Figure 3.7), the hospitality sector had the highest median electrical energy intensity (191 kWh/m^2) followed by retail (118 kWh/m^2) and emergency services (100 kWh/m^2). All other sectors had medians of less than 100 kWh/m^2.

For the cohort of all-electric premises (Figure 3.8), the overall median electrical intensity was over 50 per cent higher than for premises with non-electrcial consumption with the median up to 3 times higher in some sectors. Hospitality again had the highest median intensity (490 kWh/m^2). This was followed by health (275 kWh/m^2) and emergency services (187 kWh/m^2) The median energy intensity of offices and retail was significantly lower (124 and 115 kWh/m^2 respectively). Other sectors were far lower with energy intensities below 80 kWh/m^2.

For non-electrical energy intensity in the relevant premises, Figure 3.9 shows the highest median was for emergency services (209 kWh/m^2), followed by hospitality (197 kWh/m^2). Education, community, arts & leisure, health and military had similar mid-range medians of respectively 133, 124, 112, and 111 kWh/m^2. The median for offices was significantly lower (90 kWh/m^2), reflecting their shorter hours of use.

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

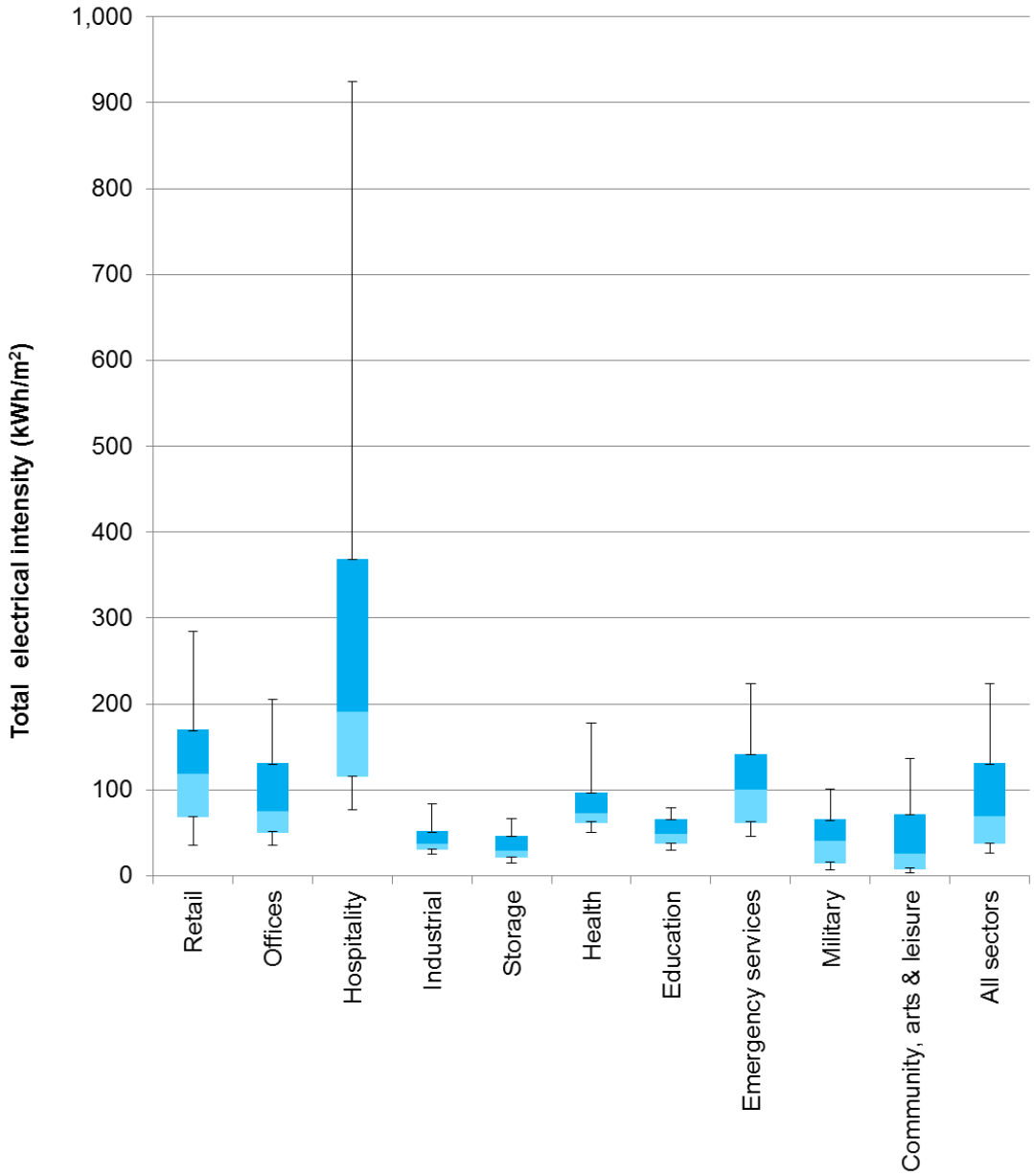
Figure 3.6: Distribution of total energy intensity by sector, 2014–15 (all premises)



Source: Energy use model results by sector, England and Wales
Unweighted base N=3,690

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 sector, 80 per cent of the total number of data points are displayed.

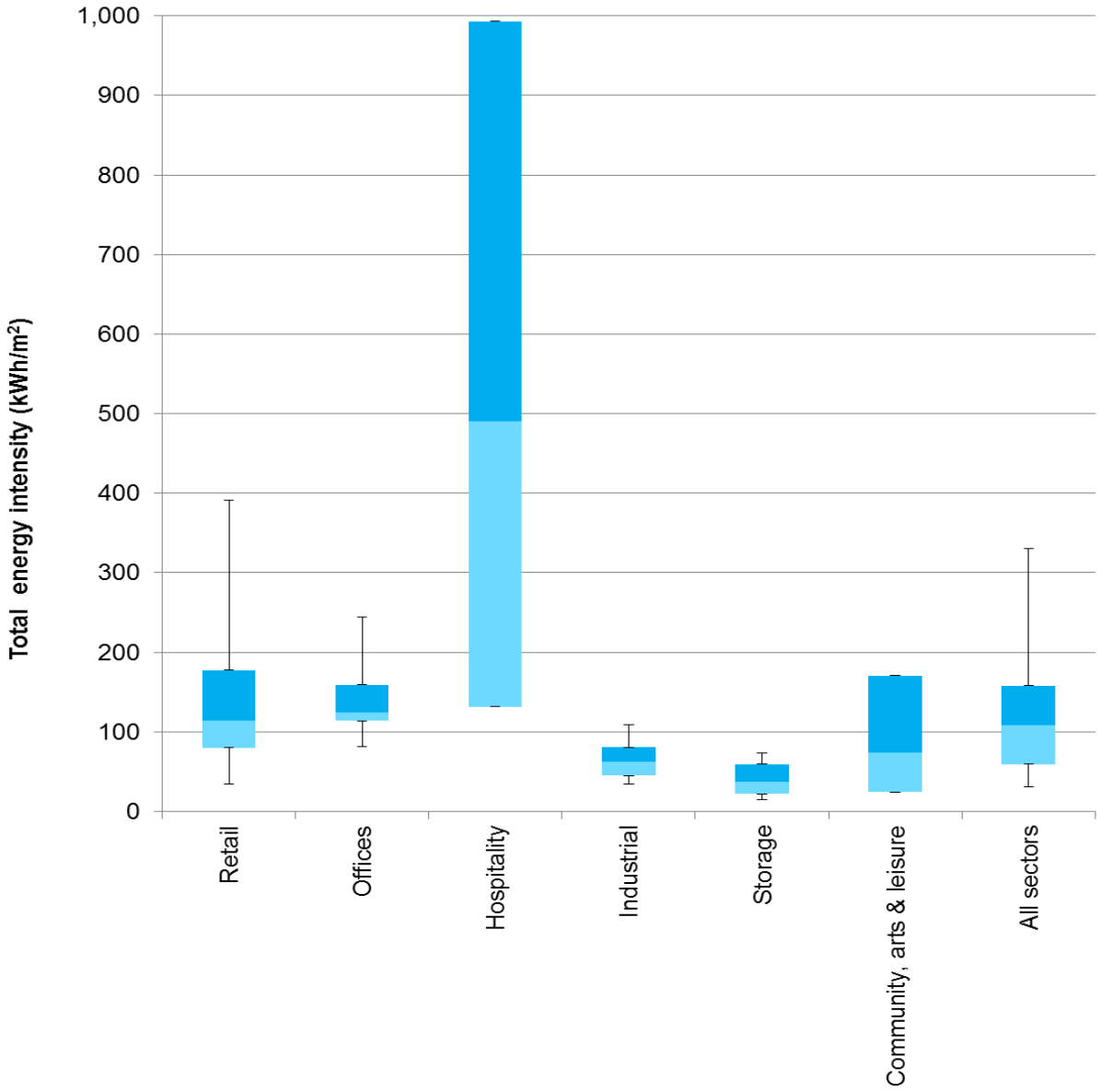
Figure 3.7: Distribution of electrical energy intensity by sector, 2014–15 (premises that have non-electrical end uses)



Source: Energy use model results by sector, England and Wales
Unweighted base N=2,880

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 sector, 80 per cent of the total number of data points are displayed.

Figure 3.8: Distribution of electrical energy intensity by sector, 2014–15 (all-electric premises only)

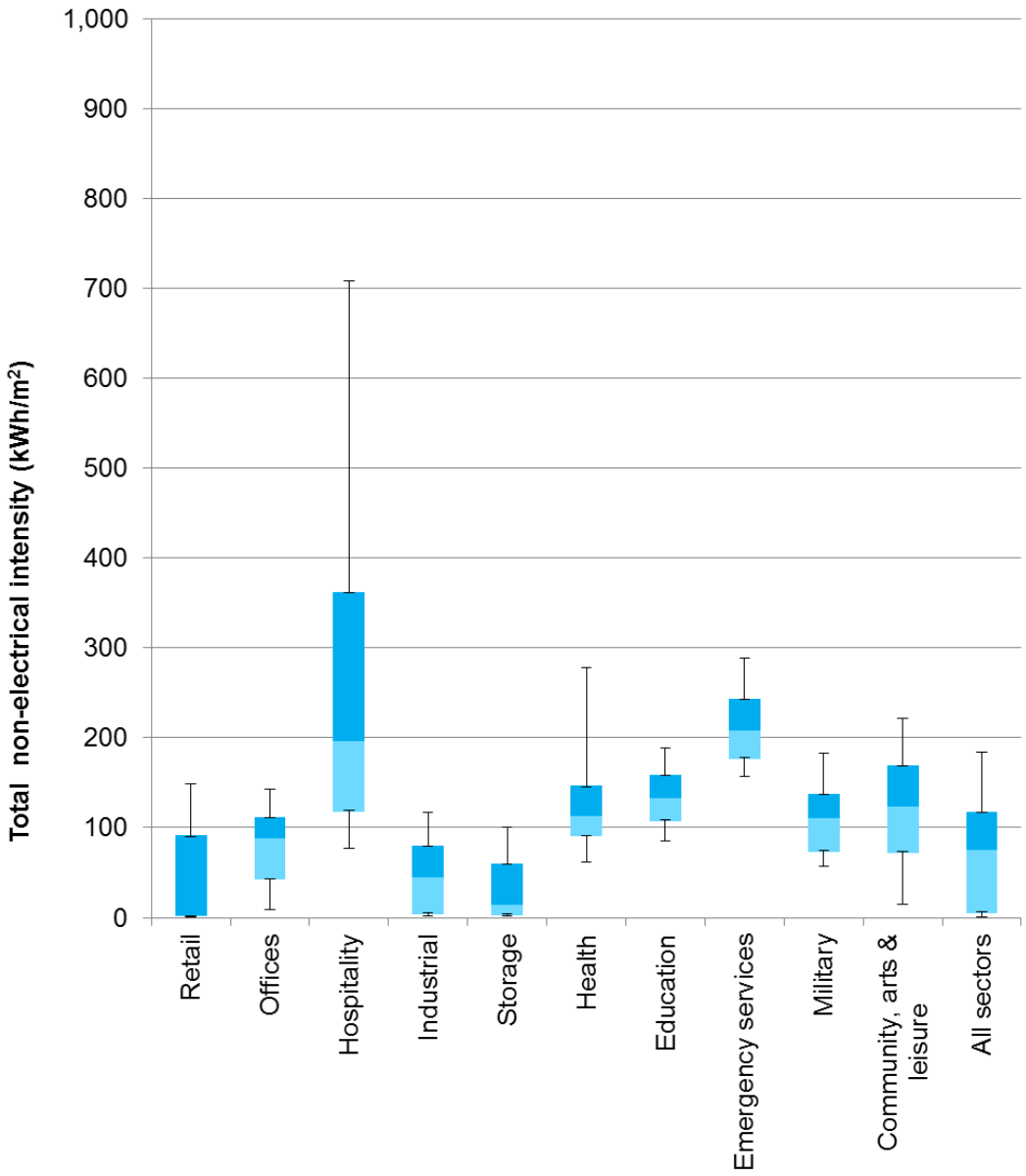


Source: Energy use model results by sector, England and Wales
Unweighted base N=810

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 sector, 80 per cent of the total number of data points are displayed. The black bars are not shown in sectors with less than 50 records.

Only six sectors are displayed in Figure 3.8 as very few electric only premises were surveyed in Health, Education, Emergency Services or Military.

Figure 3.9: Distribution of non-electrical energy intensity by sector, 2014–15 (premises that have non-electrical end uses)



Source: Energy use model results by sector, England and Wales
Unweighted base N=2,880

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 sector, 80 per cent of the total number of data points are displayed.

3.4 Non-domestic stock sector energy end use breakdowns

Figure 3.10 and Figure 3.11 show the energy consumption and mean modelled energy intensity by end use for each of the sectors in the non-domestic stock respectively. Each end use intensity estimate (kWh/m^2) was calculated by summing the entire predicted energy consumption for that end use for all records, and dividing by the total floor area of all records in that sector regardless of whether they used that type of energy or had that end use. For example, heating electrical intensity is the ratio of all electricity used for heating across the sector relative to the entire floor area of buildings in that sector. Similarly, the energy intensity of swimming pools in hotels is based on the floor area of all hotels regardless of whether they had swimming pools. Further data is provided in Appendix C where energy intensity is provided separately for electrical and non-electrical energy end use breakdowns by sector.

Space heating is a significant energy end use in all sectors, but is particularly significant in health, education and emergency services with energy intensity greater than 100 kWh/m^2/year. In health and emergency services, this was linked to the inclusion of overnight accommodation for patients, detainees[33] or staff in these sectors, and a number of sub-sectors (e.g. hospitals, police stations, and fire & ambulance stations) where buildings typically operate 24 hours a day. In community, arts and leisure, there were a small number of sub-sectors with high heating energy intensities (theatres, clubs & community centres and leisure centres). These sub-sectors all tended to operate long hours, and leisure centres and theatres often had extensive ventilation which contributed to increased heating energy consumption.

Hot water use was significant in only four sectors; health, hospitality, emergency services and education. In health and emergency services, overnight accommodation drove the need for washing facilities which contributed to hot water load. In education, buildings often had a high density of occupants; universities include accommodation, and both schools and universities included sports facilities which created a demand for washing facilities. In hospitality, hotels had a high hot water consumption related to washing facilities, which was the major driver for hot water consumption in the sector.

Cooling and humidification demand was relatively low in many sectors. It was most significant in offices, military, health, hospitality and retail. In community, arts & leisure, air conditioning was common in leisure centres, theatres and museums. In museums, close control of environmental conditions was important for preserving exhibits, whereas in leisure centres and theatres heat gains from customers resulted in significant use of air conditioning.

Unsurprisingly lighting was heavily used in all sectors, but was an especially large contributor to consumption in retail and industrial premises. In retail premises, both high lighting levels and long hours of use were common; in industrial premises, the high consumption was linked primarily to long operational hours (double or 24 hour shift patterns were common).

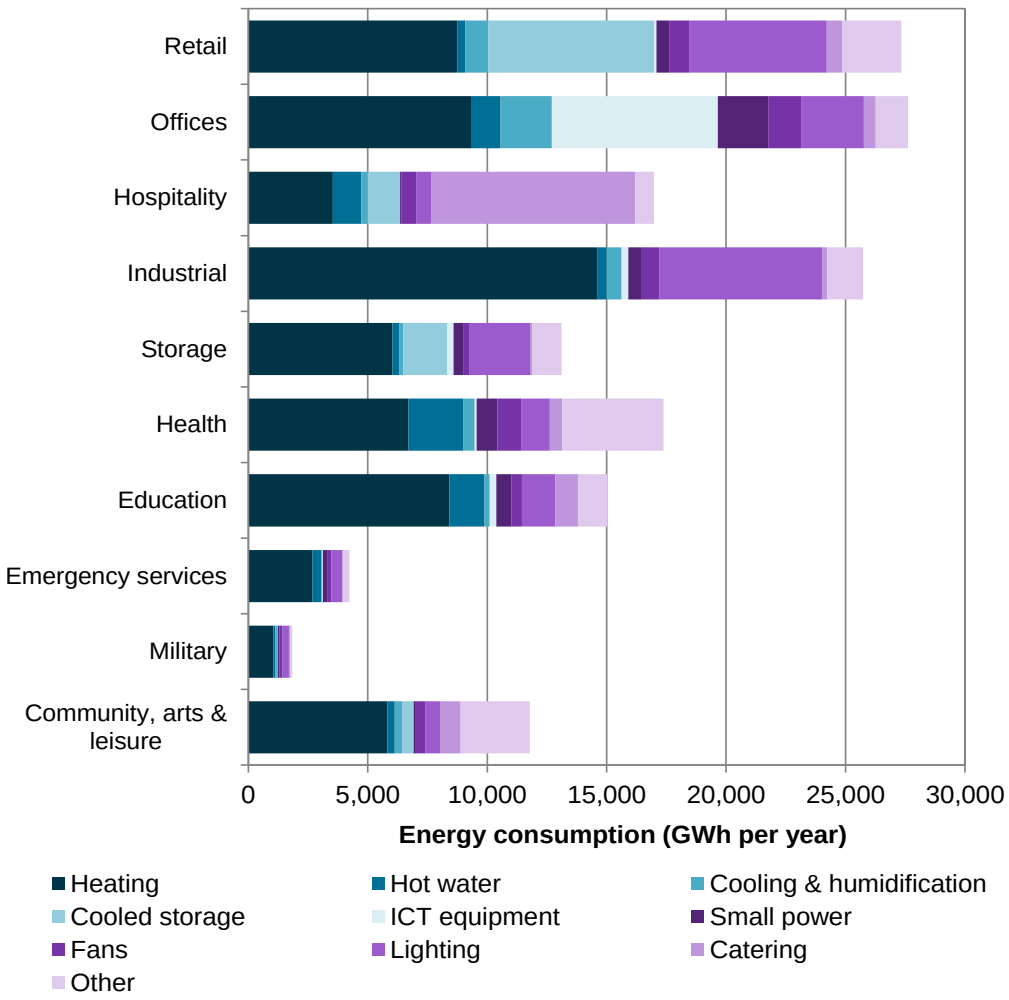
[33] These were relevant in the prisons and police station sub-sectors.

Energy consumption for fans was most significant in sectors with long hours of use (health and emergency services), or a need for extract ventilation to deal with catering odours and heat gain (communities, arts & leisure and hospitality).

Of the key activity based loads presented, catering was very high in the hospitality sector. It was also high in community, arts & leisure, health, education and retail sectors where food is often provided for patients, students and customers respectively. ICT loads were very significant in offices, with server rooms being common in this sector. Cooled storage energy use was substantial in the retail sector (for the sale of chilled and frozen foods), in commercial cold stores which fell into the storage sector, and in the hospitality sector, where chilled storage of food and drinks was significant. Small power consumption (office equipment) was relatively minor in most sectors, but was significant in offices and health, where many desk based workstations were common, and also to a lesser extent in the education sector.

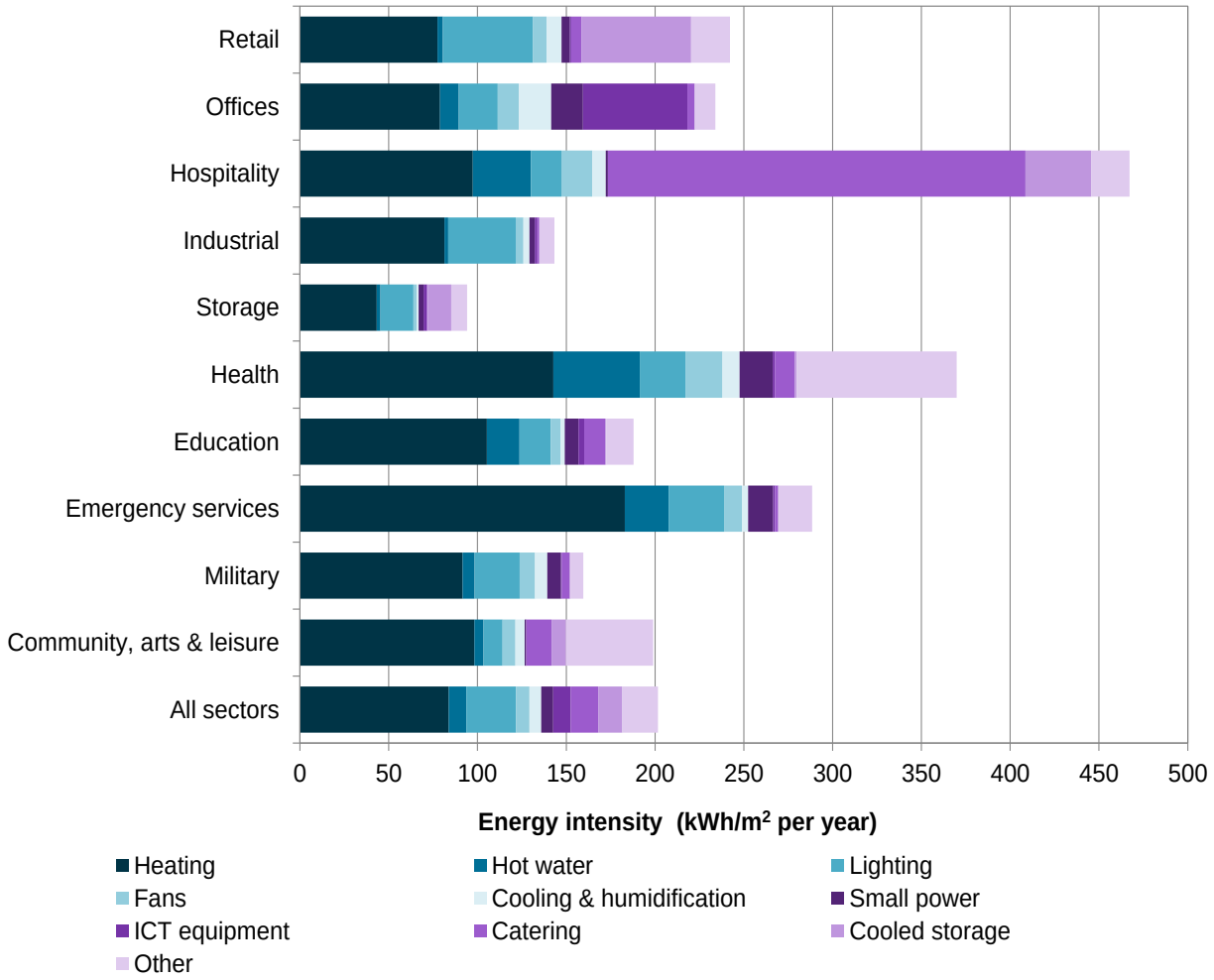
Within the “other” category, certain specialist end uses were very significant within certain sectors. Swimming pools were a significant load in the communities, arts & leisure sector, and medical equipment was a major contributor to health sector energy consumption.

Figure 3.10: Energy consumption by energy end use and sector, 2014–15



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

Figure 3.11: Energy intensity by energy end use and sector, 2014–15



Source: Energy use model results by sector, England and Wales[34]

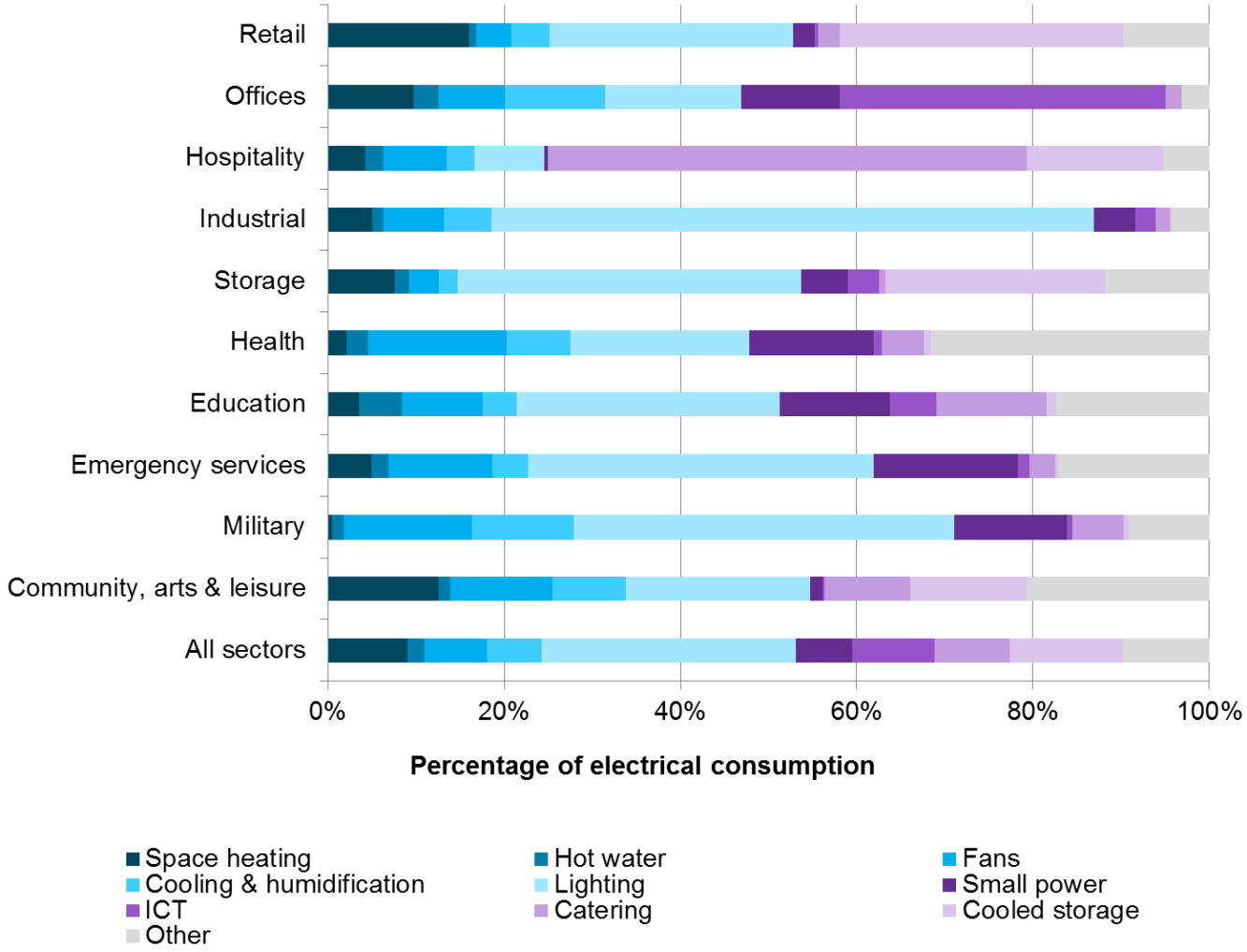
The variation between sectors of the split of total electrical and non-electrical energy between different end uses is shown in Figure 3.12 and Figure 3.13 respectively.

For electrical consumption lighting was commonly the largest end use. This was particularly the case for industrial (68 per cent), military (43 per cent) and emergency services (39 per cent) premises. In hospitality the largest end use was catering (54 per cent), offices ICT (37 per cent) and medical equipment in the health sector (23 per cent).

For non-electrical consumption, space heating was the largest end use for all sectors, although in hospitality, community, arts & leisure and health, catering (47 per cent), swimming pool (24 per cent) and medical equipment (18 per cent) consumption, were also substantial.

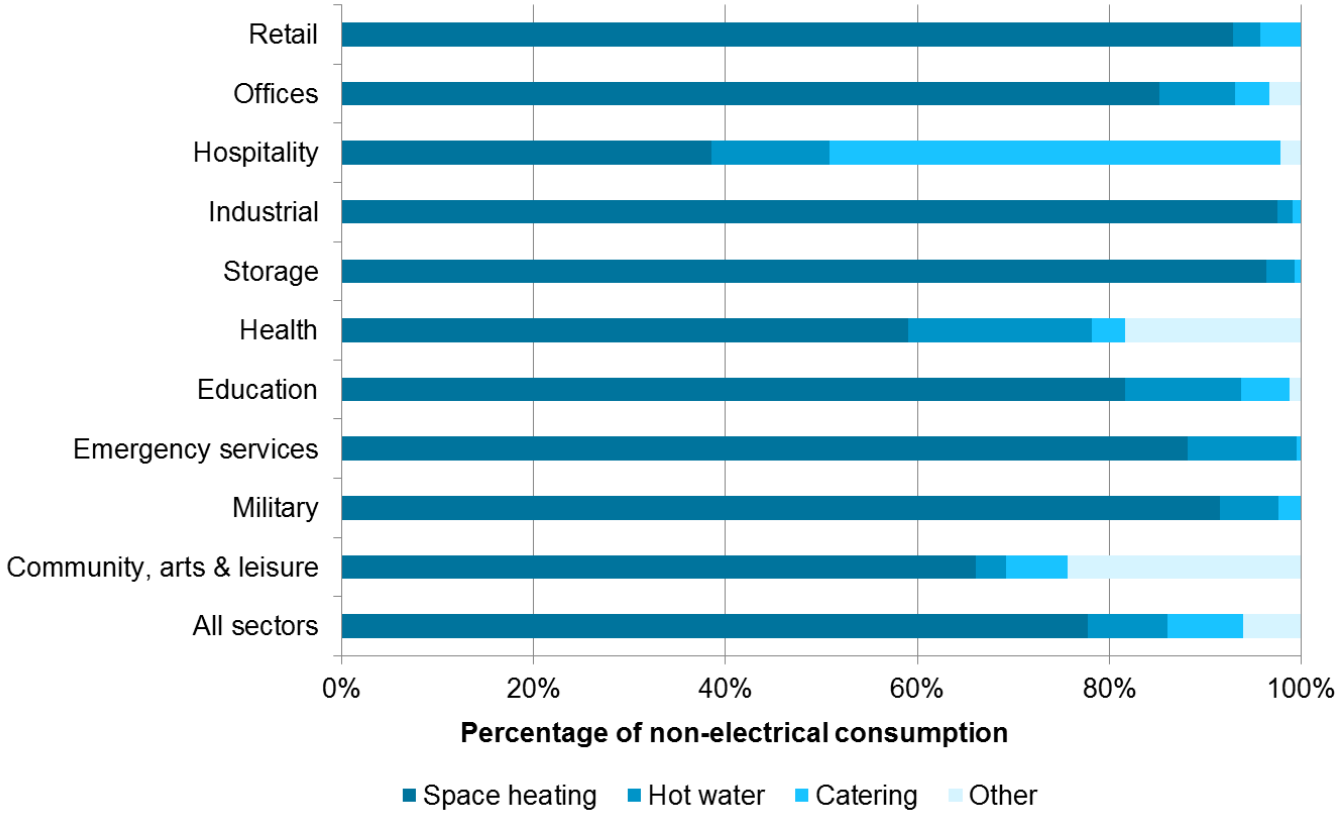
[34] The energy intensity totals in this chart are based on weighted floor area i.e. the full energy consumption for each end use is divided by the full universe floor area within each sector.

Figure 3.12: Electrical energy consumption by energy end use and sector, 2014–15



Source: Energy use model results, England and Wales

Figure 3.13: Non-electrical energy consumption by sector, 2014–15

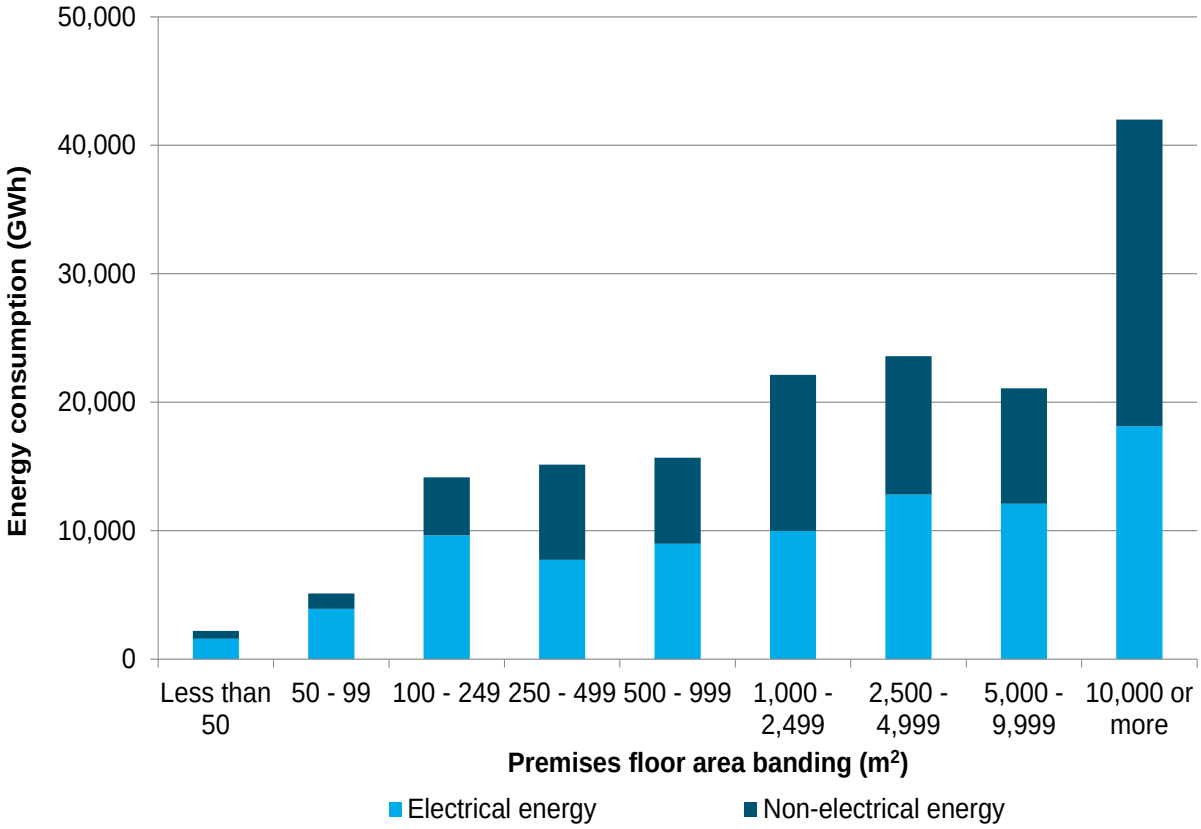


Source: Energy use model results, England and Wales

3.5 Non-domestic stock energy consumption by floor area

Figure 3.14 shows the energy consumption by different premises floor area bandings. 14, 15, 13 and 26 per cent of consumption was in premises with a floor area of greater than 1,000 m^2, 2,500 m^2, 5,000 m^2 and 10,000 m^2 respectively. Relatively little consumption was associated with premises under 100 m^2 (5 per cent, 7,300 GWh).

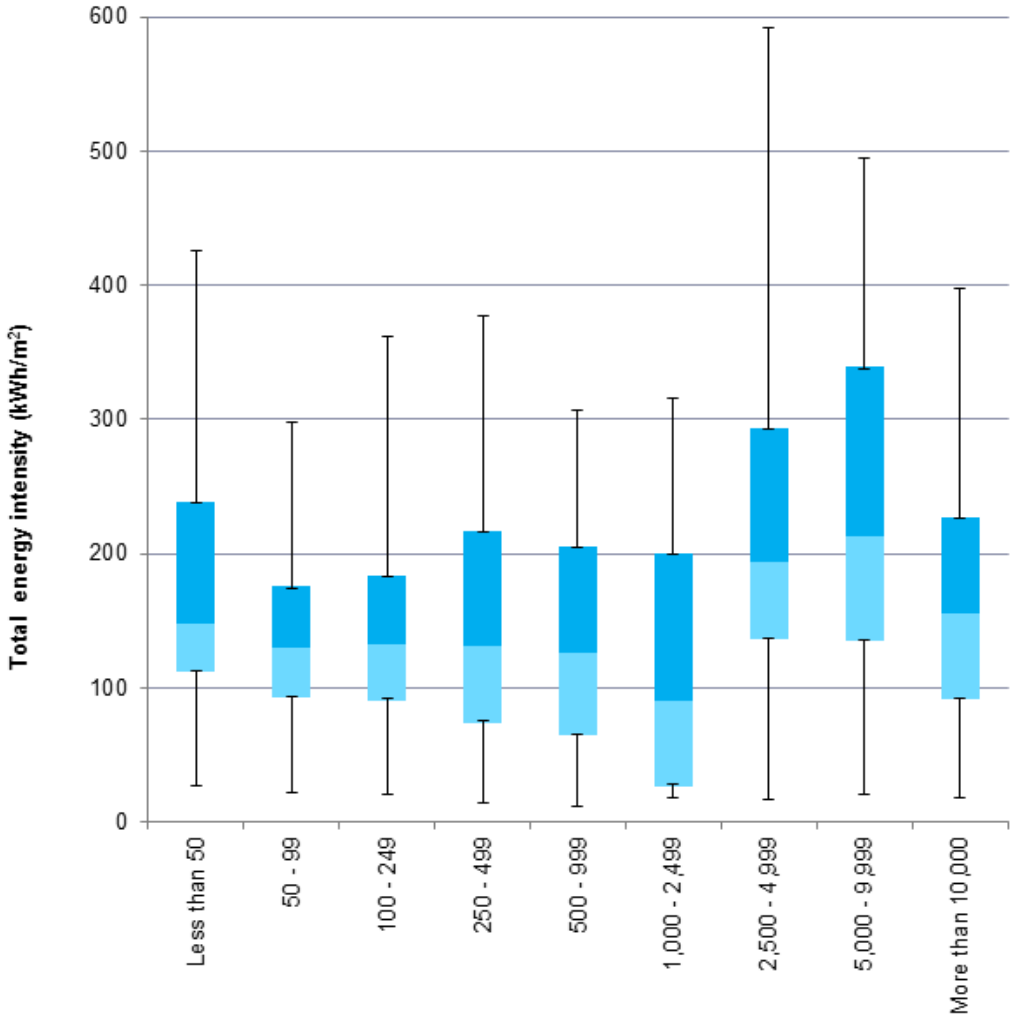
Figure 3.14: Energy consumption by floor area and energy type, 2014–15



Source: Energy use model results, England and Wales

In terms of overall energy intensity, the highest intensity was associated with larger premises (between 2,500 and 10,000 m^2) (Figure 3.15). This is likely to be due to the increased likelihood of energy intensive services being present in larger premises, such as servers, data centres, medical equipment and entertainment equipment. There was also a peak in median energy intensities in very small premises (less than 50m^2 in floor area). This is likely to be due to the clustering of higher energy intensity hospitality and retail premises in this banding.

Figure 3.15: Total energy intensity by floor area, 2014–15



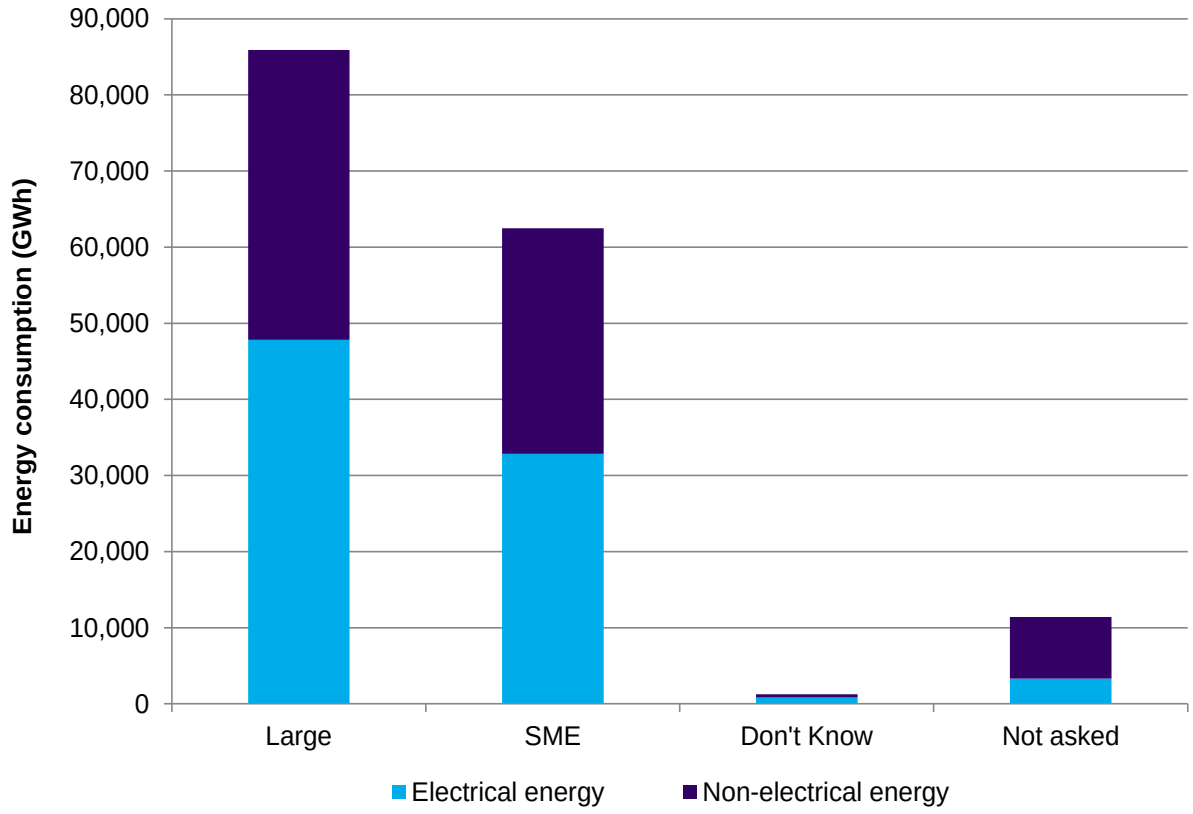
Source: Energy use model results, England and Wales

3.6 Non-domestic stock energy consumption by organisation size

The relationship between organisation size and energy consumption is presented. Energy consumption by organisation size group is shown, followed by a breakdown by sector. This was based on a standard definition or organisation size across sectors, based on the number of employees in the organisation. Enterprises with 250 or more employees were considered large. This differs to sector specific definitions or organisation size were used in the sector reports.

The survey estimated that 53 per cent of energy consumption was by large enterprises (50 per cent of non-electrical energy, or 38,070 GWh, and 56 per cent of electrical energy, 47,840 GWh)[35]. It should be noted that organisation size was not controlled for in the survey response rates and therefore this split is subject to higher uncertainty. Organisation size was also self-reported by respondents, so may not match with approaches to defining organisation size in other studies.

Figure 3.16: Energy consumption by organisation size and energy type, 2014–15



Source: Energy use model results, England and Wales

3.6.1 Non-domestic stock energy consumption by organisation size and sector

The proportion of energy used in large organisations varied by sector (Table 3.2). Large organisations accounted for the majority of energy consumption in emergency services (89 per cent), military (100 per cent), health (91 per cent), storage (61 per cent) and offices (61 per cent). SMEs consumed more energy in industrial (69 per cent), education (65 per cent),

[35] Please note that these percentages include a small proportion of energy consumption associated with respondents who gave a 'Don't know' response to the question of organisation size, or were not asked. These account for 7 per cent of the overall consumption.

community, arts & leisure (62 per cent) and hospitality (62 per cent). Retail had a comparatively even split between large enterprises (54 per cent) and SMEs (46 per cent).

Table 3.2: Energy consumption by organisation size and sector, 2014–15

	Energy consumption by organisation size (GWh/year)				
Sector	**Large**	**SME**	**Don't know**	**Not asked**	**Total**
Retail	14,780	12,310	240	-	**27,330**
Offices	16,890	10,130	600	-	**27,620**
Hospitality	6,460	10,210	310	-	**16,980**
Industrial	8,070	17,630	40	-	**25,740**
Storage	8,020	5,080	10	-	**13,110**
Health	15,780	-	-	1,600	**17,380**
Education	9,970	4,570	-	490	**15,030**
Emergency services	3,770	450	10	-	**4,240**
Military	1,840	-	-	-	**1,840**
Community, arts & leisure	340	2,090	50	9,310	**11,790**
Total	**85,910**	**62,480**	**1,260**	**11,400**	**161,060**
Unweighted base	*1,088*	*2,202*	*40*	*360*	*3,690*

Source: Energy use model results, England and Wales

3.6.2 Non-domestic stock energy consumption by organisation size, energy management resource and energy management ambition

Table 3.3 provides comparison of energy consumption by organisation size, energy management resource and energy management ambition. Energy management resource [36] indicates the level of dedicated energy management resources in place for a given premises, whereas energy management ambition[37] is a measure of the policy mechanisms in place to

[36] 'Specialist energy manager' relates to respondents who indicated that they either had 'An organisation energy manager who does not normally work in the building' or 'An energy manager who does normally work in the building', 'Non-specialist energy manager' relates to respondents who indicated that they either had 'Someone who is not a full time energy manager e.g. building or operations manager' or 'An enthusiast or energy champion in the building', 'No energy management' relates to respondents who indicated that they had 'No energy management'

[37] '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".

engage with energy management processes. Overall, 56 per cent of energy was used in premises with active energy management policies, compared with 34 per cent of energy used in premises with passive policies, and 6 per cent in those with no energy management policies.

In terms of resources available to manage energy, 50 per cent of energy was used in premises with specialist energy management resources, 31 per cent of energy was used in premises with non-specialist energy management, and 15 per cent of premises had no energy management resources.

Energy management resource and energy management ambition differed significantly between large enterprises and SMEs. For large enterprises, 65 per cent of premises had active policies on energy management and dedicated energy management resources (i.e. specialist or non-specialist). In contrast, this was the case for only 44 per cent of SME premises.

SMEs were also far less likely to have access to dedicated energy management resources. 23 per cent of energy used in premises occupied by SMEs had no energy management resources. This compared to 8 per cent of energy used in premises in large enterprises.

Table 3.3: Percentage of energy consumed by organisation size, energy management resource and energy management ambition, 2014–15

Organisation size	Energy management ambition	Energy management resource (%)				
		Specialist energy manager	Non-specialist energy manager	No energy management	Don't know	Total
All	Active	35%	18%	3%	-	**56%**
	Passive	14%	12%	8%	-	**34%**
	None	1%	1%	3%	-	**6%**
	Not asked	0%	-	-	4%	**4%**
	Total	**50%**	**31%**	**15%**	**4%**	**100%**
Large	Active	44%	20%	2%	-	**65%**
	Passive	13%	7%	3%	-	**23%**
	None	0%	0%	3%	-	**4%**
	Not asked	0%	-	-	8%	**8%**
	Total	**57%**	**27%**	**8%**	**8%**	**100%**
SME	Active	25%	16%	4%	-	**44%**
	Passive	14%	17%	15%	-	**46%**
	None	3%	2%	4%	-	**9%**
	Not asked	-	-	-	0%	**-**
	Total	**42%**	**35%**	**23%**	**0%**	**100%**
Not asked	Active	25%	19%	4%	-	**48%**
	Passive	21%	18%	7%	-	**46%**
	None	1%	1%	4%	-	**6%**
	Not asked	-	-	-	-	**0%**
	Total	**46%**	**38%**	**15%**	**-**	**100%**
Don't know	Active	20%	3%	5%	-	**28%**
	Passive	22%	35%	14%	-	**71%**
	None	-	-	1%	-	**1%**
	Not asked	-	-	-	-	**0%**
	Total	**42%**	**38%**	**20%**	**-**	**100%**
Unweighted base		1,292	*1,289*	*1,006*	*103*	*3,690*

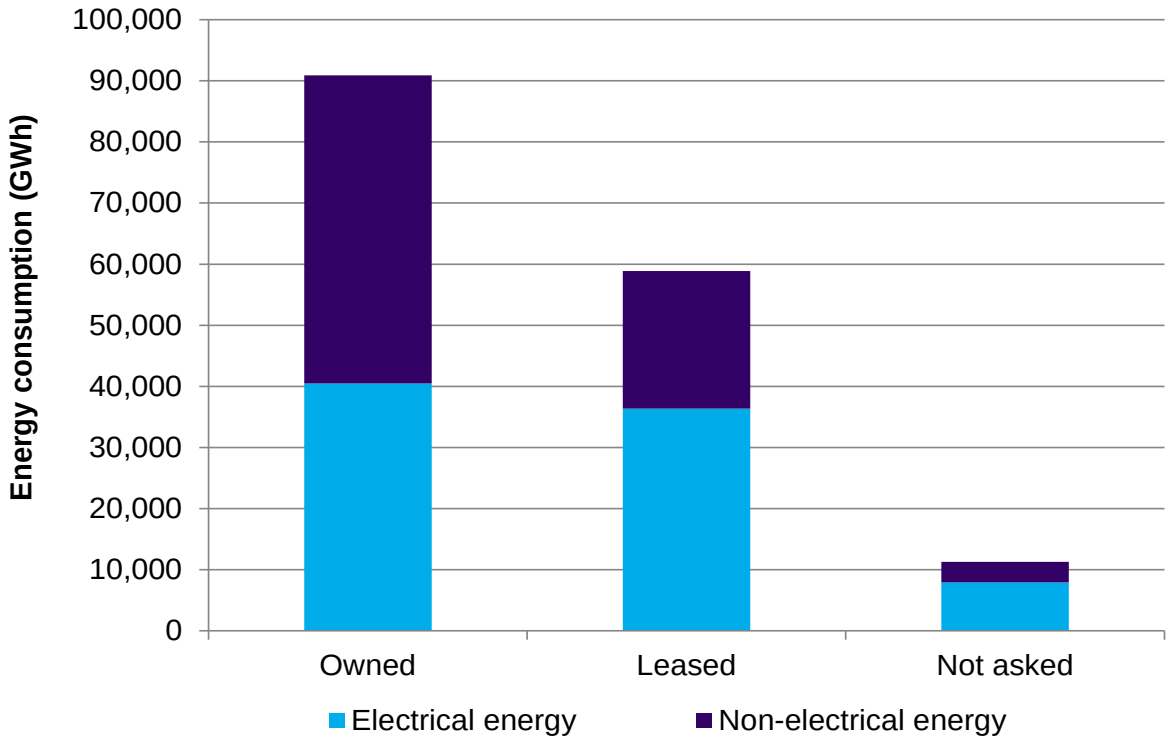
Source: Energy use model results, England and Wales

3.7 Non-domestic stock energy consumption by tenure

The relationship between the occupancy characteristics of premises and energy consumption is presented. Factors such as tenure and the extent of the building that is occupied by the premises, i.e. whole or part of the building, are shown based on total energy consumption, and also how this varied across sectors.

As shown in Figure 3.17, the majority of energy consumption in the non-domestic stock was in owner occupied premises (56 per cent, 90,890 GWh). Owner occupied premises were also more likely to have a higher proportion of non-electrical consumption relative to total premises consumption. 55 per cent of owner occupied premises consumption was non-electrical energy (50,400 GWh) whilst only 38 per cent of rented premises consumption was non-electrical energy (23,000 GWh).

Figure 3.17: Energy consumption by tenure, 2014–15



Source: Energy use model results, England and Wales

3.7.1 Non-domestic stock energy consumption by sector by tenure

There were a number of sectors where energy consumption was primarily in owner occupied premises (Table 3.4). This was the case for the sectors within the public sector - emergency services (94 per cent, 3,970 GWh), military (92 per cent, 1,690 GWh), education (85 per cent, 12,750 GWh) and health (76 per cent, 13,250 GWh) – as well as industrial (72 per cent, 18,460 GWh) and community, arts & leisure (68 per cent, 7,960 GWh). In offices and hospitality energy was consumed in predominantly rented premises (61 per cent and 58 per cent respectively, 16,780 GWh and 9,840 GWh). In retail the split between consumption in rented and owner occupied premises was reasonably equal although it should be noted that there was a significant proportion of retail premises where the tenure status had not been determined ('Not asked') (36 per cent, 9,950 GWh).

Table 3.4: Energy consumption by tenure and sector, 2014–15

	Energy consumption by tenure (GWh/year)			
Sector	**Owned**	**Rented**	**Not Asked**	**Total**
Retail	7,850	9,550	9,950	**27,340**
Offices	10,760	16,780	80	**27,620**
Hospitality	7,110	9,840	30	**16,980**
Industrial	18,460	7,260	20	**25,740**
Storage	7,090	5,300	730	**13,110**
Health	13,250	4,130	0	**17,380**
Education	12,750	2,090	190	**15,030**
Emergency Services	3,970	260	-	**4,230**
Military	1,690	140	10	**1,840**
Community, arts & leisure	7,960	3,540	290	**11,790**
Total	**90,890**	**58,880**	**11,290**	**161,060**
Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Energy use model results, England and Wales

3.7.2 Non-domestic stock energy consumption by end use by tenure

Table 3.5 breaks down the energy consumption by end use and tenure. The end use consumption is grouped into servicing relating to the conditioning of the building ('building services') and those relating primarily to the activities carried out in a building. In rented premises the activities are under the tenants control whilst the building services could be under either the tenant or the landlords control dependent on the rental arrangements. 37 per cent of energy consumption in rented premises was related to tenant activities (21,420 GWh), whilst for owner occupied premises the proportion was half this.

Table 3.5: Energy consumption by end use and tenure, 2014–15

Energy category	End use	Tenure (GWh/year) Owned	Rent	Not Asked	Total
Building services	Heating	43,960	19,390	3,590	**66,940**
	Hot water	5,110	2,700	120	**7,930**
	Cooling	2,620	2,390	80	**5,090**
	Fans	3,150	2,380	500	**6,030**
	Pumps	710	340	50	**1,100**
	Controls	410	270	40	**720**
	Humidification	30	230	-	**260**
	Lighting	13,550	8,860	2,110	**24,520**
	Vertical transport	340	100	-	**440**
	Total	**69,880**	**36,660**	**6,490**	**113,030**
Activities	Small power	2,980	2,320	150	**5,440**
	ICT	2,100	5,770	40	**7,910**
	Catering	5,900	6,710	660	**13,280**
	Cooled storage	4,210	3,590	3,000	**10,800**
	Entertainment lighting	10	10	-	**20**
	Entertainment equipment	780	580	90	**1,450**
	Laundry	140	60	-	**200**
	Medical equipment	2,560	850	-	**3,410**
	Lab equipment	250	40	-	**290**
	Swimming pools	1,200	1,670	130	**3,000**
	Other	880	620	730	**2,220**
	Total	**21,010**	**22,210**	**4,800**	**48,010**
	Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Energy use model results, England and Wales

3.7.3 Non-domestic stock energy consumption by tenure by energy management resource

In terms of energy management resource (i.e. capacity to act on energy efficiency), premises that were owner occupied had a significantly higher proportion of consumption that was managed by specialist energy managers (Table 3.6). 59 per cent of consumption in owner occupied premises was managed by specialist energy managers (53,480 GWh), compared with 40 per cent of consumption in rented premises (23,410 GWh). This may indicate that where organisations own premises they are more likely to invest in its efficient management. It could also be the case that the landlords might be providing energy management for the heating, cooling, ventilation and hot water services they might be providing to their tenants, but this was not asked in the telephone survey because it was considered unlikely a tenant respondent could give a reliable response.

Table 3.6: Energy consumption by tenure by energy management resource, 2014–15

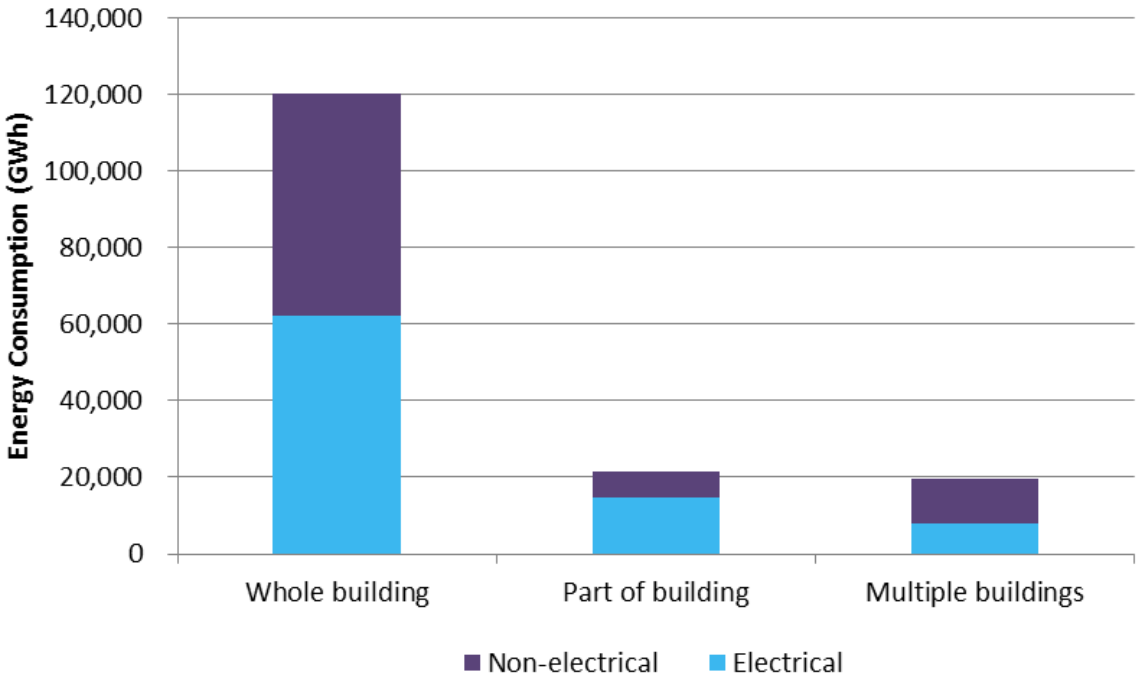
	Tenure (GWh/year)			
Energy management resource	**Owned**	**Rented**	**Not Asked**	**Total**
Specialist energy manager	53,480	23,410	3,940	**80,830**
Non-specialist energy manager	26,980	22,710	230	**49,920**
No energy management	10,420	12,750	210	**23,380**
Not asked			6,920	**6,920**
Total	**90,880**	**58,870**	**4,380**	**161,060**
Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Energy use model results, England and Wales

3.7.4 Non-domestic stock energy consumption by premises relationship to building

The majority of energy consumption (75 per cent) was in premises that occupied a whole building. 65,700 GWh of electrical consumption and 58,240 GWh of non-electrical consumption was in whole building premises (Figure 3.18). The remaining 25 per cent of consumption was evenly split between those premises that occupied only part of a building and those that were located on multi-building sites.

Figure 3.18: Energy consumption by fuel type and premises relationship to building, 2014–15



Source: Energy use model results, England and Wales

3.7.5 Non-domestic stock energy consumption by premises relationship to building

Table 3.7 shows the sectors that primarily contributed to the consumption in part of building premises are offices, hospitality and retail (collectively constituting 82 per cent of energy used in part of building premises, 17,500 GWh). Similarly those premises that are based on multi-building sites are primarily restricted to three sectors; education, health and industrial (collectively constituting 72 per cent of energy used in multi-building sites, 14,120 GWh).

It should be noted that the share of part of building premises was not controlled for in the survey response rates and therefore this split is subject to higher uncertainty.

Table 3.7: Energy consumption by premises relationship to building and sector, 2014–15

	Premises relationship to building			
Sector	**Multiple buildings**	**Whole building**	**Part of building**	**Total**
Retail	130	19,870	7,840	**27,340**
Office	1,210	20,890	5,520	**27,620**
Hospitality	-	12,850	4,130	**16,980**
Industrial	4,010	19,930	1,800	**25,740**
Storage	2,100	10,240	770	**13,110**
Health	5,280	11,910	190	**17,380**
Education	4,830	10,140	60	**15,020**
Emergency services	1,260	2,940	40	**4,230**
Military	550	1,280	10	**1,840**
Community, arts & leisure	210	10,610	970	**11,790**
Total	**19,580**	**120,150**	**21,330**	**161,060**
Unweighted base	*182*	*2,633*	*875*	*3,690*

Source: Energy use model results, England and Wales

3.7.6 Extent of split incentives

A major barrier to energy efficiency is split incentives between landlord and tenants where the building owner pays for energy efficiency improvements but cannot recover savings from reduced energy use that accrue to the tenant[38]. These will arise most materially in multi-let premises where landlords typically pay for the energy[39] and then settle costs with each tenant separately. In single-let premises tenants will often be directly paying for utilities with suppliers, yet because they do not own the asset the incentive to make long-term investments in the premises may still be reduced.

As shown below (Table 3.8) the energy used by premises most likely to be severely adversely affected by landlord tenant split incentives i.e. those premises that are rented and only occupy part of a building, was 13,600 GWh or 8 per cent of the total non-domestic energy consumption. However, the majority of such premises are in retail, hospitality and office premises and it is in these sectors where the issue of landlord-tenant split incentives is likely to be greatest.

Table 3.8: Energy consumption by premises relationship to building and tenure, 2014–15

Premises relationship to building	Energy consumption by tenure (GWh/year)			
	Owned	Rented	Not asked	**Total**
Whole building	69,360	41,900	8,890	**120,150**
Part of building	5,750	13,600	1,980	**21,330**
Multiple buildings	15,780	3,370	430	**19,580**
Total	**90,890**	**58,880**	**11,290**	**161,060**
Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Energy use model results, England and Wales

[38] European Commission, 2014. (Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC90407/2014_jrc_sci_pol_rep_cov_template_online_final.pdf)

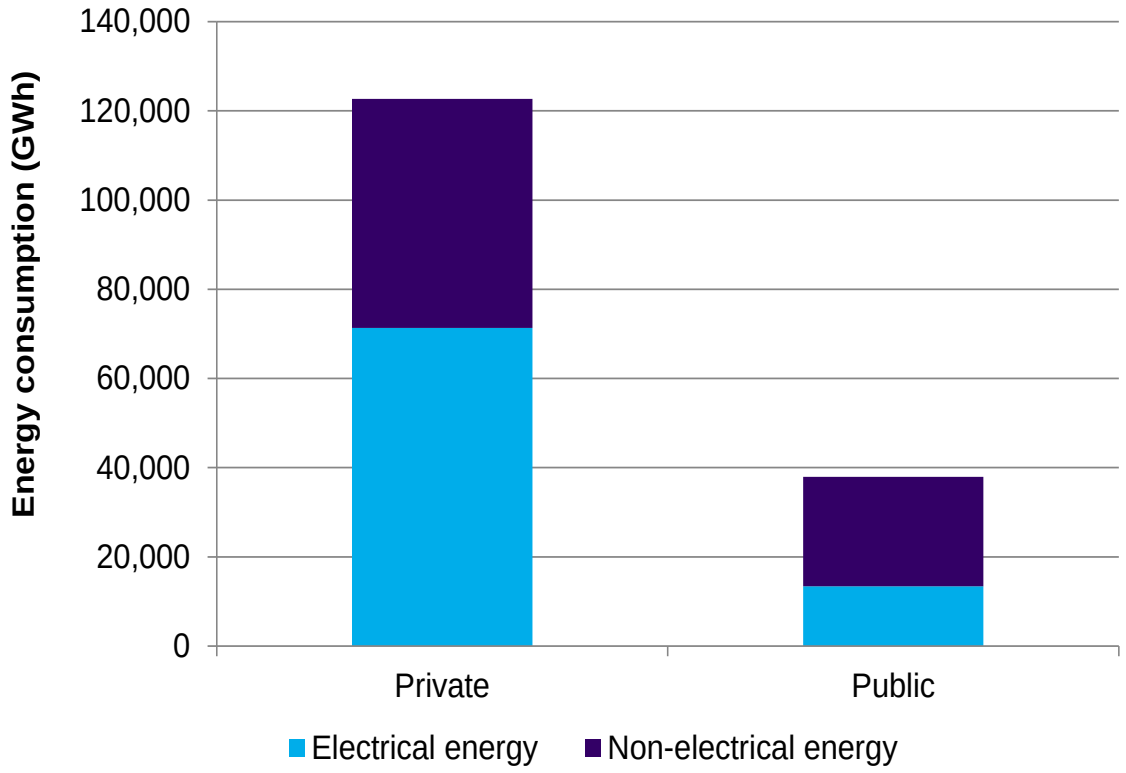
[39] Most buildings are provided with only a single electricity and gas utility meter and the landlord is then likely to be the counter-party to the utility company's energy supply contract. For example, see a good practice guide to the UK leasing process at: http://www.greenleases-uk.co.uk/Good%20Practise%20Guide%203-for%20web.pdf – Section 2.1.

3.8 Non-domestic stock energy consumption by private or public sector organisation type

The characteristics of public[40] and private sector energy use are presented. Factors such as energy management ambition, energy management resource and tenure are compared.

76 per cent of the non-domestic stock energy consumption was in the private sector (122,700 GWh) (Figure 3.19). 71,340 GWh (84 per cent) of electrical consumption and 51,370 GWh (68 per cent) of non-electrical consumption related to private sector activities. In comparison, 37,950 GWh (24 per cent) was in relation to those premises solely in the public sector of which 13,400 GWh was electrical consumption and 24,550 GWh was non-electrical consumption (16 per cent and 32 per cent of total electrical and non-electrical consumption respectively).

Figure 3.19: Energy consumption by private or public sector and energy type, 2014–15



Source: Energy use model results, England and Wales

[40] Public sector includes all premises from the health, education, military and emergency service sectors excluding private hospitals and private schools and includes public sector offices. Those sectors that have been identified as 'mixed' relate to leisure centres and nurseries. Those sectors identified as 'majority public sector' relates to health centres.

3.8.1 Private and public sector energy consumption by sector

The energy consumption by sector shows the majority of sectors are either wholly public or wholly private (Table 3.9). Hospitality, industrial, retail and storage were all private sector. Emergency services and military were all public sector. Education and health were predominantly public sector. Offices and arts, leisure & community were predominantly private sector.

Table 3.9: Energy consumption by private or public sector and sector, 2014–15

	Energy consumption by sector (GWh/year)			
Sector	Private sector	Public sector	Don't know	**Total**
Retail	27,340	-		27,340
Office	24,030	3,590		27,620
Hospitality	16,980	-		16,980
Industrial	25,740	-		25,740
Storage	13,110	-		13,110
Health	6,000	11,380		17,380
Education	1,490	13,530		15,030
Emergency Services	-	4,230		4,240
Military	-	1,840		1,840
Community, arts & leisure	8,020	3,370	400	11,790
Total	**122,700**	**37,950**	**400**	**161,060**
Unweighted base	*3,036*	*652*	*2*	*3,690*

Source: Energy use model results, England and Wales

3.8.2 Energy consumption by private or public sector and floor area

When considering the energy consumption by floor area bandings, public sector premises tended to be larger (Table 3.10). 52 per cent of public sector consumption was in premises with floor area greater than 5,000 m^2 (19,580 GWh). This compared to only 35 per of private sector consumption in the same floor area banding.

Table 3.10: Percentage energy consumption by private or public sector and floor area, 2014–15

	Percentage of energy consumption by sector			
Total floor area (m^2)	Private sector (%)	Public sector (%)	Don't know (%)	**Total (%)**
Less than 50 m^2	2	0	0	**1**
50-99	4	0	0	**3**
100-249	11	1	0	**9**
250- 499	12	2	0	**9**
500- 999	11	4	0	**10**
1,000- 2,499	12	21	0	**14**
2,500-4,999	13	20	100	**15**
5,000 - 9,999	12	18	0	**13**
10,000 or more	24	34	0	**26**
Total	**100**	**100**	**100**	**100**
Unweighted base	*3,036*	*652*	*2*	*3,690*

Source: Energy use model results, England and Wales

3.8.3 Energy consumption by private and public sector and tenure

In terms of tenure, 80 per cent (30,370 GWh) of public sector consumption was in owner occupied premises, compared to 49 per cent (60,110 GWh) of private sector consumption (Table 3.11).

Table 3.11: Energy consumption by tenure and private or public sector, 2014–15

	Energy consumption by tenure (GWh/year)			
Sector	Owned	Rented	Not Asked	**Total**
Private	60,110	51,500	11,090	**122,700**
Public	30,370	7,380	200	**37,950**
Don't know	400	-	-	**400**
Total	**90,890**	**58,880**	**11,290**	**161,060**
Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Energy use model results, England and Wales

3.8.4 Energy consumption by private or public sector, energy management resource and energy management ambition

In terms of energy management resource and energy management ambition, organisations in the public sector were more likely to have active energy management policies and specialist resources to manage energy (Table 3.12). The majority of public sector energy was used in premises where the organisation has an active policy towards energy management (64 per cent), and 72 per cent of energy was used in premises where specialist energy management resources are available. This compared to 53 per cent and 43 per cent in the private sector respectively.

Table 3.12: Energy consumption by private or public sector, energy management resource and energy management ambition, 2014–15

Sector grouping	Energy management ambition	Energy management resource				
		Specialist energy manager	Non-specialist energy manager	No energy manage-ment	Not asked/ Don't know	**Total**
All	Active	35%	18%	3%	-	**56%**
	Passive	14%	12%	8%	-	**34%**
	None	1%	1%	3%	-	**6%**
	Not Asked	-	-	-	4%	**4%**
	Total	**50%**	**31%**	**15%**	**4%**	**100%**
Public	Active	51%	11%	1%	-	**64%**
	Passive	20%	9%	4%	-	**33%**
	None	1%	1%	2%	-	**3%**
	Not Asked	-	-	-	-	**0%**
	Total	**72%**	**21%**	**7%**	**-**	**100%**
Private	Active	30%	20%	3%	-	**53%**
	Passive	12%	13%	10%	-	**35%**
	None	2%	1%	4%	-	**7%**
	Not Asked	-	-	-	6%	**6%**
	Total	**43%**	**34%**	**17%**	**6%**	**100%**
Don't know	Active	100%	-	-	-	**100%**
	Passive	-	-	-	-	**0%**
	None	-	-	-	-	**0%**
	Not Asked	-	-	-	-	**0%**
	Total	**100%**	-	-	-	**100%**
Unweighted base		*1,292*	*1,289*	*1,006*	*103*	*3,690*

Source: Energy use model results, England and Wales

4 Abatement potential

This section presents a series of summary charts and tables of the abatement modelling undertaken during the analysis of the non-domestic building stock.

4.1 Abatement method

In order to determine the abatement potential for each premises in the survey, the abatement model identified appropriate abatement measures based on the responses from the telephone survey, and then calculated the energy saved from the measure compared with the current energy end use consumption calculated in the energy use model. The technical annex sets out a detailed explanation of the abatement model. The abatement model includes 95 individual measures which are grouped into larger categories. Within each group of measures there will be some that are more cost-effective than others for a given sector or sub-sector. 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 the 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 the absolute installation costs, while the benefits were only based on the incremental reduction in energy consumption. This means that measures may be more cost-effective if systems are replaced at the end of their life, when the equipment or plant would be due for replacement regardless. While the costs include an allowance for installation costs and hassle costs[41], 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 or at the end of a lease. [42]

To account for the impact of interactions between measures affecting the same end use - for example if more efficient lights are installed the impact of using better lighting controls is smaller

[41] Hassle costs are a subset of indirect costs associated relating to inconvenience caused primarily during installation

[42] For example in the military sector the BEES findings have been compared to a parallel study conducted by the Military as part of the DIO EUS BEIM programme (Defence Infrastructure Organisation, Energy Utilities and Sustainability, Built Environment Improvement Measures). This project found that the capital cost for energy efficiency measures was substantially greater than in typical commercial environments. This was due in large part to restrictions on staff and requirements for security clearance. As a result BEES costs, which are based on more typical commercial environments, may underestimate the cost of implementing measures in this sector.

- the abatement measures in each premises were ordered by their return on investment. This way the savings estimated from each measure could be adjusted to take account of the impact of installing more privately cost-effective measures first. The calculated costs and energy savings were weighted to represent the non-domestic stock throughout England and Wales.

4.2 Abatement potential for non-domestic stock

The technical abatement potential for the non-domestic stock is 63,160 GWh. Of this total the electrical abatement potential was 28,870 GWh (46 per cent) and the non-electrical abatement potential was 34,290 GWh (54 per cent). [43] The capital expenditure required was £28.4 billion (Table 4.1). There was more non-electrical energy abatement potential than electrical. This was because the primary use of non-electrical energy was for space heating and there were a large number of abatement measures that were linked to this end use.

Table 4.1: Abatement potential by sector, 2014–15

Sector	Capital Expenditure required to deliver abatement potential (£ billion)	Baseline		Abatement potential		
		Annual electrical energy consumption (GWh/year)	Annual non-electrical energy consumption (GWh/year)	Annual electrical energy savings (GWh/year)	Annual non-electrical energy savings (GWh/year)	Overall reduction (%)
Retail	5.8	21,670	5,670	7,250	2,180	34
Offices	6.8	18,840	8,780	6,270	4,280	38
Hospitality	1.8	8,760	8,230	2,040	2,260	25
Industrial	4.6	11,320	14,410	4,520	7,190	46
Storage	2.5	7,440	5,670	2,430	2,690	39
Health	1.7	6,240	11,140	2,350	4,730	41
Education	2.1	4,930	10,100	1,670	5,090	45
Emergency services	0.6	1,260	2,970	530	1,610	51
Military	0.3	690	1,150	380	610	54
Community, arts & leisure	2.2	3,680	8,110	1,450	3,640	43
Total	**28.4**	**84,820**	**76,240**	**28,870**	**34,290**	**39**

Source: Abatement model results by sector, England and Wales

[43] 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.

Each sector could achieve between 25 and 54 per cent savings in energy consumption. Savings in electrical energy consumption were between 23 to 55 per cent and in non-electrical energy consumption between 27 to 54 per cent savings.

Military had the largest proportional scope for reduction (54 per cent overall) and hospitality the lowest (25 per cent). The relatively low reductions for health and hospitality were due in part to the high level of medical equipment and catering energy use in these sectors respectively. For such end uses the abatement model had only limited capability to calculate abatement potential.

Table 4.2 shows the abatement potential by measure group. The largest savings were in carbon & energy management, lighting and building instrumentation and control measures.

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

Measure group	Total annual energy bill saving (£ thousands)	Total annual carbon saving ($ktCO_2$)	Total annual energy savings (GWh/year)	Total capital cost of measure (£ thousands)
Air conditioning and cooling	128,900	370	1,300	1,369,900
Building fabric	294,700	1,480	8,260	6,362,600
Building instrumentation and control	415,600	2,120	11,190	2,447,500
Building services distribution systems	75,200	240	760	1,310,500
Carbon and Energy Management	721,700	3,030	12,580	1,604,200
Hot water	49,600	290	1,520	496,800
Humidification	100	0	1	1,700
Lighting	1,085,400	3,260	10,930	4,401,300
Cooled storage	212,100	650	2,140	1,193,100
Small appliances	127,700	420	1,390	2,077,200
Space heating	294,700	1,690	9,260	3,735,200
Swimming pools	25,000	130	640	275,500
Ventilation	311,100	950	3,210	3,115,300
Total	**3,741,800**	**14,630**	**63,160**	**28,390,800**

Source: Abatement model results, England and Wales

4.3 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.[44] 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 benefits to society outweigh the total costs to society over the lifetime of the measure. This is a static measure of cost-effectiveness based on current expected costs and benefits. For example, it does not take into account potential reductions in capital costs that could result from more of a particular 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. Measures that are socially cost-effective have a negative social cost-effectiveness metric.

As shown in Table 4.3 there is 27,890 GWh of socially cost-effective potential, calculated by aggregating up socially cost-effective measures groups from each sub-sector. This splits between 14,140 GWh of electrical consumption (51 per cent) and 13,740 GWh of non-electrical energy consumption (49 per cent).[45] Table 4.3 also shows how the potential varies by sector. This indicates that proportionally education has the highest socially cost-effective potential (64 per cent of the total abatement potential). In contrast, community, arts and leisure and offices have the lowest at 22 per cent and 20 per cent respectively. These differences are likely driven by a range of factors; such as the age of the building plant and the average premises size.

In addition Table 4.3 shows how much of the potential has a private payback of less than 3 years to indicate 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.[46] The abatement potential relating only to measures that have a private payback of up to 3 years was 22,080 GWh split between 9,850 GWh (45 per cent) of electrical consumption and 12,230 GWh (55 per cent) of non-electrical consumption (calculated by aggregating up measure groups with payback of up to 3 years from each sub-sector). Over 50 per cent of the abatement potential in the industrial, military, and health sectors had a private payback of less

[44] 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

[45] Cost-effectiveness has been calculated for each individual measure. The sector reports show a lower level of socially cost-effective potential as it has calculated cost-effective potential on the basis of larger groups of measures which means that some cost-effective measures are not identified as they are combined with more expensive measures..

[46] 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.

than 3 years. Conversely less than 20 per cent of the abatement potential in offices, storage, and community, arts & leisure had a private payback of less than 3 years.

Table 4.3: Socially cost-effective and privately cost-effective abatement potential by sector, 2014–15

Sector	Socially cost-effective potential (GWh/year)	Socially cost-effective bill savings (£bn/year)	Measures with less than 3 years payback (GWh/year)	Bill savings with less than 3 years payback (£bn/year)	Technical abatement potential (GWh/year)
Retail	3,830	0.3	2,200	0.2	9,420
Office	2,110	0.2	2,150	0.1	10,550
Hospitality	1,580	0.1	1,660	0.1	4,300
Industrial	7,380	0.4	7,380	0.4	11,710
Storage	1,580	0.1	290	0	5,120
Health	4,240	0.2	3,900	0.2	7,080
Education	4,340	0.2	2,190	0.1	6,760
Emergency Services	1,270	0.1	780	0	2,140
Military	440	0	580	0	990
Community, arts & leisure	1,120	0.1	960	0.1	5,090
Total	**27,890**	**1.8**	**22,080**	**1.3**	**63,160**

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

Table 4.4 shows how the social cost-effectiveness and private payback of less than 3 years varies by measure groups. Measures with a simple payback period of less than 3 years were mostly in the building instrumentation and controls, carbon and energy management, lighting, and space heating measure groups and would result in a total annual bill saving of £1.3bn.[47] These measure groups were also generally socially cost effective, along with hot water and some building fabric measures.

Table 4.4: Socially cost-effective and privately cost-effective abatement potential by measure group, 2014–15

Measure group	Socially cost-effective potential (GWh/year)	Socially cost-effective bill savings (£bn/year)	Measures with less than 3 years payback (GWh/year)	Bill savings with less than 3 years payback (£bn/year)	Technical abatement potential (GWh/year)
Air conditioning and cooling	0	0	0	0	1,290
Building fabric	960	0	0	0	8,250
Building instrumentation and control	6,890	0.2	5,710	0.2	11,180
Building services distribution systems	0	0	20	0	770
Carbon and Energy Management	6,670	0.3	10,790	0.6	12,580
Hot water	1,120	0	0	0	1,510
Humidification	0	0	0	0	0
Lighting	10,530	1.0	4,390	0.4	10,920
Refrigeration	480	0	20	0	2,140
Small appliances	20	0	20	0	1,390
Space heating	1,210	0	1,120	0	9,290
Swimming pools	0	0	0	0	640
Ventilation	0	0	0	0	3,200
Total	**27,890**	**1.8**	**22,080**	**1.3**	**63,160**

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

Note: Cost-effectiveness has been calculated for each measure group at the sub-sector level. Socially cost-effective measures are those with a negative marginal abatement value. Measures with less than 3 years payback are those where the annual savings over three years exceed the initial capital investment.

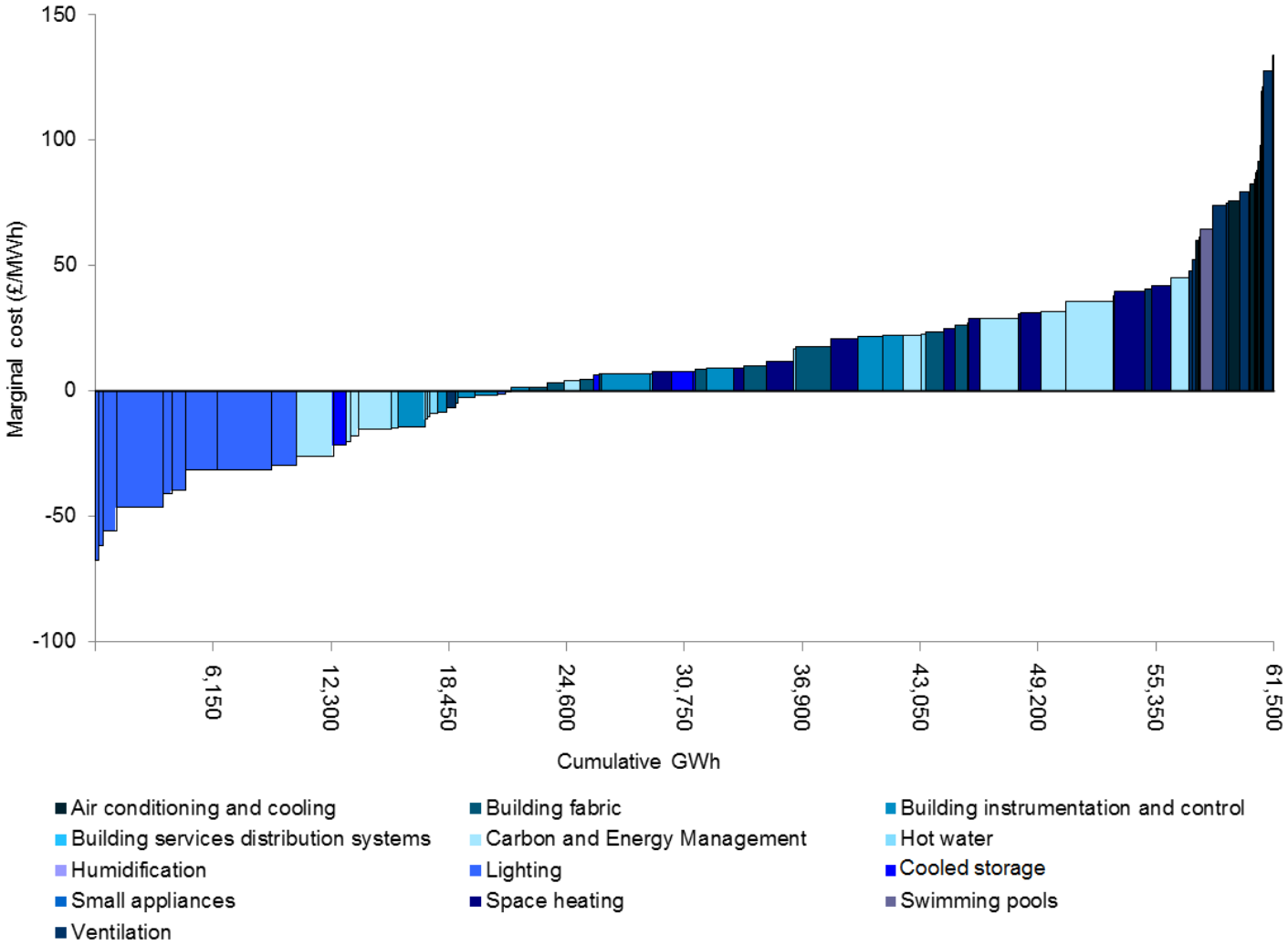
[47] The payback periods have been calculated on a measure group basis instead of the individual measure basis.

A Marginal Abatement Cost Curve (MACC) shows the level of abatement opportunity available and the costs associated with this opportunity if implemented in 2014–15, in order of social cost-effectiveness. The MACC graphically represents abatement opportunity 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 measures 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, measures become less cost-effective.

Figure 4.1 shows the marginal abatement cost and total abatement potential for the 100 most socially-cost-effective measure groups in each sector for the non-domestic stock. This shows that lightling is highly cost-effective, along with some measures to improve building instrumentation and controls. Measures relating to space heating are spread across the MACC as this group of measures has a mix of cost-effective and less cost-effective measures depending on the age of existing equipment and patterns of use of the building. It should be noted that as Figure 4.1 has been collated at the sector level, instead of at sub-sector level, it has a lower overall level of socially cost-effective potential as the result of aggregating together measures groups with different costs and benefits given different patterns of use in different sub-sectors.

It should be reiterated in different premises some measures will be more cost-effective than others, or deliver benefits or drawbacks that have not been included in calculations (e.g. improved occupant productivity as a result of greater temperature stability from controls adjustments, or a reduction in the efficiency of existing plant as demand reduction moves plant away from the ideal operating point and down the efficiency curve).

Figure 4.1: Marginal abatement cost curve for the 100 most socially cost-effective measure groups at sector level, 2014–15



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

4.4 Abatement potential by sector

Table 4.5 shows the abatement potential by measure type and by sector. In each sector different measure types were more significant. In many cases this will be related to the significance of an associated end use. For instance, retail, storage and industrial premises all had relatively high proportions of lighting savings (30 per cent, 25 per cent and 21 per cent respectively compared to 17 per cent on average). In emergency services, community, arts and leisure, and education, space heating measures were a particularly high proportion of savings at 23 per cent, 20 per cent and 21 per cent respectively. In both groups the savings related to the largest end uses associated with these sectors.

Table 4.5: Abatement potential by measure type and by sector, 2014–15

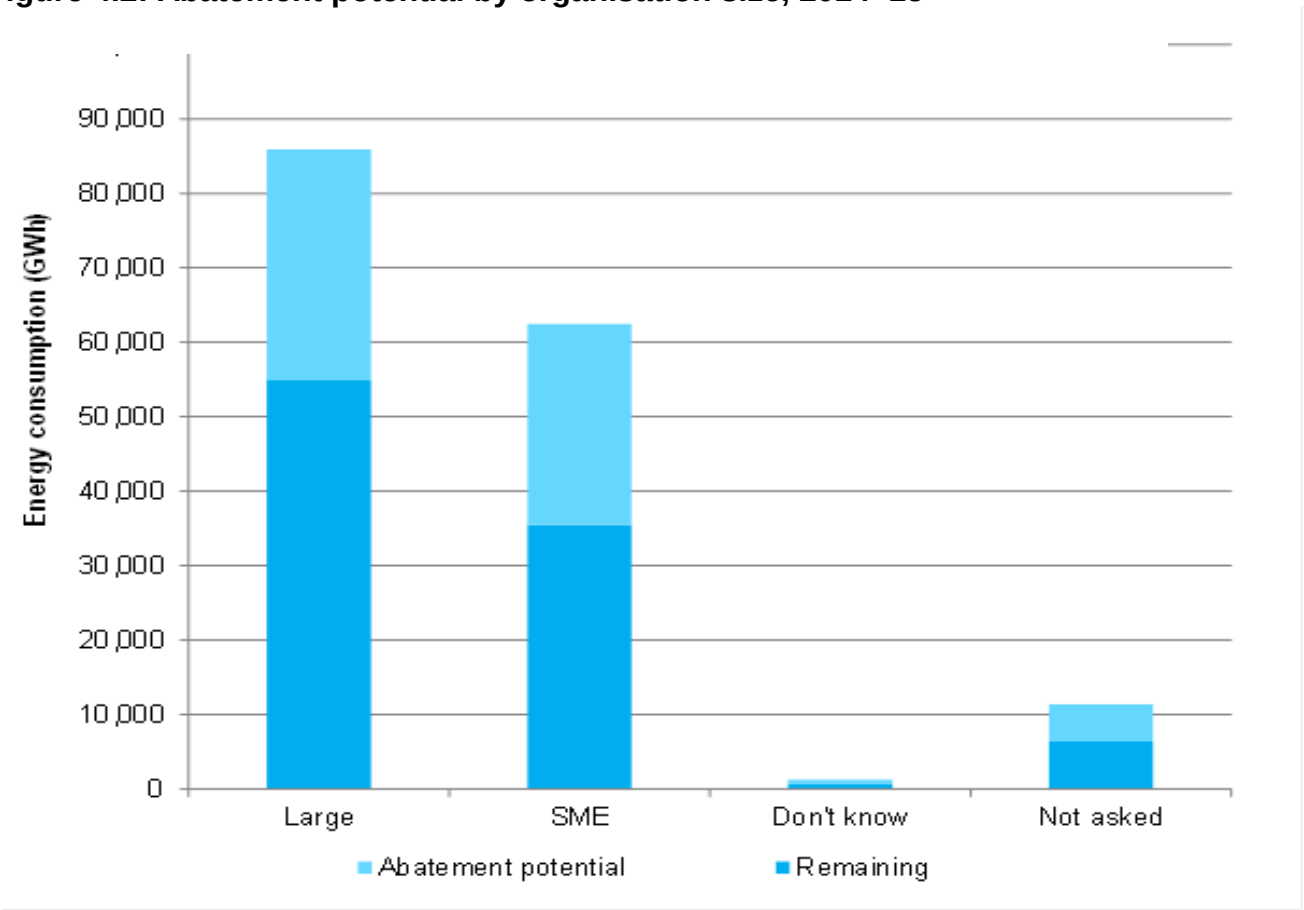
Measure type	Abatement potential by sector (GWh)										
	Retail	Office	Hospitality	Industrial	Storage	Health	Education	Emerg-ency services	Military	Comm-unity, arts & leisure	**All sectors**
Air conditioning and cooling	220	570	70	130	20	140	40	10	20	70	**1,300**
Building fabric	900	1,260	600	1,870	630	840	980	330	140	720	**8,260**
Building instrumentation and control	1,270	1,430	850	2,520	1,090	1,420	1,170	460	140	850	**11,190**
Building services distribution systems	90	140	10	240	70	100	60	10	20	20	**760**
Carbon and energy management	1,360	1,950	730	2,450	900	1,920	1,700	370	270	940	**12,580**
Hot water	50	220	100	80	50	410	400	100	20	80	**1,520**
Lighting	2,820	1,650	400	2,480	1,300	690	730	270	170	420	**10,930**
Cooled storage	1,120	7	550	7	280	4	30	1	1	140	**2,140**
Small appliances	70	1,030	80	30	10	50	50	30	20	10	**1,390**
Space heating	1,040	1,580	580	1,430	640	960	1,390	490	140	1,020	**9,260**
Swimming pools	-	-	20	-	-	2	8	-	-	620	**640**
Ventilation	490	720	310	470	130	560	210	70	40	200	**3,210**
Total	**9,420**	**10,550**	**4,300**	**11,710**	**5,120**	**7,080**	**6,760**	**2,140**	**1,000**	**5,090**	**63,160**
Unweighted base	*1,033*	*637*	*272*	*475*	*398*	*166*	*165*	*129*	*64*	*351*	*3,690*

Source: Abatement model results, England and Wales

4.5 Abatement potential by organisation size

At an absolute level, the abatement potential in large organisations (30,800 GWh) was slightly greater than the potential in SMEs (26,840 GWh) (Figure 4.2). On a relative basis however, the scope for efficiencies is greater in SMEs (43 percent of consumption) than in large organisations (36 percent of consumption).

Figure 4.2: Abatement potential by organisation size, 2014–15



Source: Abatement model results, England and Wales

4.5.1 Abatement potential by organisation size, energy management resource and energy management ambition

The ability of owners or occupiers to implement abatement opportunities, and the success of doing so, is strongly affected by the availability of any energy management resource, either as a presence in the premises itself or, for organisations occupying a portfolio of premises, through a centralised energy management function.

Table 4.6 compares the abatement potential by organisation size, energy management resource and energy management ambition. As per energy consumption, a large portion of abatement potential was in organisations with active energy management policies (52 per cent). A further 38 per cent was in organisations with passive energy management policies and 7 per cent was in organisations with no energy management.

In terms of resources available to manage energy, 51 per cent of the abatement potential was in premises that had specialist energy management resources available. 30 per cent was in premises where non-specialist energy management resources were dedicated and 16 per cent had no energy management resources.

Table 4.6: Percentage total available of technical abatement potential by organisation size, energy management resource and energy management ambition, 2014–15

Organisation size	Energy management ambition	Energy management resource (%)				
		Specialist energy manager	Non-specialist energy manager	No energy management	Don't know	Total
All	Active	34%	15%	2%	-	**52%**
	Passive	15%	13%	10%	-	**38%**
	None	2%	1%	4%	-	**7%**
	Not asked	0%	-	-	3%	**3%**
	Total	**51%**	**30%**	**16%**	**3%**	**100%**
Large	Active	21%	8%	1%	-	**30%**
	Passive	7%	4%	2%	-	**14%**
	None	0%	0%	2%	-	**2%**
	Not asked	0%	-	-	3%	**3%**
	Total	**29%**	**13%**	**5%**	**3%**	**49%**
SME	Active	11%	6%	1%	-	**18%**
	Passive	6%	7%	7%	-	**20%**
	None	2%	1%	2%	-	**4%**
	Not asked	-	-	-	0%	**0%**
	Total	**19%**	**13%**	**10%**	**0%**	**42%**
Not asked	Active	2%	1%	0%	-	**3%**
	Passive	2%	2%	1%	-	**4%**
	None	0%	0%	0%	-	**1%**
	Not asked	-	-	-	-	**-**
	Total	**3%**	**3%**	**1%**	**-**	**8%**
Don't know	Active	0%	0%	0%	-	**0%**
	Passive	0%	0%	0%	-	**1%**
	None	-	-	0%	-	**0%**
	Not asked	-	-	-	-	**-**
	Total	**0%**	**0%**	**0%**	**-**	**1%**
Unweighted base		*1292*	*1289*	*1006*	*103*	*3690*

Source: Abatement model results, England and Wales

There was a relationship between abatement potential and energy management resource and energy management ambition. This is shown in table 4.7 which compares the average

abatement potential at premises across different organisation sizes, levels of energy management resource and levels of energy management ambition.

The average abatement potential was greatest in organisations with no energy management ambition (49 per cent) regardless of organisation size and available energy management resource. The reduction potential was consistently the greatest for this cohort in each of the organisation size groups. Those organisations with passive energy management also had greater average abatement potential (44 per cent) when compared to those with active ones. The level of dedicated energy management resource appears to have some impact although to a significantly lesser degree (average abatement potential of 44 per cent where there is no energy manager compared to 40 per cent where there was a specialist energy manager).

This could be indicative of the importance of energy management policies. These can help coordinate resources and senior management efforts towards achieving energy efficiency improvements. Organisations with active energy management have been significantly more successful in achieving more efficient premises.

Table 4.7: Average abatement potential in a premises by organisation size, energy management resource and energy management ambition, 2014–15

Organisation size	Energy management ambition	Energy management resource (%)				
		Specialist energy manager	Non-specialist energy manager	No energy management	Don't know	Total
All	Active	38%	33%	34%	-	**36%**
	Passive	43%	43%	46%	-	**44%**
	None	55%	51%	46%	-	**49%**
	Not asked	17%	-	-	26%	**26%**
	Total	**40%**	**38%**	**44%**	**26%**	**39%**
Large	Active	35%	32%	31%	-	**34%**
	Passive	42%	45%	44%	-	**43%**
	None	52%	65%	42%	-	**44%**
	Not asked	17%	-	-	25%	**25%**
	Total	**37%**	**36%**	**41%**	**25%**	**36%**
SME	Active	45%	34%	34%	-	**40%**
	Passive	45%	40%	47%	-	**44%**
	None	56%	49%	48%	-	**51%**
	Not asked	-	-	-	42%	**42%**
	Total	**46%**	**38%**	**45%**	**42%**	**43%**
Not asked	Active	35%	41%	45%	-	**38%**
	Passive	45%	50%	48%	-	**48%**
	None	50%	56%	60%	-	**58%**
	Not asked	-	-	-	-	**-**
	Total	**40%**	**46%**	**51%**	**-**	**44%**
Don't know	Active	28%	40%	46%	-	**33%**
	Passive	33%	47%	33%	-	**40%**
	None	-	-	54%	-	**54%**
	Not asked	-	-	-	-	**-**
	Total	**31%**	**47%**	**37%**	**-**	**38%**
Unweighted base		*1292*	*1289*	*1006*	*103*	*3690*

Source: Abatement model results, England and Wales

4.6 Abatement potential by tenure and by premises relationship to building

The abatement potential by tenure and premises type is shown in Table 4.8, and Table 4.9. 61 per cent of abatement potential was in owned premises (38,400 GWh) which also had a higher percentage reduction potential than rented properties. In terms of premises type, 74 per cent of abatement was in whole building premises but the premises type which had the greatest

abatement potential were those based on multiple building sites, such as hospitals and universities.

Table 4.8: Abatement potential by tenure, 2014–15

Tenure	Baseline energy consumption (GWh/year)	Abatement potential (GWh/year)	Reduction (%)	Capital cost (£bn)	Total annual energy bill savings (£bn)
Owned	90,890	38,400	42	14.7	2.1
Rented	58,880	22,040	37	12.7	1.5
Not asked	11,290	2,720	24	1.0	0.2
Total	**161,060**	**63,160**	**39**	**28.4**	**3.7**
Unweighted base	3,690	3,690	3,690	3,690	3,690

Source: Abatement model results, England and Wales

Table 4.9: Abatement potential by premises relationship to building, 2014–15

Premises relationship to building	Baseline energy consumption (GWh/year)	Abatement potential (GWh/year)	Reduction (%)	Capital cost (£bn)	Total annual energy bill savings (£bn)
Whole building	120,150	46,790	39	19.9	**2.7**
Part of building	21,330	7,670	36	5.9	**0.6**
Multiple buildings	19,580	8,700	44	2.6	**0.4**
Total	**161,060**	**63,160**	**39**	**28.4**	**3.7**
Unweighted base	3,690	3,690	3,690	3,690	3,690

Source: Abatement model results, England and Wales

4.6.1 Extent of split incentives

As discussed in Section 3, the abatement potential most adversely affected by landlord-tenant split incentives includes those premises that are rented and only occupy part of a building. Such premises typically arise in retail, offices and hospitality. This is explored in further detail in the barriers section (section 5). Table 4.10 shows that this represented a total abatement potential of 5,200 GWh (8 per cent of total abatement potential). This was similar in proportion to the amount of energy that is associated with such premises relative to the total energy consumption in the non-domestic stock.

Table 4.10: Abatement potential by premises relationship to building and tenure, 2014–15

Premises relationship to building	Total abatement potential (GWh)			
	Owned	Rented	Not asked	**Total**
Whole building	29,660	15,260	1,860	**46,790**
Part of building	1,820	5,200	660	**7,670**
Multiple buildings	6,920	1,580	200	**8,700**
Total	**38,400**	**22,040**	**2,720**	**63,160**
Unweighted base	*1,839*	*1,710*	*141*	*3,690*

Source: Abatement model results, England and Wales

4.7 Abatement potential by private or public sector

As shown in prior sections, the characteristics of public sector organisations were highly favourable to energy efficiency. They tended towards having active energy management policies, having in house specialist energy resources, being owner occupiers of whole buildings and generally occupying larger premises.

In terms of abatement potential there was 17,230 GWh of reduction potential in the public sector (Table 4.11). This compared to 45,800 GWh of reduction potential in the private sector. This can be achieved at a capital cost of £5.1bn and £23.2bn respectively.

On a relative basis the scope for reduction in the public sector was greater than the private sector. The public sector can reduce consumption by 45 per cent whereas the private sector reduction potential was 37 per cent. There was also more abatement potential with a payback period of less than 3 years in the public sector (41 per cent of abatement potential) than the private sector (32 per cent of abatement potential). This could be linked to the higher proportion of larger premises in the public sector, their longer operating hours, or additional heating requirements such as in hospitals. Some of the difference could also be caused by limitations in the abatement model in relation to end uses such as catering, which are predominantly in the private sector.

Table 4.11: Abatement potential by private or public sector, 2014–15

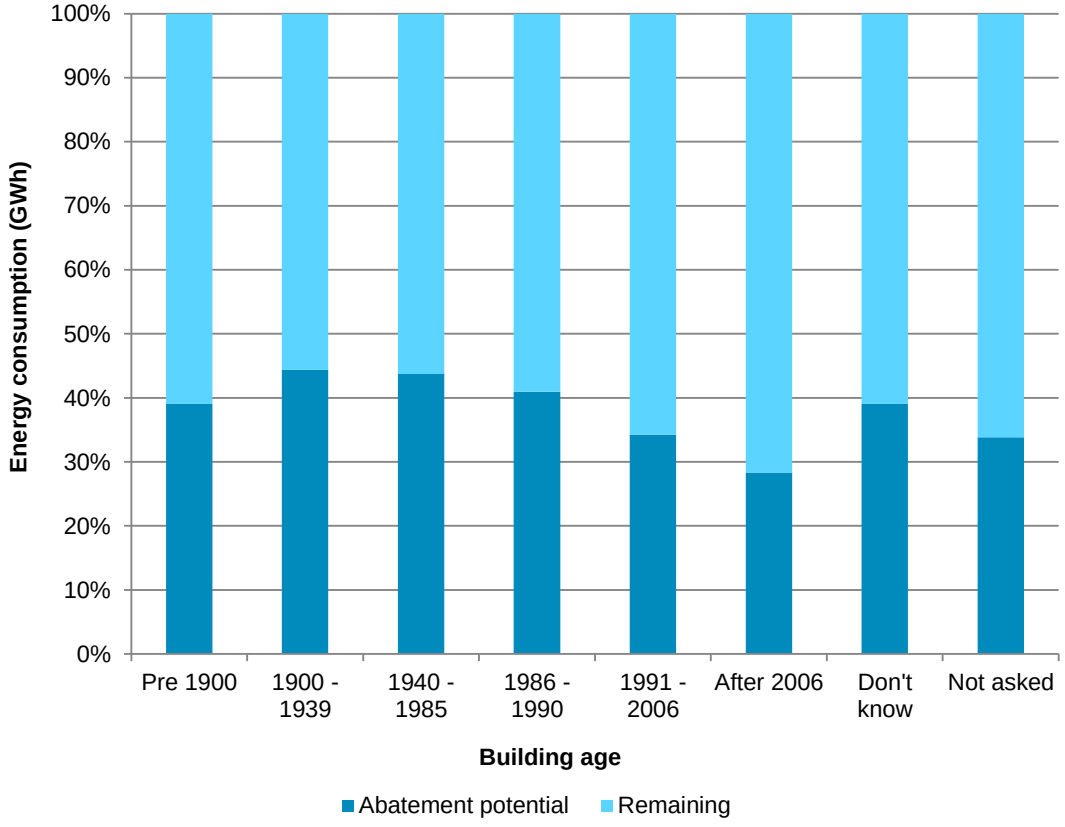
Sector	Baseline energy consumption (GWh)	Abatement potential (GWh)	Reduction (%)	Capital cost (£bn)	Total annual energy bill savings (£bn)
Private	122,700	45,800	37	23.2	2.9
Public	37,950	17,230	45	5.1	0.8
Don't know	400	130	33	0	0
Total	**161,060**	**63,160**	**39**	**28.4**	**3.7**
Unweighted base	*3,690*	*3,690*	*3,690*	*3,690*	*3,690*

Source: Abatement model results, England and Wales

4.8 Abatement potential by building age

Figure 4.3 shows that the abatement potential increases with building age. The newest buildings have an abatement potential of 28 per cent whilst buildings constructed between the 1900 and 1939 had a reduction potential of 44 per cent. This difference is likely to be driven in part by the increased likelihood that older premises will be serviced with older equipment.

Figure 4.3: Abatement potential by building age, 2014–15



Source: Abatement model results, England and Wales

5 Barriers

In this section the barriers and enablers discussed during barriers interviews are presented. These interviews were conducted as part of some of the site surveys conducted as part of the Building Energy Efficiency Survey (BEES). The method in which these interview responses have been coded is set out first, followed by a presentation of those barriers which were most frequently noted as well as their relative impact. Organisational energy management capability is then analysed. Finally this section considers the enablers raised by respondents i.e. those factors deemed to be the most likely to enable energy efficiency measures.

5.1 Barrier interviews and processing

As part of each barriers interview, respondents took part in a semi-structured interview to identify factors they perceived to affect their ability to implement energy efficiency measures on site. The target respondent was the individual accompanying the surveyor at a BEES site visit (although in some cases it was necessary to telephone other staff members based off site to get this information).

There were three parts to the interview:

- Barriers interview: this focussed on barriers to implementing energy efficiency measures. The respondent was presented with three potential energy efficiency measures[48] identified on the site visit and asked to name any factors impacting their ability to implement them. The participant was also asked to rank these barriers according to their impact using a 3-point scale (low, medium or high) [49].
    a. Following the interview, notes were recorded by interviewers and these were later coded into five overarching barrier categories - financial, behavioural, external, technical or other.
    b. Barriers were also classified on a more granular level according to a published barrier typology[50]. It should be noted that this process of coding barriers was undertaken by the research team and can be by its nature reasonably subjective on a case by case basis.
    c. The extracts noted are based on these interview notes rather than necessarily direct quotes from respondents. Please refer to Appendix F for further information on the interview method.

[48] one 'behavioural' measure (e.g. an energy awareness campaign among staff), one 'controls' measure (e.g. improved – and controls on the heating system) and one 'capital expenditure' measure (e.g. an upgrade to LED lighting)
[49] Interviewees were asked to rank barriers based on their impact on the likelihood of a measure being implemented. The impact grades ranged from 'high' to 'low'.
[50] Cagno, E., Worrell, E., Trianni, A. and Pugliese, G., (2013). A novel approach for barriers to industrial energy efficiency, Renewable and Sustainable Energy Reviews, pp. 290 – 308. Available at: https://www.researchgate.net/publication/256438140_A_novel_approach_for_barriers_to_industrial_energy_efficiency

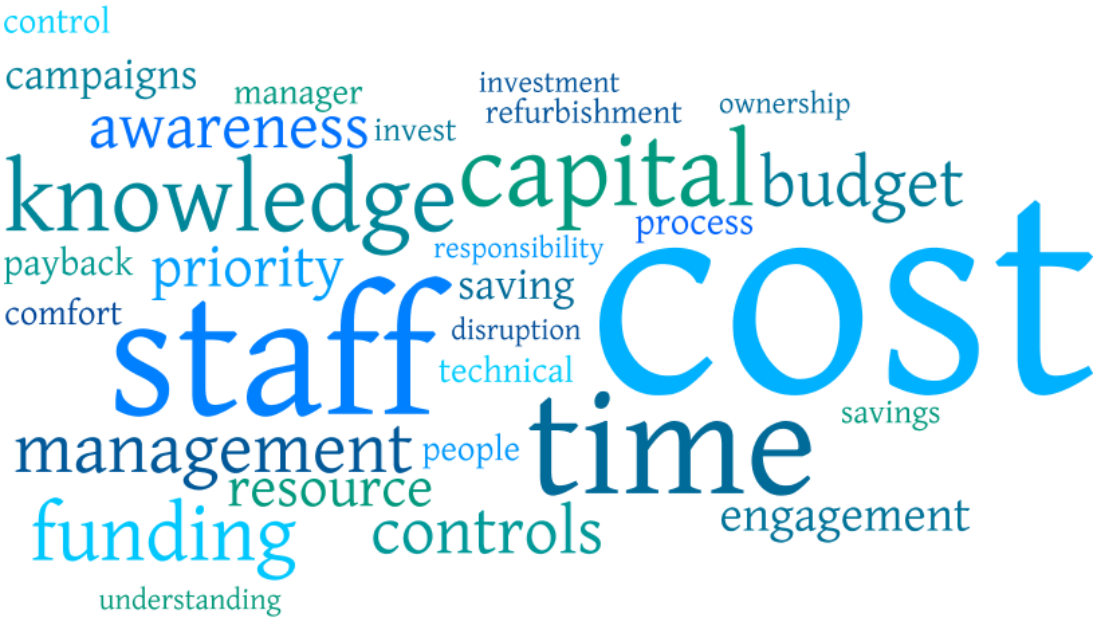
- Structured capability survey: this part of the interview focussed on the energy management practices conducted on site. This consisted of a structured interview of 15 questions.
    a. The responses were scored for each site according to energy management competency in the following six categories: Corporate strategy, Programme management, Responsibility, Data management, Communications & Training and Finance & investment.
    b. These scores were derived by associating different development levels in a competency based on the responses. These development levels were defined by the research team and were broadly based on a typical energy management matrix[51], where each response directly links to maturity of an organisation for a given competency.
- Enablers interview: this part of the interview focussed on the potential 'enablers' which might allow the respondent to better implement energy efficiency measures on site.
    a. These were also classified according to type and the likelihood of implementation.

5.2 Frequency of barriers

The word cloud reflects the frequency of key words that were described in the barriers interview (part 1) by the respondent and recorded by the surveyor/interviewer. The more commonly mentioned –or frequent- the larger the word displayed. These words were contained in the notes recorded by interviewers to the barriers part of the interview (first part of the interview), which respondents had discussed in relation to the three opportunities identified on site by the interviewer/surveyor (Figure 5.1). Unsurprisingly, the most common words related to financial barriers and resourcing constraints. For example, the words 'budget', 'capital', 'cost' and ''payback' feature prominently, as do 'knowledge', 'time' and 'staff'. This just gives a flavour of the barriers and these are explored in more detail next.

[51] For an overview of maturity matrices please refer to BRECSU and ETSU, 1996, Good practice guide 119, Organising energy management - a corporate approach, a digital archived copy is available at http://www.cibse.org/getmedia/8e7d033a-56e1-49f5-9344-d7a78329ac3b/GPG119-Organising-Energy-Management-a-Corporate-Approach.pdf.aspx

Figure 5.1: Barrier word cloud



Source: Barriers interviews (n=126)

Respondents had been asked to rank the three barriers they discussed based on their impact.[52] The barriers discussed are shown by how commonly they are mentioned and their impact rating in Table 5.1 .The most common perceived barrier group was economic barriers. These were followed by organisational, awareness, competency and behavioural barriers. The least commonly mentioned barriers were those related to information, technology and government.

Table 5.1: Barriers by frequency and average impact

Area	Barrier	Frequency	Average impact
Awareness	Lack of awareness or Ignorance	25	2.1
Barriers related to competencies	Identifying the inefficiencies	41	2.1
	Identifying the opportunities	40	2.0
	Implementing the interventions	59	1.8
Behavioural	Imperfect evaluation criteria	4	2.0
	Inertia	54	2.2
	Lack of interest in energy efficiency	39	2.1
	Lack of sharing the objectives	13	2.0
	Other priorities	137	2.2
	Split incentives	11	2.4

[52] Interviewees were asked to rank barriers based on their impact on the likelihood of a measure being implemented. The impact grades ranged from 'high'(3) to 'low' (1).

Table 5.1 continued

Area	Barrier	Frequency	Average impact
Economic	Hidden costs	26	1.9
	Intervention-related risks	51	2.2
	Interventions not sufficiently profitable	57	2.4
	Investment costs	24	1.7
	Low capital availability	207	2.4
Government	Lack of proper regulation	3	2.0
Information barriers	Lack of information on costs and benefits	16	2.3
	Trustworthiness of the information source	3	2.3
	Unclear information by technology suppliers	3	1.3
Organisational	Complex decision chain	53	2.4
	Divergent interests	2	3.0
	Lack of internal control	24	2.1
	Lack of time	92	2.0
	Low status of energy efficiency	33	2.2
Technology related barriers	Technologies not adequate	35	2.0
	Technologies not available	8	2.0

Source: Barriers interviews (n=126)

5.3 Barriers groups

Based on the finding of the first part of the interview each of the barrier groups are now considered separately;

5.3.1 Economic barriers

Economic barriers included low capital availability, investment costs, hidden costs, intervention-related risks, external risks and interventions not sufficiently profitable. All of these barriers are to some degree interrelated but when coding the interview notes the research team categorised against what appeared to be the key factor.

Low capital availability was frequently perceived to be a barrier. It was also generally allocated a high impact where it was noted. There appeared to be a general connection between organisation size and the degree to which funds would be available to invest in energy efficiency. Organisations of a smaller size may need to focus their funds on core activities limiting capital for energy efficiency measures. For instance a church noted that a measure was "*Too expensive - the church is not a rich one and only barely gets by, so they can hardly invest in retrofits"* and a hotel stated that they "*can't afford the technologies of bigger chains (electronic key cards interlocked with room lighting and heating, etc.)"*

Energy efficiency measures were also perceived as not being sufficiently profitable for a reasonable proportion of interviewees. Where this was the case the impact would be high, because there would be no means of sourcing funding if certain minimal financial thresholds were not met. This was exacerbated if premises occupancy was short term or uncertain. In cases of leased premises there was a requirement for returns to be achieved within the lease

length. A small shop said their "[our] *Average shop will use £5k of [electricity] per annum - to put in £500 of investment is a lot [and it needs to achieve at least a] 3 year payback"* and an occupant of a leased office said the "*Building is on a lease - two years' time. [Measure] has to payback [within this time frame]".*

Another commonly perceived high impact barrier related to intervention-related risks. This captured a wide range of concerns, which included disruption to business as usual operations, impact on the core activities associated with premises or concerns relating to the lifetime performance of newer technology. A hotel highlighted how *"[it is] Difficult to predict the level or duration of disruption. [there is therefore a] Risk to business as usual operation[s]*", whilst a hospital noted that "*Replacing controls in a 24/7 acute hospital invites risk".*

The remaining economic barriers were 'hidden costs' and 'investment costs' but these were less often mentioned. The issues highlighted were often associated with the disruption caused through implementing a measure but beyond this were also concerns about ongoing hidden costs (associated with complex financing arrangements) and the difficulties associated with wider infrastructure-related upgrades required to enable a new technology. Investment cost barriers, were similar to capital availability, where for smaller sites any non-core capital outlay was difficult to justify. In many cases organisations might struggle to finance measures, which cannot funded under a standard capital project. For example a Primary school mentioned hidden costs such as being "*Hesitant to pursuing financing deals for capital projects", "the fear of concealed costs / penalties"* and a Police station about the "*Hassle of changing the wiring arrangement to accommodate the PIR sensor"* whilst a Prison raised investment costs as an issue in terms of securing *"Funding for contractors"* outside of standard capital budgets.

5.3.2 Behavioural barriers

Behavioural barriers included imperfect evaluation criteria, inertia, lack of interest in energy efficiency, lack of sharing the objectives, other priorities and split incentives.

Other priorities were commonly perceived as a barrier and where they were noted they were typically classed as having a high impact. Energy efficiency for some respondents was not a high priority area and other issues would take precedence. This could either be linked to core activities or other wider more generic issues such as ensuring health and safety standards were met. Indeed there were a number of instances, particularly in the private sector, where respondents believed there was a conflict between energy efficiency and their core operational priorities. In some case respondents also mentioned budgetary constraints as being linked to the need to focus on a limited number of high priority areas. For instance a health centre noted that "i*n the patient centred environment of health care, Estates projects are seen as low priority - not contributing to the delivery of the core service"* and a place of worship highlighted how "*other, more important refurbishment takes precedence over EE improvements (e.g. dealing with their rotting floor)".*

There were a number of cases where respondents believed there was a direct conflict between energy efficiency measures and the other core activities, which were classed under 'other priorities'. The types of issued raised included adverse impact on product quality, space

comfort, product marketing and disruption in access to space. Generally this issue was raised more often in the private sector and particularly in consumer facing environments where customer comfort was essential. A theatre, for instance, said that due to "*Health and safety - we don't want dimly lit corridors*" whilst a small shop was concerned about *"Aesthetics - Light colour and Lux levels need to be considered".*

Inertia was also regularly perceived to be a barrier. Where measures required the replacement of the equipment, a number of organisations had end of life replacements policies, where existing plant was only replaced once it had reached the end of its usable life. Where this was the case it would be noted as being a high impact barrier. Some organisations were also perceived to be more risk averse to novel technology, meaning that it would require a far greater time investment from individuals to seek approval of the capital funds required. Finally, for one site the existence of minimum quality standards meant that it would be difficult to exceed or modify these without additional justification. A leisure centre, for instance, said that "a*sset lifecycles - unlikely to replace major plant items unless they're at the end of their usable life"* and this was echoed by a small shop who said "*Don't replace until they need to be"* and a workshop who simply stated "*Inertia - "if it ain't broke, don't fix it".*

There were a number of respondents who perceived a lack of interest in energy efficiency. This was a reasonably high impact issue for awareness campaigns, where interviewees were sceptical that it would be possible to proactively engage the building users on energy efficiency. For example a Store said "*Forgetfulness and not caring enough (people just leave things on because it's convenient) [I] try to turn off all the machines, electric scales in warehouse, plastic bag sealer, but one person walks around and does it." and a* showroom that *"Staff are not in the practice of switching these lights off - would require consistent communication to overcome inertia".*

The remaining behavioural barriers 'split incentives', 'imperfect evaluation criteria'[53] and 'lack of sharing the objectives' were less frequently mentioned but could have a large impact where they arose.

This was particularly the case for split incentives. These occurred in either leased premises or Public Finance Initiatives (PFI)[54], where there can be a significant disincentive by any party to invest in energy efficiency. In leased premises the landlord will often recharge the utility bill, whilst the tenant may only occupy the premises for a limited period of time. Under PFI arrangements, a contractor may be in place to deliver a service outcome but will not pay the cost of energy. Any additional energy efficiency requirements may result in further contractor

[53] The decision-makers might lack the proper knowledge or criteria to evaluate investments. In particular the decision-maker might adopt approximate criteria or routines that do not allow him/her to thoroughly evaluate the effective performance of the interventions.

[54] The House of Commons Treasury Committee defines PFI's as arrangements involving groups of private investors who manage the design, build, finance and operation of public infrastructure available at: http://www.publications.parliament.uk/pa/cm201012/cmselect/cmtreasy/1146/1146.pdf

fees meaning the business case is no longer viable. For example a hospital said "*{under the] PFI [the contractor needs] to get as much as they can from the kit before they change"*

5.3.3 Organisational barriers

Organisational barriers included complex decision chain, lack of internal control, lack of time, low status of energy efficiency and divergent interests.

'Lack of time' was regularly perceived as a barrier by respondents. Whilst the frequency was high the impact was generally only classed as moderate. In these cases, there was a perception that the core team was constrained and therefore could only focus on essential tasks. A fire / ambulance station highlighted that *"Budget cuts mean that there is very little effort put into energy saving due to lack of resource*" while a warehouse noted that they had difficulty "*finding the time to put together the programme of behaviour change / awareness improvements".*

Complex decision chains were noted a number of times and where they occurred they were perceived to have a high impact. Complex decision chains often arose where approval to proceed required agreement across multiple parties. This might be between landlords and tenants, planning departments and building occupants or a central funding body and the premises. A primary school noted that a *"county council (funding body) not responsive to capital request which has been submitted accompanied by a compelling business case*" whilst a pub highlighted that before proceeding that needed approval from their "*Pub landlord - need to get their buy in".*

As with 'lack of interest in energy efficiency', it was also regularly believed that energy efficiency had a low status. This was typically characterised by senior management not supporting energy management. For instance in a higher education teaching and research premises the respondent said "*Lack of importance given to energy management"* whilst in a retail warehouse it was noted that "*Senior management focused on cost control*".

Sometimes occupants have limited control over the premises. This can occur in PFI or leased situations, where premises ownership and operations are split across parties, which can mean the premises occupier has limited scope to autonomously make improvements. In some cases respondents also highlighted a shift towards centralised energy management, resulting in opportunities being missed locally. Finally, in one case it was noted that customers may tamper with the building control settings. In this instance, the occupier has limited control over the building users in this regard. A leisure centre highlighted that a *"boiler replacement is totally out of hands of swimming pool operator. It is totally down to the Council's decision"* while a pub noted that the "p*ublic tamper with TRV settings - beyond our direct control".*

'Divergent interests' were highlighted where organisations did not necessarily fully realise the benefits associated with energy efficiency measure. For instance in a higher education teaching and research premises the respondent said *"No incentive [to reduce energy] - energy is paid centrally [so] they don't see the cost".*

5.3.4 Barriers related to competencies

Barriers related to competencies included: identifying the inefficiencies; identifying the opportunities; and implementing the interventions.

All three barriers were perceived at a number of premises. This was based on what respondents would identify as a lack of key skills that was affecting their ability to proceed with a measure.

A hotel for instance noted that they had a "*lack of required skills" to* identify the inefficiencies. A community club in turn observed that they had a "*lack of knowledge about possibilities and paybacks"*, whilst a fire / ambulance station noted that despite having a system in place no one was trained in its use – "*No member of staff knows how to use the [building management] system"*.

It should be noted that the responses are only based on where respondents themselves had identified themselves or their team's as lacking key competencies. There were a number of cases where respondents believed they had achieved the majority of possible savings and had not identified a capacity gap but the site surveyors were able to identify significant further opportunities. This indicates that competency may be a greater barrier than perceived, but because this method is based on self-reported data, not all cases will be highlighted.

5.3.5 Technology-related barriers

Barriers related to competencies included technologies not being adequate or technologies not being available.

Existing technology or other physical characteristics relating to the site were perceived to be a barrier in a number of site surveys. This might be due to either accessibility constraints or limitations in further measures due to the existing infrastructure available on site. For example, a showroom noted that due to the "*aged nature of lighting system – [it] may be difficult to retrofit controls compared to more conventional designs",* and a military premises had difficulties implementing measures because the "*BMS [Building Management System] equipment is very old and difficult to gather any relevant information".*

There were relatively few cases where respondents perceived a lack of available technology as being a barrier for implementation. This was possibly because the opportunities being investigated focused on reasonably typical opportunities, as opposed to novel emergent technology, which could be more context specific in its application. One office however did state that *"Sourcing technology that is fit for purpose [was difficult]".*

5.3.6 Information barriers

Information barriers included lack of information on costs and benefits, trustworthiness of the information source and unclear information by technology suppliers.

Information barriers were rarely perceived to be an issue. Where information barriers were highlighted the two most commonly mentioned were lack of information on costs and benefits. For example, a leisure centre stated that there was a "*Lack of information on range of LED*

options available". Some respondents questioned the trustworthiness of the information source – a nursery said they were "*Suspicious of technology being valid",* whilst others had unclear information from technology suppliers and a leisure centre found that it was "*difficult to get suppliers to quote for costs".*

5.3.7 Government

Government barriers only included a lack of proper regulation. This barrier was not often highlighted - with the only possible example being raised in prisons - relating to minimum comfort levels being achieved for prisoners and the fear of litigation in the event of these not being achieved. In this case however the issue could primarily relate to the building manager's perception of the regulation that applies and how it impacts on their ability to implement measures.

5.3.8 Awareness

Awareness barriers only included a lack of awareness or ignorance. This barrier was noted on a number of site surveys, however the impact tended to be moderate to low. They related to a lack of awareness either general energy management knowledge, of how energy consumption related to cost, emergent technologies or, if there was a need to engage with wide range of building users, the knowledge of these building users in relation to energy efficiency. For example a Museum said that "*Information isn't made plain to gallery staff - timings, set points etc."* and a Café that *"New best thing comes along all the time - difficult to follow / keep up with technology".* The example provided from the museum is similar to information barriers and this is indicative of the subjective nature of grouping barriers.

5.4 Barriers by sector

Using the findings from the first part of the interview the variation in barriers across sectors is now explored. Overall the main differences in the nature of barriers between sectors was driven to some degree by underlying structural differences between them.

A lack of access to capital was the most frequently perceived barrier across every sector. It was the only barrier that was noted by respondents in every sector. Furthermore, it was often perceived as having a high impact on the ability of a site to proceed with investment.

Sectors with smaller premises or a high reliance on volunteers, such as community, arts and leisure, retail and industrial often identified capacity constraints. Respondents noted a lack time and ability to identify measures. A club said that the key person involved *"…has many responsibilities beyond energy efficiency, so he doesn't want to spend time training the staff or running incentivisation programmes".*

In the education and emergency services sectors key internal stakeholders were believed to have 'other priorities', which significantly undermined the organisation's ability to implement energy efficiency measures. This particularly affected the implementation of behavioural change programmes. A fire and ambulance station said that energy efficiency "*is not on their radar"*.

Other priorities were also noted in the hospitality, industrial and retail sectors. In these sectors respondents raised concerns about the impact of energy efficiency measures on core business activities. As an example a pub said that the "*primary focus is customer satisfaction - not energy efficiency".*

Complex decision chains were believed to have the greatest impact in the community, arts and leisure, hospitality education and military sectors. This was perceived to arise through either burdensome external or internal approval processes.

Sectors, such as hospitality and community, arts and leisure with older, and potentially listed, building stock often require external approval from planning authorities for further energy efficiency projects. In other sectors, such as education, third parties were involved in the funding and operation of premises which was felt to introduce additional approval complications. For instance, a church said that they *"would need to get permission from the Parish Council and from the Diocese if it's a big thing they want to do (like replacing the heating system). Light bulbs much easier and they are replacing them as they blow".*

In other sectors internal decision making processes were believed to delay progress. In the military sector complex decisions chains were recorded which arose primarily through the range of internal stakeholders that were required to approve works.

5.5 Barriers by technology

The first part of the interview also compared the barriers for range of opportunities. Each site was asked about one measure in each of the following categories; behavioural, controls (i.e. building instrumentation and control measures, which consist of a range of opportunities such heating or lighting control measures) and major capital expenditure measures.

Behavioural measures, such as awareness campaigns, predominantly impacted organisational or behavioural barriers. These included a lack of time, other priorities and a lack of interest in energy efficiency measures.

Some respondents also perceived a lack of technical skills, meaning they did not feel capable of advising on what an awareness campaign could include. Where this arose respondents would often cite financial barriers, such as low capital availability. This would be associated with procuring third party support to provide energy management training.

With control measures low capital availability was most commonly believed to be a barrier. Beyond capital availability many respondents also noted a lack of technical skills, meaning they did not necessarily have the skills to identify where controls were required and then have the ability to maintain systems going forward. In a similar vein, respondents also highlighted a lack of time, which coupled with a lack of technical knowledge could act a large barrier to implementation.

There were also cases of respondents having concerns about the intervention related risks as well as other priorities relating to controls. In these instances the potential impact on core

operations was believed tosignificantly affect the organisation's willingness to progress with the control measure. This could be either due to perceived disruption costs from implementation or, more commonly, associated with concerns on occupant satisfaction or safety levels post intervention. This meant that respondents would favour the status quo.

For major capital expenditure measures economic barriers were believed to be the key issue, specifically low capital availability is the key barrier. Linked to this was also the issue that in many cases measures were not sufficiently profitable to meet internal investment requirements.

Beyond the economic barriers, respondents also commonly believed inertia to be a major barrier to investment in major capital expenditure measures. In many cases operational plant would not be replaced unless it had reached the end of its useful life or when the premises was in a position where a major refurbishment or plant replacement was viable.

5.6 Barriers by organisation size

Using the data from the first part of the interview it is possible to compare the perception of barriers identified by organisations of different sizes. The barriers faced by large organisations and SMEs were similar on the whole. Most organisations highlighted a low capital availability and lack of time being key issues. For example "*Finance to implement the solution"* Higher education – Teaching and research (large organisation) and "*Budgetary constraints. Energy is one of a number of areas that vie for attention"* – Museum (SME).

The areas where they differed were that SMEs were far more likely to believe that other priorities was a concern, often taking the view that there was a risk of customer or building user dissatisfaction from energy efficiency measures. For instance a small shop noted that LED replacements were not of interest because they would affect the *"look and feel"* of the shop – Small shop (SME).

In contrast, for large organisations there was a tendency to perceive complex decision chains and other priorities far more often as the main barrier to implementing energy efficiency measures. An office in a large public sector organisation for instance stated that "*capital funds would need cabinet approval more than £25K*". The barriers therefore in SMEs were slightly more behavioural in nature whilst the barriers in large organisations were organisational.

5.7 Barriers by tenure

The first part interview can also be used to compare premises across different tenures. In looking at rented premises, the most common perceived barriers were associated with interventions not being sufficiently profitable (economic), complex decision chains (organisational) and split incentives (behavioural). These were classed as having a high impact on the ability to implement energy efficiency measures, particularly those related to large capital investment i.e. plant replacement.

Tenants will often restrict investment returns on energy efficiency measures based on their lease renewal cycles. As a result the requirement for an intervention to pay back rapidly may be even more important in an organisation in a rented premises than it would be if that organisation owned the premises. For instance a factory noted that the "*site is leased. 4 more years* [is the pay back limit]"*."*

Complex decision chains were believed to arise because of the requirement, in many cases, to seek third party approval for the implementation of measures. At a minimum this will often require sign off from the landlord, but in some cases other parties such as tenants or property managers may also need to be included in discussions. For instance a large distribution centre said that "*Building is leased as a lease hold for 15 years. Landlord permission is needed to make changes to the site".*

Finally split incentives were perceived to arise where the owners of the premises are not paying the energy bills associated with energy use in the premises. This cost lies with the occupiers. In this instance no single party is sufficiently incentivised to invest in energy efficiency. One rented office for instance observed that "*people don't take ownership - they're not paying the bill".*

5.8 Barriers by private and public sector

Public sector and private sector organisations were perceived to have broadly similar barriers to implementing energy efficiency measures. In the private sector however there was an emphasis on economic barriers where as in the public sector issues associated with organisational barriers had a higher impact.

It is worth noting that the majority of public sector premises are occupied by large organisations whilst private sector organisations are far more diverse. To this extent where there were differences to the barriers faced by public and private sector organisations, they were often similar to those differences identified between large organisations and SMEs.

Private sector organisations were far more likely to believe that interventions were not sufficiently profitable was a barrier to implementing energy efficiency measures. For instance a pub said, when discussing an LED investment, that "p*ayback needs to be good - 3yrs".* Many smaller private sector companies highlighted payback thresholds of less than a year. Private sector organisations would also often identify concerns relating to intervention related risks and divergent interests where there was a perception that energy efficiency measures could conflict with core operational priorities. Finally private sector organisations were also more likely to believe that capability gaps affected the implementation of energy efficiency measures. This could be the product of the significant numbers of SMEs that operate in the private sector, who typically have less capability in terms of energy management resources.

In the public sector the perceived barriers most often related to key stakeholders having other priorities, complex decision chains and inertia. For instance in a number of public sector premises energy efficiency was relatively low priority compared to maintaining critical operational equipment on site. A law court noted that "e*nergy efficiency is deprioritised next to*

pressing issues that arise on an ad-hoc basis (e.g. [water] leaks in the court rooms)". Complex decision chains involving either third parties, such as Public Finance Initiative contractors in hospitals or local education authorities for schools, or internal stakeholders, like in the military, were often believed to be important. For instance, a respondent on a military site noted that "t*he influence of senior management means that decision making is very slow and communication up the chain of command is difficult."* Finally, in public sector organisations inertia was more commonly perceived to be a barrier. Often policies were in place to ensure plant was only replaced at the end of its useful life. For example a primary school said that *"Energy efficiency is not a concern, as equipment is only replaced when it stops working."*

5.9 Maturity of energy management systems

The second part of the interview was a short structured survey. Respondents were asked multiple choice questions relating to their organisation's energy management system.,The respondent's organisation was then assessed in terms of capability across six typical energy management competencies using a simple snap shot at that point in time. In this section these competencies are grouped into performance bandings to illustrate how organisations tend to develop their energy management competencies and what type of organisations have more developed systems.

The six competencies are listed below and their maturity levels are defined in Figure 5.2:

- Corporate strategy: This determines how formalised and far reaching the corporate strategy is in terms of published performance targets.
- Programme management: This assesses how the energy management programme is managed and monitored on an annual cycle.
- Responsibility: This represents the degree to which roles and responsibilities have been defined with respect to energy use. This will account for senior management, core delivery team and site team responsibilities.
- Data management: This covers the sophistication of the energy data management systems in place. It considers how data is gathered, stored, processed and reported
- Communications & Training: This covers internal training investments in both the core programme delivery team as well as wider organisation employees.
- Finance & investment: This considers the sophistication of the finance and investment methods in relation the energy management opportunities.

The structured interview questions had been designed as multiple choice options, where each option described a differing level of maturity. Using the interview responses, each attribute was ranked from 1 (Developmental) to 5 (Leadership). These levels broadly relate to the standard energy management maturity matrix levels, where developmental would indicate no action on competency whilst leadership would indicate that a comprehensive approach was in place. The

rank for a given competency was based on average score from each of the associated questions.

Figure 5.2: Maturity level by competency

	Competency					
Level	Corporate strategy	Programme management	Responsibility	Data management	Comms & Training	Finance & investment
5	Long term target set for whole organisation for carbon and energy consumption reduction.	Executive team review progress against targets on quarterly basis and progress against target published externally.	Key managers have accountability for energy reduction, energy management integrated into responsibilities of senior management and staff and other third parties engaged though green champion network.	Energy data compiled on a regular basis. This is collated through automatic metering feeds on fiscal meters. Where relevant submetering has been installed. Data is also verified against a bill validation process and data is stored in energy management system.	Central operational team given comprehensive operational training. All wider staff given formalised energy management training and staff awareness tested through surveys.	2 year or more plan agreed with financial budget for energy reduction initiatives, with a ring fenced finance programme. External funding being routinely obtained and a finance representative is on the energy management team.
4	Short term target set for whole organisation for energy consumption reduction.	Sponsor reviews progress and removes blockages through regular programme boards and progress against targets routinely reported to senior management team.	Key managers have accountability for energy reduction, energy management integrated into responsibilities of senior management and staff engaged though green champion network.	Energy data compiled on a regular basis. This is collated through automatic metering feeds on fiscal meters. Data is also verified against a bill validation process and data is stored in various MS excel files or other similar none energy focused systems/tools.	Central operational team given comprehensive technical training and all wider staff given formalised energy management training.	2 year or more plan agreed with financial budget for energy reduction initiatives. Adhoc external financing sought. There is no finance representative on the energy management team.
3	Vision for energy reduction clearly stated and published.	Core team regularly review energy managememt progress.	Key managers have accountability for energy reduction and senior sponsor actively engaged but has no formalised targets.	Energy data compiled on a regular basis, but majority is based on bill data only. Data is also verified against a bill with accounts team and data is stored in various MS excel files or other similar none energy focused systems/tools.	Central operational team given ad hoc training and wider staff given formalised energy management training.	1 year plan agreed with financial budget for energy reduction initiatives. Adhoc external financing sought. There is no finance representative on the energy management team.
2	Draft energy policy.	Ad hoc reviews of energy management actions progress.	Energy reduction a part-time responsibility of a central operational team member.	Energy data compiled on a regular basis, but majority is based on bill data only. Data is verified against a bill with accounts team but there is no systemic means of capturing data.	Central operational team given energy management information on ad-hoc basis and wider staff given energy management information on ad-hoc basis.	Some financial budget allocated to energy reduction, but no clear plan. Adhoc external financing sought. There is no finance representative on the energy management team.
1	No policy .	No oversight and monitoring.	No recognised energy reduction responsibility within central operational team.	No energy data compiled and high reliance on estimated billing, No systemic means of capturing data and there is no data verification.	No training to central operational team and no communication or training to wider staff.	All finance allocated to energy reduction is done so on an ad hoc basis. Adhoc external financing sought. There is no finance representative on the energy management team.

It should be noted that for some organisations it would be reasonable to not have highly sophisticated energy management systems in place. For instance a small shop does not require the same systems and processes as a large multi-site organisation to manage energy effectively.

Figure 5.3 shows example site surveys with a range of capability scores used to illustrate typical high and low capability responses. An example capability score has been used to illustrate the characteristics of respondents at different maturity levels. This shows which attributes organisations appear to have developed first as their mature in their energy management capability.

The lowest performers had all competencies at a developmental stage. Typically these respondents private sector small to medium sized organisations who occupied smaller premises (less than 1,000 m^2).

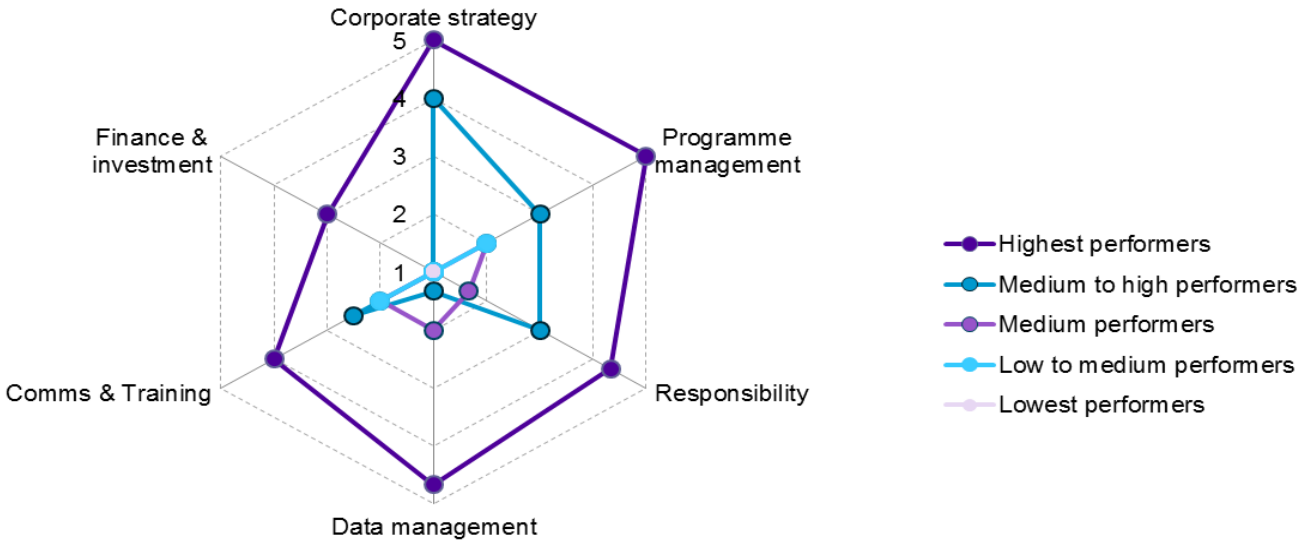
The site surveys with low to medium capability profile typically had achieved the second level of maturity in one or two competencies. The competencies most likely to have improved were programme management, data management or communication & training. Responders in the profile were similar to the lowest performers,

Sites with medium level of capability would often have achieved a reasonable level of maturity on two or three competencies. In all cases programme management would have developed to a middle level of maturity. In many cases data management and responsibility would also have developed to a similar point. Some sites would also have established a basic overarching energy policy. The profile of medium level respondents was still predominantly private sector small to medium sized organisations. There were however some public sector respondents with this level of capability and also the typical premises size was slightly larger.

Medium to high capability performers often achieved a reasonable level of maturity across four or five competencies. Typically for one competency a very high level of maturity would have been achieved, which often related to the robustness of the corporate strategy. The only competency, which often tended to be weaker was finance & investment. In terms of profile, there was a reasonably even split of private and public sector organisations and also a reasonably even split in terms of organisation sizes. There was a tendency for the premises to have a greater floor area than 1,000 m^2.

The highest performers would demonstrate high levels of maturity across all competencies. The majority of these respondents were public sector organisations and almost all were large organisations. The average premises size was also the highest of any group, with most premises being between 2,500–4,999 m^2.

Figure 5.3: Energy management systems across different organisations



Source: Barriers interviews (n=126)

5.10 Enablers

In the final part of the interview, each respondent was asked which enablers they believed might allow the respondent to better implement energy efficiency measures on site. These were also classified according to type and the likelihood of implementation. The outputs of these questions were then coded into common categories.

227 enablers were self-reported by the 126 respondents. The project team developed the following categories into which these were grouped. These are ordered by the number of times they were mentioned from most to least (the number of mentions is indicated in brackets):

- Increased availability of funding: Additional funding to manage energy is made available. (75)
- Knowledge: The respondent will have improved energy management knowledge. (48)
- Stakeholder engagement: Greater buy in from key internal and external stakeholders is achieved. (27)
- Resource: Additional resources, in terms of team capacity, to manage energy is made available. (25)

- Internal control: This is the likelihood that the respondent will have increased control over energy usage and its management in the premises. (23)
- Improved communication: This can be both internal and external. When internal it relates to better communication on roles and responsibilities. In terms of external communication, it relates to better coordination at trade association level. (15)
- Target setting: Organisational targets will be adopted which will empower the energy management team. (10)
- Reputational benefits: If additional standards were available, these could be used to increase the reputational benefits from energy management. (4)

The most commonly perceived enablers were improved knowledge, increased availability of finance and improved stakeholder engagement. This reinforces the findings from the earlier barrier analysis which showed that economic, behavioural and organisational barriers were very common.

In terms of likelihood, the only enablers that respondents thought was likely to change were reputational benefits. This was based on asking respondents how likely they believed an enabler would occur on a five-point scale ranging from highly likely to highly unlikely. In the few instances where respondents believed that this would enable change, then they assessed it as having a high likelihood of occurring. Often these enablers were linked to the implementation of public standards and the associated positive reputational benefits.

Respondents believed that the availability of funding was unlikely to improve. Nor was the level of resourcing available likely to change. This indicates that of the key barriers believed to exist, in many cases, respondents did not think that the situation was likely to change in the near term. Furthermore, all of the remaining enablers (bar reputational benefits) were also considered generally unlikely to change.

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 sector are provided, and the the telephone survey response rates by sector.

Confidence intervals

Table A.1: 95% Confidence intervals for electrical energy intensity

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Retail	192	± 17
Offices	160	± 26
Hospitality	241	± 61
Industrial	63	± 5
Storage	53	± 13
Health	133	± 15
Education	62	± 10
Emergency services	86	± 13
Military	60	± 16
Community, arts & leisure	62	± 11
All sectors	**106**	**± 8**

Table A.2: 95% Confidence intervals for non- electrical energy intensity

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Retail	50	± 9
Offices	74	± 16
Hospitality	226	± 55
Industrial	80	± 13
Storage	41	± 9
Health	237	± 23
Education	126	± 11
Emergency services	203	± 21
Military	100	± 16
Community, arts & leisure	137	± 24
All sectors	**95**	**± 6**

Response rates

Table A.3: Telephone survey response rates for the non domestic stock

	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency services (%)	Community, arts & leisure (%)	**All sectors (%)**
Completed interview	13	13	9	9	9	10	9	12	9	**10**
Still live[55]	50	46	62	69	30	43	50	30	61	**50**
Screening failure/other non-response[56]	0	1	0	1	5	0	0	0	2	**1**
Refusal	21	18	15	10	22	7	5	5	5	**14**
Other non-response	6	5	5	4	21	3	3	7	8	**8**
Invalid contact details	9	16	9	7	14	36	33	47	16	**16**

[55] 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).

[56] 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: End use definitions and further energy end use breakdowns

This appendix provides definitions on the energy end uses and the energy end use breakdowns across each sector within the non-domestic stock. 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 B.1.

Table B.1: Definitions for energy end uses

End use category		Description
1	**Space heating**	Energy consumption for space heating (including via ventilation), excluding domestic hot water heating, process heating and unusual end-uses such as swimming pool heating and frost protection of ramps. Electricity input to heat pumps directly associated with space heating should be included.
2	**Hot water**	Energy used for domestic 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. Include pumps used for central

End use category		Description
		heating, hot water, and boiler ancillaries such as burner fans, flue boost or dilution fans and gas pressure boosters, chilled water and condenser water, cold water booster pumps and sump pumps.
6	**Controls**	Controls for mechanical and electrical services, building energy management systems, security and alarm systems.
7	**Humidification**	All humidification plant used to provide humidification for general building services including ventilation and air conditioning but excluding special energy uses such as swimming pool de-humidification.
8	**Lighting (Internal)**	All general internal lighting including task lights and emergency lights.
9	**Lighting (External)**	All external lighting associated with the premises, including for dedicated car parks and street lighting for dedicated access routes.
8	**Lighting (Display)**	All display lighting including retail/artwork display or demonstration lighting, decorative lighting in lobbies etc.
10	**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.
11	**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.
12	**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.
13	**Catering - Central**	Kitchen (or café) catering preparation and serving equipment including dishwashers, and water heating associated with catering. Excludes restaurant lighting, ventilation and air conditioning.
14	**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

End use category		Description
		areas.
15	**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.
16	**Entertainment: lighting**	Stage or performance lighting.
17	**Entertainment: equipment**	Audio-visual equipment, gaming machines, etc. Includes projectors, TV screens, and sound systems in all premises types.
18	**Laundry**	Fabric washing and drying machines.
19	**Medical equipment**	Energy used for medical equipment or health services in hospitals, doctor's surgeries, dentists, vet centres, etc. Excludes equipment in laboratories.
20	**Laboratory equipment**	Energy used for equipment in laboratories.
21	**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.
22	**Other normal**	Any other energy uses which fall outside categories 1 to 21, which are "normal" - i.e. are typical for the specific building type.
23	**Other special**	Any other energy uses which fall outside categories 1 to 21, which are "special" - i.e. are in some way atypical 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 B.2.

Table B.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
	Medical equipment	Medical equipment
	Central catering	Other
	Distributed catering	Other
	Small power	Other
	Pumps	Other
	Controls	Other
	Lighting - display	Other
	Lighting - external	Other
	Vertical transport	Other
	Cooled storage	Other
	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
	Medical equipment	Medical equipment
	Catering	Other
	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).

Table B.3: Energy consumption simplified energy end use by sector and energy type, 2014–15

		Energy consumption by sector (GWh/year)										
End use	**Energy type**	Retail	Offices	Hospitality	Industrial	Storage	Health	Education	ES[57]	Military	CAL[58]	**All sectors**
Heating	Electricity	3,470	1,830	370	570	560	130	180	60	-	460	**7,650**
	Natural gas	4,800	7,120	2,580	13,100	4,930	6,450	7,390	2,530	670	4,850	**54,420**
	Oil	210	90	190	490	170	10	540	80	-	80	**1,850**
	District heating	-	50	-	60	-	110	260	10	360	130	**990**
	Other	260	240	400	400	360	10	40	10	10	300	**2,040**
Hot water	Electricity	180	550	170	140	120	150	240	20	10	50	**1,640**
	Natural gas	160	670	890	220	150	2,120	1,130	320	60	220	**5,950**
	Oil	-	-	30	10	-	-	50	20	-	10	**120**
	District heating	-	-	-	-	-	10	30	-	10	-	**60**
	Other	-	20	90	10	10	-	10	-	-	20	**170**
Cooling & humidification	Electricity	950	2,150	280	610	150	450	190	50	80	310	**5,220**
	Natural gas	-	130	-	-	-	-	-	-	-	-	**130**
Fans	Electricity	860	1,400	630	780	250	980	450	150	100	430	**6,030**
Lighting	Electricity	5,970	2,920	690	7,730	2,900	1,270	1,470	490	300	770	**24,520**
ICT equipment	Electricity	90	6,950	-	270	270	60	260	20	-	10	**7,910**
Small Power	Electricity	530	2,110	40	530	390	880	620	210	90	50	**5,440**

[57] ES – Emergency services
[58] CAL - Community, arts & leisure

Table B.3 continued

End use	Energy type	Energy consumption by sector (GWh/year)										
		Retail	Offices	Hospitality	Industrial	Storage	Health	Education	ES[59]	Military	CAL[60]	**All sectors**
Catering	Electricity	540	350	4,750	180	60	300	620	40	40	360	**7,230**
	Non-electric	240	310	3,870	120	40	390	510	10	30	520	**6,040**
Cooled storage	Electricity	6,960	10	1,350	20	1,850	50	50	0	0	490	**10,790**
Other	Electricity	2,110	580	460	480	880	1,970	860	220	60	760	**8,380**
	Non electric	0	160	180	0	0	2,040	120	0	0	1,970	**4,480**
Total		**27,330**	**27,640**	**16,970**	**25,720**	**13,090**	**17,380**	**15,020**	**4,240**	**1,820**	**11,790**	**161,060**
Unweighted base		*1,033*	*637*	*272*	*475*	*398*	*166*	*165*	*129*	*64*	*351*	*3,690*

Source: Energy use model results, England and Wales

[59] ES – Emergency services
[60] CAL - Community, arts & leisure

Table B.4: Range of building and premises characteristics by sector and total energy consumption, 2014–15

	Energy consumption by sector (GWh/year)										
	Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency Services	Military	CAL[61]	**All sectors**
Organisation size											
Micro (0-9)	8,470	2,530	4,020	3,000	800	0	930	-	-	1,290	**21,690**
Small (10-49)	2,710	4,570	3,330	4,390	1,600	0	2,790	150	-	470	**27,310**
Medium (50-249)	1,130	3,030	2,870	10,240	2,680	0	5,720	300	-	2,360	**28,900**
Large (250+)	14,780	16,890	6,460	8,070	8,020	15,780	4,860	3,770	1,840	2,340	**72,390**
Don't know	240	600	310	40	10	2,610	720	10	-	50	**5,210**
Not Asked	-	-	-	-	-	260	-	-	-	5,290	**5,550**
Total floor area (m^2)											
Less than 50	790	790	530	30	10	10	-	-	-	-	**2,260**
50-99	2,860	1,280	460	980	80	40	10	110	-	-	**5,730**
100-249	5,240	3,110	3,450	2,320	270	200	70	70	30	550	**15,440**
250-499	1,930	1,870	5,910	4,530	630	280	650	210	20	1,990	**17,910**
500-999	1,870	3,960	3,800	2,180	1,070	530	950	380	80	2,210	**16,030**
1,000-4,999	8,080	10,430	430	5,090	3,360	3,570	7,040	2,590	860	5,880	**47,330**
5,000-9,999	4,830	5,070	710	450	1,120	3,240	3,090	410	540	660	**20,120**
10,000 or more	1,750	1,100	1,370	10,160	6,560	9,500	3,220	470	300	500	**34,930**
Don't know	-	-	1,320	-	-	-	-	-	-	-	**1,320**

[61] CAL - Community, arts & leisure

Table B.4 continued

	Energy consumption by sector (GWh)										
	Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency Services	Military	CAL[62]	**All sectors**
Tenure											
Owned	7,850	10,760	7,110	18,460	7,090	13,250	12,800	3,970	1,690	7,960	**90,930**
Leased	9,380	16,780	9,840	7,260	5,300	4,130	2,040	260	140	3,540	**58,670**
Don't know	6930	80	30	20	360	0	190	0	10	290	**7,910**
Not asked	3,180	0	0	0	370	0	0	0	0	0	**3,550**
Energy management ambition[63]											
Active	10,530	14,820	10,700	14,000	5,840	12,070	6,930	3,300	1,240	6,110	**85,530**
Passive	8,070	10,080	5,860	10,010	6,210	4,960	6,860	930	600	5,150	**58,720**
None	1,920	2,720	430	1,730	1060	350	1,240	0	0	520	**9,980**
Do not know	-	-	-	-	-	-	-	-	-	-	**-**
Not asked	6,820	-	-	-	-	-	-	-	-	-	**6,820**

[62] CAL - Community, arts & leisure

[63] '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 B.4 continued

	Energy consumption by sector (GWh)										
	Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency Services	Military	CAL[64]	**All sectors**
Age of building											
Pre-1900	4,390	3,870	8,190	390	220	1,080	2,280	480	0	3,410	**24,310**
1900-1939	3,200	2,390	880	670	580	1,550	1,820	20	500	930	**12,550**
1940-1985	3,590	5,350	1,100	16,190	4,810	7,220	5,790	1,560	490	2,720	**48,810**
1986-1990	750	3,230	640	2,070	1,530	4,790	1,050	1,000	40	260	**15,350**
1991-2006	4,190	10,240	4,440	2,710	3,190	2,280	2,040	1,020	790	2,940	**33,840**
2007 or later	4,400	980	520	1,420	1060	390	1,910	150	10	600	**11,440**
Don’t know	4,400	1,560	1,220	2,290	1720	70	140	10	10	930	**12,350**
Not asked	2,410	0	0	0	0	0	0	0	0	0	**2,410**
Premises relation to building											
Whole building	19,370	20,890	12,850	19,930	10,240	11,910	10,140	2,940	1,280	10,610	**120,150**
Part of building	7,840	5,520	4,130	1,800	770	190	60	40	10	970	**21,330**
Multiple buildings	130	1,210	0	4,010	2,100	5,280	4,830	1,260	550	210	**19,580**
Not asked	-	-	-	-	-	-	-	-	-	-	**-**

[64] CAL - Community, arts & leisure

Table B.4 continued

	Energy consumption by sector (GWh)										
	Retail	Offices	Hospitality	Industrial	Storage	Health	Education	Emergency Services	Military	CAL[65]	**All sectors**
Peak operating hours[66]											
8 or less	7,060	17,740	1,320	4,050	5,120	410	11,850	1,190	440	4,870	**54,050**
9-15	17,920	9,450	7,540	7,530	5,150	3,730	3,060	1,400	1,190	3,770	**60,740**
16-23	1,460	250	2,330	2,040	1,500	90	20	600	60	1,570	**9,930**
24	580	20	5,670	12,090	1,160	13,050	60	900	-	10	**33,530**
Don't know	320	170	120	30	180	100	30	140	150	1,580	**2,810**
Opening hours[67]											
8 or less	4,670	5,400	460	2,360	3,400	40	940	110	230	2,650	**20,280**
9-15	14,430	19,980	5,640	7,870	4,920	1,530	11,690	300	930	3,920	**71,220**
16-23	1,630	1,820	4,290	1,590	1,220	880	820	170	80	3,300	**15,800**
24	6,280	270	6,480	13,880	3,390	14,820	1,530	3,510	450	330	**50,950**
Don't know	7910	2090	10770	15470	4610	15700	2350	3680	530	3630	**66,750**
Total	**27,340**	**27,660**	**16,970**	**25,710**	**13,090**	**17,380**	**15,020**	**4,230**	**1,820**	**11,790**	**161,060**
Unweighted base	*1,033*	*637*	*272*	*475*	*398*	*166*	*165*	*129*	*64*	*351*	*3,690*

Source: Energy use model results, England and Wales

[65] CAL - Community, arts & leisure
[66] 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)?".
[67] This was defined as the total number of hours that the premises were at least partially occupied by staff (when at least 20 per cent of the maximum number of staff - on a typical working day- were present).

Appendix C: Additional sector characteristics analysis

Table C.1 shows sector characteristics based on the number of premises. This differs from Table 2.3, which showed the distribution of stock chartacteristics based on the share of floor area. By considering the characteristics based on premises count, it provides greater insight on the typical profile of a premises, regardless of size, in a given sector.

Table C.1: Range of building and premises characteristics by sector percentage of premises count, 2014–15

Column percentages

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	CAL[68] (%)	**All sectors (%)**
Organisation size											
Micro (0-9)	74	48	52	69	50	0	3	0	0	16	**55**
Small (10-49)	10	29	24	18	21	0	12	14	0	4	**17**
Medium (50-249)	3	11	5	3	4	0	5	12	0	1	**5**
Large (250+)	11	11	17	8	24	7	60	73	100	2	**15**
Don't know	2	2	2	1	1	0	0	1	0	1	**1**
Not Asked	0	0	0	0	0	93	20	0	0	76	**6**

[68] CAL – Community, arts & leisure

Table C.1 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	CAL[69] (%)	**All sectors (%)**
Total floor area (m^2)											
Less than 50	21	26	8	6	5	7	0	0	0	0	**15**
50-99	40	29	9	18	12	11	2	15	4	0	**24**
100-249	28	27	24	31	26	35	6	11	13	24	**27**
250-499	5	9	44	24	21	18	18	12	6	37	**16**
500-999	3	5	13	11	19	16	15	15	14	23	**9**
1,000-4,999	2	4	1	7	14	9	47	46	50	14	**8**
5,000-9,999	0	1	1	1	1	1	8	2	11	1	**1**
10,000 or more	0	0	0	2	2	1	4	0	2	1	**1**
Don’t know	-	-	-	-	-	-	-	-	-	-	**-**
Tenure											
Owned	31	37	36	35	34	61	82	90	96	86	**40**
Leased	68	63	64	65	66	39	18	10	4	14	**60**
Don’t know	0	0	0	0	0	0	0	0	0	0	**0**
Not asked	1	1	0	0	0	0	0	0	1	0	**1**

[69] CAL – Community, arts & leisure

Table C.1 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	CAL[70] (%)	**All sectors (%)**
Energy management ambition[71]											
Active	31	27	55	25	41	24	44	84	66	42	**33**
Passive	57	61	42	66	45	60	48	16	34	52	**56**
None	12	12	3	9	13	16	8	0	0	7	**10**
Do not know	1	0	0	0	0	0	0	0	0	0	**0**
Not asked	-	-	-	-	-	-	-	-	-	-	**-**

[70] CAL – Community, arts & leisure

[71] '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 C.1 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	CAL[72] (%)	**All sectors (%)**
Age of building											
Pre-1900	35	31	67	4	10	12	22	3	0	47	**27**
1900-1939	23	15	10	7	8	13	11	2	21	15	**15**
1940-1985	20	16	6	46	33	28	30	59	41	25	**25**
1986-1990	2	5	2	13	12	10	4	16	7	2	**6**
1991-2006	3	16	4	12	21	27	21	14	25	4	**11**
2007 or later	1	6	2	2	3	5	7	5	4	2	**3**
Don't know	16	12	8	17	13	5	4	1	1	5	**13**
Not asked	0	0	0	0	0	0	0	0	0	0	**0**
Premises relation to building											
Whole building	40	42	75	74	76	68	69	88	69	92	**57**
Part of building	60	57	25	19	19	29	2	2	1	7	**39**
Multiple buildings	1	1	0	7	5	3	29	10	31	0	**4**
Not asked	-	-	-	-	-	-	-	-	-	-	**-**

[72] CAL – Community, arts & leisure

Table C.1 continued

	Non-domestic stock sector										
	Retail (%)	Offices (%)	Hospitality (%)	Industrial (%)	Storage (%)	Health (%)	Education (%)	Emergency Services (%)	Military (%)	CAL[73] (%)	**All sectors (%)**
Peak operating hours[74]											
8 or less	58	66	23	42	40	34	71	40	22	59	**52**
9-15	40	33	61	54	53	60	26	14	57	25	**43**
16-23	1	0	5	2	1	1	1	10	6	2	**1**
24	0	0	11	2	1	6	1	24	0	0	**1**
Don't know	1	1	0	0	5	0	1	12	16	13	**2**
Opening hours[75]											
8 or less	42	34	10	27	18	9	13	13	13	38	**31**
9-15	50	63	55	63	70	81	69	15	48	36	**58**
16-23	7	2	20	7	3	2	2	4	1	11	**6**
24	0	0	14	3	5	7	14	56	22	3	**3**
Don't know	1	1	0	0	5	0	1	12	16	13	**2**
Unweighted base	*1,033*	*637*	*272*	*475*	*398*	*166*	*165*	*129*	*64*	*351*	***3,960***

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

[73] CAL – Community, arts & leisure
[74] Respondents in most sub-sectors 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)?". See sector reports for not standard uses of this question.
[75] This was defined as the total number of hours that the premises were at least partially occupied by staff (when at least 20 per cent of the maximum number of staff - on a typical working day - were present).

Appendix D: Full list of sub-sectors and definitions

A full list of sub-sector definitions[76] is included below:

Table D. 1 List of sub-sector definitions

Sector	Sub-sector	Definition
Education	Nurseries	Refers to premises used for educational programmes or daytime supervision/recreation for young children before they attend primary school. Gross internal floor area should include all space within the premises, including classrooms, administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoriums, stairways, lift shafts, and storage areas.
	Primary schools	Refers to premises used for the education of children up to Year 6 (ages 10 and 11) prior to secondary prior to secondary school. Gross internal floor area should include all space within the premises, including classrooms, administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoriums, laboratory classrooms, portable classrooms, greenhouses, stairways, atriums, lift shafts, small landscaping sheds, and storage areas.
	Secondary schools	Refers to premises used for providing children with part or all of their secondary education, typically between the ages of 11-18 Gross internal floor area should include all space within the premises, including classrooms, administrative space, conference rooms, kitchens used by staff, lobbies, cafeterias, gymnasiums, auditoriums, laboratory classrooms, portable classrooms, greenhouses, stairways, atriums, lift shafts, small landscaping sheds, and storage

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

Sector	Sub-sector	Definition
		areas.[77] State and Private colleges (6th form and other forms of Further Education) have been included within this sub-sector.[78]
	Higher education teaching and research	Refers to premises used for the purposes of higher education. This includes public and private colleges and universities, but excludes residential buildings. Gross internal floor area should include all space within the premises, including classrooms, laboratories, offices, cafeterias, maintenance facilities, arts facilities, athletic facilities, storage rooms, toilets, lift shafts, and stairways.
	Higher education residential	Refers to premises used for the provision of accommodation for students studying for higher education.
Military	Offices	Office provision both cellular and open plan depending on function.
	Storage	Storage and warehousing for non-specialist materials, hazardous materials, explosive materials, Military vehicle garages, bulk vehicle storage and railway & locomotive sheds.
	Accommodation	Single Living Accommodation (SLA) generally consisting of blocks of single occupancy bedrooms with en suite provision (shower, basin and WC) and communal facilities (utility, drying, snack and common rooms). Home to servicemen and women during their training or posting to a unit.
Health	Health centres	Refers to health care facilities that provide same-day healthcare appointments and surgical care including diagnostic and preventive procedures. This may include doctor and dentist's surgeries and outpatient rehabilitation/physical therapy offices.

77 In order to qualify for the telephone survey premises needed to include teaching space. Residential areas were excluded from analysis. A building within the premises of a school which was dedicated to accommodation would be screened out in the telephone survey.
78 Sampling was based on DEC categories - secondary schools with integrated 6th form facilities would in most cases be part of'secondary schools', while 6th form colleges in independent premises would be categorised as 'higher education'.

Sector	Sub-sector	Definition
	Hospitals	Refers to public sector, general medical and surgical hospitals (including critical access hospitals, children's hospitals and community or long stay hospitals), along with buildings used for the provision of private medical and surgical treatment. These facilities provide both acute and routine care services intended to treat patients for short periods of time, including emergency medical care, physician's office services, diagnostic care, ambulatory care, surgical care, and limited specialty services such as rehabilitation and cancer care.
	Nursing homes	Refers to premises that house and provide residential accommodation, health care and assistance, in particular for the elderly and those with chronic illness or disability. Gross Floor Area should include all space within the building(s) including individual rooms or units, wellness centres, exam rooms, community rooms, small shops or service areas for residents and visitors (e.g. hair salons, convenience stores), staff offices, lobbies, atriums, cafeterias, kitchens, storage areas, hallways, basements, stairways, corridors between buildings, and lift shafts.
Emergency services	Fire/ambulance stations	'Fire station' refers to premises used to provide emergency response services associated with fires. Fire stations may be staffed by either volunteer or full-time paid fire-officers. Gross Floor Area should include all space within the building(s), including office areas, vehicle storage areas, residential areas (if applicable), storage areas, break rooms, kitchens, lifts shafts, and stairwells. 'Ambulance station' refers to premises used to provide emergency response services associated with medical emergencies. Space within these stations will be allocated for the storage of ambulance vehicles, medical equipment, personal protective equipment, and other medical supplies. Gross Floor Area should include all space within the building(s), including office areas, vehicle storage areas, residential areas (if applicable), storage areas, break rooms, kitchens, lift shafts, and stairwells.
	Law courts	Refers to premises used for police forces and their associated office space. Gross Floor Area should include all space within the building(s), including offices, temporary

Sector	Sub-sector	Definition
		holding cells, kitchens used by staff, lobbies, atriums, conference rooms and auditoriums, fitness areas for staff, storage areas, stairways, and lift shafts.
	Police stations	Refers to premises used for national, county, or local courts, and associated administrative office space. Gross Floor Area should include all space within the building(s), including temporary holding cells, court rooms, kitchens used by staff, lobbies, atriums, conference rooms and auditoriums, fitness areas for staff, storage areas, stairways, and lift shafts.
	Prisons	Refers to premises used for the detention of persons awaiting trial or convicted of crimes. Gross Floor Area should include all space within the building(s), including holding cells, cafeterias, administrative spaces, educational and work areas (e.g. workshops), kitchens, lobbies, atriums, conference rooms and auditoriums, fitness areas, storage areas, stairways, and lift shafts. Our modelling covers accommodation blocks – cells, common areas and washing facilities. Allowances for workshops, educational facilities and libraries are included where these are present. Catering and laundry located within the accommodation block identified are also included. In some cases telephone survey respondents have responded for a whole prison or large proportion of the total, where it was not possible to select an individual building. In these cases features are likely to be present in the actual building which the model has not accounted for.
Hospitality	Cafes	Refers to premises used for the preparation and sale of food and beverages; often with a focus on the provision of hot drinks and/or breakfasts and light meals. Gross Floor Area should include all space within the premises, including kitchens, sales areas, dining areas, staff break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported.

Sector	Sub-sector	Definition
	Hotels	Refers to premises used for renting overnight accommodation on a room/suite and nightly basis, and typically include a bath/shower and other facilities in guest rooms. Hotels typically have daily services available to guests including housekeeping/laundry and a front desk/concierge; food and drink services may be for non-guests too. Hotels should be majority-owned by a single entity and have rooms available on a nightly basis. Gross Floor Area should include all interior space within the premises, including guestrooms, halls, lobbies, atriums, food preparation and restaurant space, conference and banquet space, fitness centres/spas, indoor pool areas, laundry facilities, lift shafts, stairways, mechanical rooms, storage areas, employee break rooms, and back-of-house offices.
	Public houses (pubs)	Refers to premises with a bar and one or more public room licensed for the sale and consumption of alcoholic drink. Gross Floor Area should include all internal spaces including public bars, corridors, toilets, offices, kitchens and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting.
	Restaurants & Takeaway food outlets (restaurants & takeaways)	Restaurants refers to premises used for preparation and sale of ready-to-eat food and beverages, with a focus on the provision of sit-down meals. Examples of restaurants include fast casual, casual, and fine dining restaurants. Gross Floor Area should include all space within the premises, including kitchens, sales areas, dining areas, offices, staff break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting. The restaurant sub-sector includes premises which offer both a dining area and a take-away service. Takeaways refers to premises used for the preparation and sale of ready-to-eat food. Takeaways are characterised by a limited menu of food prepared quickly (often within a few minutes), and sometimes cooked in bulk in advance and kept hot. Gross Floor Area should include all space within the premises, including kitchens, sales areas, offices, staff

Sector	Sub-sector	Definition
		break rooms, and storage areas. Gross Floor Area should not include any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported, such as through external lighting. Takeaways which also have dining areas are treated as restaurants. Restaurants & takeaways were originally separate sub-sectors but were combined to provide a robust sample size and in recognition that there was high variability in the share of food sold for consumption offsite in premises classed as restaurants.
Offices	Public sector offices	Refers to premises in which business, clerical, or professional activities are undertaken on behalf of central and local government services. It excludes office space in other public sector premises, such as defence, education, health and emergency services. It includes parts of predominantly office premises which have minor parts used for non-office activities e.g. an office building with retail premises on the ground floor.
	Private sector offices	Refers to premises in which business, clerical, or professional activities are conducted on behalf of non-government services. It includes parts of predominantly office premises which have minor parts used for non-office activities e.g. an office premises with retail premises on the ground floor.
Retail	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

Sector	Sub-sector	Definition
		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 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[79]. '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

79 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.

Sector	Sub-sector	Definition
		originally separate sub-sectors but were combined to provide a robust sample size.
	Small shops	Refers to small premises used 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) or betting shops. '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.
Storage	Large distribution warehouses	A warehouse of sufficient clear height and floor loading to accommodate racking systems designed to facilitate "just in time" and other goods distribution. The premises will be situated close to the motorway network (or occasionally to a mainline rail inter-connection) and will have excellent provision for loading and unloading goods with sufficient space for the easy movement of large articulated vehicles within the site and for trailer and container parking. Large distribution warehouses will usually have a floor area of greater than 5,000m^2.
	Warehouses	Refers to unrefrigerated premises that are used for the temporary storage and redistribution of goods, manufactured products, merchandise or raw materials prior to their distribution for sale. Gross Floor Area should include all space within the premises including space designed to store non-perishable goods and merchandise, offices, lobbies, stairways, rest rooms, equipment storage areas, and lift shafts. This should not include exterior/outdoor loading bays or docks.
	Stores	Refers to a premises used for bulk storage of items, which has minimal or transient staff occupancy. As distinct from a warehouse, factory, or distribution centre which have staff operating in the main space on a regular basis.

Sector	Sub-sector	Definition
	Cold stores	Refers to refrigerated premises that are used to store perishable goods or merchandise under refrigeration at temperatures below10 degrees Celsius . Gross Floor Area should include all space within the premises, which includes temperature-controlled areas, administrative offices, lobbies, stairways, restrooms, equipment storage areas, and lift shafts. This should not include exterior/outdoor loading bays or docks.
Industrial	Factories	Factories' refers to buildings used for manufacturing or assembling goods. This may include heavy industry, large scale manufacturing, chemical, food, metals, minerals, brewing and other large scale production & processing activities. Typically a factory includes a main production area that has high-ceilings and contains heavy equipment used for assembly line production. Gross Floor Area should include all space within the building(s) at the plant, including production areas, offices, conference rooms, employee break rooms, storage areas, mechanical rooms, stairways, and lift shafts.
	Workshops	Refers to smaller premises used for the manufacture or repair of goods and equipment. Gross Floor Area should include all internal spaces including workshop area, offices, toilets, corridors, stairways, lift shafts and common areas.
Community, arts & leisure	Leisure centres	Refers to public and private sector premises used for sporting, exercise and/or leisure activities. Facilities may include swimming pools, large sports hall, squash courts, fitness suite, aerobics studios, outdoor grass and/or artificial pitches for football, hockey etc., a solarium, sauna and/or steam room.
	Clubs & Community centres	'Clubs' refers to premises used for the meetings and activities of associations dedicated to a particular interest or activity, e.g. political clubs, social clubs etc. 'Community centres' refers to premises primarily used for public or private gatherings. This may include community group meetings, seminars, workshops, or performances. Gross Floor Area should include all space within the building(s), including meeting rooms, auditoriums, food service areas, lobbies, administrative/office space,

Sector	Sub-sector	Definition
		mechanical rooms[80], storage areas, lift shafts, and stairwells.
	Museums, Art galleries and Libraries (referred to as 'Museums')	'Museums' refers to premises that display collections to outside visitors for public viewing. Gross Floor Area should include all space within the building(s), including public collection display areas, meeting rooms, classrooms, gift shops, food service areas, administrative/office space, mechanical rooms, storage areas for collections, lift shafts, and stairwells. 'Art galleries' refers to premises in which works of art are exhibited such as paintings, sculpture and other installations. Gross Floor Area should include all space within the building(s), including public collection display areas, meeting rooms, classrooms, gift shops, food service areas, administrative/office space, mechanical rooms, storage areas for collections, lift shafts, and stairwells. 'Libraries' refers to premises used to store and manage collections of literary and artistic materials such as books, periodicals, newspapers, films, etc. that can be used for reference or lending. Gross Floor Area should include all space within the building(s), including circulation rooms, storage areas, reading/study rooms, administrative space, kitchens used by staff, lobbies, conference rooms and auditoriums, fitness areas for staff, storage areas, stairways, and lift shafts.
	Theatres, Cinemas and Concert halls (referred to as 'Theatres')	'Theatres' refers to premises in which plays and other dramatic performances are given. Gross Floor Area should include all space within the building(s), including seating areas, lobbies, concession stands, bathrooms, changing rooms, administrative/office space, mechanical rooms, storage areas, lift shafts, and stairwells. 'Cinemas' refers to premises used for public or private film screenings. Gross Floor Area should include all space within the building(s), including seating areas, lobbies, concession stands, bathrooms, administrative/office space, mechanical

80 Refers to rooms dedicated to mechanical and electrical equipment.

Sector	Sub-sector	Definition
		rooms, storage areas, lift shafts, and stairwells. ‘Concert halls’ refers to public premises designed for the performance of concerts. Gross Floor Area should include all space within the building(s), including seating areas, lobbies, concession stands, bathrooms, changing rooms, administrative/office space, mechanical rooms, storage areas, lift shafts, and stairwells.
	Places of worship	Refers to premises that are used for religious worship. This includes churches, temples, mosques, synagogues, meeting houses, or any other buildings that primarily function as a place of religious worship. Gross Floor Area should include all areas inside the building that includes the primary worship area, including food preparation, community rooms, classrooms, and supporting areas such as toilets, storage areas, hallways, and lift shafts.
	Leisure centres	Refers to public and private sector premises used for sporting, exercise and/or leisure activities. Facilities may include swimming pools, large sports hall, squash courts, fitness suite, aerobics studios, outdoor grass and/or artificial pitches for football, hockey etc., a solarium, sauna and/or steam room.

Appendix E: Barrier categories

The categories below are based on the following paper: Cagno, E., Worrell, E., Trianni, A. and Pugliese, G., (2013). A novel approach for barriers to industrial energy efficiency, *Renewable and Sustainable Energy Reviews*, pp. 290 – 308.

Table E.1: Barrier typology

Barrier area	Barrier	Description
Technology-related barriers	Technologies not adequate	The technical characteristics of energy-efficient technologies might be very particular, resulting hardly to be adopted in some cases, irrespectively of their costs
	Technologies not available	Current technologies are not available which provide the required solution
Information barriers	Lack of information on costs and benefits	There is a lack of information on the costs and benefits of technologies
	Unclear information by technology suppliers	Energy-efficient technologies might be ignored if suppliers are not able to communicate their effective performance.
	Trustworthiness of the information source	There may be a lack of trust in the robustness of the product performance
	Information issues on energy contracts	Different options in energy contracts can be presented in a form that might be unclear and not-vivid, thus resulting to be unattractive for the customers
Economic	Low capital availability	Even with a great awareness on the benefits of energy-efficient technologies, and considerable commitment of management and personnel to energy, the firm does not have sufficient own capital to invest in energy-efficient technologies
	Investment cost	The type of investment cost affects the ability of the organisation to proceed

Barrier area	Barrier	Description
	Hidden costs	Costs might differ significantly from the estimate in investment analyses, all the transaction costs to obtain information on energy-efficient technologies and related personnel training fall within this category
	Intervention-related risks	Some uncertainties and risks occur when implementing the energy efficiency interventions
	External risks	Implementation of the investment, the introduction of new technologies may require the interruption, at least partially, of normal operations, thus incurring in to disruption costs
	Interventions not sufficiently profitable	Some enterprises often rationally discard investments with a rate of return lower than their internal rate of return. This can be particularly critical especially for energy-efficient technologies requiring a significant change
Behavioural	Lack of interest in energy-efficiency interventions	Includes several elements, each of those contributing to the perception that energy issues are not sufficiently interesting: Energy costs do not have sufficient weight with respect to the firm's production costs; The firm perceives itself as already efficient
	Other priorities	Where decision-makers might be focused almost uniquely on few core business activities. Therefore, they tend to exclusively evaluate the interventions with considerable impact on the main production system activities, thus disregarding energy efficiency
	Inertia	This barrier represents the resistance to change and risk, and the more radical the change, the higher the barrier will be. It can result in preferring interventions with quick and low investments and returns
	Imperfect evaluation criteria	The decision-makers might lack the proper knowledge or criteria to evaluate investments. In particular the decision-maker might adopt approximate criteria or routines that do not allow him/her to thoroughly evaluate the effective performance of the interventions. In other cases the decision-maker might adopt criteria for the evaluation (as pay-back period, or rate of return of the investment) without any relationship with the uncertainty associated to the considered alternatives.
	Lack of sharing	Some misalignments between the behaviour of

Barrier area	Barrier	Description
	the objectives	personnel and energy management objectives might occur, resulting in a low implementation of energy management practices
Organisational	Low status of energy efficiency	The functions devoted to energy management do not have sufficient power to act effectively to improve energy efficiency
	Divergent interests	The decision-maker might not gain the benefits from improving energy efficiency
	Complex decision chain	If the decision-making process involves several functions, the information flow might not be straight and smooth.
	Lack of time	The decision maker does not have enough time to consider energy efficiency opportunities
	Lack of internal control	Without adequate control systems established by the management, the personnel within firms might not implement energy efficiency practices
Barriers related to competences	Identifying the inefficiencies	Even with awareness of the energy issues, and consciousness of the benefits of energy-efficient technologies, specific competences on methods and tools to identify energy waste are lacking
	Identifying the opportunities	The difficulty to identify the opportunities to improve energy efficiency
	Implementing the interventions	The difficulty to implement practices and interventions for energy efficiency, without the support of external consultants or personnel
	Difficulty in gathering external competences	A lack of expertise in the market to allow the implementation of a given measure
Awareness	Lack of awareness or ignorance	Lack of awareness or ignorance of decision-makers, in which they simply ignore or are unaware of the possible benefits coming from the implementation of energy efficiency opportunities.

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