Department for Business, Energy & Industrial Strategy

Building Energy Efficiency Survey: Emergency services sector, 2014–15

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Contents

Notes on statistical conventions

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

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

Executive summary

Introduction

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

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

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

Overview of project method

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

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

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

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

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

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

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

The overall project method had weaknesses in two key areas:

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

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

Emergency services sector overview

The emergency services sector consisted of fire/ambulance stations, police stations, law courts and prisons; for the purpose of this study, it did not include emergency services premises that were present in other building types. The emergency services sector had a total floor area of 14 million m^2 (2 per cent of the total non-domestic stock) across 5,100 premises (0.3 per cent of the total non-domestic stock). The emergency services sector's total energy consumption was 4,230 GWh. The sector's electrical energy consumption was 1,260 GWh (1 per cent of the total non-domestic stock) and non-electrical consumption was 2,970 GWh (4 per cent of total non-domestic stock).

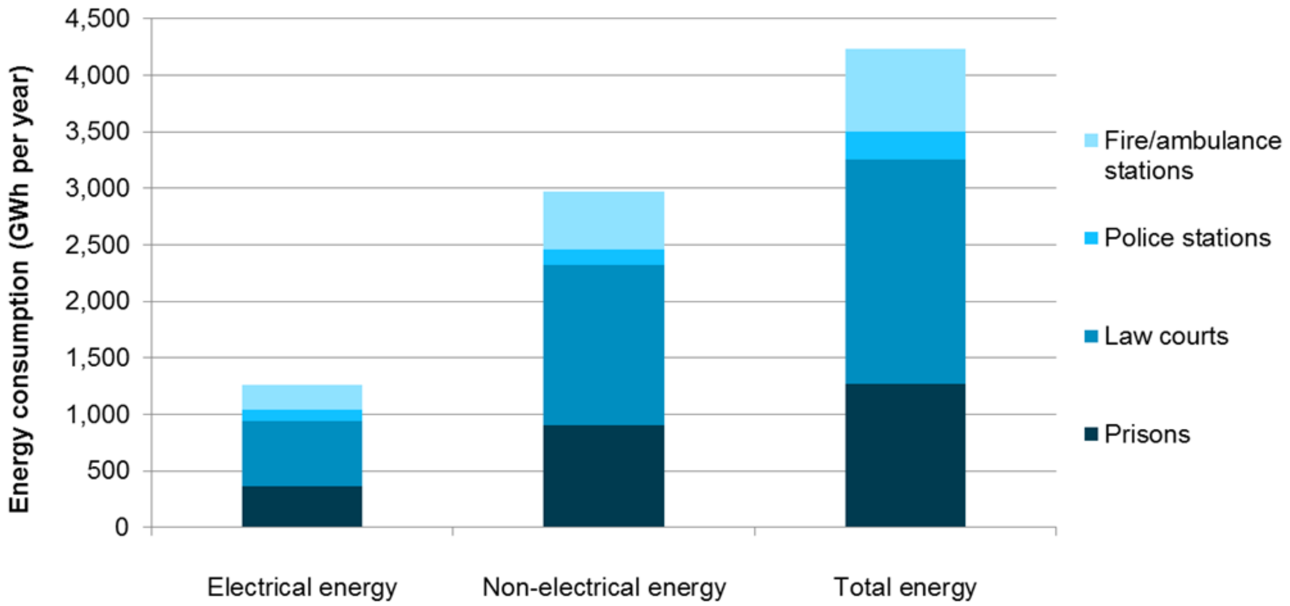
The findings in this report are based on data collected through 129 telephone surveys used in the energy use and abatement models and 14 site surveys surveys in 2014–15.

Key findings

Energy consumption in the emergency services sector, 2014–15

- According to modelled data based on telephone survey responses, the sector consumed 4,230 GWh of energy. This included 1,260 GWh of electrical energy and 2,970 GWh of non-electrical energy per year (Figure 0.1).
- The largest energy consumer in this sector was police stations, with 1,990 GWh total energy consumption (47 per cent of sector total). Prisons were the second largest consumer, with 1,280 GWh of total energy consumption (30 per cent of sector total).
- The difference in absolute consumption between the sub-sectors matched to some extent with their overall size. Police stations represented the largest sub-sector in terms of energy consumption, while also representing 44 per cent of the sector's overall floor area.
- Police stations typically displayed the highest median overall energy intensity (345 kWh/m^2), followed by prisons (316 kWh/m^2).
- Police stations typically displayed the highest median electrical energy intensity (128 kWh/m^2 for electrical energy). The second most energy intensive sub-sector in terms of electrical energy was prisons (91 kWh/m^2). Whilst the sub-sectors were similar in terms of non-electrical energy intensity, Prisons and firme/ambulance stations displayed the highest median intensity of 216 kWh/m^2 for both followed by police stations (209 kWh/m^2).
- The energy consumption of the emergency services sector was broken down into specific 'end uses'. The most significant end use was space heating (2,690 GWh, 64 per cent of total energy consumption), followed by internal lighting (440 GWh, 10 per cent of total energy consumption).

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



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

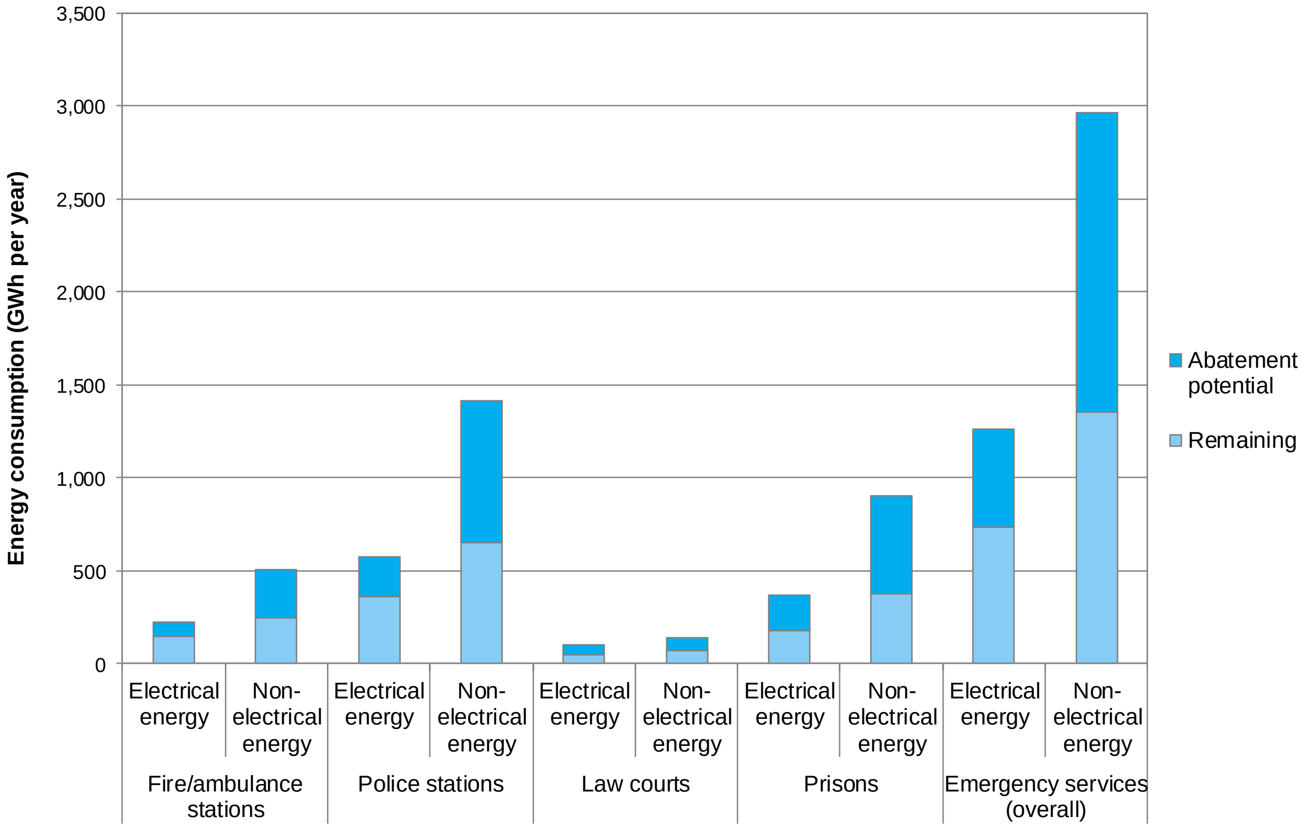
Abatement potential in the emergency services sector, 2014–15

- According to modelled data based on telephone survey responses, Figure 0.2 shows abatement potential for the sector, broken down by sub-sector and fuel type. This represents the total abatement potential that is technically available, which relates to the possible reductions in energy consumption following implementation of all applicable measures. The results include measures that are not cost-effective and the model applies a simple assessment of measure suitability. Building specific installation requirements that may impose additional costs are not accounted for.
- The total abatement potential in the emergency services sector was 2,140 GWh of total energy. This includes 530 GWh of electrical energy (a 42 per cent reduction on consumption) and 1,610 GWh of non-electrical energy (a 54 per cent reduction on consumption).
- This could be achieved at a capital cost of £613 million. The socially cost effective potential was 1,190 GWh of total energy consumption: 380 GWh of electrical energy consumption and 810 GWh of non-electrical energy consumption. Public sector organsations are more likely to be influenced by the payback period for improvement: : overall there were 630 GWh of total energy savings with a private payback period[4] of 3 years or less (350 GWh of electrical energy savings and 280 GWh of non-electrical energy savings).

[4] Payback is calculated by dividing the capital installation cost associated with a measure by the annual financial savings achieved based on energy cost reductions accounting for any annual operational costs.

- The sub-sector with the largest absolute abatement potential was police stations, with 220 GWh of electrical energy (38 per cent reduction on consumption) and 760 GWh of non-electrical energy (54 per cent reduction on consumption).

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



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

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

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

Measure type	Savings					Total capital cost of measure (£ thousands)
	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	
Air conditioning and cooling	1,200		10	-	10	15,800
Building fabric	8,900	60	7	320	330	167,500
Building instrumentation and control	13,800	90	30	440	460	57,200
Building services distribution systems	1,100		10	-	10	22,100
Carbon and energy management	15,800	80	90	280	370	15,700
Hot water	2,700	20	3	90	100	13,500
Humidification	-	-	-	-	-	-
Lighting	26,500	80	270	-	270	82,500
Cooled storage	100	0	1	-	1	300
Small appliances	3,100	10	30	3	30	59,500
Space heating	13,200	90	10	480	490	95,100
Swimming pools	-	-	-	-	-	-
Ventilation	7,000	20	70	-	70	84,000
Total	**93,400**	**450**	**530**	**1,610**	**2,140**	**613,200**

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

1. Emergency services sector

This report relates to the emergency services sector (one of 10 sectors covered in the Building Energy Efficiency Survey (BEES)). The sector also covers wider justice sectors. This section provides definitions for the four sub-sectors (fire/ambulance stations, police stations, law courts and prisons). It then sets the emergency services sector in the wider non domestic stock context in terms of both the number of premises and floor area it represents. Police stations and prisons are based on fewer than 20 surveys so it should be noted that results for these sub-sectors are subject to higher uncertainty.

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

Table 1.1: Table of emergency services sub-sector definitions[5]

Sub-sector	Definition
Fire stations and ambulance stations (referred to as '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.
Police stations	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 holding cells, kitchens used by staff, lobbies, atriums, conference rooms and auditoriums, fitness areas for staff, storage areas, stairways, and lift shafts.
Law courts	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.

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

Sub-sector	Definition
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.

Emergency services sector in the context of the wider non-domestic stock

The emergency services sector accounts for 0.3 per cent of the non-domestic stock in terms of premises count (5,100) and 2 per cent in terms of floor area (14 million m^2 GIA[6]).[7]

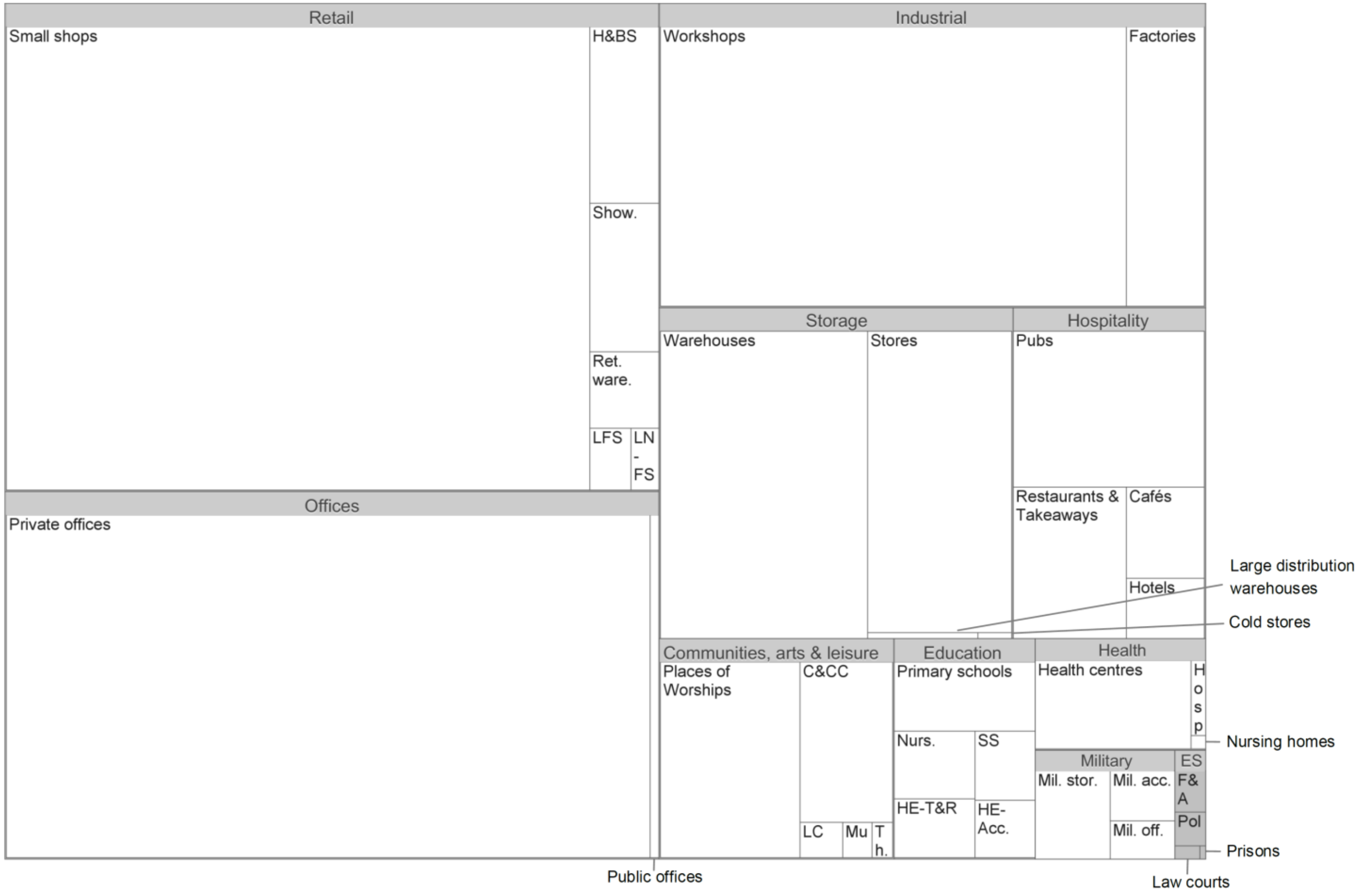
In terms of energy consumption the sector consumed 4,230 GWh total energy per year. This comprised 1,260 GWh of electrical energy and 2,970 GWh of non-electrical energy per year, which is equivalent to 1 per cent and 4 per cent of non-domestic stock totals respectively. This information is set out in Figure 1.1 to Figure 1.3.

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

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

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

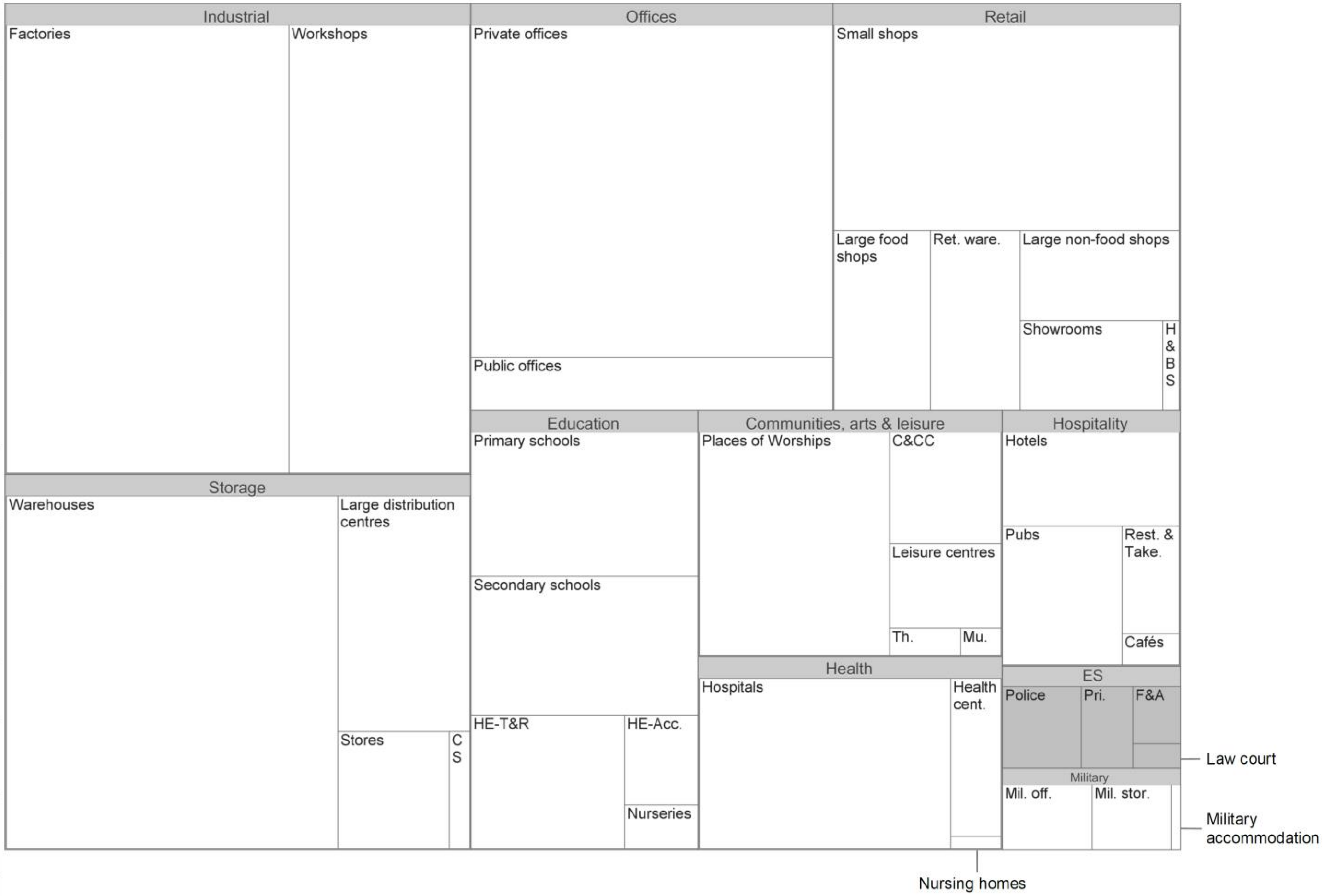
ID	Sub-sector
H&BS	Hairdressing & beauty salons
Show.	Showrooms
Ret. ware.	Retail warehouses
LFS	Large food shops
LN-FS	Large non-food shops
C&CC	Clubs & community centres
LC	Leisure centres
Mu.	Museums, Art galleries and Libraries
Th.	Theatres, cinemas and concert halls
Nurs.	Nurseries
SS	Secondary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



Source: Population table

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

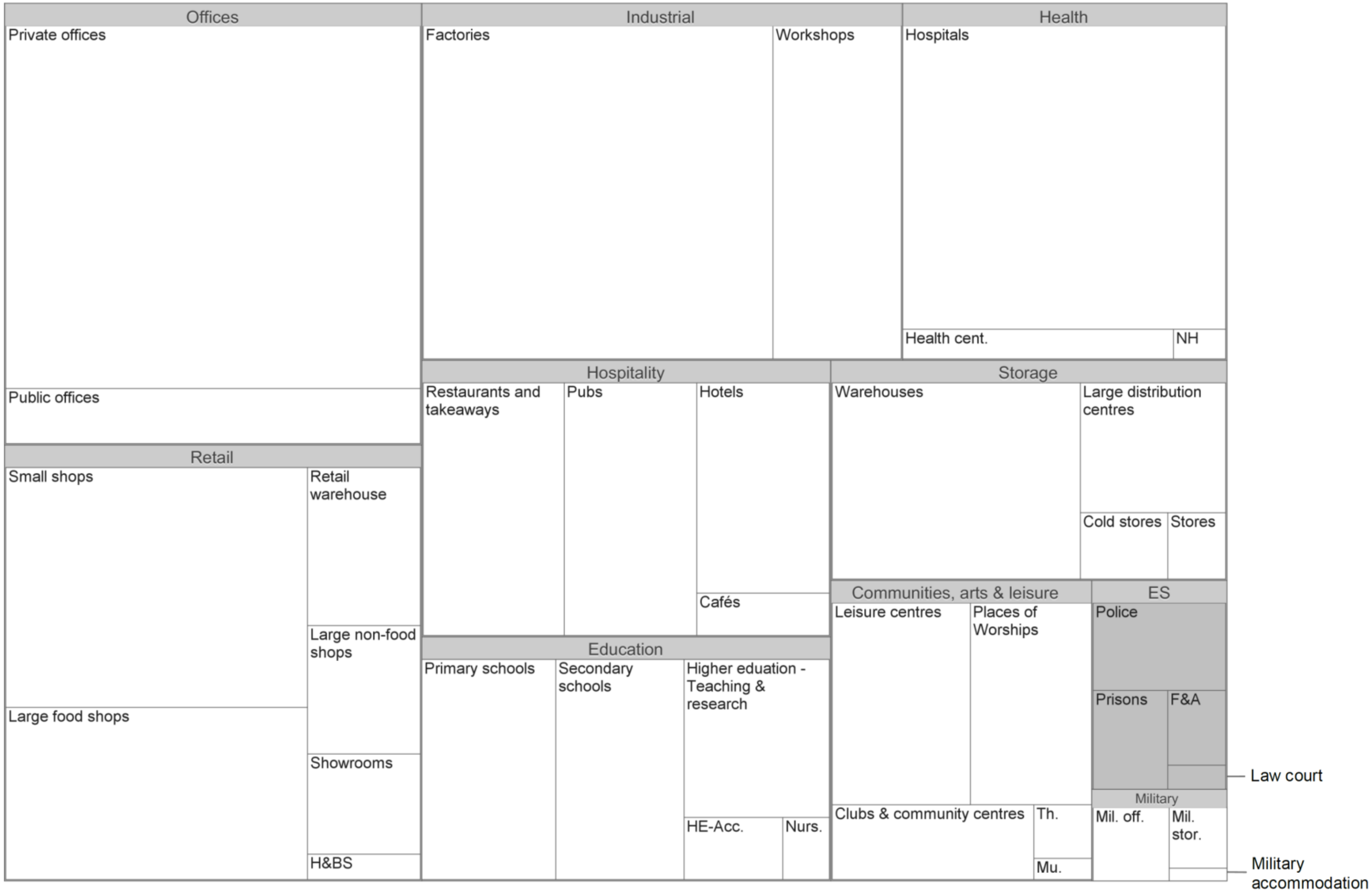
ID	Sub-sector
Ret. ware.	Retail warehouse
H&BS	Hairdressing & beauty salons
CS	Cold stores
HE-T&R	HE—Teaching and research
HE-Acc.	HE — Accommodation
C&CC	Clubs & community centres
LC	Leisure centres
Th.	Theatres, cinemas and concert halls
Mu.	Museums, Art galleries and Libraries
Health cent.	Health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



Source: Population table

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

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



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

General characteristics of the emergency services sector

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

Emergency services premises varied significantly in size and complexity from small ambulance stations that comprised a garage space, small office/staff room with a basic heating system, to very large prisons with a full range of facilities including cell blocks, catering facilities, education facilities, sporting facilities and other areas.

Court premises tended to operate similar hours and activity profiles to offices[8]; occupancy was predominantly office hours Monday to Friday, with courtrooms and office space taking up much of the floor area. These premises were often large, with mechanical ventilation and comfort cooling common. Common areas were very common in criminal courts; holding cells were also present in some criminal courts but made up only a small part of the floor space.

Prisons were a complex sub-sector because the typical prison site included all the facilities required for an inmate's day to day life, such as catering and basic recreational facilities as well as secure accomodation. The BEES study focussed on cell blocks and therefore targeted premises where cell blocks were the main activity. This activity was chosen because cell-blocks were the dominant activities, on floor area basis, within the prison sector overall. In some cases, an entire prison was a single building encompassing all activities while in others the prison was a wider site incorporating many separate buildings each with a specific purpose. The telephone survey was designed to capture data in both scenarios, but the emphasis of the energy related data collection was on the characteristics of the accommodation activities. As a result of their multi-purpose nature it was common, within a prison premises, to have some areas which required mechanical ventilation and cooling whilst other areas were only provided with heating and natural ventilation.

Police, fire and ambulance stations shared common features. Some buildings with 24-hour operation were found in all cases; all buildings tended to include staff rest facilities, large amounts of office space, and training facilities for staff. Police stations, for example, tended to have extensive office and storage space and staff changing facilities. Where a 24-hour custody suite was present, the cells were included in the police station.

Fire and ambulance stations tended to have large amounts of garaging space for vehicles; this was the dominant activity area in ambulance stations. Despite 24- hour operation, ambulance stations rarely included sleeping accommodation for staff whereas it was common in fire stations (such accommodation was supported by staff rest areas and cooking facilities).

Headquarters premises were also encountered in police, fire and ambulance stations. These tended to be dominated by office and training activities; and could also include the 24- hour telephone control centre for the region. These were very large premises and were quite different to the 'typical' police, fire or ambulance station. It should also be noted that it was increasingly common for control centre facilities to be shared between across the police, fire and ambulance services. In BEES reporting, headquarters are fully attributed to the main sub-sector operating from a premises.

Within the emergency services sector, energy-intensive equipment and activities included server rooms, laundry facilities, catering facilities, 24-hour call centres, compressed air systems and specialist training equipment.

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[8] Please refer to the 'Building Energy Efficiency Survey: Office sector report, 2014–15' for further information on the Office sector.

Summary statistics for the emergency services sector

A number of standard characteristics for the emergency services sector are set out in Table 1.3, Figure 1.4 and Figure 1.5; from premises and organisation size through to operating hours and premises tenure. These key characteristics for the emergency services sector and how these vary across the emergency services sub-sectors themselves are described.

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

Based on the floor area weighted records, premises in the emergency services sector had some clear similarities, and some clear differences:

- In all sub-sectors most premises were whole building owner occupied with most a floor area of more than 1,000 m^2. In most cases the premises occupants were also part of large organisations (250+ employees);
- Prisons typically considered energy management as a substantially lower priority than in other sub-sectors, which tended to be 'actively seeking new ways to reduce energy use';
- Opening hours, peak operating hours and the age of buildings varied considerably across the sub-sectors.

The prison sub-sector organisation sizes were tailored to improve their relevance to the sub-sector. These were defined as displayed in Table 1.2. All prisons surveyed were classed as large based on the number of prisoners.

Table 1.2: Organisation size tailoring by sub-sector

Sub-sector	**Prison**
Organisation size	Number of prisoners
Micro	1-9
Small	10-49
Medium	50-249
Large	250 or more

For all sub-sectors (except prisons), organisation size allocations were based on the response to the following question: "How many people are employed by your organisation as a whole?". Police stations were occupied solely by large organisations (those employing 250+ employees). The most common size for the law courts and fire/ambulance stations was also large organisations (250+ employees); however, both sub-sectors included a small number of premises which were part of smaller organisations.

Prisons typically occupied floor areas of greater than 1,000 m^2. Police stations and fire/ambulance stations also mostly occupied premises with a floor area of greater than 1,000 m^2, although some smaller premises between 500 m^2 and 999 m^2 were found. The limited presence of smaller premises i.e. those below 1,000 m^2 could be due to sampling biases, as is described in more detail in the method challenges section later in this report.

With regards to tenure, the majority of emergency services premises were owner occupied; the highest occurrence of owner occupied premises was for the police stations, with 99 per cent of premises being owner occupied. In comparison, for fire/ambulance stations prisons, and law courts owner occupancy rates were slightly lower at 90 per cent, 88 per cent and 85 per cent respectively.

In terms energy management ambition, the police stations, law courts, and fire/ambulance stations premises were more proactive on energy management, with between 83 and 97 per cent ‘actively seeking new ways to reduce energy use’. For prisons, energy management was a lower priority, with 55 per cent of premises ‘trying to reduce energy use where possible, but it’s not a priority’.

In relation to building age, prison and law courts had a number of premises which were constructed pre 1900’s (35 per cent and 14 per cent respectively). In contrast fire/ambulance stations had a number of much newer premises with 20 per cent of building being constructed after 2007. The remaining sub-sectors occupied buildings across each age banding.

Typically premises across the sub-sectors occupied a whole building (between 89 to 97 per cent of floor area). Prisons differed slightly in this regard. In prisons 88 per cent of premises occupied whole buildings on sites of multiple buildings.

With regards to peak operating hours, there is a clear variation between each of the sub-sectors. For example, 62 per cent of law courts had 8 hours or less of peak operating time. This compared to prisons, with 67 per cent of prisons operating for 9-15 hours, and 33 per cent operating for 24 hours a day. There was a clear split in fire/ambulance stations, with 40 per cent of premises operating at 8 hours or less of peak operating time, and 48 per cent with 24 hours of peak operating time. The peak operating hours of police stations varied considerably.

With regards to opening hours, there was a clear variation among the sub-sectors. Unsurprisingly, 95 per cent of prisons were open for 24 hours per day. 95 per cent of police stations were open for 24 hours per day. The opening hours of fire/ambulance stations premises were split across all of the opening hour brackets (59 per cent of premises having opening hours of 24 hours per day, and 13 per cent having opening hours of 8 hours or less per day). 98 per cent of law courts premises had opening hours of 9-15 hours, presumably to accommodate the set-up and cleaning requirements around the general court hearing times.

Table 1.3: Range of building and premises characteristics by emergency services sub-sector by percentage of floor area, 2014–15

Column percentages

	Emergency services sub-sector				
	Fire/ ambulance stations (%)	Police stations (%)	Law courts (%)	Prisons (%)	**Emergency services sector (%)**
Organisation size					
Micro (0-9)	-	-	-	-	-
Small (10-49)	14	-	23	-	4
Medium (50-249)	29	-	23	-	7
Large (250+)	57	100	47	100	88
Don't know	-	-	6	-	1
Total floor area (m^2)					
Less than 50	-	-	-	-	-
50-99	-	4	-	-	2
100-249	2	2	-	-	1
250-499	4	6	1	1	4
500-999	8	15	5	-	9
1,000-4,999	80	48	73	37	62
5,000-9,999	5	27	-	24	10
10,000 or more	-	18	-	37	12
Tenure					
Owned	90	99	85	88	93
Leased	10	1	15	12	7
Don't know	-	-	-	-	-
Energy management ambition[9]					
Active	83	97	86	45	78
Passive	17	3	14	55	22
None	-	-	-	-	-
Don't know	-	-	-	-	-
Age of building					
Pre-1900	-	-	14	35	11
1900-1939	1	-	5	-	1
1940-1985	50	45	27	16	36
1986-1990	10	29	21	20	22
1991-2006	20	26	26	30	26
2007 or later	20	-	5	-	4
Don't know	-	-	3	-	-

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

Table 1.3 continued.

	Emergency services sub-sector				
	Fire/ ambulance stations (%)	Police stations (%)	Law courts (%)	Prisons (%)	**Emergency services sector (%)**
Building structure					
Part of building	5	-	4	-	1
Whole building	89	97	91	12	70
Multiple buildings	6	3	5	88	29
Peak operating hours[10]					
8 or less	32	44	62	0	30
9-15	12	16	38	67	32
16-23	0	31	0	0	14
24	48	6	0	33	21
Don't know	*8*	4	0	0	3
Opening hours[11]					
8 or less	13	1	2	0	3
9-15	10	0	98	0	10
16-23	10	1	0	4	3
24	59	95	0	95	81
Don't know	*8*	*4*	-	*0*	*3*
Unweighted base	*53*	*19*	*43*	*14*	***129***

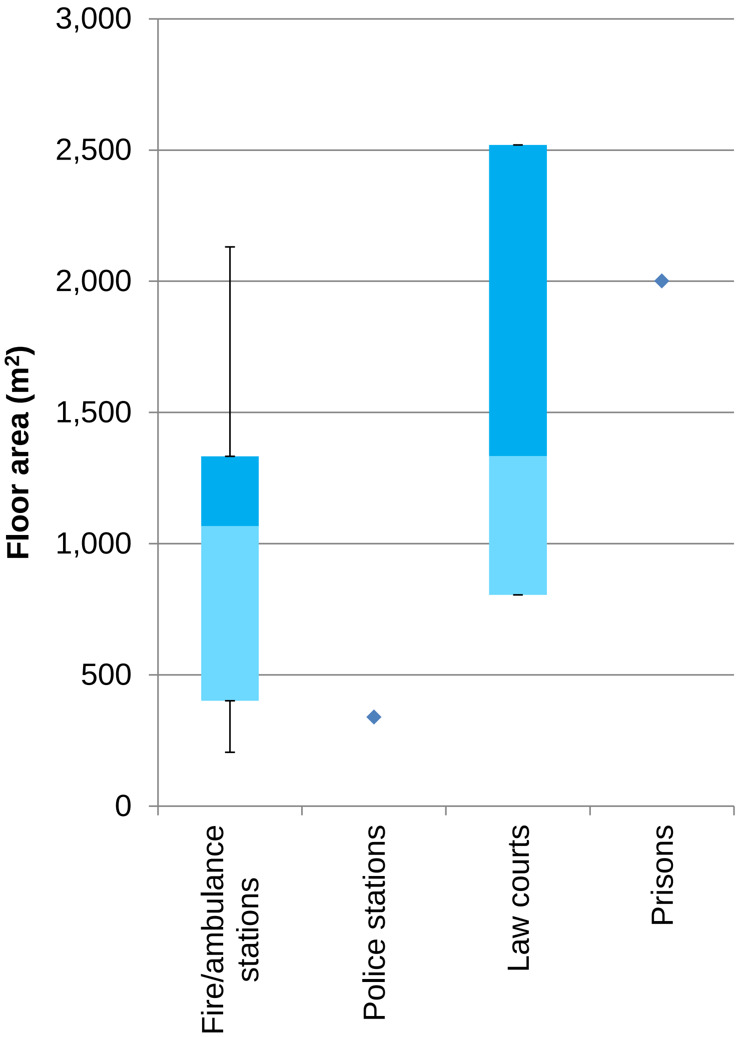
Source: Telephone survey or equivalent records for the sector, England and Wales

[10] 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)?".

[11] 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).

Figure 1.4 shows the distribution of premises sizes, in terms of floor area, by sub-sector. The plot shows that prisons had the largest median floor area in the emergency services sector at 2,000 m^2, followed by law courts (1,330 m^2), fire/ambulance stations (1,070 m^2) and police stations (340 m^2)[12].

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



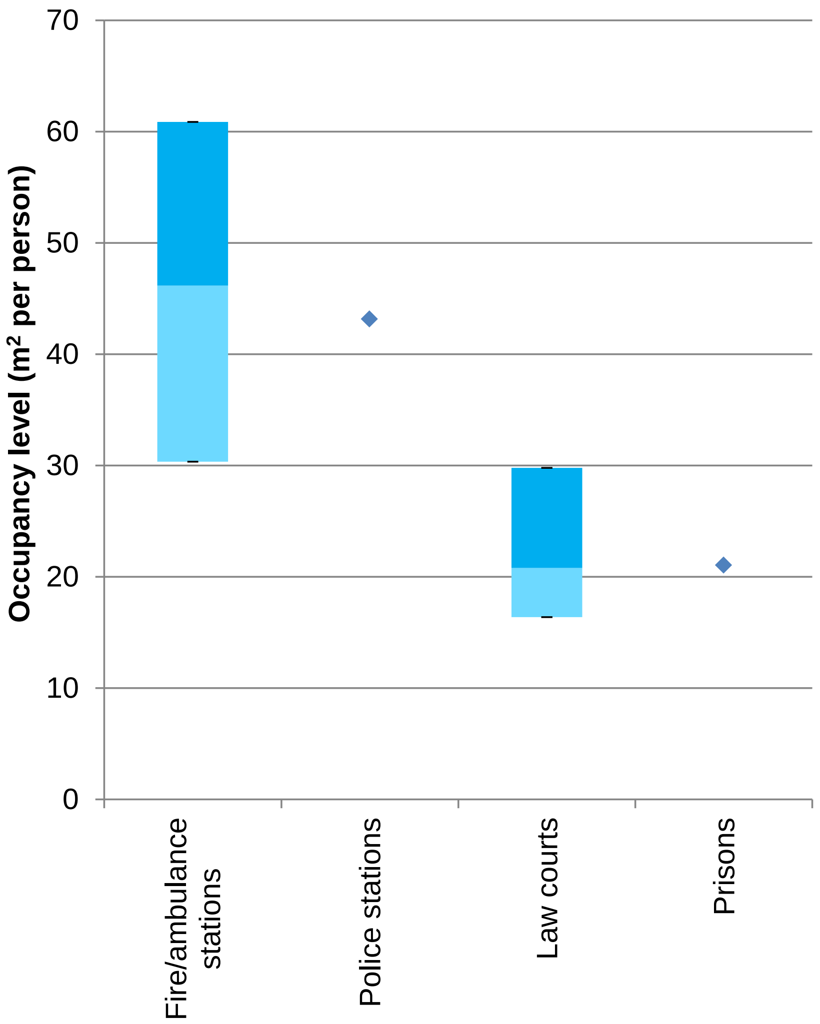
Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded. For series with fewer than 20 data points, only the median is displayed as a single point.

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

[12] The median floor areas for police stations and fire/ambulance stations are inconsistent with the sector characteristics table (table 1.2), which indicated that the majority of these sub-sectors floor area is in premises with greater than 1,000m^2. The difference is because the figure below is based on the sample whilst sector characteristics table is based on weighted floor area for each record.

Figure 1.5 shows the distribution of occupancy level (the floor area per staff and visitor number) based on the number of staff and visitors present over a typical working day.[13] Fire/ambulance stations shows the lowest median occupancy level of 50 m^2 per person. This compares with a median of 40 m^2 per person in police stations and 20 m^2 per person in both law courts and prisons.

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



Note: In box 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). For series with fewer than 50 data points no percentiles outside the interquartile range can be shown. For series with fewer than 20 data points, only the median is displayed as a single point.

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

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

2. Methods

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

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

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

Research objectives

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

- To update the Department's understanding of how energy is used, for a snap-shot in time, across the non-domestic building stock in more detail than is available at present;[14]
- To update the Department's understanding of how energy use can be abated across the non-domestic building stock in more detail than is available at present;
- To understand the barriers and enablers of energy abatement.[15]

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

Standard approach

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

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

The study generated a database of 3,690 records. Each record may represent an entire building or a premises within a larger building. The findings in this report are based on data collected for the emergency services sector through 129 telephone surveys and 14 site surveys during 2015.

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

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

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

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

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

1. **Sample design** - BEES has been sampled and grossed primarily based on data from DECC's non-domestic National Energy Efficiency Data-framework (ND-NEED). This dataset uses the Valuation Office Agency's (VOA) property rating list. Where a sector was out of scope of the VOA database, alternative data sources were used. This gives a base record of address, floor area, building type, and energy use[16]. Using the Experian references in ND-NEED it was possible to add a contact telephone number. Analysis shows that the scope of BEES included 89 per cent of building floor area in England & Wales. The number of surveys per sub-sector was determined based on their overall size with a minimum of 50 surveys sought where possible. Overall 1 per cent of floor areas has been surveyed based on the sub-sectors in scope.
2. **Data collection** – A sub-sector tailored telephone survey, supplemented with data from a more detailed site survey in a subset of cases, was used to gather the information required to model the energy end uses within these premises.
    - The telephone survey involved a single stage and took around 25 minutes to complete. It gathered basic information on the premises, its servicing and usage. It also included sub-sector specific key questions to gather further data on the most significant energy end uses. These questions were designed with input from expert interviewers and, if necessary, trial site surveys at the design stage of the research programme. The survey was conducted with the person responsible for energy management, building management or another suitable manager.
    - A limited number of site surveys were undertaken on the telephone survey sample. The candidates were selected based on a range of characteristics such as energy intensity, location and floor area size. The site surveys gathered detailed information on the energy end use consumption, activities (extent and intensity), abatement potential and the barriers and facilitators to implementing energy efficiency measures in the premises. The outputs were used to test the energy use and abatement models. Data collected on site was also used to correct and overwrite findings from the initial telephone survey. The data on barriers was collected via semi-structured face to face interviews.
3. **Data cleansing** - Prior to modelling, the data were cleansed firstly through record exclusion. Records were screened for outliers, and then they were reviewed for quality. The outlier analysis was based on typical operating metrics, such as occupancy level (the number of square metres per person in a premises). Where extreme values were identified the record would be removed. The quality assurance process identified the proportion of questions for which a response was required to model energy use. Any records which failed to meet the minimum data quality thresholds, measured by the percentage of 'Don't know' responses were excluded. Exclusion of these records was deemed necessary on the grounds that a significant prevalence of 'Don't know' responses was considered indicative of a respondent who lacked engagement or had a poor understanding of their building's core services and equipment. Within the emergency services sector, a total of 156 telephone survey or equivalent records were collected – following the record exclusion process a total of 129 records were retained for analysis. In this sector the share of records excluded was moderately low (17 per cent of total), as many of the records in the available sample yielded a low proportion of 'Don't know' responses, considered to indicate poor record reliability.
4. Secondly, record amendment was conducted on the remaining data. The remaining

[16] 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

records were reviewed and in some cases data amended to overcome isolated yet important instances of ‘Don’t know’. These amendments were applied to the telephone survey dataset. Where telephone survey records contained a ‘Don’t know’, the response was estimated where possible based on the most likely response based on what was typical for the premises, or was proxied based on other question responses[17].

5. **Data processing** – Two models were used to process the cleaned telephone survey outputs. The **energy use model** was used to estimate the energy use in each premises, and the **abatement model** was used to estimate the cost and abatement potential of different abatement measures if they were to be installed in that premises. These models are outlined below, for more details see the technical annex. It should be noted that all processed outputs relate to the time when the original data was collected.[18]
    - The energy use model used an energy calculator to estimate a premises energy consumption, split by end use and fuel type, based on the cleaned telephone survey responses. A calibration process was carried out for each sub-sector to map telephone survey responses to different values of parameters in the energy calculator. This calibration was based on alternative data sources, previous knowledge of the sub-sector and the site surveys. The energy use mode did not take dynamic effects or building geometry into account, given the nature of the telephone survey data.
    - The abatement model used the cleaned telephone survey outputs and a set of relatively simplistic measure applicability rules to assess whether or not different abatement measures were applicable to a particular premises. The effect of applicable measures was estimated by changing relevant parameters in the energy calculator and recalculating the energy consumption of the premises.
6. **Weighting** – All the data generated was weighted upwards to represent the sub-sector population, based on the likelihood the premises was selected and on the overall share of floor area in the achieved sample.

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

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

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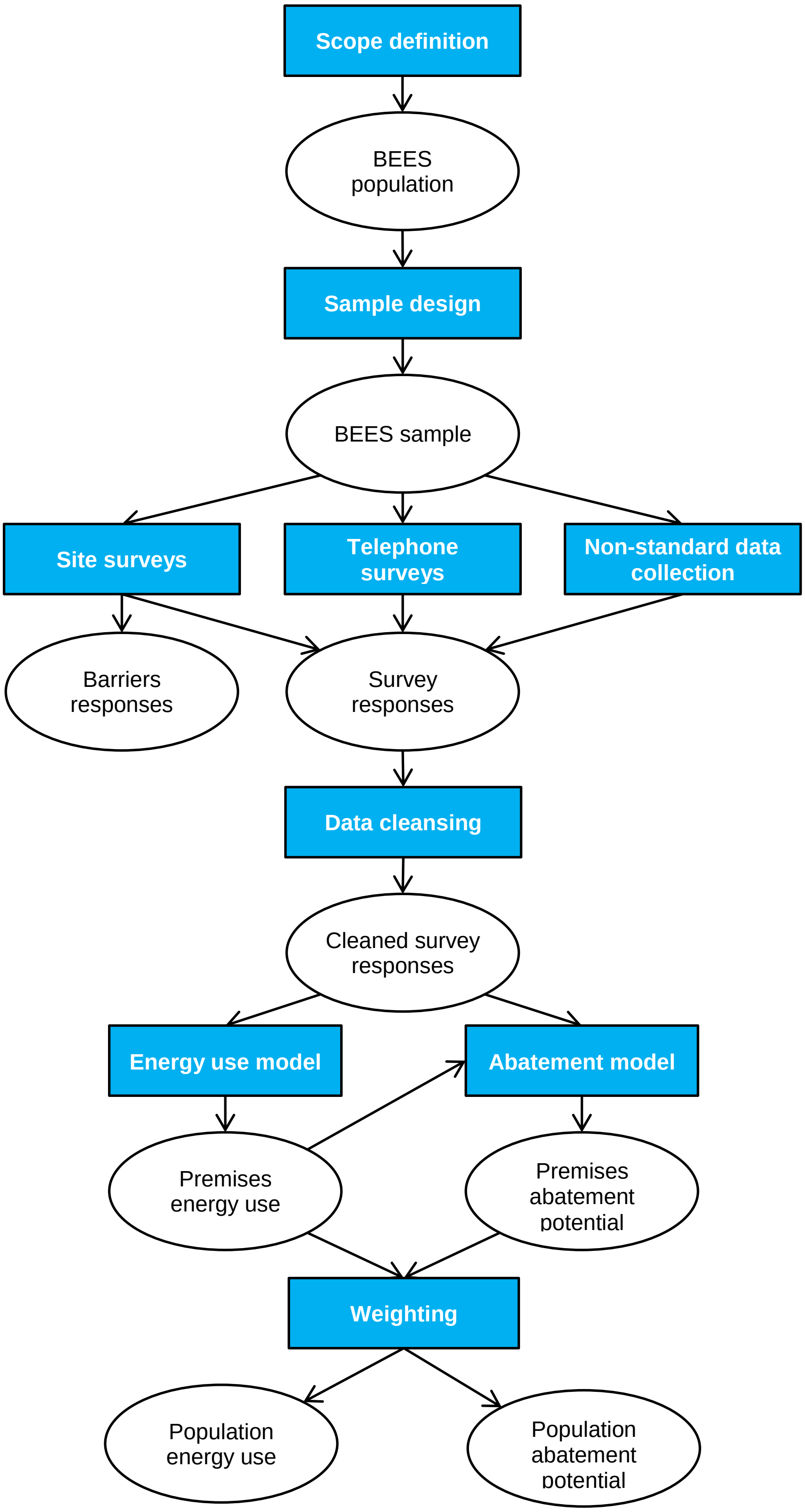
[17] For example, in one sub-sector a small number of respondents gave a ‘Don’t know’ response to the question “Do you use electricity to heat tap water and/or showers and if so how much?”. The vast majority of responses to within the sub-sector were ‘None’, so this was used as a proxy as it was deemed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

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

Figure 2.1: Methodology flowchart



Methodology challenges in the emergency services sector

For emergency services sub-sectors a customised approach was required in certain cases due to limitations of available datasets and specific issues encountered within sub-sectors.

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

- **Sample design & data collection** Police and ambulance station telephone numbers could not be matched to NEED. Police constabularies and ambulance trusts were approached directly and contacts were asked to select premises meeting the sub-sector criteria and to complete multiple telephone survey responses for their buildings. This resulted in a biased sample with a limited number of organisations providing multiple responses. It was also noted that where one respondent completed multiple surveys, repetition of answers was common which may indicate a quality issue with this data but the impact on the inputs to the energy use model are unknown.
- **Data collection** Prison facilities had a very wide range of activities included on site. The modelling tools used were designed to focus on key activities in a sub-sector. In sub-sectors which were highly varied the primary activity was determined and the models were designed to accurately calculate energy consumption associated with these. In the prison sub-sector a respondent was required to select a building with cells from within their prison. This approach has meant that the results were biased towards accommodation block activity, meaning that other activities such as catering facilties or gymnasiums, may be under-represented. This would affect the average energy intensity for the sector and the split between end-uses.
- **Data collection** Prison facilities had very little sub-metering of premises within their sites. This limited the quality of both the site survey findings and the reliability of matched energy data from Display Energy Certificates for these premises. These limitations reduced the confidence with which calibration procedures could be completed. This impacts on the accuracy of the modelled total energy consumption.

3. Energy consumption

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

Energy consumption and greenhouse gas emissions in the emergency services sector

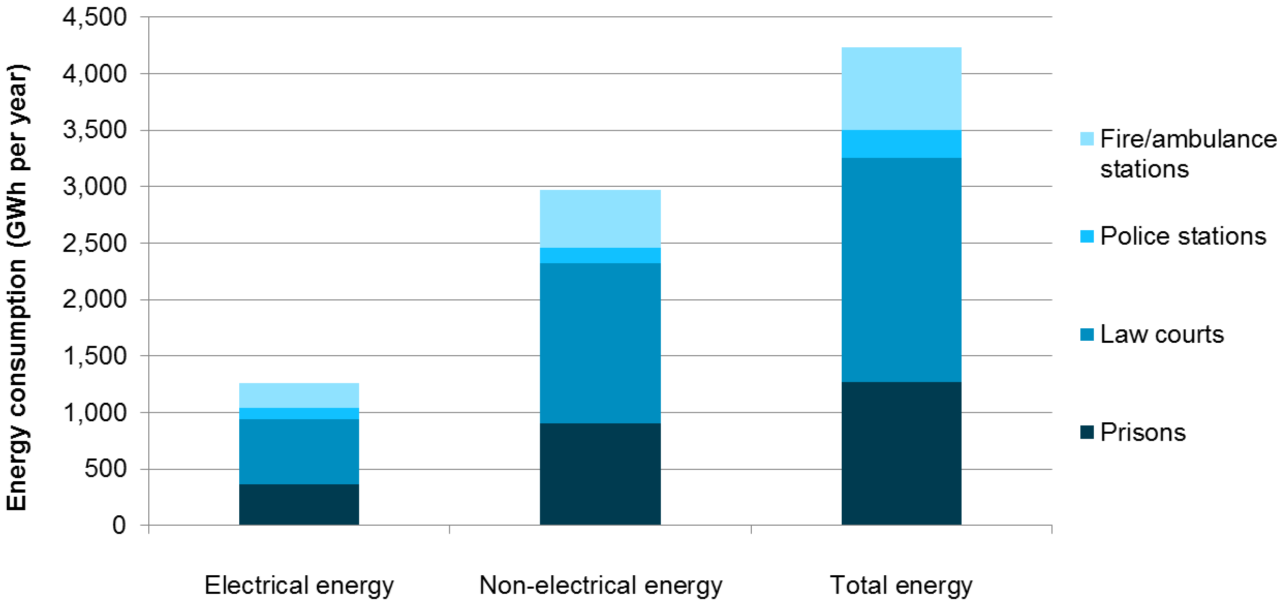
The electrical and non-electrical energy consumption of the emergency services sector is presented in Figure 3.1, broken down by the four emergency services sub-sectors (covering fire/ambulance stations, police stations, law courts and prisons).

The emergency services sector consumed 4,230 GWh of energy. This consisted of 1,260 GWh of electrical energy and 2,970 GWh of non-electrical energy per year (Figure 3.1).

The largest energy consumer was police stations with a consumption of 1,990 GWh of energy. This consisted of 580 GWh of electrical energy (46 per cent of sector total) and 1,410 GWh of non-electrical energy (47 per cent of sector total). This was partly due to this sub-sector being the largest in the emergency services sector in terms of floor area (6 million m^2 compared with 4 million m^2 for prisons and 3 million m^2 for fire/ambulance stations).

Prisons were the second largest consumer in the sector with 1,270 GWh of total energy consumption. This consisted of 370 GWh of electrical energy consumption (29 per cent of sector total) and 910 GWh of non-electrical energy consumption (30 per cent of sector total). Law courts were the smallest consumer in the sector at 240 GWh of total energy consumption, which was comprised of 100 GWh of electrical energy (8 per cent of sector total) and 140 GWh of non-electrical energy (5 per cent of sector total).

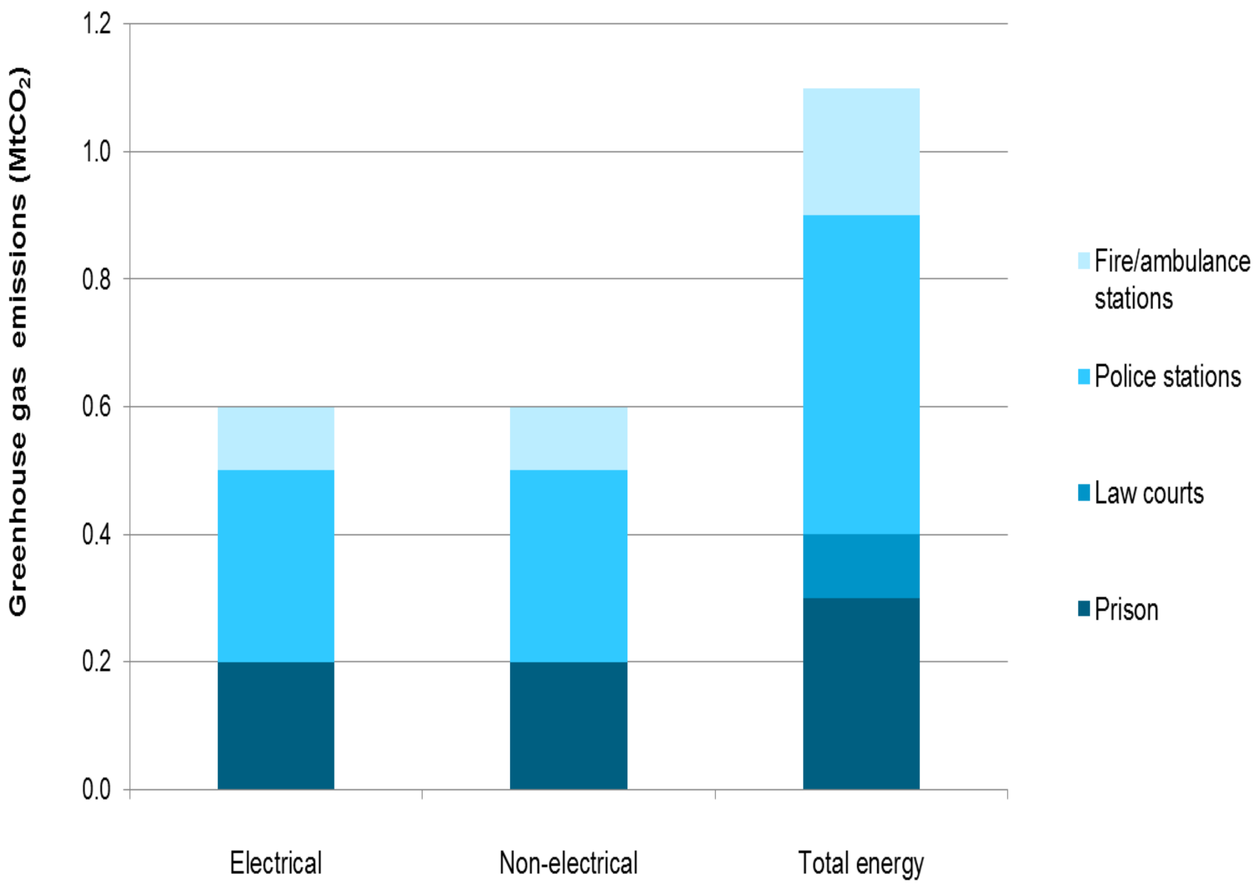
Figure 3.1: Electrical and non-electrical energy consumption by energy type and emergency services sub-sector, 2014–15



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

The greenhouse gas emissions for the emergency services sector are presented in Figure 3.2.[19] The total greenhouse gas emissions from the emergency services sector were estimated to be 1.1 $MtCO_2e$ per year. The annual emissions from electrical energy consumption were 0.6 $MtCO_2e$ and those from non-electrical energy consumption were 0.6 $MtCO_2e$.

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



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

Energy consumption by end use

The total energy consumption by end use is presented in Figure 3.3 and Table 3.1.[20]

The energy use model defined 23 separate energy end uses in its analysis. These were derived by modelling the telephone survey inputs and were calibrated using site survey data. For the

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

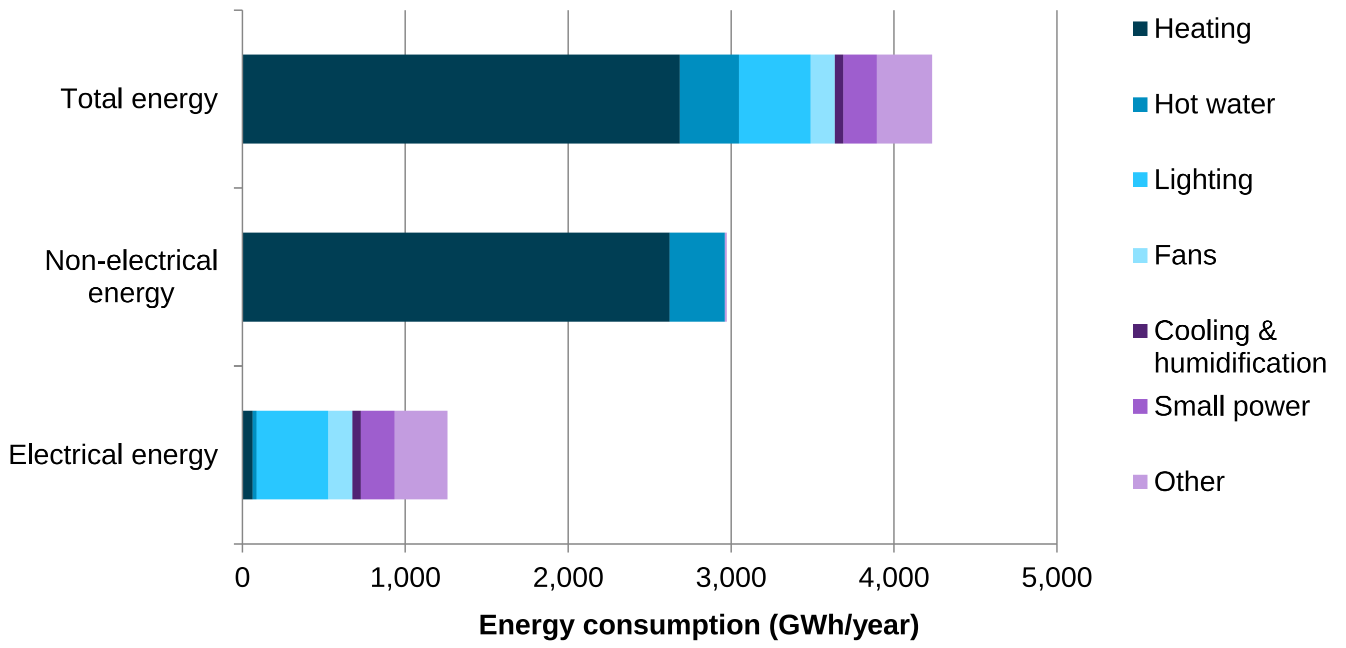
[20] In the context of the BEES study, small power represents office equipment (comprising computers, printers and ancillary desktop equipment). Other plug-in loads are disaggregated into entertainment equipment, catering, pool/leisure equipment etc.

purposes of presentation in Figure 3.3, the 23 uses have been simplified to six categories, covering key building services end uses (heating, hot water, lighting, fans, cooling & humidification and other) and one custom category relevant to the sector (small power). The simplified classification is shown against the more detailed classification results in Table 3.1.

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

The total energy consumption for the emergency services sector was 4,230 GWh. The most significant end use was space heating (2,690 GWh, 63 per cent of total energy consumption), followed by internal lighting (440 GWh, 10 per cent of total energy consumption). The most common end uses of electrical energy were internal lighting at 440 GWh (35 per cent of total), followed by small power (210 GWh, 16 per cent). The next major end uses included fans (150 GWh, 12 per cent), space heating (60 GWh, 5 per cent) and entertainment equipment (60 GWh, 5 per cent). The most significant non-electrical energy end uses were space heating at 2,620 GWh (88 per cent) followed by hot water (340 GWh, 11 per cent). Non-electrical energy consumption for heating was much higher than electrical energy consumption (2,620 GWh compared with 60 GWh).

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



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

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

Energy end use category (Simplified)	BEES end use category[21]	Electrical energy consumption (GWh/year)	Non-electrical energy consumption (GWh/year)	Total energy consumption (GWh/year)
Heating	Space heating	60	2,620	2,690
Hot water	Hot water	20	340	360
Lighting	Lighting - internal	440	-	440
Fans	Fans	150	-	150
Cooling & humidification	Space cooling	50	-	50
Small power	Small power	210	-	210
Other	Pumps	50	-	50
	Catering	40	10	50
	Cooled storage	4	-	4
	Controls	20	-	20
	Lighting - external	40	-	40
	Vertical transport	3	-	0
	Lighting - display	20	-	20
	Entertainment equipment	60	-	60
	Pool/leisure	-	-	-
	ICT equipment	20	-	20
	Laundry	30	-	30
	Other	50	-	50
Total		**1,260**	**2,970**	**4,230**
Unweighted base		*129*	*125*	*129*

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

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

Emergency services sector energy intensity distributions

Energy intensity (energy use per m^2 floor area) enables activities across sectors to be compared, and is used for benchmarking in the building services industry.[22] Figure 3.4, Figure 3.5 and Figure 3.6 present the distribution of energy intensity for all modelled records in each sub-sector within the emergency services sector, in terms of total energy intensity, electrical energy intensity and non-electrical energy intensity respectively.[23] In this report all intensity figures (excluding box plots) have been calculated using the total sector or sub-sector floor area regardless or whether they have a particular energy source or end-use.

Figure 3.4 shows that police stations typically displayed the highest median overall energy intensity (345 kWh/m^2), followed by prisons (316 kWh/m^2). Figure 3.5 and Figure 3.6 shows that police stations typically displayed the highest median electrical energy intensity (128 kWh/m^2 for electrical energy). The second most energy intensive sub-sector in terms of electrical energy was prisons (91 kWh/m^2). Whilst the sub-sectors were similar in terms of non-electrical energy intensity, prisons and fire/ambulance stations displayed the highest median of 216 kWh/m^2 for both followed by police stations (209 kWh/m^2).

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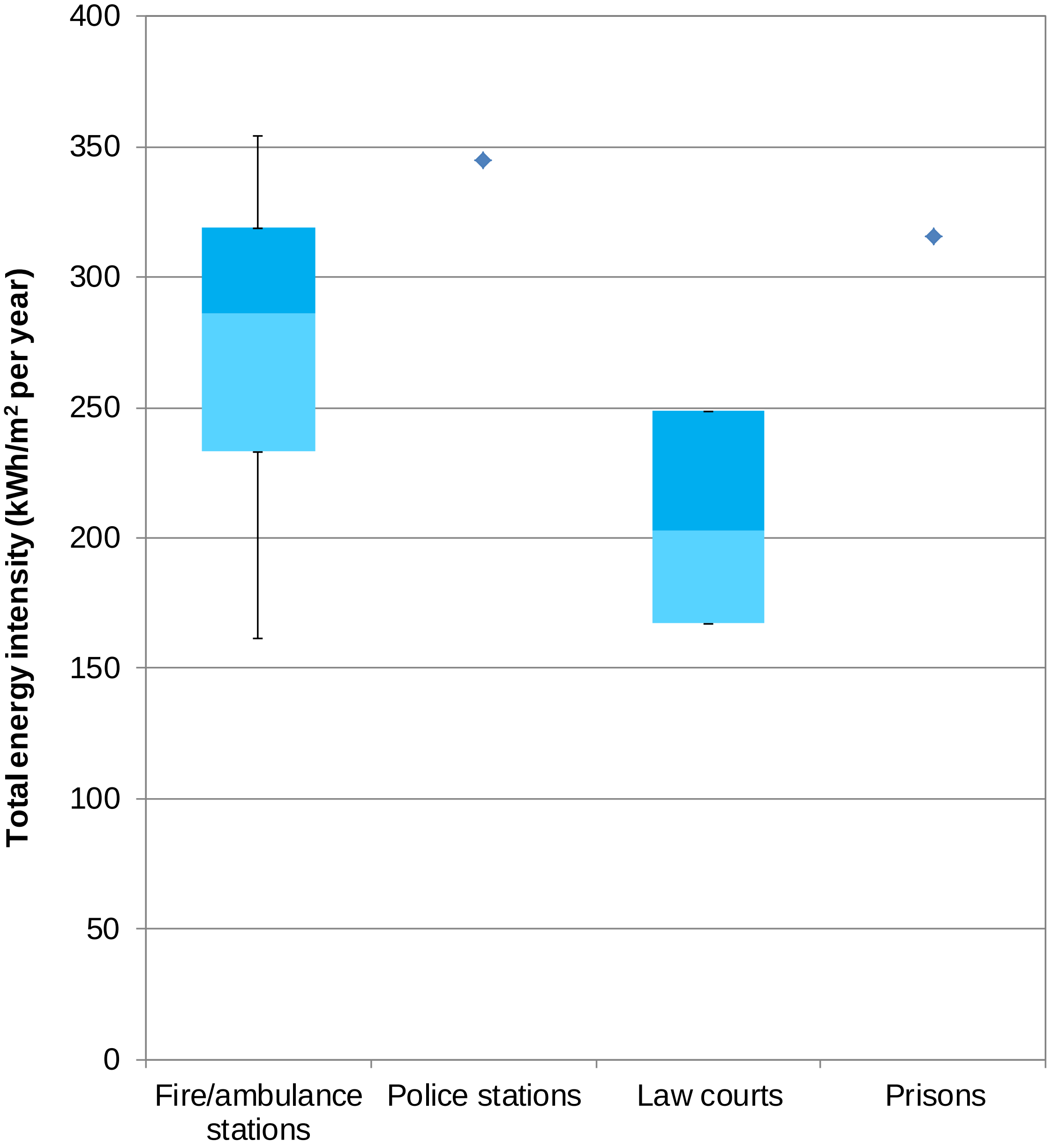
[22] As employed in CIBSE TM46 Energy Benchmarks (available at: http://www.cibse.org/knowledge/cibse-tm/tm46-energy-benchmarks), and others.

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

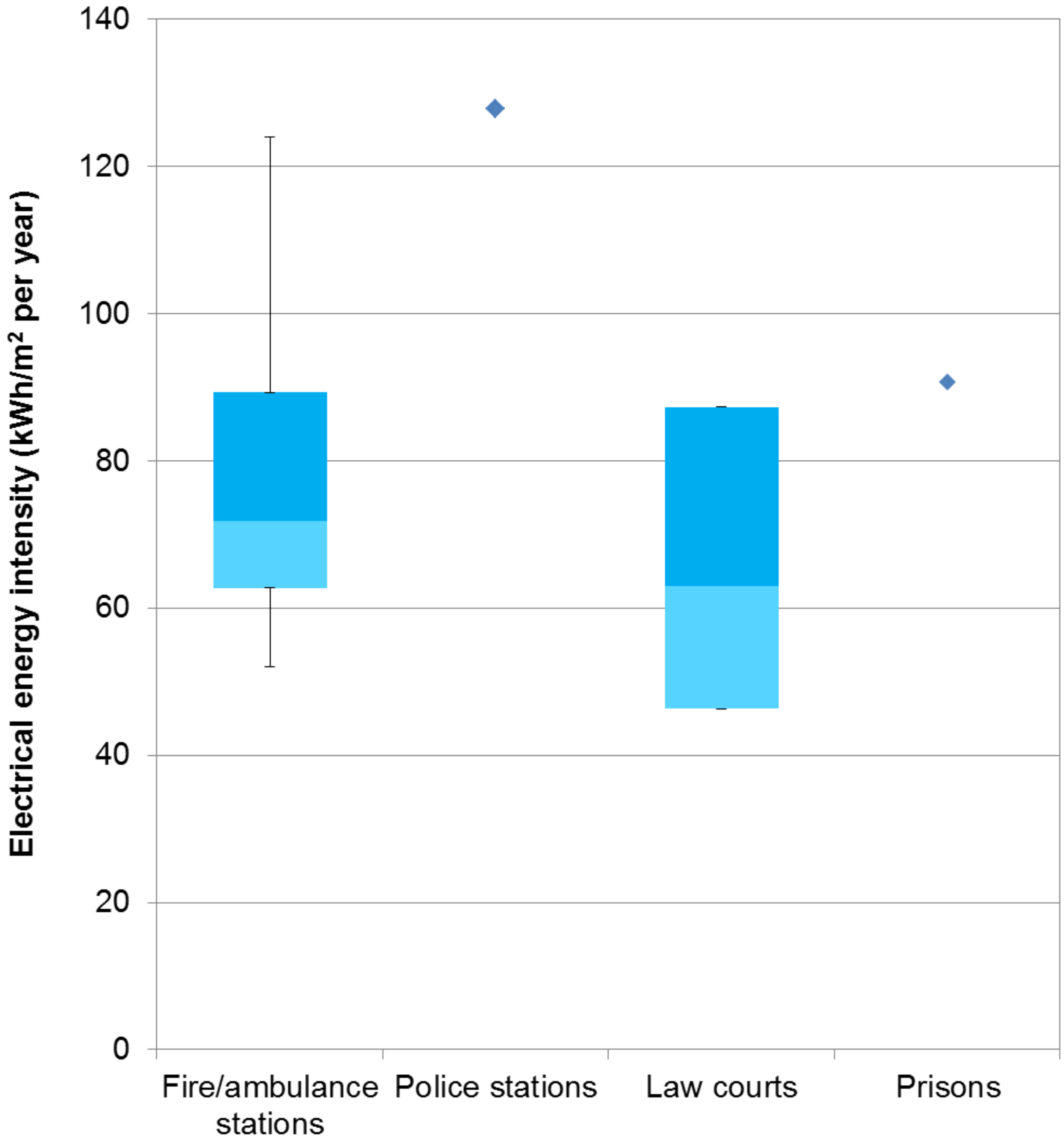
Figure 3.4: Distribution of total energy intensity by emergency services sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded. For series with fewer than 20 data points, only the median is displayed as a single point.

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

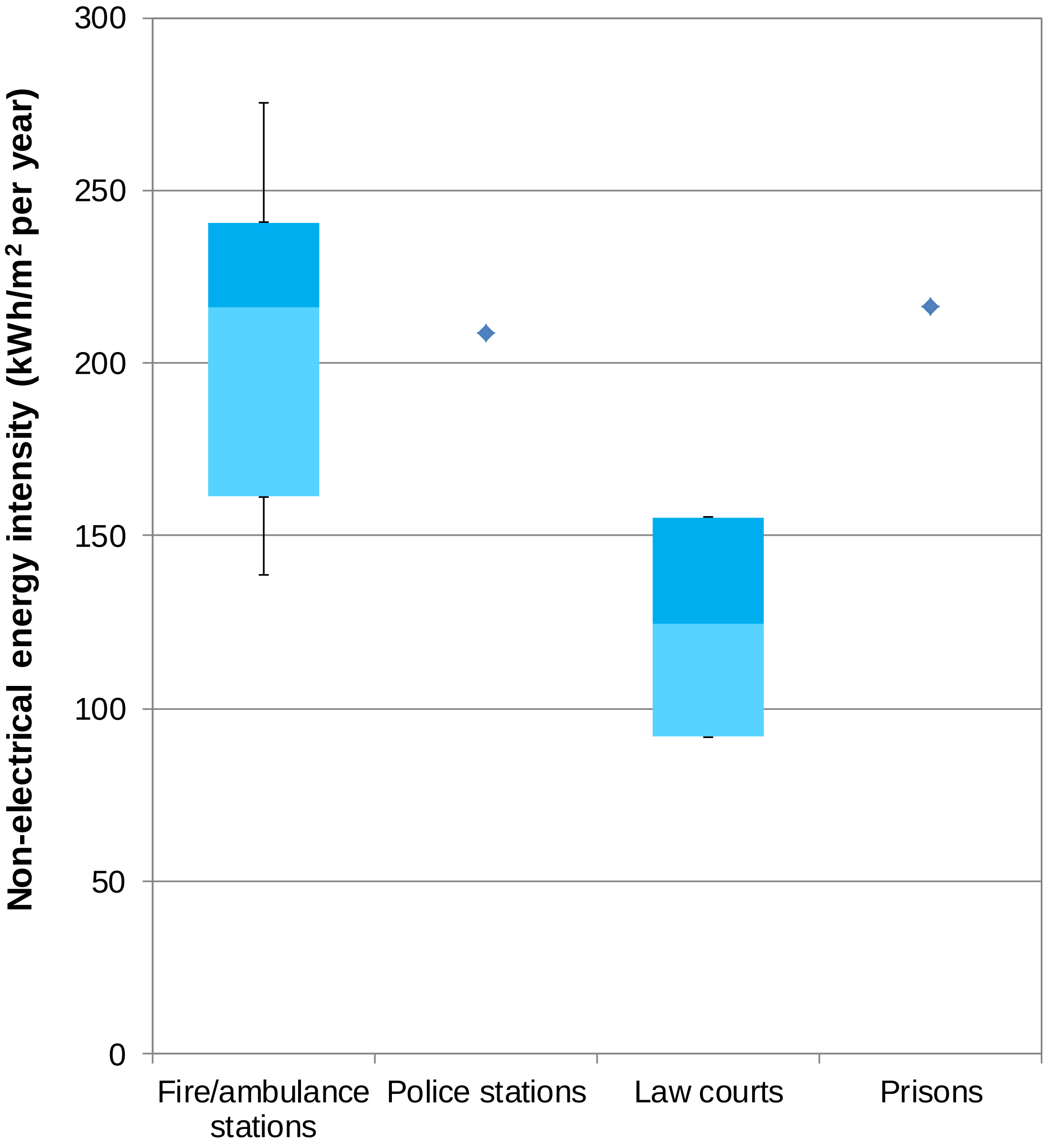
Figure 3.5: Distribution of electrical energy intensity by emergency services sub-sector, 2014–15



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded. For series with fewer than 20 data points, only the median is displayed as a single point.

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

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



Note: In box and whisker plots, the blue columns, when combined, indicate the range of floor areas covered by the interquartile range of results (the middle 50 per cent of data points). The upper black bars extend to the 90th percentile, capturing a further 15 per cent of the total number of data points. The lower black bars span to the 10th percentile, also capturing 15 per cent of the total number of data points. Therefore within each sub-sector, 80 per cent of the total number of data points are displayed, with the outlying maxima and minima (10 per cent of data points each) excluded. For series with fewer than 50 data points, the black bars are excluded. For series with fewer than 20 data points, only the median is displayed as a single point.

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

Emergency services sub-sector energy end use breakdowns

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

Heating energy intensity was the largest contributor to the sector's overall energy intensity. Prisons, police stations and fire/ambulance stations all exhibited high heating intensity, which was linked to the common trend for 24 hour operation. Law courts had a lower heating intensity than the other sub-sectors, but higher than typical for office type premises; there was a trend towards older premises, and high ceilinged spaces were quite common which increased the heated volume.

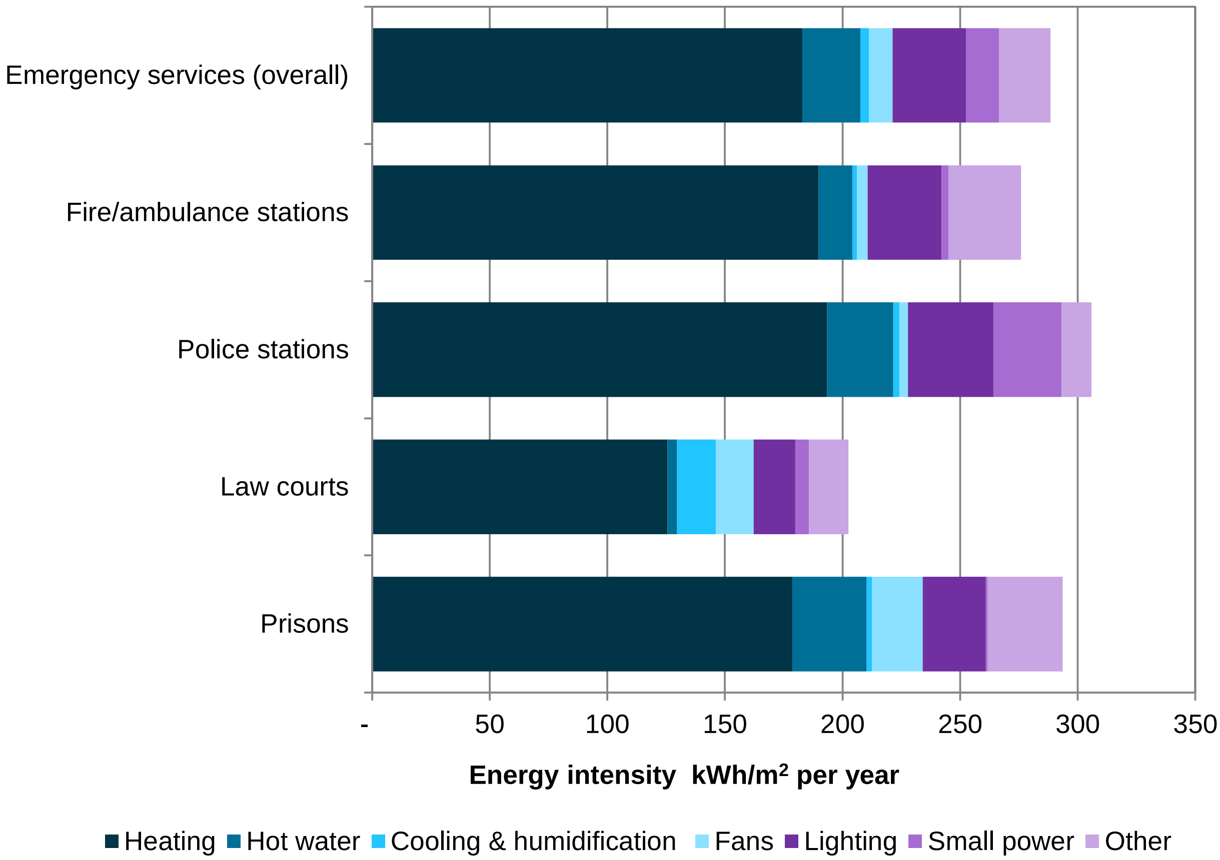
Hot water energy intensity was significant in prisons and police stations in particular; in prisons this was driven by showers and washing for inmates, whereas in police stations it was linked to a high occupancy levels – facilities were provided both for office staff and officers on the beat, with showers provided for staff and cells. In fire/ambulance stations, fire stations contributed significant hot water use as they commonly included residential facilities and gyms, meaning that showers were regularly used; however in ambulance stations there were typically few people on site and the consumption of hot water was low.

Energy intensity for fans was high in prisons; this was due to ventilation commonly running 24 hours a day. Mechanical ventilation was also common in law courts. Comfort cooling was also common in law courts but rare in the other three sub-sectors.

Lighting energy intensity was highest in police stations where there was a significant prevalence of 24 hour office space with correspondingly high light levels. Fire/ambulance stations also had high lighting consumption; again this was linked to 24 hour operation, but light levels were lower on average than in police stations. Despite the fact that lighting may be left on 24 hours a day, prisons used significantly less energy for lighting, due to relatively low light levels required in circulation areas and cells. Law courts exhibited the lowest lighting energy intensity, linked to them generally operating office hours, and a high proportion of common areas with low light levels.

Small power energy intensity was significant primarily in the police stations sub-sector where desk based office equipment is common, and may be used 24 hours a day. Office spaces were also found in court premises but as a much smaller share of the total floor area. The greatest contributor to the "other" end use category was catering energy use.

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



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

4. Abatement potential

In this section, abatement potential[24] for the emergency services sector is considered. Abatement potential is calculated at a sub-sector and sector level.

Abatement method

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

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

The costs were based on standardised absolute installation costs[25], while the benefits were only based on the incremental reduction in energy consumption[26]. Replacement of systems which were not at the end of their life were therefore included. This will be more expensive than end of life replacement, as the impact on energy consumption is likely to be smaller for where equipment is newer, while the full capital costs are taken into account. This means that a measure may be cost-effective if the system is replaced at the end of its life – especially as at the end of life the cost of the more energy efficient alternative would be compared to replacement with a less efficient alternative - but, the same measure may not be cost-effective if the system is replaced earlier in its life. Replacing measures at the end of life will be less costly for organisations, but it would take longer for the full potential to be realised. While the costs include an allowance for installation costs and hassle costs, this may not not include all the wider disruption costs that may be faced by organisations upgrading equipment; for example it does not factor in the costs of relocating staff if it is not possible for staff to work on site while work is underway. The extent to which organisations face these costs will depend on whether upgrades are scheduled as part of a wider refurbishment.

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

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

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

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

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

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

Total technical abatement potential for emergency services sector

The abatement potential for each sub-sector where it is available is shown in Table 4.1 and Figure 4.1. The total abatement potential is between 46 and 56 per cent of total energy consumption.[27] Each sub-sector can achieve between 35 to 51 per cent savings in electrical energy consumption and 49 to 58 per cent savings in non-electrical energy consumption. This could be achieved at an overall capital expenditure of £613 million.

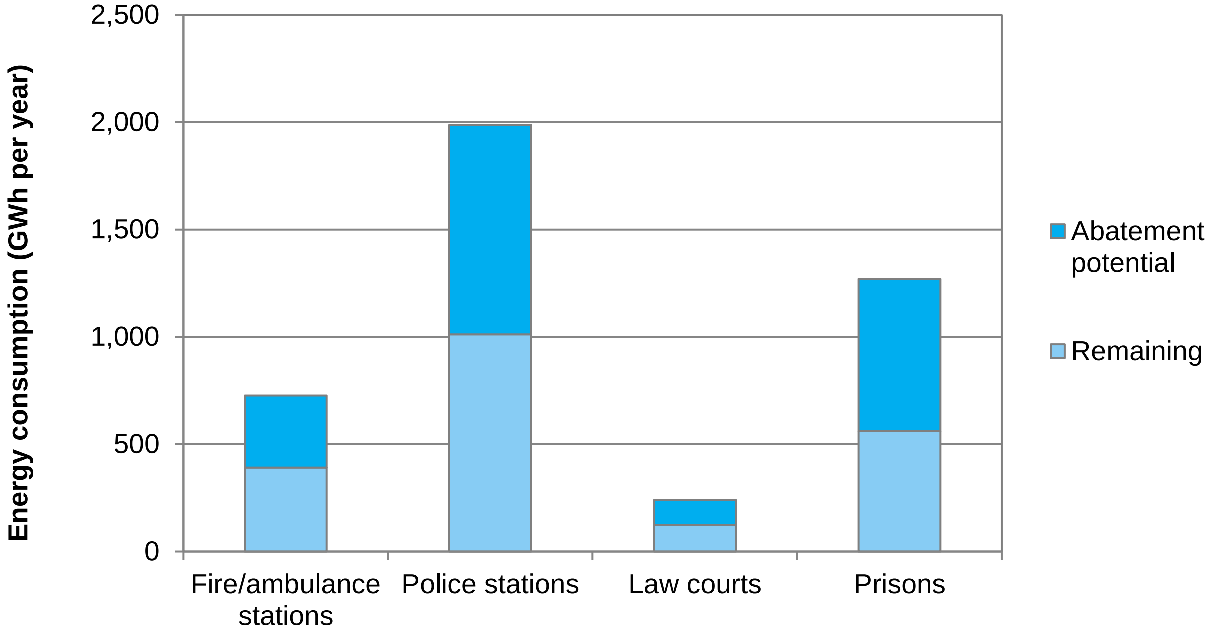
Table 4.1: Total abatement potential by emergency services sub-sector, 2014–15

Sub-sector	Capital Expenditure required to deliver abatement potential (£ thousands)	Baseline energy consumption (Energy Use model)		Total abatement potential		
		Annual electrical energy consumption (GWh)	Annual non-electrical energy consumption (GWh)	Annual electrical energy savings (GWh)	Annual non-electrical energy savings (GWh)	Overall reduction (per cent)
Fire/ambulance stations	91,800	220	520	80	260	46
Police stations	284,100	580	1,410	220	760	49
Law courts	45,700	100	140	50	70	49
Prisons	191,500	370	910	190	530	56
Total	**613,200**	**1,260**	**2,970**	**530**	**1,610**	**50**

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

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

Figure 4.1: Total abatement potential by emergency services sub-sector, 2014–15

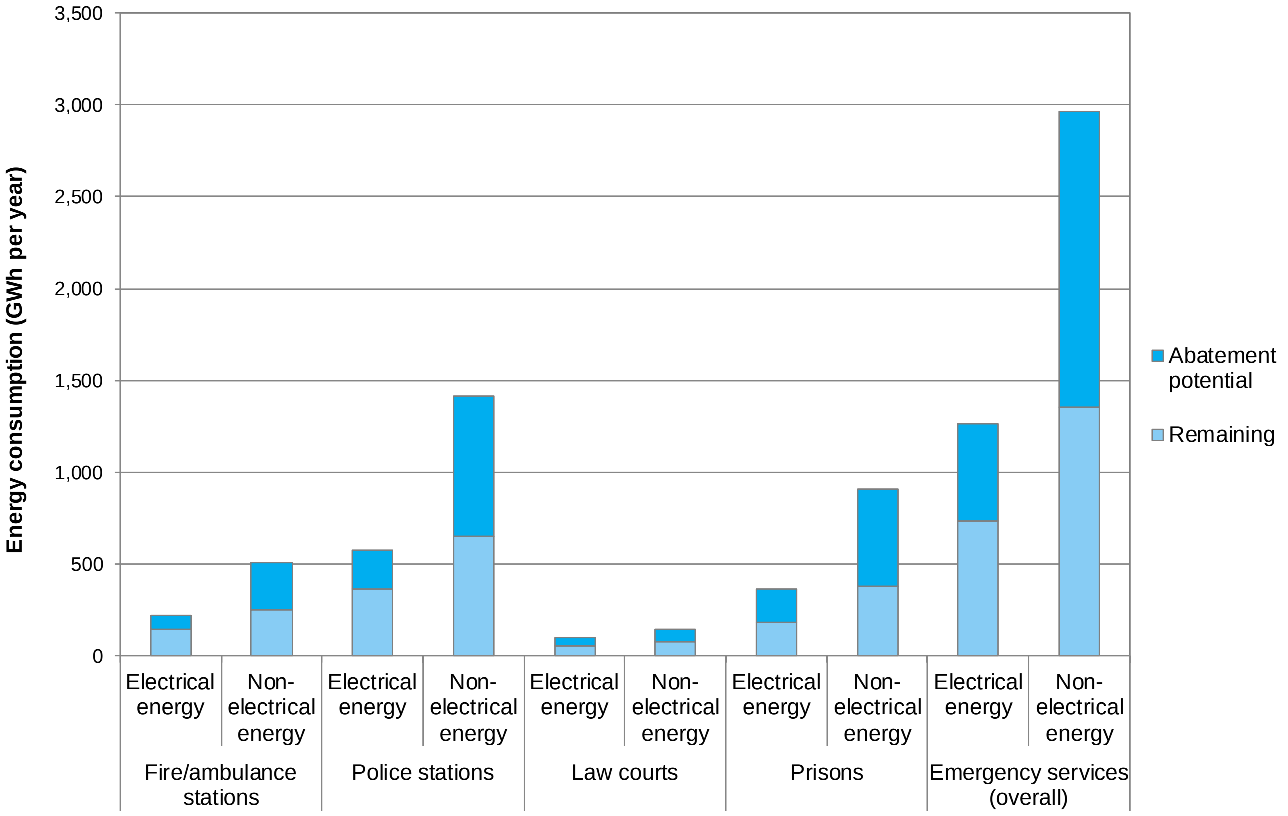


Source: Abatement model results by sub-sector, England and Wales

Figure 4.2 shows that the total technical abatement potential in 2014-15 varied by sub-sector. Police stations had the largest absolute scope for reduction of 980 GWh of total energy, comprised of 220 GWh of electrical energy (38 per cent reduction on consumption) and 760 GWh of non-electrical energy (54 per cent reduction on consumption). Prisons had the largest proportional scope for reduction (56 per cent of total energy consumption overall). This compared with 49 per cent in police stations and law courts, and 46 per cent in fire/ambulance stations. It should be noted that police stations and prisons are based on fewer than 20 surveys so results for these sub-sectors are subject to higher uncertainty.

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

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



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

Marginal Abatement Cost Curve

As well as the total abatement potential and the costs of delivery, it is important to understand the overall cost-effectiveness of measures. Using the abatement model it was possible to assess the costs and benefits of measures from the point of view of society as a whole, by following Government guidance on the valuation of energy use and emissions.[28] This takes into account the capital expenditure, operational expenditure, social cost of energy, air quality impacts, and value of emissions, all discounted at the social discount rate. While this includes the main categories of costs, it was not possible to include the costs and benefits of all impacts on occupants: for example some measures may provide a potentially better occupant experience through improved illumination, or a potentially worse occupant experience through lack of control over light switches.

A measure is socially cost effective if the total social benefits outweigh the total social costs of the measure across the lifetime of the measure. This is a static measure of cost effectiveness based on current expected costs and benefits - for example this does not take into account potential reductions in capital costs that could result from more of that technology being installed. To enable groups of measures to be compared, a metric of social-cost effectiveness was calculated: Net Present Value of costs and benefits (NPV) divided by total energy savings

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

over the lifetime of the measures in the group and plotted on a Marginal Abatement Cost Curve (MACC), which shows the level of abatement opportunity available and the costs associated with this opportunity if they were all implemented in 2014–15. The MACC in Figure 4.3 graphically represents each group of abatement opportunities as a block. The width of the block represents the total amount of abatement the measure can deliver in GWh and the height represents the cost-effectiveness. Because the measure groups are ranked by cost-effectiveness, the most cost-effective (delivering abatement at the least-cost per GWh) will be found on the left of the diagram. Moving to the right, measure groups become subsequently more costly.

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

The total abatement potential of the socially cost effective measure groups was 1,190 GWh, of which 380 GWh was electrical energy consumption and 810 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 630 GWh, of which 350 GWh was electrical energy consumption and 280 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole. Similarly the aggregation of measure groups from the sub-sector level to the sector level may hide measure groups that are cost effective in a particular sub-sector, but not for the sector as a whole.

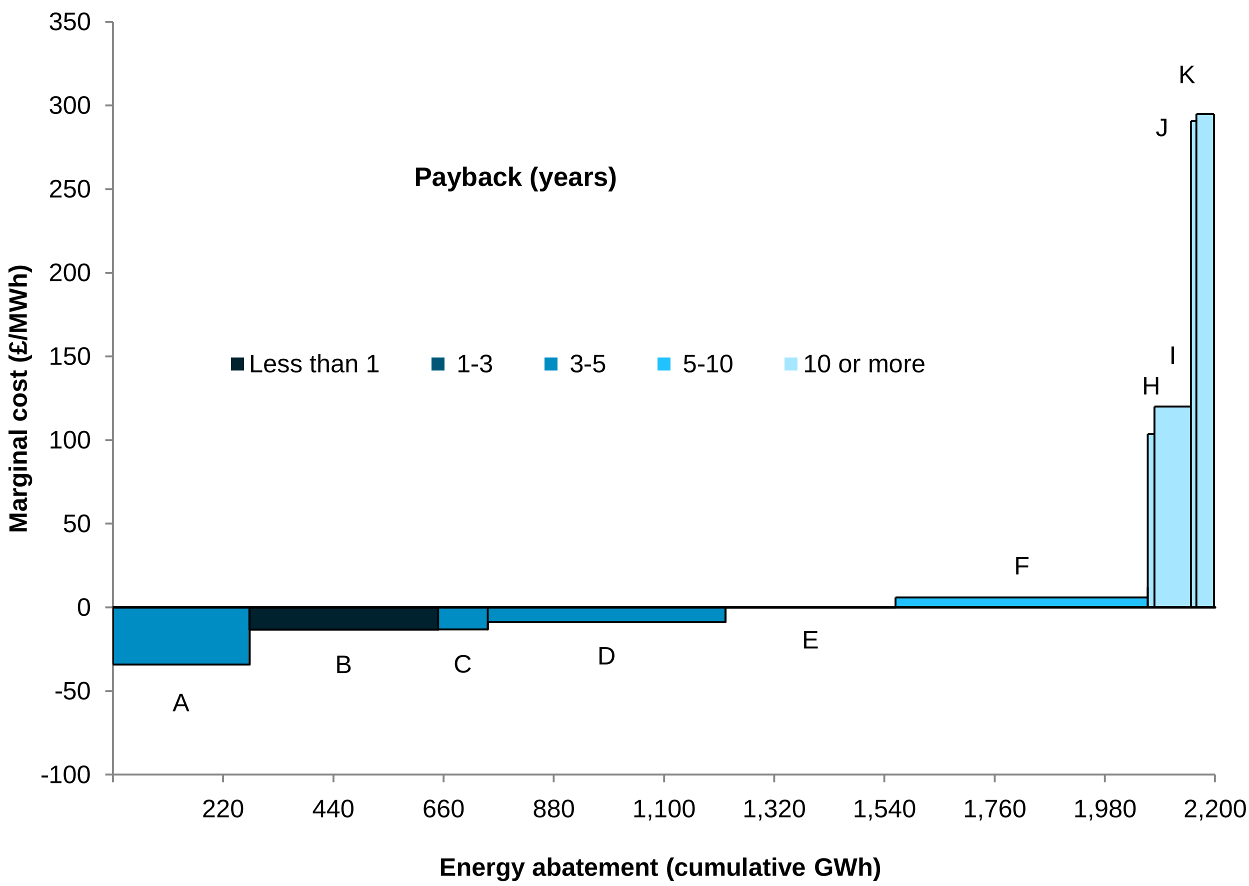
There were a number of measure groups that were socially cost-effective. If implemented, these measure groups provide more financial benefits to society than costs. The largest cost-effective opportunities were lighting upgrades, carbon & energy management and hot water upgrades. These measures also had relatively low payback periods, suggesting they may be more likely to get taken up, but recognising that take-up will also depend on the extent to which there are barriers.

These modelled findings corresponded broadly with opportunities identified in the site surveys. Opportunities for lighting upgrades were identified on almost every site surveyed, with standard fluorescent lights and no automated controls the most common lighting system encountered. Awareness campaigns were identified as an opportunity on a number of sites with comments such as “Much of the office lighting is left on 24/7. LEDs would pay-back” and “There appeared to be very little energy awareness in the building” noted by surveyors. While refrigeration upgrades appear to be cost-effective with very short payback periodsthese were not identified as priority actions in the site surveys, as the scale of the savings available were relatively small compared to the total energy consumption of surveyed premises.

Building fabric measures were also identified on a number of sites; flat roof insulation and draught proofing were the most common measures identified, but uninsulated solid walled buildings were also present in the sector.

Opportunities to improve heating plant and controls were identified in every sub-sector. Review and re-setting of controls in building management systems was commonly identified. Zone controls were particularly applicable in fire and police stations where it was common for some areas to operate 24 hours a day while others only operate a daytime pattern. Other heating measures identified included boiler replacement, insulation of pipework in plant rooms, installing interlock controls on garage doors and summer heating system shutdowns. In police stations, opportunities to replace hot water generation with point of use heaters were also identified. Linked to the wider controls issues identified, installation of variable speed drives on pumps and fans was also identified as a viable opportunity on a number of sites.

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



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

A Lighting [MAC: £-34 per MWh. GWh: 270]

B Carbon and Energy Management [MAC: £-14 per MWh. GWh: 370]

C Hot water [MAC: £-13 per MWh. GWh: 100]

D Building instrumentation and control [MAC: £-9 per MWh. GWh: 460]

E Building fabric [MAC: £-1 per MWh. GWh: 330]

F Space heating [MAC: £6 per MWh. GWh: 490]

Cooled storage [MAC: £12 per MWh. GWh: 1]

H Air conditioning and cooling [MAC: £104 per MWh. GWh: 10]

I Ventilation [MAC: £120 per MWh. GWh: 70]

J Building services distribution systems [MAC: £291 per MWh. GWh: 10]

K Small appliances [MAC: £295 per MWh. GWh: 30]

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

Table 4.2[29] shows the abatement potential by measure type. The most significant available energy savings were associated with space heating, building instrumentation and control, carbon and energy management, and building fabric measures.

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

Measure type	**Savings**					
	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**
Air conditioning and cooling	1,200	3	10	-	10	15,800
Building fabric	8,900	60	7	320	330	167,500
Building instrumentation and control	13,800	90	30	440	460	57,200
Building services distribution systems	1,100	4	10	-	10	22,100
Carbon and energy management	15,800	80	90	280	370	15,700
Hot water	2,700	20	3	90	100	13,500
Humidification	-	-	-	-	-	-
Lighting	26,500	80	270	-	270	82,500
Cooled storage	100	0	1	-	1	300
Small appliances	3,100	10	30	3	30	59,500
Space heating	13,200	90	10	480	490	95,100
Swimming pools	-	-	-	-	-	-
Ventilation	7,000	20	70	-	70	84,000
Total	**93,400**	**450**	**530**	**1,610**	**2,140**	**613,200**

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

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

Appendix A: Sampling statistics

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

Confidence intervals

Table A.1: Confidence intervals for electrical energy intensity

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Fire/ambulance stations	83	± 10
Law courts	82	± 17
Police stations	89	± 23
Prisons	84	± 16
Emergency Services	**86**	**± 13**

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

	Mean (kWh/m^2)	Confidence interval (kWh/m^2)
Fire/ambulance stations	193	± 30
Law courts	120	± 17
Police stations	217	± 28
Prisons	209	± 26
Emergency Services	**203**	**± 21**

Response rates

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

	Fire/ambulance stations (%)	Police stations (%)	Law courts (%)	Prisons (%)	**Emergency services sector (%)**
Completed interview	17	N/A	9	16	12
Still live[30]	42	N/A	30	13	30
Screening failure/other non-response[31]	0	N/A	0	0	0
Refusal	3	N/A	5	5	5
Other non-response	14	N/A	5	4	7
Invalid contact details	23	N/A	50	62	47

[30] 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).

[31] 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: Emergency services method challenges and data collection

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

Emergency services sector methodology challenges

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

Table B.1: Emergency services sector approach challenges

Stage	Challenge	Response	Impact
Sample source data	Ambulance station and police station telephone numbers could not be matched to NEED	Ambulance trusts and police constabularies were approached directly in order to identify a sample.	The team could not select the sample directly. There was a reliance on ambulance trusts and police constabularies to select premises which fit each quota. This could result in an uncontrolled selection bias.
Data collection	Police station telephone numbers could not be matched to NEED	Police constabularies were approached directly in order to identify a sample.	The total sample achieved of 24 records for police stations was below the target sample quota of 30 completed remote survey records. This means that findings extrapolated from this sample have reduced confidence associated with them.
Data collection	Energy management is handled through regional energy managers (ambulance stations) or constabulary level contacts (police stations).	The team successfully engaged with several police constabularies and 3 ambulance trusts to provide telephone survey data for BEES. In each case, telephone survey responses were handled by 1 individual. They provided responses for a number of premises they were	The reliance on a single point of contact meant that the responses were of a lower quality than anticipated. In order to efficiently populate the survey, respondents tended to auto populate data with the same response for many premises. There was also a risk that the study was restricted to those organisations that have the resources and data available to respond. It is possible that organisations without energy management are not represented in our data.

Stage	Challenge	Response	Impact
		responsible for. Only two police constabularies and one ambulance trust were willing to support the site surveys.	Respondents may also only have had limited direct or recent knowledge of the premises they were responding on.
Data processing	Buildings on prison sites were rarely directly metered	The energy use model was calibrated based on site survey data on sub-metered buildings where available, and on plant used on site and against benchmark data for prisons as a whole.	The calibration process could not be fully completed for this sector due to the strong tendency for the matched data to represent a whole prison rather than a single building. This resulted in a significant shortfall in the energy use estimates for this sub-sector when compared to matched data.
Data processing	Ambulance station telephone numbers could not be matched to NEED	Ambulance trusts were approached directly in order to identify a sample.	All site surveys in Ambulance Trusts were with one organisation, as they were the only Ambulance Trust willing to undertake site surveys.
Data aggregation	On prison sites, the energy model focussed on accommodation blocks as the iconic building. In our modelling of the universe the team have assumed that all premises fit this description.	The team have clearly defined the scope of the analysis.	Further use of this report and data contained will need to be caveated to account for the building type assumptions. No data has been made available to allow for a more accurate calculation of the relative prevalence of this activity and there is a risk that it is being over represented while other energy uses are excluded.

Telephone survey and site survey data collection

Table B.2 shows that 129 telephone survey or equivalent records and 14 site surveys were completed in total.

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

	Telephone survey						Site surveys	
Sub-sector	Target sample quota	Number of telephone surveys completed	Number of telephone survey equivalent records completed	Total telephone survey or equivalent records completed	Number of telephone survey records retained post-screening[32]	Average interview length (minutes)	Target sample size	Site surveys completed
Fire/ambulance stations	50	61	0	61	53	27	6	6
Police stations	30	0	24	24	19	n/a	3	3
Law courts	50	51	0	51	43	26	3	2
Prisons	20	20	0	20	14	29	3	3
Emergency services sector	**150**	**132**	**24**	**156**	**129**	**n/a**	**15**	**14**

Source: Telephone survey or equivalent records, England and Wales

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

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

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

Energy end use definitions

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

Table C.1: Definitions for energy end uses

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

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

End use category		Description
	equipment	
22	**Pool/leisure**	All energy use associated with pool and sport leisure facilities within the premises. This should include heating, lighting, pumps, ventilation, humidification, and dedicated controls, alarms etc.
23	**Other**	Any other energy uses which fall outside categories 1 to 21, which are "normal" - i.e. are typical for the specific building type.

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

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

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

Energy type	Detailed end use category	Reduced end use category
Electrical	Space heating	Heating
	Hot water	Hot water
	Space cooling	Cooling & humidification
	Fans	Fans
	Lighting - internal	Lighting
	Central catering	Other
	Distributed catering	Other
	Small power	Small power
	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
	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 C.3 and Table C.4 show energy consumption by end use for each emergency services sub-sector and for the sector combined. Table C.5 and Table C.6 show energy intensity by end use for each emergency services sub-sector and for the sector combined.

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

		Electrical energy consumption (GWh per year)				
Simplified end use category	**BEES end use category**	Fire/ ambulance stations	Police stations	Law courts	Prisons	**Emergency services sector**
Heating	Space heating	30	20	10	-	60
Hot water	Hot water	10	4	1	10	20
Cooling & humidification	Space cooling	10	20	20	10	50
Fans	Fans	10	20	20	90	150
Lighting	Lighting - internal	80	240	20	110	440
Small power	Small power	10	190	10	3	210
Other	ICT equipment	3	10	2	2	20
	Cooled storage	4	-	-	-	4
	Pumps	10	20	3	10	50
	Controls	2	10	2	10	20
	Humidification	-	-	-	-	-
	Laundry	1	-	-	30	30
	Lighting - display	10	-	-	10	20
	Lighting - external	10	20	1	10	40
	Entertainment lighting	-	-	-	-	-
	Vertical transport	1	1	1	-	3
	Distributed catering	10	10	3	10	30
	Central catering	2	-	-	10	10
	Entertainment equipment	10	10	10	40	60
	Lab equipment	-	-	-	-	-
	Pool/leisure	-	-	-	-	-
	Other - normal	40	10	-	10	50
Total		**220**	**580**	**100**	**370**	**1,260**
Unweighted base		*53*	*19*	*43*	*14*	*129*

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

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

Simplified end use category	**BEES end use category**	**Non-electrical energy consumption (GWh per year)**				
		Fire/ ambulance stations	Police stations	Law courts	Prisons	**Emergency services (overall)**
Heating	Space heating	480	1,230	140	770	2,620
Hot water	Hot water	30	180	4	120	340
Other	Catering	2	-	1	10	10
	Medical equipment	-	-	-	-	-
	Pool/leisure	-	-	-	-	-
	Humidification	-	-	-	-	-
Total		**520**	**1,410**	**140**	**910**	**2,970**
Unweighted base		*52*	*17*	*42*	*14*	*125*

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

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

Simplified end use category	BEES end use category	Electrical energy intensity (kWh/m^2 per year)				
		Fire/ ambulance stations	Police stations	Law courts	Prisons	**Emergency services (overall)**
Heating	Space heating	10	4	9	-	4
Hot water	Hot water	2	1	1	3	2
Cooling & humidification	Space cooling	2	3	16	2	3
Fans	Fans	4	4	16	21	10
Lighting	Lighting - internal	29	36	18	25	30
Small power	Small power	3	29	6	1	14
Other	ICT equipment	1	1	2	0	1
	Cooled storage	1	-	-	-	0
	Pumps	3	3	2	3	3
	Controls	1	1	2	1	1
	Humidification	-	-	-	-	-
	Laundry	0	-	-	5	2
	Lighting - display	3	-	-	2	1
	Lighting - external	2	3	1	2	2
	Entertainment lighting	-	-	-	-	-
	Vertical transport	0	0	1	0	0
	Distributed catering	2	1	2	2	2
	Central catering	1	-	0	2	1
	Entertainment equipment	3	1	6	8	4
	Lab equipment	-	-	-	-	-
	Pool/leisure	-	-	-	-	-
	Other	14	1	-	4	4
Total		**83**	**89**	**82**	**84**	**86**
Unweighted base		*53*	*19*	*43*	*14*	*129*

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

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

Simplified end use category	BEES end use category	Non-electrical energy intensity (kWh/m^2 per year)				
		Fire/ ambulance stations	Police stations	Law courts	Prisons	**Emergency services (overall)**
Heating	Space heating	180	190	116	179	179
Hot water	Hot water	12	28	3	28	23
Other	Catering	1	-	1	2	1
	Pool/leisure	-	-	-	-	-
	Humidification	-	-	-	-	-
Total		**193**	**217**	**120**	**209**	**203**
Unweighted base[33]		*53*	*19*	*43*	*14*	*129*

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

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

Appendix D: Abatement potential

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

Measure type definitions

The measure type definitions are included in Table D.1. The research team determined these definitions based on their experience as energy specialists. The full list of abatement model measures, and their mapping into relevant measure groups, is also shown.

Table D.1: Measure type definitions

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

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

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

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

Fire/ambulance stations

In fire/ambulance stations there was an annual abatement potential of 80 GWh of electrical energy and 260 GWh of non-electrical energy (equivalent to 70 $ktCO_2e$ combined). This equates to a 35 per cent and 50 per cent reduction on energy consumption respectively. The capital cost to achieve this is £92m. The annual savings delivered would be £14m[34]. These figures are grouped according to measure type in Table D.2. The total abatement potential of the socially cost effective measure groups was 200 GWh, of which 60 GWh was electrical energy consumption and 140 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 120 GWh, of which 60 GWh was electrical energy consumption and 60 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.1).

Table D.2: Abatement opportunity data for fire/ambulance stations, 2014–15

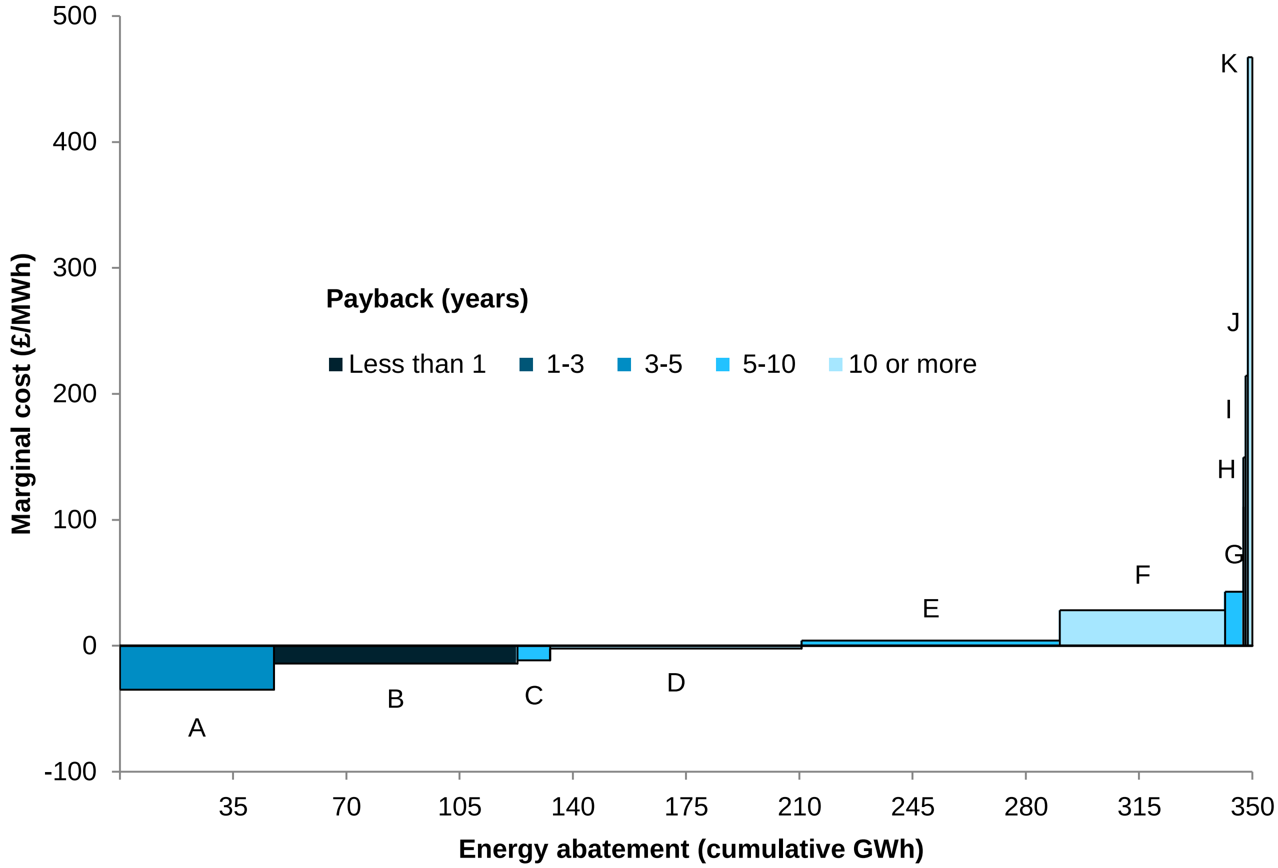
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electric-al energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	**Payback period (years)** [35]
Air conditioning and cooling	100	0	1	-	1	1,200	27
Building fabric	2,100	10	2	70	80	31,900	10
Building instrumentation and control	2,200	20	3	70	80	13,200	5
Building services distribution systems	100	0	1	-	1	4,200	12
Carbon and energy management	2,900	20	10	60	70	2,900	1
Hot water	300	2	1	9	10	1,600	4
Humidification	-	-	-	-	-	-	-
Lighting	4,500	10	50	-	50	13,900	3
Cooled storage	0	0	0	-	0	100	8
Small appliances	0	0	0	1	1	500	13
Space heating	1,500	9	3	50	50	18,800	13
Swimming pools	-	-	-	-	-	-	-
Ventilation	500	2	5	-	5	3,700	6
Total	**14,200**	**70**	**80**	**260**	**340**	**91,800**	‘’

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

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

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

Figure D.1: Marginal abatement cost curve for fire/ambulance stations, 2014–15



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

A Lighting [MAC: £-35 per MWh. GWh: 50]
B Carbon and energy management [MAC: £-14 per MWh. GWh: 70]
C Hot water [MAC: £-12 per MWh. GWh: 10]
D Building fabric [MAC: £-2 per MWh. GWh: 80]
E Building instrumentation and control [MAC: £4 per MWh. GWh: 80]
F Space heating [MAC: £28 per MWh. GWh: 50]
G Ventilation [MAC: £43 per MWh. GWh: 5]
H Refrigeration [MAC: £107 per MWh. GWh: 0]
I Small appliances [MAC: £148 per MWh. GWh: 1]
J Air conditioning and cooling [MAC: £214 per MWh. GWh: 1]
K Building services distribution systems [MAC: £470 per MWh. GWh:1]

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

Police stations

Police stations are based on fewer than 20 surveys so it should be noted that results for these sub-sectors are subject to higher uncertainty. In police stations there was an annual abatement potential of 220 GWh of electrical energy and 760 GWh of non-electrical energy (equivalent to 200 $ktCO_2e$ combined). This equates to a 38 per cent and 54 per cent reduction on energy consumption respectively. The capital cost to achieve this is £284m. The annual savings delivered would be £41m[36]. These figures are grouped according to measure type in Table D.3. The total abatement potential of the socially cost effective measure groups was 580 GWh, of which 150 GWh was electrical energy consumption and 430 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 210 GWh, of which 160 GWh was electrical energy consumption and 50 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.2).

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

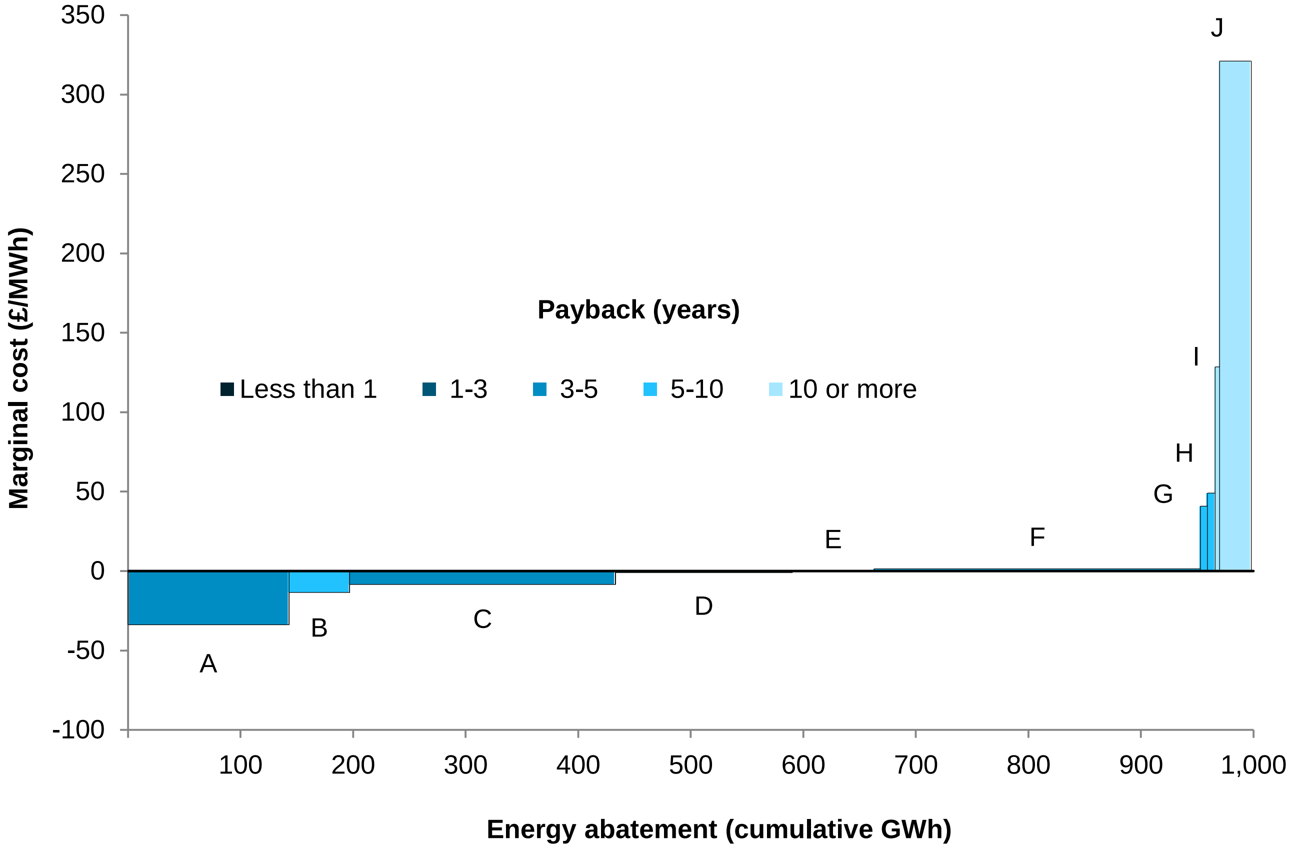
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	**Pay -back period (years)** [37]
Air conditioning and cooling	400	1	4	-	4	6,800	24
Building fabric	4,200	30	4	150	150	83,800	12
Building instrumentation and control	6,300	40	6	230	230	31,200	4
Building services distribution systems	700	2	7	-	7	3,400	4
Carbon and energy management	3,200	20	20	50	70	5,200	1
Hot water	1,400	10	1	50	50	7,100	5
Humidification	-	-	-	-	-	-	-
Lighting	13,900	40	140	-	140	43,600	3
Cooled storage	-	-	-	-	-	-	-
Small appliances	2,700	8	30	1	30	52,800	18
Space heating	7,600	50	5	280	290	47,100	7
Swimming pools	-	-	-	-	-	-	-
Ventilation	600	2	6	-	6	3,300	5
Total	**40,900**	**200**	**220**	**760**	**980**	**284,100**	‘’

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

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

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

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



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

A Lighting [MAC: £-34 per MWh. GWh:140]
B Hot water [MAC: £-13 per MWh. GWh: 50]
C Building instrumentation and control [MAC: £-8 per MWh. GWh: 230]
D Building fabric [MAC: £-1 per MWh. GWh: 150]
E Carbon and Energy Management . [MAC: £0 per MWh. GWh: 70]
F Space heating [MAC: £2 per MWh. GWh: 280]
G Ventilation [MAC: £41 per MWh. GWh: 6]
H Building services distribution systems [MAC: £49 per MWh. GWh: 7]
I Air conditioning and cooling [MAC: £129 per MWh. GWh: 4]
J Small appliances [MAC: £321 per MWh. GWh: 30]

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

Law courts

In law courts there was an annual abatement potential of 50 GWh of electrical energy and 70 GWh of non-electrical energy (equivalent to 30 ktCO_2e combined). This equates to a 48 per cent and 49 per cent reduction on energy consumption respectively. The capital cost to achieve this is £46m. The annual savings delivered would be £7m[38]. These figures are grouped according to measure type in Table D.4. The total abatement potential of the socially cost effective measure groups was 60 GWh, of which 30 GWh was electrical energy consumption and 40 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 50 GWh, of which 10 GWh was electrical energy consumption and 40 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.3).

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

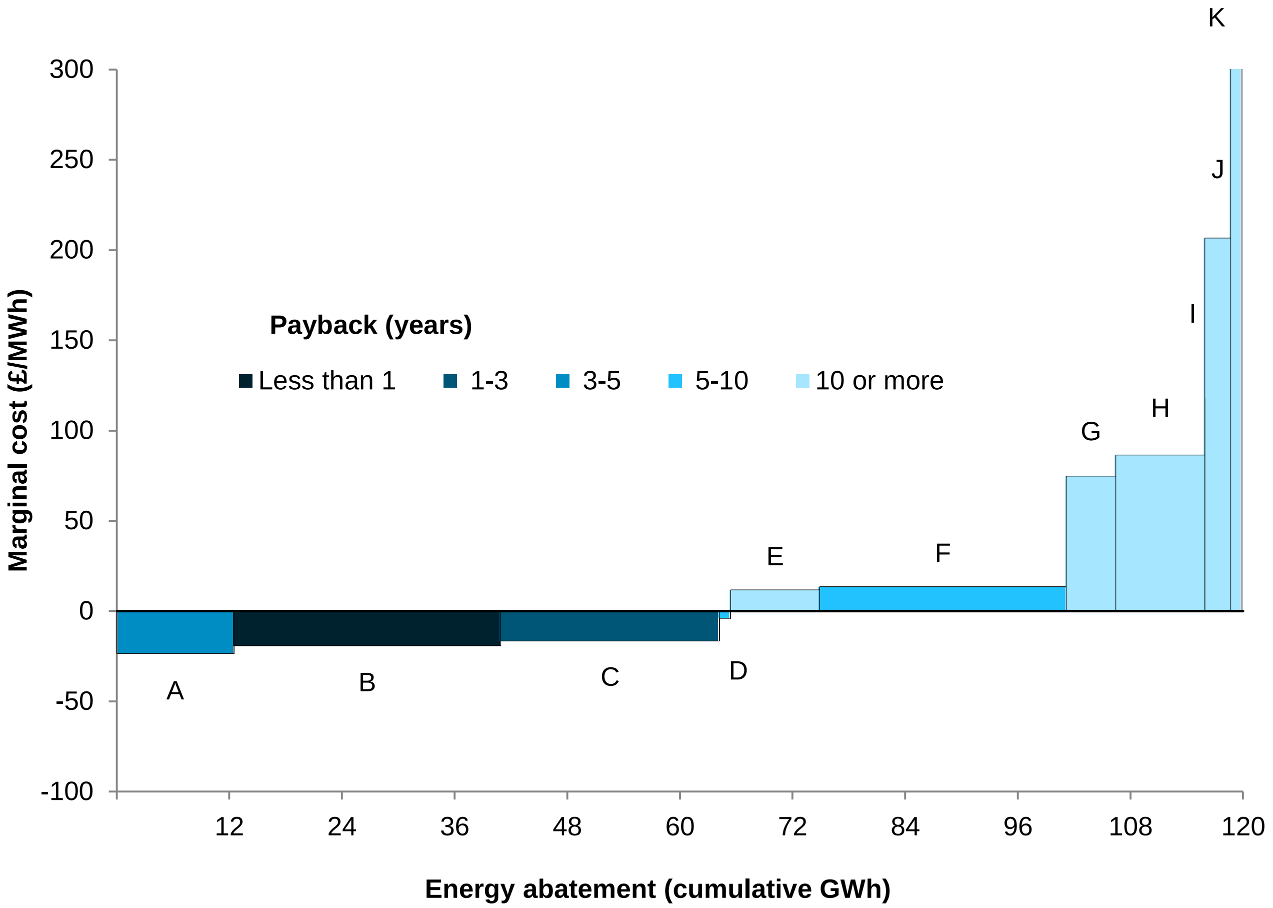
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving (ktCO_2e)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	**Payback period (years)** [39]
Air conditioning and cooling	500	1	5	-	5	5,400	13
Building fabric	300	2	1	8	9	5,200	9
Building instrumentation and control	900	5	4	20	20	2,400	2
Building services distribution systems	100	0	1	-	1	5,500	26
Carbon and energy management	1,400	6	10	20	30	1,100	1
Hot water	0	0	0	1	1	300	7
Humidification	-	-	-	-	-	-	-
Lighting	1,200	3	10	-	10	5,000	4
Cooled storage	0	0	0	-	0	0	8
Small appliances	300	1	3	0	3	3,700	12
Space heating	800	5	2	20	30	7,100	8
Swimming pools	-	-	-	-	-	-	-
Ventilation	900	3	9	-	9	10,000	7
Total	**6,500**	**30**	**50**	**70**	**120**	**45,700**	‘’

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

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

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

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



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

A Lighting [MAC: £-23 per MWh. GWh: 10]

B Carbon and Energy Management [MAC: £-19 per MWh. GWh: 30]

C Building instrumentation and control [MAC: £-17 per MWh. GWh: 20]

D Hot water [MAC: £-4 per MWh. GWh: 1]

E Building fabric [MAC: £12 per MWh. GWh: 9]

F Space heating [MAC: £14 per MWh. GWh: 30]

G Air conditioning and cooling [MAC: £75 per MWh. GWh: 5]

H Ventilation [MAC: £87 per MWh. GWh: 10]

I Refrigeration [MAC: £123 per MWh. GWh: 0]

J Small appliances [MAC: £207 per MWh. GWh: 3]

K Building services distribution systems [MAC: £703 per MWh. GWh: 1]

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

Prisons

Prisons are based on fewer than 20 surveys so it should be noted that results for these sub-sectors are subject to higher uncertainty. In prisons there was an annual abatement potential of 190 GWh of electrical energy and 530 GWh of non-electrical energy (equivalent to 150 $ktCO_2e$ combined). This equates to a 51 per cent and 58 per cent reduction on energy consumption respectively. The capital cost to achieve this is £192m. The annual savings delivered would be £32m[40]. These figures are grouped according to measure type in Table D.5. The total abatement potential of the socially cost effective measure groups was 430 GWh, of which 130 GWh was electrical energy consumption and 300 GWh was non-electrical energy consumption. This represents the energy savings that could be achieved through measures where the benefits outweigh the costs to society. The total abatement potential relating to measure groups with a private payback of 3 years or less was 400 GWh, of which 130 GWh was electrical energy consumption and 270 GWh non-electrical energy consumption. Within each group of measures there will be some measures that are more cost-effective than others for each sub-sector. Some cost effective measures will therefore be hidden within groups that are not considered cost effective as a whole (Figure D.4).

Table D.5: Abatement opportunity data for prisons, 2014–15

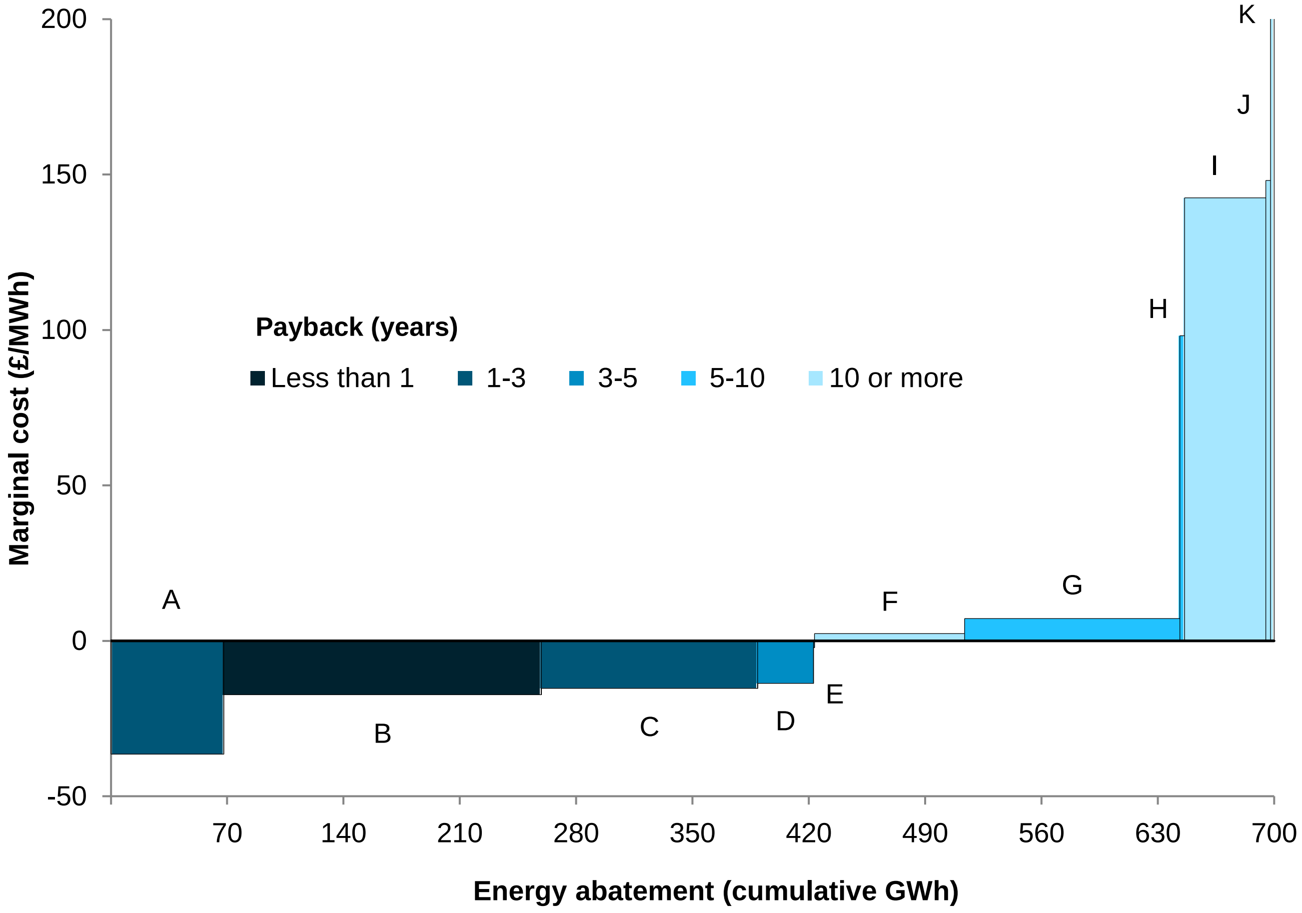
	Savings						
Measure type	Total annual energy bill saving (£ thousands)	Total annual greenhouse gas saving ($ktCO_2e$)	Total annual electrical energy savings (GWh)	Total annual non-electrical energy savings (GWh)	Total annual energy savings (GWh)	**Total capital cost of measure (£ thousands)**	**Payback period (years)** [41]
Air conditioning and cooling	200	1	3	-	3	2,400	12
Building fabric	2,300	20	-	90	90	46,800	10
Building instrumentation and control	4,400	30	10	120	130	10,400	2
Building services distribution systems	200	1	2	-	2	9,000	13
Carbon and energy management	8,300	40	50	150	190	6,600	1
Hot water	1,000	6	2	30	30	4,500	4
Humidification	-	-	-	-	-	-	-
Lighting	6,900	20	70	-	70	20,100	2
Cooled storage	100	0	1	-	1	200	3
Small appliances	100	1	1	2	3	2,400	12
Space heating	3,400	20	0	130	130	22,100	6
Swimming pools	-	-	-	-	-	-	-
Ventilation	5,000	20	50	-	50	67,000	7
Total	**31,800**	**150**	**190**	**530**	**710**	**191,600**	‘’

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

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

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

Figure D.4: Marginal abatement cost curve for prisons, 2014–15



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

A Lighting [MAC: £-36 per MWh. GWh: 70]
B Carbon and energy management [MAC: £-17 per MWh. GWh: 190]
C Building instrumentation and control [MAC: £-15 per MWh. GWh: 130]
D Hot water [MAC: £-14 per MWh. GWh: 30]
E Refrigeration [MAC: £-2 per MWh. GWh: 1]
F Building fabric [MAC: £2 per MWh. GWh: 90]
G Space heating [MAC: £7 per MWh. GWh: 130]
H Air conditioning and cooling [MAC: £98 per MWh. GWh: 3]
I Ventilation [MAC: £143 per MWh. GWh: 50]
J Small appliances [MAC: £148 per MWh. GWh: 3]
K Building services distribution systems [MAC: £669 per MWh. GWh:2]

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

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