Department for Energy Security & Net Zero

Non-domestic Building Stock in England and Wales

Supplementary Report: Large Off Gas Grid Premises

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Executive Summary

As part of the Non-domestic Building Stock project a detailed analysis was undertaken of large (>1000 m^2) off-gas grid buildings to understand the specific challenges associated with decarbonising these buildings. These premises are referred to as LOGG premises.

The population of LOGG premises was quantified for the first time. A total of 5,811 met the definition, but this does not mean that this is all such premises that may exist, only those that could be identified using the available data and the methods used in this work. Therefore, as there is no definitive list of LOGG premises, it is not possible to accurately quantify the percentage of such premises that have been identified as being LOGG. The majority of the identified LOGG population (the LOGG population, henceforth) is in the Factory and Warehouse activity classes (62% combined) with smaller numbers in Shop and Office (38% combined). For the floor space, the split was 68% and 32%, respectively. No statistically significant differences were found between floor areas of LOGG premises in the Shop and Office activity classes and those of similar size connected to the gas grid. The area of premises in the Factory class is smaller in LOGG, but larger in Warehouse.

LOGG premises are distributed throughout England and Wales with the largest concentrations of floorspace in Greater London (14 m² per hectare) and the East of England (2 m² per hectare). 18% of LOGG floor space has been constructed since 2011, more than half of this space is in the Warehouse activity class. Energy Performance Certificate coverage is similar in LOGG and non-LOGG populations apart from in the Warehouse activity class where LOGG premises are more likely to have EPC certificates which may reflect the tendency for these premises to have been constructed more recently.

Remote (telephone) surveys were undertaken with a sample of premises to gain a more detailed understanding of LOGG premises. On-site verification surveys were undertaken for a small number of remote survey premises to assess the robustness of the remote survey process. Deep-dive probe audits were undertaken for a small number of sites to supplement this. In four instances (out of eight) occupiers/ owners stated that the costs associated either with heat decarbonisation, upgrading fabric, or the hang over effect of historic underinvestment in properties, were becoming ever more material considerations in their property strategies. In many cases, associated costs were seen as prohibitive to continuing to occupy the same buildings over the longer term.

It was possible for contact details to be attached to database records for 31% of the population, this was the pool from which survey participants were recruited. The original aim for proportional representation of the four largest activity classes (Factory, Warehouse, Office, Shop) was relaxed due to challenges in recruitment. This resulted in the Factory activity class being over-represented relative to Shop and Office. In total it was possible to recruit 63 remote survey participants compared with the original target of 200.

Surveyed premises were likely to be older and more rural than the overall population, this may be due to contact details being more likely to be attached for older, more established premises.

For this reason, although the majority of surveyed premises indicated that they were in control of their premises and able to make fundamental investment decisions, this may not be indicative of the population as a whole.

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Purpose

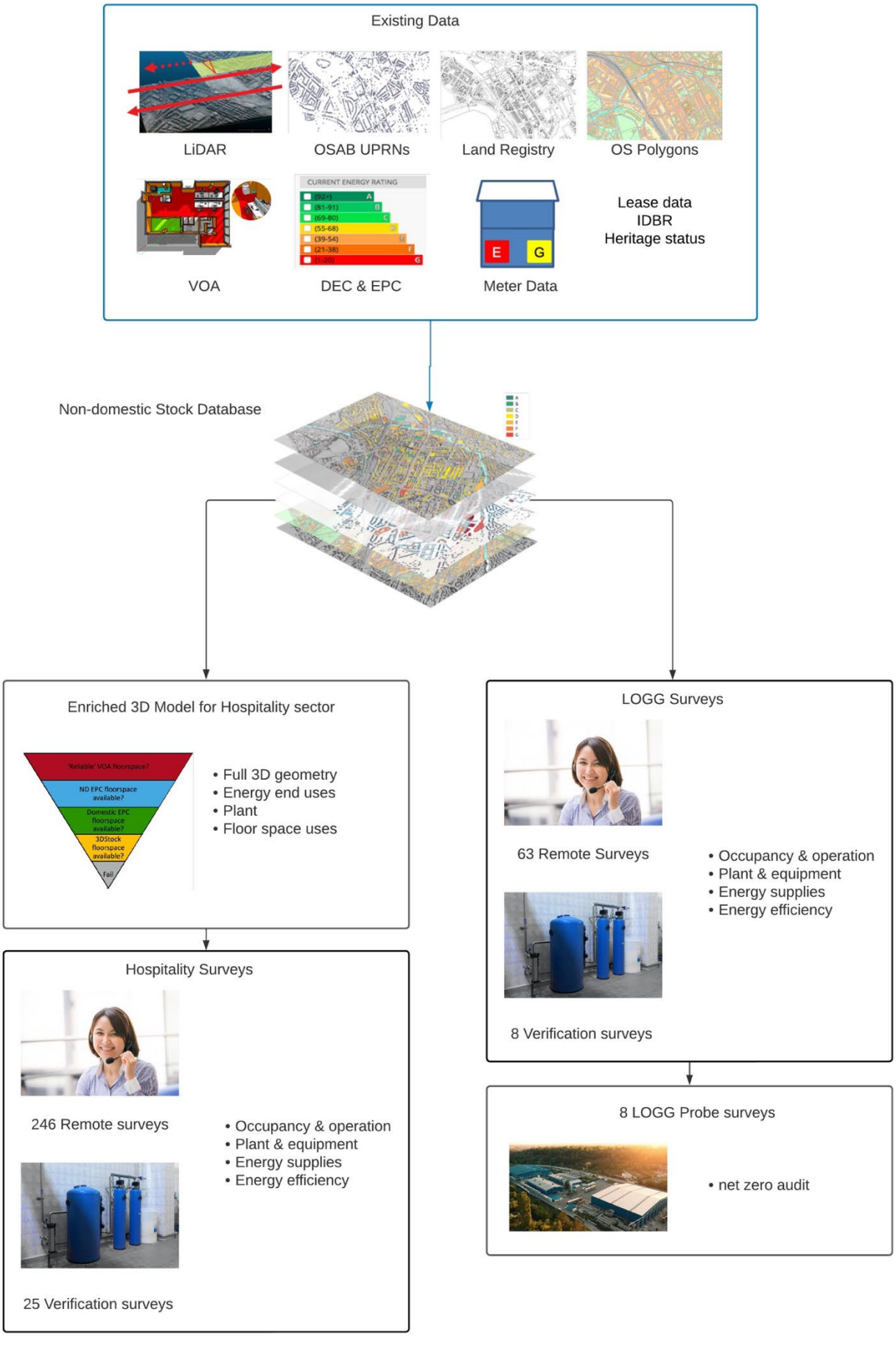
This report forms part of the response to the Non-domestic Building Survey commissioned by the Department for Business, Energy and Industrial Strategy (BEIS). Part 1 of the response sets out a description of the Non-domestic Building Stock in England and Wales, Part 2 focusses on the energy consumption characteristics of the stock and Part 3 reports a more detailed pilot study which was undertaken for the Hospitality activity class. This document, reports a more detailed analysis of the stock of large premises (>1000 m²) not connected to the gas grid. This work was commissioned in order to update understanding of these buildings and inform whether further work with large off gas grid buildings should be conducted or whether probe surveys should be adopted for other non-domestic activity classes.

This document begins with a description of the stock of large off gas grid (LOGG) buildings premises in England and Wales and details the survey methods and results used to gain a greater insight into these. The survey methods tested and used with the LOGG premises comprised:

- Remote surveys. These were principally delivered via Computer Assisted Telephone Interviewing (CATI) tested as a cost-effective means to capture data from a large sample. They primarily filled in gaps in the existing secondary data but also verified some secondary data.
- On-site verification surveys. These served the same purposes as the remote surveys but were also used to assess the accuracy of the data collected by the remote survey through physical inspection of the premises and their building(s), meters and equipment on-site. The on-site verification surveys produced an energy end use breakdown for each fuel type used, albeit with an accuracy limited by the time available on-site and for analysis for each survey.
- Probe surveys. Full audits of all the energy used in the building premises and identification of opportunities to achieve a net zero energy efficiency target. The audits provided a robust analysis of individual cases set within a broader narrative of how the premises are being used, the stakeholders involved (occupiers, facilities management (FM) teams, landlords/owners, etc.) and their interactions for energy management, maintenance, and improvement measures.

Figure 1 provides a schematic of the overall method applied in this work.

Figure 1 Overview of methods



Defining Large Off Gas Grid Buildings

The project specification defines these as ‘buildings’ of 1000 m² or larger, not connected to the gas grid. Whilst this seems like a simple and clear-cut definition, it can be difficult to implement in practice.

1000 m² floorspace

The primary data source for identifying non-domestic activity is the Valuation Office Agency (VOA) data, which include all premises that pay business rates and is thus a data source that covers almost all of the stock across England and Wales. However, it represents premises, which do not necessarily equate to buildings. Many premises may occupy one building (as is the case with an office block with multiple tenants). In such a situation, the floor area of the building might total in excess of 1000 m² whilst each individual office premises might only be say 250 m². In other cases, premises such as industrial sites might be represented by a single premises which occupies multiple buildings. The sum of the floorspace of these buildings might exceed 1000 m² whilst the floorspace of the individual buildings might fall below the threshold. Therefore, the definition is very dependent upon how a single building is defined and handled. At this stage, (and for this initial sample building phase) we have used premises rather than buildings to make the assessment.

A related issue arises due to the nature of the VOA data and how business rates are calculated. Most of the premises are given a valuation based on the activity and detailed measurements of floorspace to calculate business rates. A small number of non-domestic activities are not subject to rates, however, including places of worship, most agricultural buildings and properties of the Crown, such as some central government offices. These would currently be excluded from these samples due to this limitation of the VOA data, but they could be included in future work. Other types of premises are rated, but their floor areas are not measured: these include – amongst others – hospitals, libraries, public houses and hotels (See Annex 1 – Understanding ‘floor areas’ in the Valuation Office Agency data, for a fuller explanation). In the entirety of the VOA data for England and Wales, there are approximately 177,000 premises that do not have a floor area record. These premises constitute 269 CaRB3 activities spread across all sixteen CaRB3 classes. Not all of these 177,000 premises are LOGG premises, but some of them may be but would not make it into this current interpretation of LOGG, because they have no floor area records to meet the 1000 m² threshold.

Rather than trying to fill in the gaps left by the above issues, we have used VOA floorspace data, combined with Ordnance Survey AddressBase (OSAB) data, to provide the data ‘spine’ from which to draw the samples for LOGG.

Unlike the other reports that form this tranche of research into the non-domestic building stock of England and Wales, the floor area metric for the LOGG premises is the Valuation Office Agency’s ‘floor space area’, which has not been adjusted to gross internal area (GIA). The reasoning for this is that the remote surveys, which formed part of the project, would need

information about the premises as the occupiers/respondents would experience them and that this would not involve any normalisation of areas to GIA.

Off-Gas

Several datasets exist that can be used to identify off-gas locations, but none of them are perfect.

The first of these is the VOA data which lists fuel used as a series of codes. Some VOA records have null values for this field. It is also unknown how often these fields are updated or whether they influence the rateable value.

The second source of data is the Centre for Sustainable Energy (CSE) Open Data product which lists all Off-Gas postcodes. This work is based upon analysis using both domestic and non-domestic meter data at postcode level which identified those postcodes where no gas meters were present, in 2017. In particular, CSE note that "The data shows only those postcodes with absolutely no gas connection, domestic or non-domestic. That means that postcodes where no homes are on gas, but just one business is on gas, will not be included". Using these postcodes, it is possible to join the data to an address dataset (such as the VOA records) in order to set a flag as to whether premises are inside or outside of an 'Off-gas postcode'. Some premises that are not in an 'Off-gas' postcode may also not be connected to the gas grid through choice. As a result, the estimate of LOGG is likely to be an underestimate for these cases. Quantifying this is not straightforward.

A third dataset, the actual gas meter data, can be used to help enforce these tests. Any address that has an MPRN matched to it is effectively connected to the gas grid. By running a query that also excludes these addresses it is possible to enforce this exclusion rule. However, a lack of match is not a definitive flag for a lack of gas meter. Non-domestic energy meters are particularly difficult to address match and so a lack of match may simply be a failure for the address matching to work. For this reason, this dataset is treated as an exclusion flag rather than an inclusion flag.

From this VOA and OSAB 'data spine', along with the other data tables mentioned above, the records were filtered to produce the samples as outlined in the following sections.

LOGG population

The following steps were taken to produce the population:

- Select only premises with "floor_space_area" >= 1000
- Where OSAB classification primary code = "C" (for commercial)
- Where country is England or Wales
- Where the address is a postal address
- Where the OSAB and VOA combination indicates that the address is a building (rather than say an advertising hoarding or a car park, for example)

- Where the postcode that the address falls within is classified as an “Off-gas postcode”
- Where there is no gas meter associated with the OSAB UPRN
- Where the VOA fuel used is not ‘Gas’ (mains gas) or ‘Electricity’

For the remote and verification surveys this population was then address matched to Inter-departmental Business Register (IDBR) records in an attempt to identify Standard Industrial Classification (SIC) codes and IDBR addresses. This process produced low match rates with around 54% of the LOGG population failing to match to IDBR.

The LOGG population as a whole, identified using the criteria set out above (i.e. this is unlikely to be all such premises in the stock), totals 5,811 premises. Some of these may be large premises within the same building, as is the case with some office space in the City of London for example. When these are aggregated by the CaRB3 classification, Warehouses represent the largest percentage share, both in terms of counts and floorspace (30% and 35% respectively), followed by Factories (27% and 29%). After that, Shops (18%, 14%) and Offices (17%, 16%) take the third and fourth places depending on whether you order by counts or floorspace. However, this ranking is influenced by the fact that floorspace is not measured for certain activities in the VOA database meaning that ‘Arts and Leisure’, Hospitality and ‘Agriculture, Countryside, Animals’ might feature more strongly if floorspace figures were available. When the deeper analysis of the Hospitality sector was carried out this revealed many more premises increasing the percentage share of Hospitality LOGG premises from 1% to 17%. See Annex 1 – Understanding ‘floor areas’ in the Valuation Office Agency data, for a fuller explanation of this.

Table 1 LOGG Population counts and floorspace, in square metres, by CaRB3 class

CaRB3 class	Number of Premises	Total floorspace	Average floorspace	Q1 floorspace	Median floorspace	Q3 floorspace
Agriculture, Countryside, Animals	178	364,448	2,047	1,164	1,388	1,867
Arts and Leisure	29	63,790	2,200	1,345	1,714	2,930
Community	17	75,281	4,428	1,257	1,677	4,340
Education	19	36,436	1,918	1,256	1,568	1,875
Emergency	19	88,514	4,659	1,971	2,833	7,924
Excluded	12	35,484	2,957	2,211	2,592	2,711
Factory	1,565	6,188,229	3,954	1,314	1,935	3,573
Health	4	6,914	1,729	1,540	1,779	1,968
Hospitality	30	41,798	1,393	1,116	1,261	1,522
Miscellaneous	7	15,996	2,285	1,664	1,990	2,674
Office	1,003	3,433,679	3,423	1,247	1,729	3,207
Shop	1,046	3,024,364	2,891	1,315	1,855	3,274
Sport	76	107,954	1,420	1,113	1,211	1,488
Transport	58	243,380	4,196	1,339	1,751	3,653
Warehouse	1,748	7,547,327	4,318	1,427	2,253	4,273
All	**5,811**	**21,273,597**	**3,661**			

Table 2 IDBR match rates, by floorspace in square metres

IDBR source	Number Premises	Total floorspace	Average floorspace	Q1 floorspace	Median floorspace	Q3 floorspace
Enterprises pt2	1,058	3,640,625	3,441	1,280	1,924	3,481
local units	1,596	7,013,925	4,395	1,377	2,098	4,573
no match to IDBR	3,153	10,610,220	3,365	1,282	1,808	3,145
Sum	**5,807**	**21,264,770**				

IDBR matches were low for the LOGG data with around 54% of the count and 49% of the floorspace not making a match to IDBR at all. Matches to the IDBR 'local units' data (27% by count) were stronger than the matches to the enterprises dataset[1] (18% by count). Matches were designed to focus on business name. Since some of the enterprise dataset may represent the 'holding company' name this may explain why the address match rates were more successful for the 'local units' compared to the 'enterprise' dataset.

Using the VOA data on the age of the premises' building(s), it is possible to aggregate the data by VOA age code. Nearly 70% of the LOGG premises were built after 1971 according to the VOA age code data:

Table 3 LOGG population by age and size (floorspace m²)

VOA Age	No of Premises	Total m²	Average m²	Q1 m²	Median m²	Q3 m²
Pre-1900	293	728,942	2,488	1,205	1,544	2,620
1900 – 1918	81	279,783	3,454	1,192	1,674	2,569
1919 – 1939	233	785,183	3,370	1,315	1,947	3,912
1940 – 1954	356	1,232,044	3,461	1,446	2,220	3,670
1955 – 1964	445	1,429,713	3,213	1,280	1,882	3,572
1965 – 1970	491	1,616,752	3,293	1,302	1,814	3,191
1971 – 1980	639	2,303,164	3,604	1,323	1,937	3,653
1981 – 1990	654	2,248,054	3,437	1,325	1,956	3,552
1991 – 2000	650	2,859,998	4,400	1,348	2,052	4,401
2001 – 2010	943	3,616,437	3,835	1,308	1,869	3,602
2011 – 2020	804	3,815,586	4,746	1,422	2,086	4,253
No age code	222	357,939	1,612	1,135	1,323	1,762
All	**5,811**	**21,273,597**				

[1] The main units in the IDBR are enterprises which are an economic unit, and include partnerships, not-for-profit, public enterprises (e.g. the BBC) and sole traders. These are slightly different to companies which are legal units and are registered at Companies House. The IDBR also has details of the local units relating to the enterprises; for example the local units within the enterprise for Tesco would include stores, offices and distribution centres. The data includes employment and addresses at local unit level, but not turnover.

The number of storeys is also available in the VOA data. This shows that 67% of the premises are less than 3 storeys, as demonstrated by Table 4.

Table 4 LOGG population counts and floorspace (m²), by number of storeys

VOA storey count (grouped)	No of Premises	Total m²	Average m²	Q1 m²	Median m²	Q3 m²
0 storey	74	394,066	5,325	1,339	2,060	4,246
1 storey	2,122	6,649,216	3,133	1,303	1,859	3,121
2 storeys	1,672	6,355,583	3,801	1,337	1,964	3,799
3 storeys	352	1,439,003	4,088	1,389	2,150	4,130
4 storeys	206	918,446	4,458	1,466	2,447	4,693
5 storeys	112	475,034	4,241	1,272	1,956	3,977
6 storeys	101	463,050	4,585	1,203	1,470	3,484
7 – 10 storeys	223	881,627	3,953	1,290	1,787	3,223
11 – 20 storeys	161	525,097	3,261	1,248	1,487	2,884
21 – 30 storeys	19	36,456	1,919	1,135	1,209	1,329
31 – 40 storeys	8	22,604	2,825	1,188	2,115	3,151
41 – 50 storeys	27	66,143	2,450	1,097	1,202	1,608
51 storeys and above	1	4,524	4,524	4,524	4,524	4,524
No storey count recorded	733	3,042,749	4,151	1,271	1,838	3,698
Total	**5,811**	**21,273,597**				

Table 5 LOGG population by coverage of CEPC and DEC

% of premises covered by a CEPC or DEC	CaRB3 class	Number premises	Number of CEPCs	Number DECs	Min cert year	Max cert year	Avg CEPC rating	Avg CEPC grade	Avg DEC rating	Avg DEC grade	Q1 CEPC rating	Median CEPC rating	Q3 CEPC rating
2.25%	Agriculture, Countryside, Animals	178	3	1	2009	2021	58	C	88	D	50	65	70
17.24%	Arts and Leisure	29	4	1	2009	2021	118	E	78	D	59	101	160
35.29%	Community	17	3	3	2012	2021	53	C	64	C	33	42	68
31.58%	Education	19	3	3	2014	2021	45	B	60	C	43	48	49
57.89%	Emergency	19	1	10	2008	2021	84	D	103	E	84	84	84
16.23%	Factory	1,565	247	7	2009	2021	86	D	1,502	G	61	79	101
75.00%	Health	4	1	2	2017	2021	43	B	64	C	43	43	43
23.33%	Hospitality	30	7		2013	2021	64	C			61	66	73
0.00%	Miscellaneous	7											
17.75%	Office	1,003	127	51	2007	2021	75	C	96	D	53	77	93
33.08%	Shop	1,046	342	4	2008	2021	62	C	96	D	35	58	77
26.32%	Sport	76	16	4	2011	2021	55	C	71	C	39	51	62
12.73%	Transport	55	6	1	2012	2021	82	D	102	E	46	76	122

% of premises covered by a CEPC or DEC	CaRB3 class	Number premises	Number of CEPCs	Number DECs	Min cert year	Max cert year	Avg CEPC rating	Avg CEPC grade	Avg DEC rating	Avg DEC grade	Q1 CEPC rating	Median CEPC rating	Q3 CEPC rating
16.43%	Warehouse	1,747	279	8	2007	2021	68	C	105	E	47	65	82
		5,807	**1,039**	**95**									

Table 6 LOGG population by coverage of CEPC and DEC including floor area

% of premise covered by a CEPC or DEC	CaRB3 class	Number premises	Number of CEPCs	Number DECs	Min cert year	Max cert year	Avg ndepc floor area	Q1 ndepc floor area	Median ndepc floor area	Q3 ndepc floor area	Avg nddec total floor area	Q1 nddec total floor area	Median nddec total floor area	Q3 nddec total floor area
2.25%	Agriculture, Countryside, Animals	178	3	1	2009	2021	1,516	652	845	2,044	566	566	566	566
17.24%	Arts and Leisure	29	4	1	2009	2021	2,633	2,292	2,935	3,276	1,474	1,474	1,474	1,474
35.29%	Community	17	3	3	2012	2021	777	635	927	995	2,274	1,679	2,026	2,746
31.58%	Education	19	3	3	2014	2021	973	775	1,360	1,364	2,730	1,435	1,766	3,060
57.89%	Emergency	19	1	10	2008	2021	2,576	2,576	2,576	2,576	4,756	2,129	3,284	5,744
0.00%	Excluded	12												
16.23%	Factory	1,565	247	7	2009	2021	2,153	765	1,335	2,536	1,577	1,284	1,419	1,462
75.00%	Health	4	1	2	2017	2021	3,294	3,294	3,294	3,294	3,938	3,059	3,938	4,818
23.33%	Hospitality	30	7		2013	2021	1,327	1,013	1,354	1,781				
0.00%	Misc	7												

% of premise covered by a CEPC or DEC	CaRB3 class	Number premises	Number of CEPCs	Number DECs	Min cert year	Max cert year	Avg ndepc floor area	Q1 ndepc floor area	Median ndepc floor area	Q3 ndepc floor area	Avg nddec total floor area	Q1 nddec total floor area	Median nddec total floor area	Q3 nddec total floor area
17.75%	Office	1,003	127	51	2007	2021	14,056	1,601	3,278	11,843	5,736	1,921	3,195	7,167
33.08%	Shop	1,046	342	4	2008	2021	2,787	1,297	1,779	3,170	2,251	935	1,079	1,952
26.32%	Sport	76	16	4	2011	2021	1,279	398	1,227	1,492	1,648	1,419	1,759	1,988
12.73%	Transport	55	6	1	2012	2021	1,319	418	720	1,252	2,922	2,922	2,922	2,922
16.43%	Warehouse	1,747	279	8	2007	2021	5,490	1,125	1,778	4,212	2,080	1,497	1,742	2,499
		5,807	**1,039**	**95**										

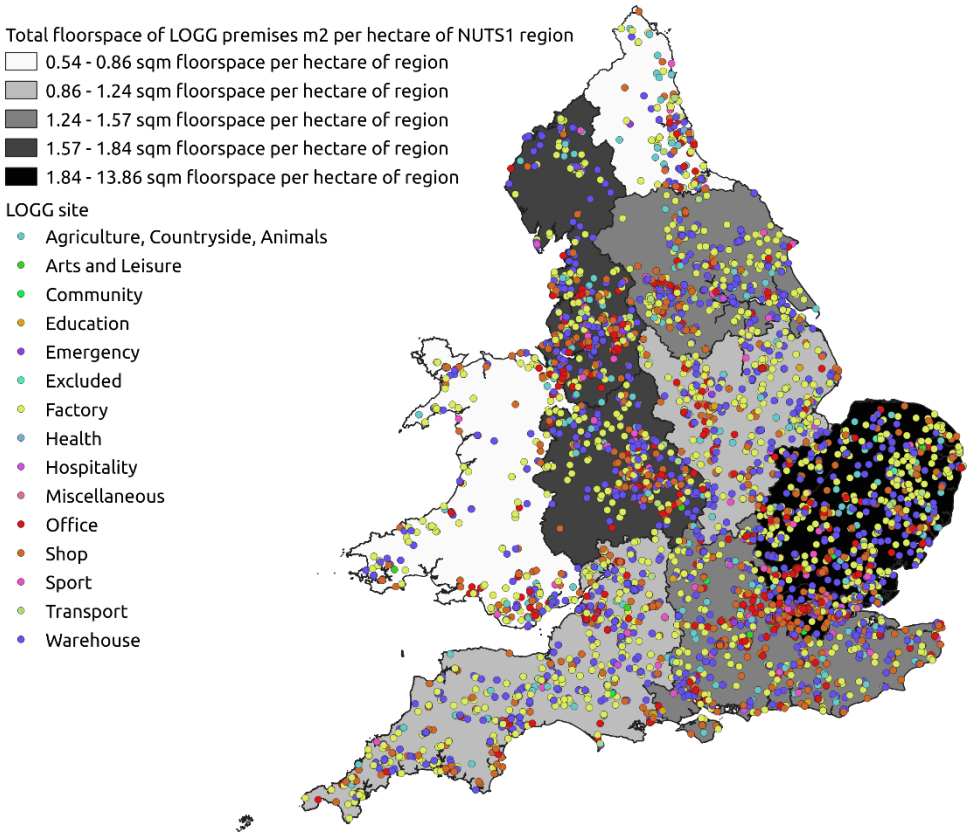
The two tables above can be thought of as one table split into two. Both take the LOGG sample and match the records through to the most recent EPC or DEC that is available. This allows us to identify the statistics associated with the EPC/DEC grade, maximum and minimum years of the certificate and so on.

The second split of the table shows the same data but then includes aggregate floor areas from EPCs and DECs when these are available.

Geographical Distribution

When we map the location of the LOGG premises it is clear that they are spread across England and Wales. The map below (Figure 2) shows the actual sites as coloured dots (depending upon the CaRB3 activity). The choropleth map shows the total floorspace of LOGG premises per region normalised by the size of the region in hectares (LOGG floorspace per hectare). This shows that The East of England and Greater London have the largest scores by this measure with nearly 14 m² per hectare in Greater London and 2 m² per hectare in the East of England.

Figure 2 Geographical distribution of LOGG buildings



Using the rurality description, around 57% of premises (61% of LOGG floorspace) are LOGG premises in some type of urban setting, as shown in Table 7.

Table 7 Rurality of LOGG buildings, counts and floorspace area (m²).

Rurality description	Number of Premises	Total floorspace	Average floorspace	Q1 floorspace	Median floorspace	Q3 floorspace
Rural hamlets and isolated dwellings	1,061	3,324,872	3,134	1,277	1,831	3,033
Rural hamlets and isolated dwellings in a sparse setting	87	255,043	2,932	1,254	1,678	3,598
Rural town and fringe	326	1,446,346	4,437	1,378	1,954	4,328
Rural town and fringe in a sparse setting	44	93,824	2,132	1,223	1,735	2,321
Rural village	872	2,833,817	3,250	1,256	1,845	3,086
Rural village in a sparse setting	92	236,770	2,574	1,231	1,623	2,848
Urban city and town	1,814	7,876,686	4,342	1,372	2,010	4,084
Urban city and town in a sparse setting	14	50,188	3,585	1,326	2,295	5,553
Urban major conurbation	1,442	4,862,950	3,372	1,278	1,838	3,529
Urban minor conurbation	59	293,099	4,968	1,510	2,406	5,194
Total	**5,811**	**21,273,597**	**3,661***			

* The average floorspace across all LOGG premises

Reliability of Off Gas Grid status assessment

When premises defined as LOGG were contacted, as part of the remote and verification enquiries, a number of them reported themselves as being on the gas grid or using gas which disqualified them from the sample. There could be a number of reasons for this:

- VOA data fields might be out of date (e.g. fuel used may not be updated very regularly).
- The VOA fuel used field simply shows fuel used. There is no field that declares the site ‘Off gas’ and we are interpolating this from the fact that fossil fuel, other than mains gas, is in use instead of gas or electricity.
- The lack of presence of a gas meter matched to the address (MPRN) does not mean that there is no gas meter. It could instead be a failure of the address matching.
- When it has been used, the CSE Off-gas postcode data may be misleading or provide incorrect information.

To overcome these issues there are a number of options which could be explored in future phases of this project:

- Use of EPC data to bolster the premises selection (but this would bias the sampling towards premises that had an EPC).
- Request gas network maps from the suppliers to accurately plot locations where gas pipework is in close proximity to premises.
- Use Renewable Heat Initiative (RHI) data. This has an ‘off gas’ flag in the data and would help to identify premises that are off the gas grid. However, this would bias a sample towards premises that had applied for RHI.

LOGG premises versus non-LOGG premises

Apart from not being connected to the natural gas grid, are the Large Off-gas Grid (LOGG) premises different from the populations of otherwise similar premises in the building stock? To answer this question, comparative data have been analysed for the populations of Shops, Offices, Factories and Warehouses that have floor space areas greater than 1,000 m².

LOGG and non-LOGG floor areas

The first of these analyses looks at floor areas and uses a Mann-Whitney non-parametric statistical method to identify where two groups of data are from statistically different populations; in this case, whether LOGG premises are different to other similar non-LOGG premises. The statistical summary and results for this test are shown in Table 8, where a p-value < 0.05 indicates that the populations are different.

Table 8 Summary statistics for LOGG and non-LOGG premises (all >= 1,000 m²), with Mann-Whitney significance test, per CaRB3 class.

CaRB3 class	Shop		Office		Factory		Warehouse	
LOGG status	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG	LOGG
count	17,712	1,046	11,921	1,003	25,088	1,565	26,908	1,747
	Floorspace area (m²)							
mean	2,953	2,891	3,152	3,423	4,331	3,954	4,020	4,318
std dev	3,284	2,829	4,962	4,952	8,321	7,466	7,639	7,940
min	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,001
Q1	1,344	1,315	1,251	1,247	1,343	1,314	1,342	1,427
median	1,876	1,855	1,754	1,729	2,022	1,935	1,997	2,250
Q3	3,312	3,274	2,947	3,207	3,904	3,573	3,695	4,271
max	131,941	32,945	100,828	55,549	308,832	146,062	231,563	141,047
	Mann-Whitney p-value							
	0.4157		0.4223		0.01011		7.71E-07	

For Factories and Warehouses, despite the statistical difference in floor areas, resulting from whether they are on the gas grid or not, the actual differences in the means and medians per CaRB3 class are moderately small (not greater than +/- 13%). It is probably the difference in the spread of the data, observing the maximum values, that accounts for the statistical differences. However, as total delivered energy use is closely aligned with floor area, the differences may be relevant to the development of policy. The distributions of floor areas are shown in the following charts (Figure 3 to Figure 6). Note the various scales on the chart axes.

Figure 3 Distribution of floor space area for LOGG and non-LOGG Shop premises.

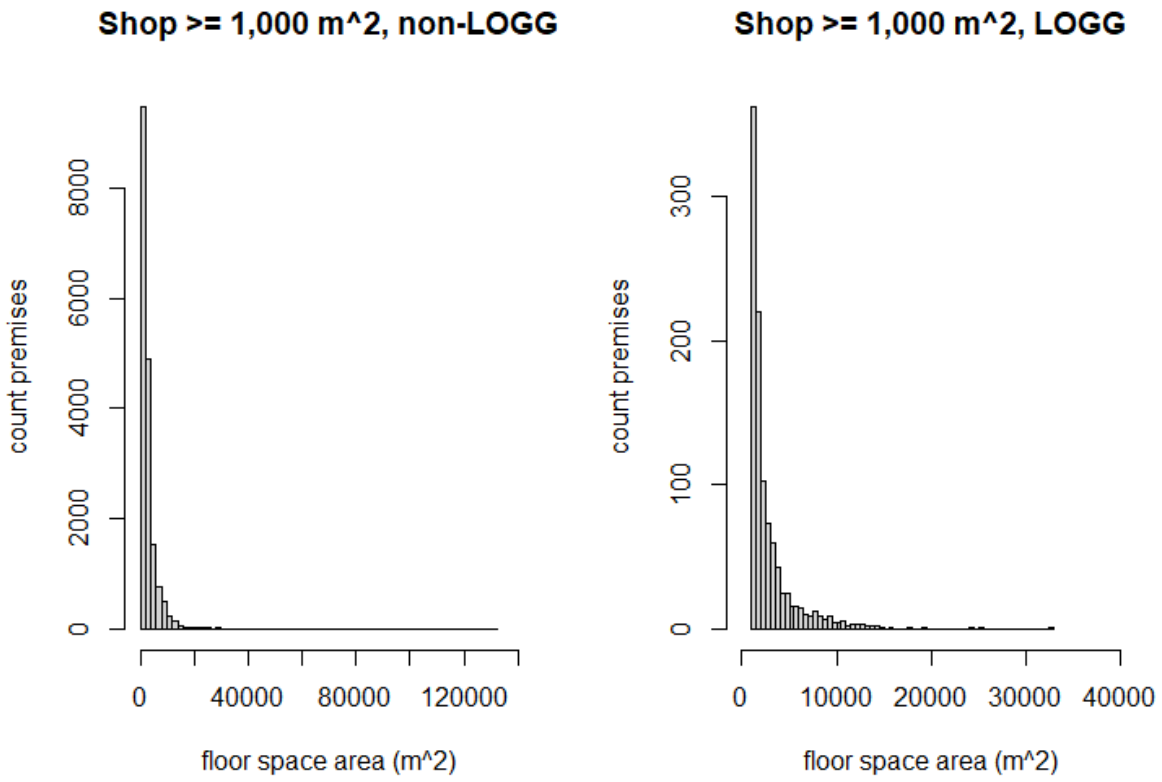


Figure 4 Distribution of floor space areas for LOGG and non-LOGG Office premises.

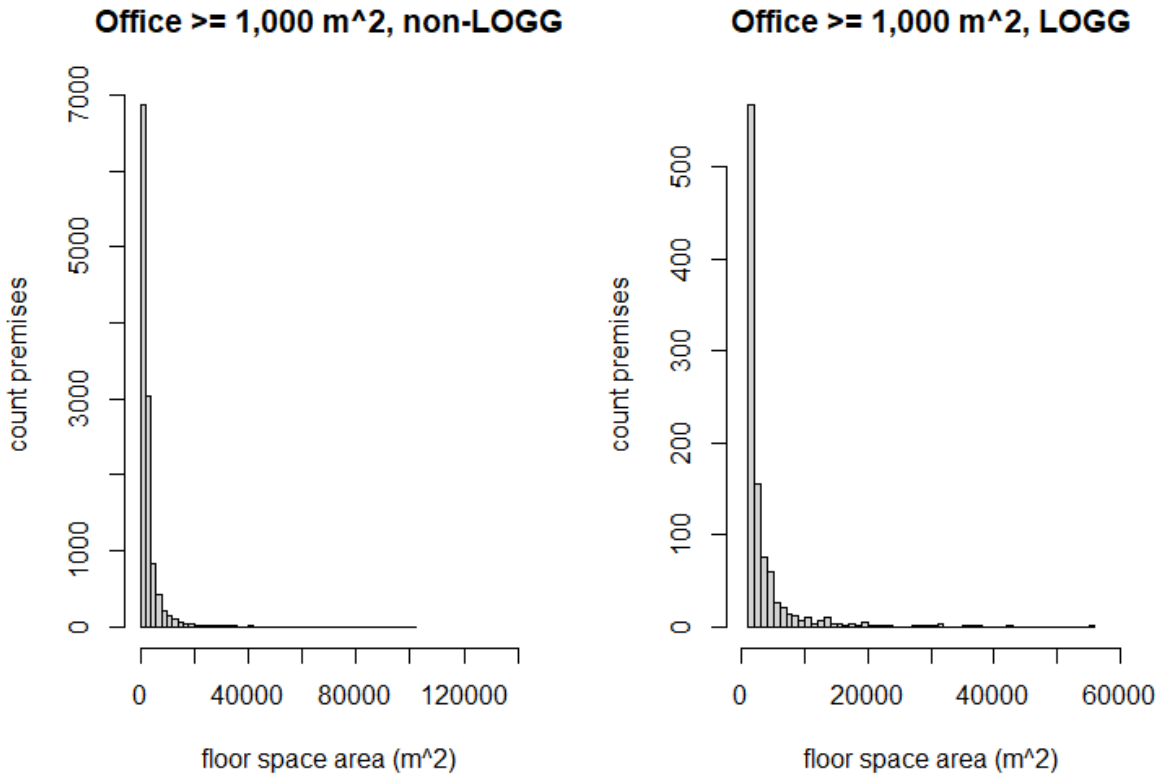


Figure 5 Distribution of floor space areas for LOGG and non-LOGG Factory premises.

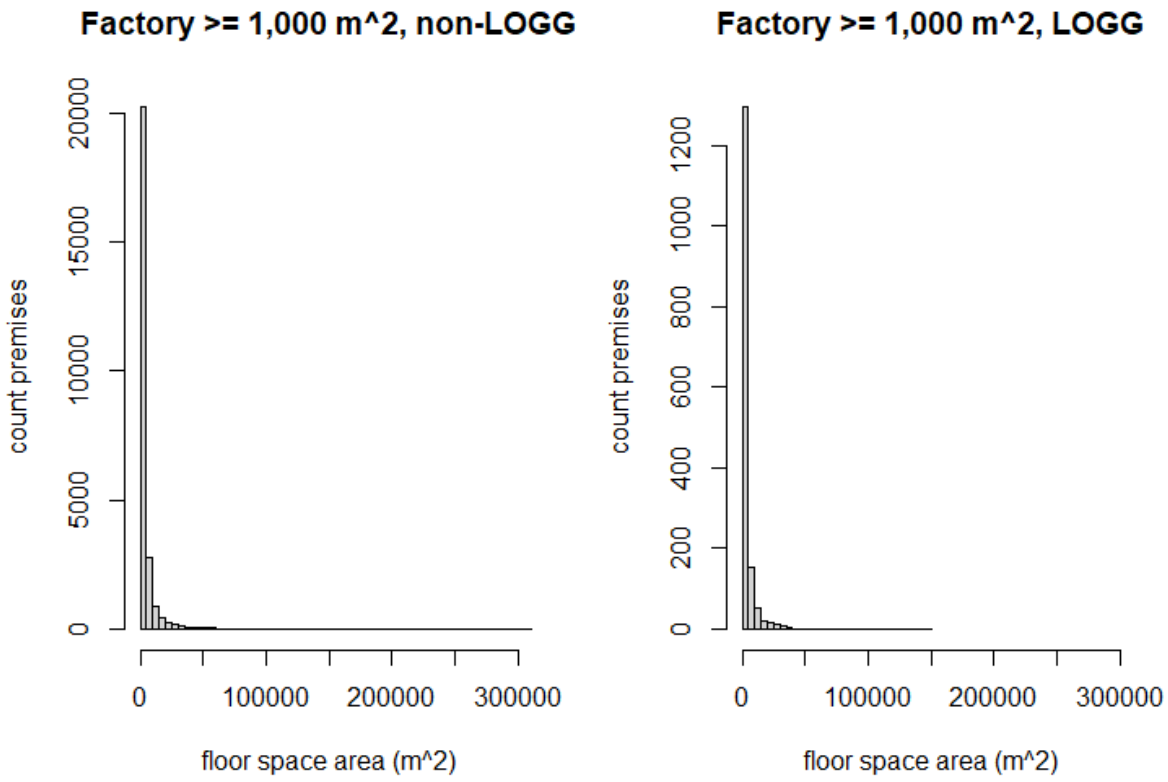
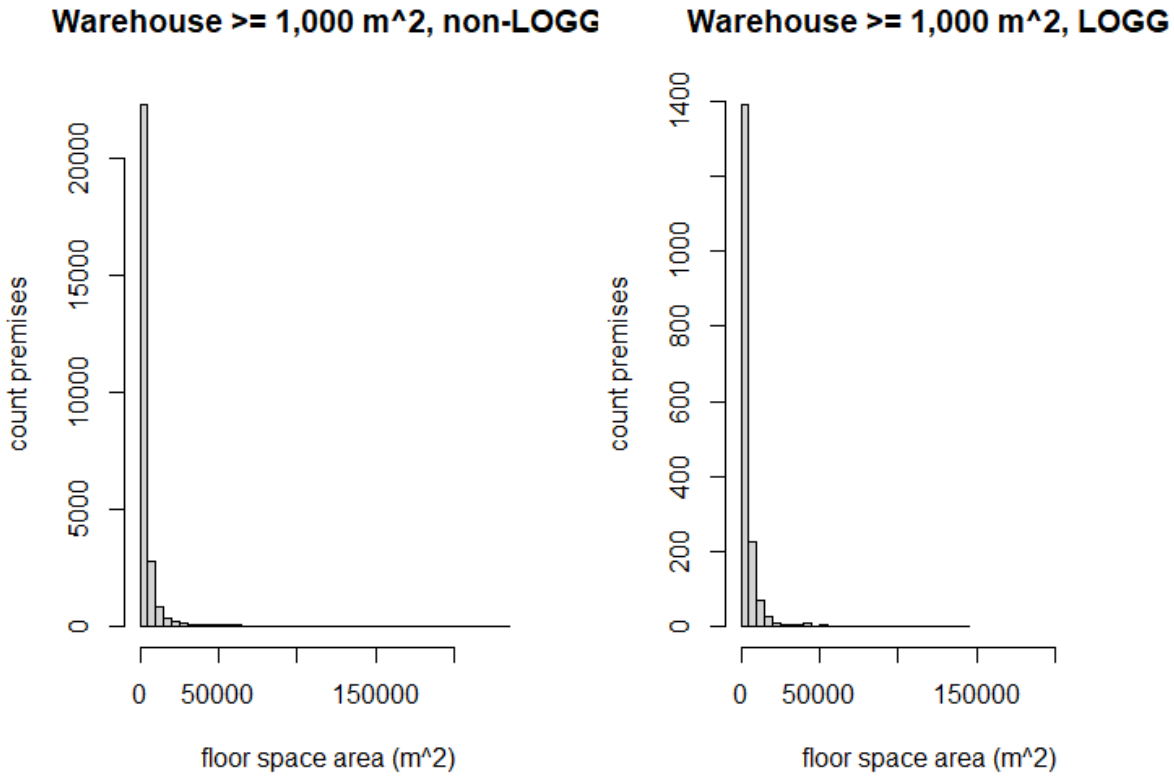


Figure 6 Distribution of floor space areas for LOGG and non-LOGG Warehouse premises.



LOGG and non-LOGG age profile

The VOA data on the age of premises are recorded at the 'line entry' level. These line entries are the detailed records providing information on the characteristics of sub-divisions of (generally) floorspace within premises. Due to this data structure, it is possible – and quite common – for premises to have different parts of their floorspace recorded as having been constructed at different times. This is perfectly logical, as the VOA will have recorded each construction date or addition to the premises, whether this be by actual construction, or absorption of parts of other buildings, or whole buildings, either from adjacent non-domestic premises, or domestic premises.

On this basis, the simplest method of comparing the age profiles of LOGG and non-LOGG premises is to sum the floor areas of all line entries with the same age code. A strength of this method is that it provides an overall picture of the age of all parts of the stock, for which age data have been recorded. The key weakness is that it does not quantify the sheer complexity of combinations of premises activity and the ages of different parts of premises with component areas of multiple ages, as these premises have developed over time. Some premises have many age codes, as indicated by Table 9, which shows all premises in the VOA data (not just LOGG) and the number of age codes per premises.

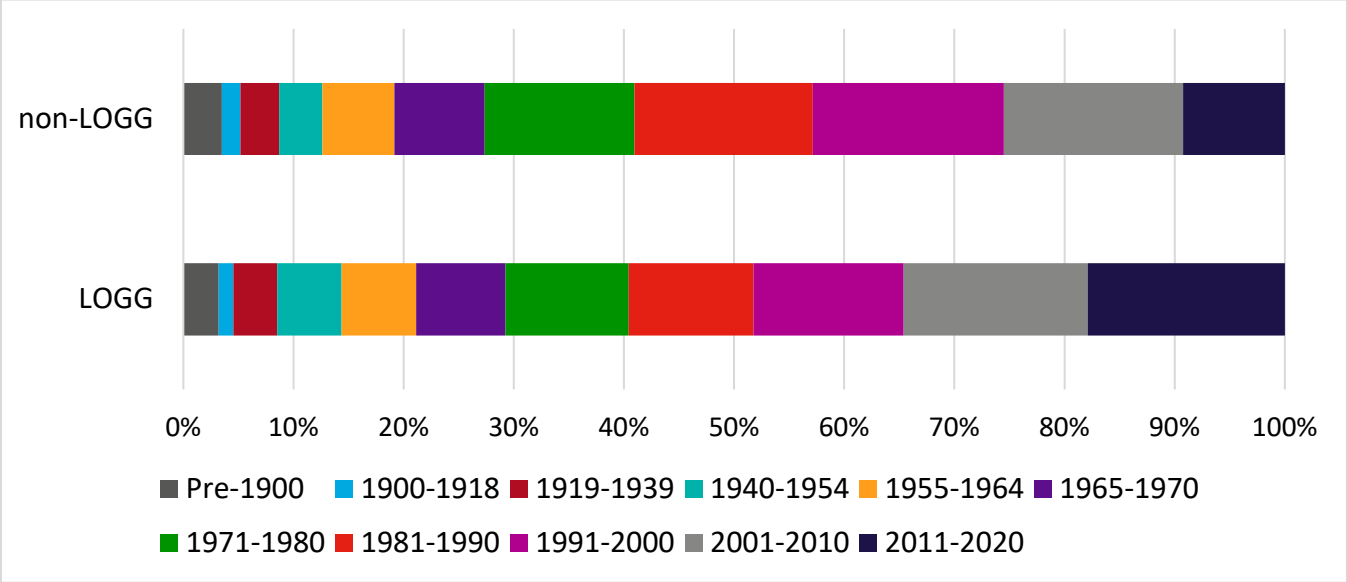
Table 9 Counts of premises and the number of age codes held in the data for those premises. All VOA premises in the 2020 data.

Count of premises	Count of age codes per premises
1,643,821	1
442,964	no code record
14,056	2
2,474	3
787	4
292	5
173	> 5

Prior to 1970, the VOA used age bands, whilst after 1970 the precise year of construction was recorded. To add readability to the data, these have been placed into ten-year age bands, or the original VOA age bands. In Figure 7, these floor areas have been summed, per age band – for the Shop, Office, Factory and Warehouse classes – and expressed as percentages of the floor area of the populations of LOGG and non-LOGG premises. Here, it may be seen that the LOGG and non-LOGG premises have similar percentages of floor area in the age bands up until 1980, with 40% of each group's floor area having been constructed prior to this date. From 1980 on, there is a divergence with higher proportions of non-LOGG being built until 2000, whilst the opposite is true for LOGG premises. This suggests a trend towards premises >= 1,000 m² being built without connection to the mains gas grid in more recent years,

particularly since 2010. Less than 0.5% of the premises' floor space, per LOGG/non-LOGG grouping, does not have an age band and this has been omitted from the figure.

Figure 7 Percentages of summed sub-premises level floor area data, per age band, for LOGG and non-LOGG premises >= 1,000 m². Shop, Office, Factory and Warehouse CaRB3 classes combined



The tabulated analysis for each CaRB3 class and age band, for summed line entry areas (accom_area) of LOGG and similar non-LOGG premises, is given in Table 10. For this analysis, it should be remembered that, although the data are grouped by age band and CaRB3 class, this is *not* an indication that *all* of the floor area of a premises falls within a single age band. The VOA's age code is attached to a premises' individual line entries, not the entirety of the premises, because different parts of a premises can be different ages: consider building extensions, or new buildings on a premises' site. Also, the areas of a premises' line entries can sum to a number greater than the floor space area record for those premises. The reason for this is that some parts of premises, such as mezzanines do not count towards a premises' floor space area. It seems that the VOA's floor space area is roughly equivalent to 'floor plate' measurements used in building surveys; however, this is merely an assumption and should be treated with care. The upshot of this constraint of the input data is that the areas quoted in Table 10 may sum to more than the total floor space area (though it can also be less).

Table 10 Total floor areas, per age band, for LOGG and non-LOGG premises >= 1,000 m², by CaRB3 class, using summed sub-premises level area data. Units millions m².

CaRB3 class	Shop		Office		Factory		Warehouse	
age band	LOGG	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG
Pre-1900	0.160	2.484	0.185	2.219	0.183	3.834	0.116	2.017
1900-1918	0.024	0.613	0.047	0.618	0.120	2.640	0.076	1.204
1919-1939	0.052	1.701	0.121	1.069	0.352	5.227	0.271	2.699
1940-1954	0.039	1.039	0.065	0.449	0.486	6.796	0.575	3.504
1955-1964	0.150	2.015	0.121	1.677	0.570	10.840	0.516	5.245
1965-1970	0.259	2.898	0.098	1.816	0.704	12.116	0.558	7.934
1971-1980	0.276	5.021	0.254	2.903	0.691	17.307	1.015	15.846
1981-1990	0.382	10.569	0.318	5.474	0.767	16.884	0.799	16.060
1991-2000	0.639	12.231	0.449	6.431	0.957	15.623	0.679	18.093
2001-2010	0.858	9.562	0.758	7.579	0.744	10.441	0.981	21.632
2011-2020	0.538	5.305	0.675	3.510	0.506	5.913	1.858	13.160
no age code	0.041	0.314	0.000	0.134	0.006	0.126	0.009	0.222

LOGG and non-LOGG Construction Characteristics

The Valuation Office Agency data include codes for the ‘structure construction’, ‘wall construction’ and ‘roof construction’ for many premises. These characteristics are generally important when considering the retrofitting, or even replacement, of existing buildings and premises. There are several thousand combinations of structure, wall and roof standard codes, plus many non-standard codes. The latter have been cleaned and interpreted to provide usable data for analysis. Where multiple codes appear in one data field, the first code is used, on the basis of this probably being the most significant. Additionally, the floor areas (‘accom_area’ in the VOA data) in the detailed records of sub-divisions of premises have been

summed, per construction characteristic, per premises, to identify each structure, wall and roof characteristic associated with the highest proportion of the premises' floor area. This provides a weighting towards the constructions most likely to be found at each premises, which is then used as being representative of those premises. The total floor space area is then presented as having this construction characteristic. No attempt has been made here to quantify the extent of mixtures of constructions, per structure/wall/roof type, as there are thousands of multi-code constructions (e.g. multiple wall types per premises) in the Valuation Office Agency data.

Each set of characteristics has been compared for LOGG and non-LOGG premises >= 1,000 m². Table 11, below, shows only small, or very small, percentages of LOGG premises per construction characteristic, commensurate with the overall proportion of premises that are LOGG. The most notable percentages are: 'Varied (mix)' category in structure (4.4%); 'Asbestos' (3.2%), 'Corrugated Iron' (2.8%), 'Portacabin/Terrapin' (3.4%) and 'PPM' (profiled plastic material) (3.2%), in wall construction. In roof constructions, only the 'Varied (mix)' category is noticeable with 4.4%.

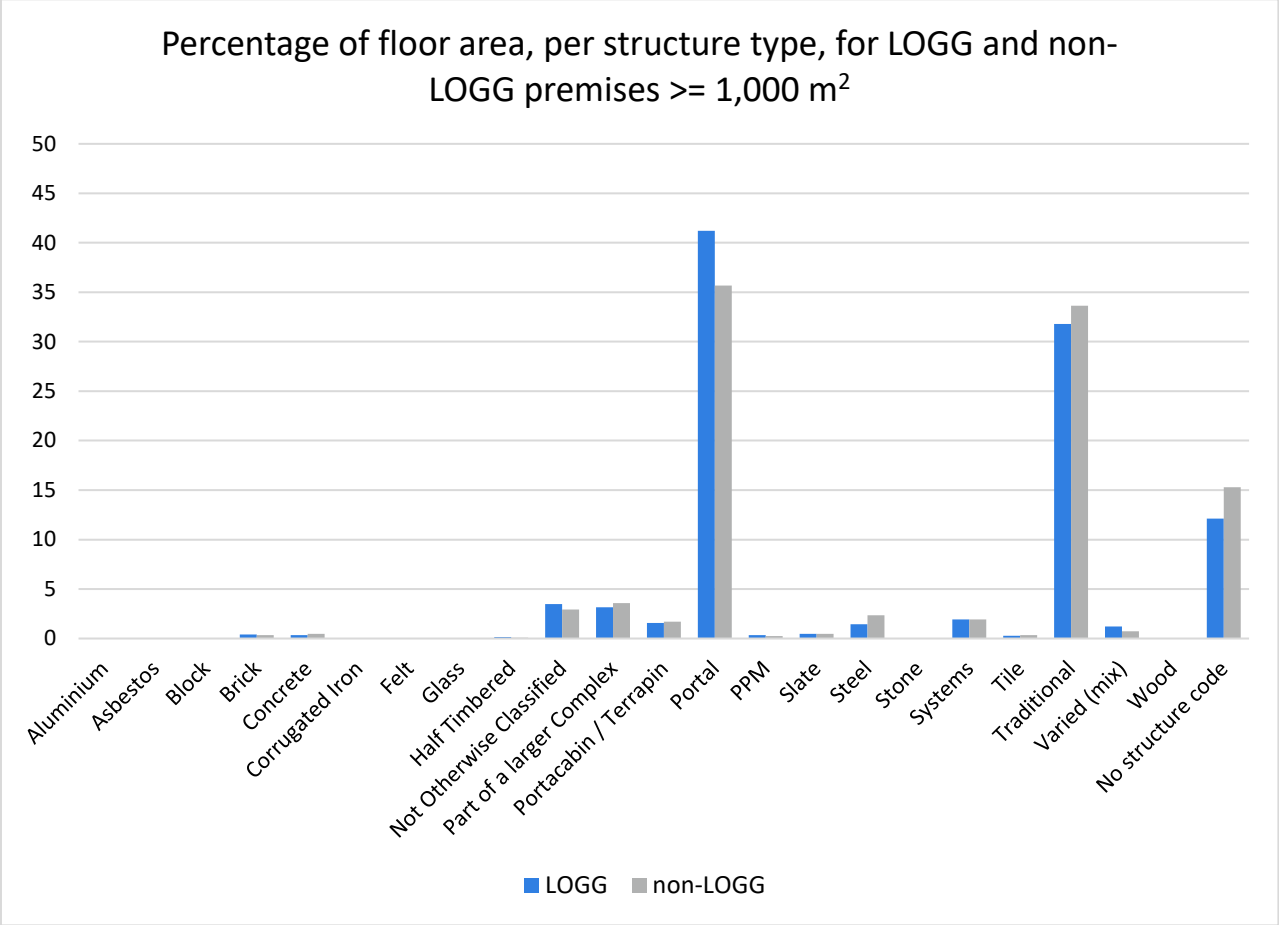
Note that there are some potentially anomalous data in these classifications, such as 'structure construction' being listed as 'Glass' or 'Felt', which are not generally considered to be structural components. Similarly, 'Portal [Frame]' is not a roof or wall type but a structural system. As it is not possible to unpick these anomalies, without visual confirmation of the characteristic, the data have been presented as recorded.

Table 11 Percentage of counts of LOGG and non-LOGG premises >= 1,000 m², per construction characteristic, expressed as a percentage of all similar premises >= 1,000 m².

	structure		walls		roof	
construction characteristic	LOGG	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG
Aluminium	1.6	98.4	1.8	98.2	1.6	98.4
Asbestos	1.6	98.4	3.2	96.8	1.6	98.4
Block	0.3	99.7	0.7	99.3	0.3	99.7
Brick	0.3	99.7	0.2	99.8	0.3	99.7
Concrete	0.7	99.3	0.9	99.1	0.7	99.3
Corrugated Iron	1.0	99.0	2.8	97.2	1.0	99.0
Felt	0.4	99.6	0.0	100.0	0.4	99.6
Glass	0.6	99.4	2.4	97.6	0.6	99.4
Half Timbered	0.4	99.6	0.0	100.0	0.4	99.6
Not Otherwise Classified	0.9	99.1	0.8	99.2	0.9	99.1
Part of a Larger Complex	0.5	99.5	0.0	100.0	0.5	99.5
Portacabin / Terrapin	1.2	98.8	3.4	96.6	1.2	98.8
Portal	1.5	98.5	0.0	100.0	1.5	98.5
PPM	0.6	99.4	3.2	96.8	0.6	99.4
Slate	0.8	99.2	0.7	99.3	0.8	99.2
Steel	0.7	99.3	1.6	98.4	0.7	99.3
Stone	0.0	100.0	0.1	99.9	0.0	100.0
Systems	0.5	99.5	-	100.0	0.5	99.5
Tile	0.6	99.4	0.6	99.4	0.6	99.4
Traditional	0.2	99.8	0.0	100.0	0.2	99.8
Varied (mix)	4.4	95.6	2.2	97.8	4.4	95.6
Wood	0.3	99.7	0.5	99.5	0.3	99.7
No construction code	1.1	98.9	0.9	99.1	1.1	98.9

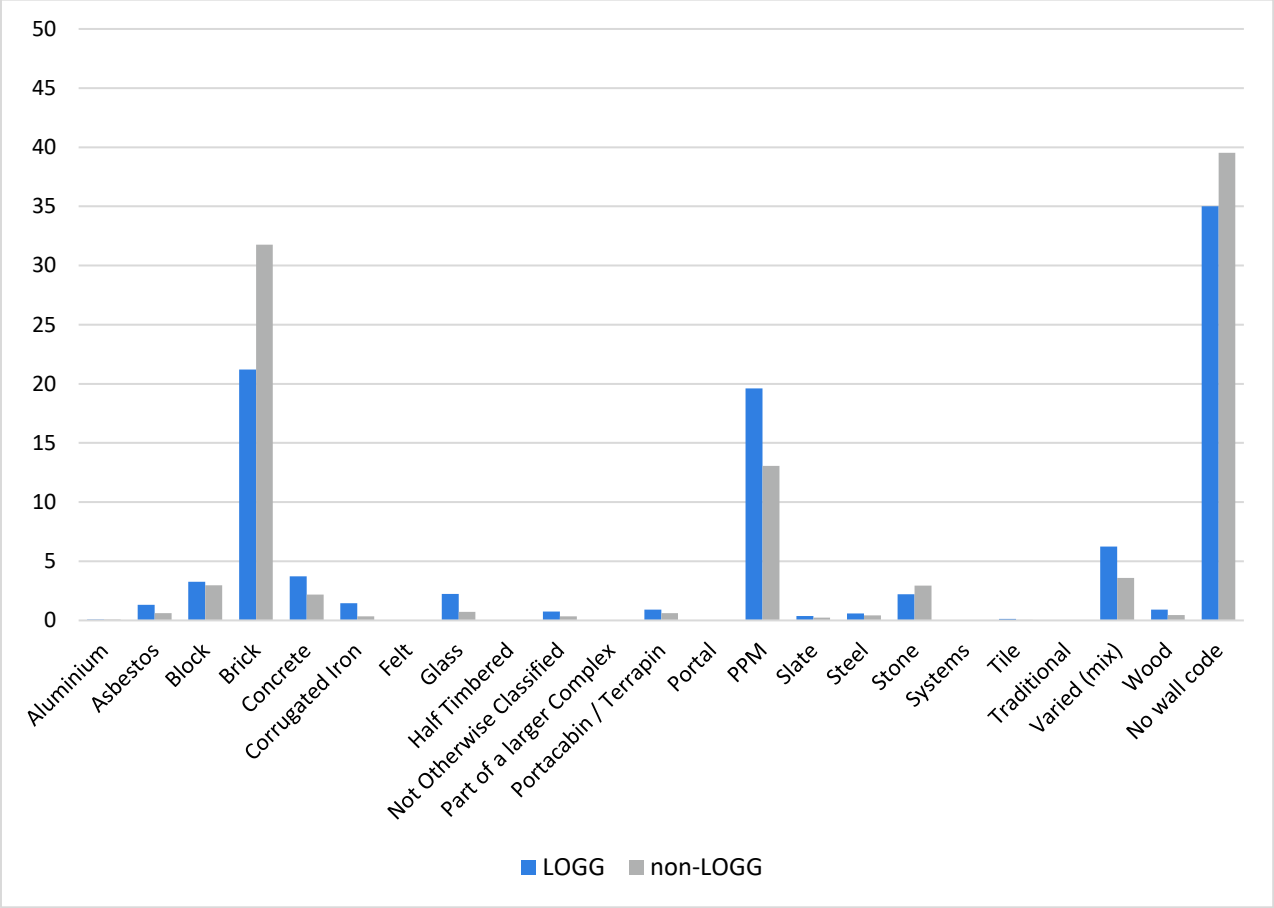
The following charts (Figure 8 to Figure 10) show the summed floor space areas for the three construction categories of the LOGG premises versus the similar non-LOGG premises, expressed as percentages. For the structure constructions (Figure 8), the percentage of floor area for each structure being approximately the same, although there appears to be slight trend towards 'Portal [frame]' construction and away from 'Traditional'. The LOGG premises have a higher percentage of their total floor area with a recorded structure, than do non-LOGG premises.

Figure 8 Percentages of floor area, per structure characteristic, in LOGG and non-LOGG premises



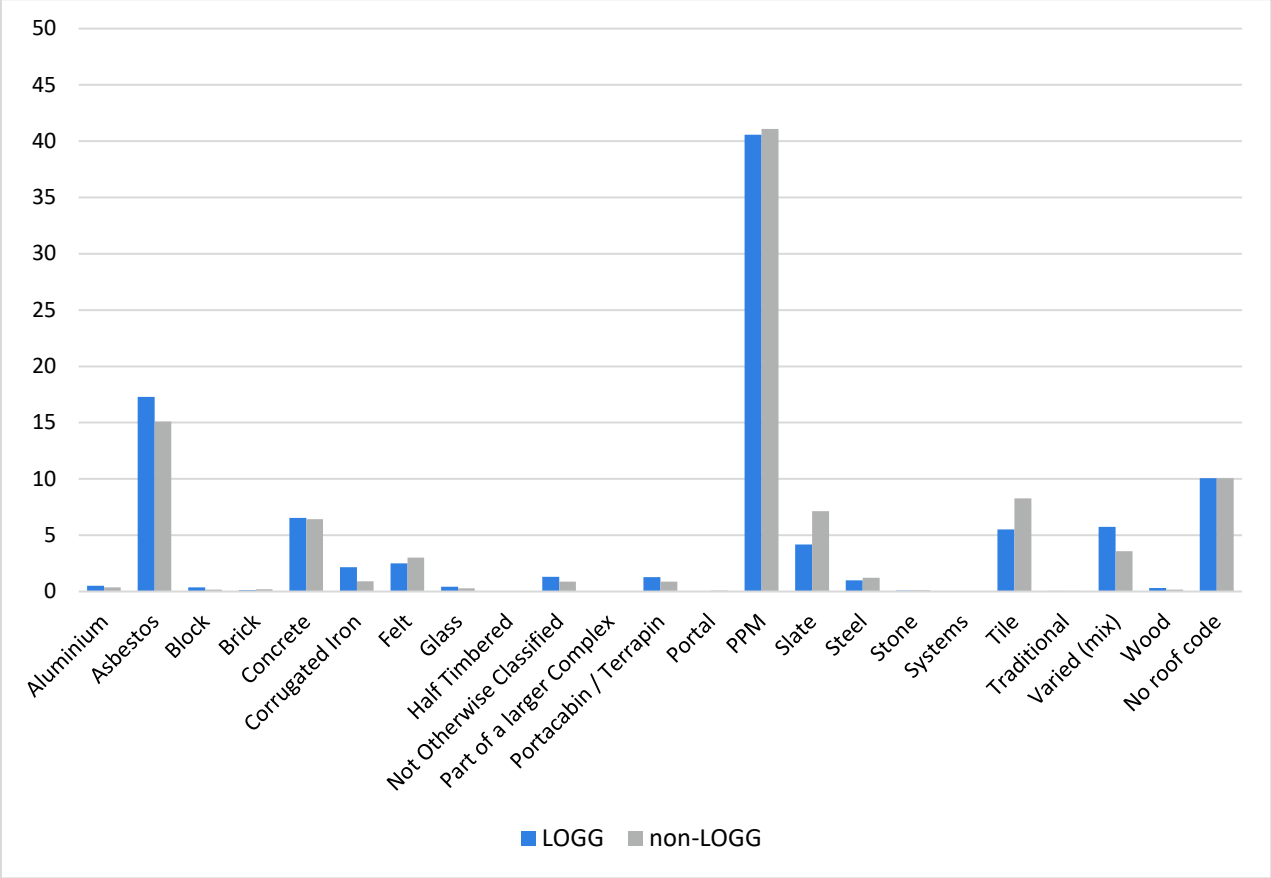
Below, Figure 9 shows LOGG premises are more likely to have floor area surrounded by lightweight ‘PPM’ walls and are less likely to have brick walls. ‘Varied (mix)’ wall construction is more likely to be found at LOGG premises, than at similar non-LOGG premises, as is ‘Glass’, which might be associated with glasshouses located away from mains gas supplies. A significant proportion of floorspace has no wall construction code, or a code that is complex enough to be problematic to decipher; these have all been classed as ‘no wall code’.

Figure 9 Percentages of floor area, per wall characteristic, in LOGG and non-LOGG premises



Below, Figure 10 provides an analysis of the roofing systems used on LOGG and similar non-LOGG premises. This indicates that there is little difference in their characteristics, except perhaps for slightly more floorspace covered by ‘Asbestos’ or ‘Varied (mix)’ and slightly less by ‘Tile’ or ‘Slate’. This is possibly a reflection of the age of premises as described above.

Figure 10 Percentages of floor area, per roof characteristic, in LOGG and non-LOGG premises



The analyses of construction characteristics are relevant to the upgrading of building envelopes, for improved energy efficiency, such that the ability of the envelope to resist the transfer of heat in either direction – outwards to the environment in cold weather, or the reverse in hot weather – is a key consideration when deciding on heating ventilation and cooling systems. The evidence suggests that LOGG premises have noticeable differences in their building fabric, which would affect retrofit decisions, compared to non-LOGG premises.

LOGG and non-LOGG Energy Performance Certificates

As with the domestic sector, not all non-domestic premises have an Energy Performance Certificate (EPC). However, the likelihood that a non-domestic premises has an EPC is considerably lower. Unlike domestic EPCs, the non-domestic EPC rating system does not run from zero (bad) to 100 (good). Instead, zero is good, whilst the ‘bad’ end of the scale is open-ended, such that there are some values of ‘9999’, which are assumed to be where insufficient data were available for a more accurate value to be calculated by the EPC assessment tool. Non-domestic EPCs have been address-matched to Valuation Office Agency premises and the subset of these with areas >= 1,000 m² are summarised for the four main CaRB3 activity classes, in Table 10. Per class, the percentages of LOGG premises with an EPC are broadly

similar to the non-LOGG premises, except perhaps for Warehouses, where the percentage with an EPC is slightly higher: 24% LOGG, versus 16% non-LOGG. The low Mann-Whitney p-value (< 0.05) indicates that these LOGG Warehouses are statistically a separate population from non-LOGG premises, in terms of EPC ratings. The same is true of LOGG Shops, whilst LOGG Offices and Factories appear to be little different to their non-LOGG counterparts.

Table 12 Analysis of main CaRB3 activity classes for presence and ratings of Energy Performance Certificates for LOGG and non-LOGG premises >= 1,000 m²

CaRB3 Class	**Shop**		**Office**		**Factory**		**Warehouse**	
LOGG status	**non-LOGG**	**LOGG**	**non-LOGG**	**LOGG**	**non-LOGG**	**LOGG**	**non-LOGG**	**LOGG**
count	17,712	1,046	11,921	1,003	25,088	1,565	26,908	1,747
count with EPC	6,237	342	1,829	127	5,034	247	6,384	278
percentage with EPC	35	33	15	13	20	16	24	16
Mean	64	62	78	75	80	86	72	69
Std dev	30	36	30	33	32	49	32	41
Min	-46	6	5	-4	-143	-60	-182	-20
Q1	44	35	60	53	62	61	57	47
Median	61	58	78	80	78	79	70	65
Q3	79	77	97	92	95	102	86	82
Max	323	256	283	174	408	480	803	320
Mann-Whitney p-value	0.01336		0.17270		0.15820		0.00122	

For the certificates themselves, EPC ratings are given a band as indicated in Table 13, such that A is ‘good’ and G is ‘bad’. Note that the G band is open-ended, hence some very high EPC ratings are feasible.

Table 13 EPC ratings and bands

EPC rating	EPC band
0 – 25	A
26 – 50	B
51 – 75	C
76 – 100	D
101 – 125	E
126 – 150	F
> 150	G

To further display the EPC data, pairs of histograms for EPC ratings for LOGG and non-LOGG premises, per CaRB3 class are provided in Figure 11 to Figure 14. Note that scales on these charts alter, due to the diversity in the counts and EPC ratings in each CaRB3 class and depending upon being LOGG or non-LOGG.

Figure 11 Distributions of Energy Performance Certificate ratings for LOGG and non-LOGG Shop premises.

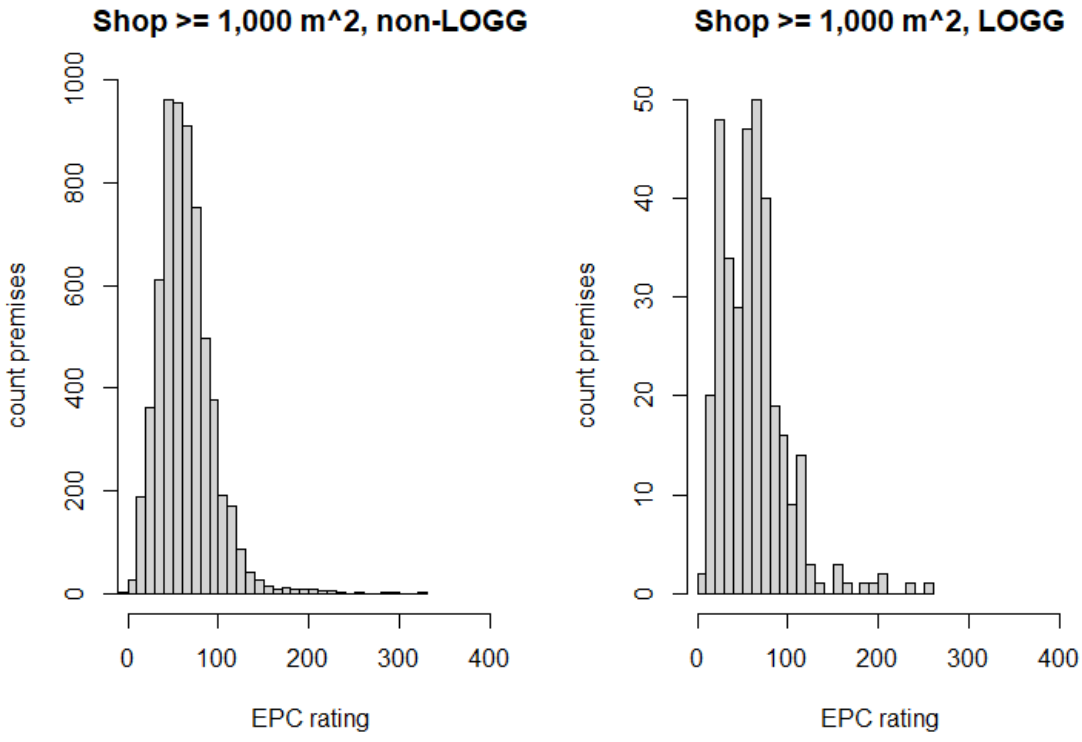


Figure 12 Distributions of Energy Performance Certificate ratings for LOGG and non-LOGG Office premises.

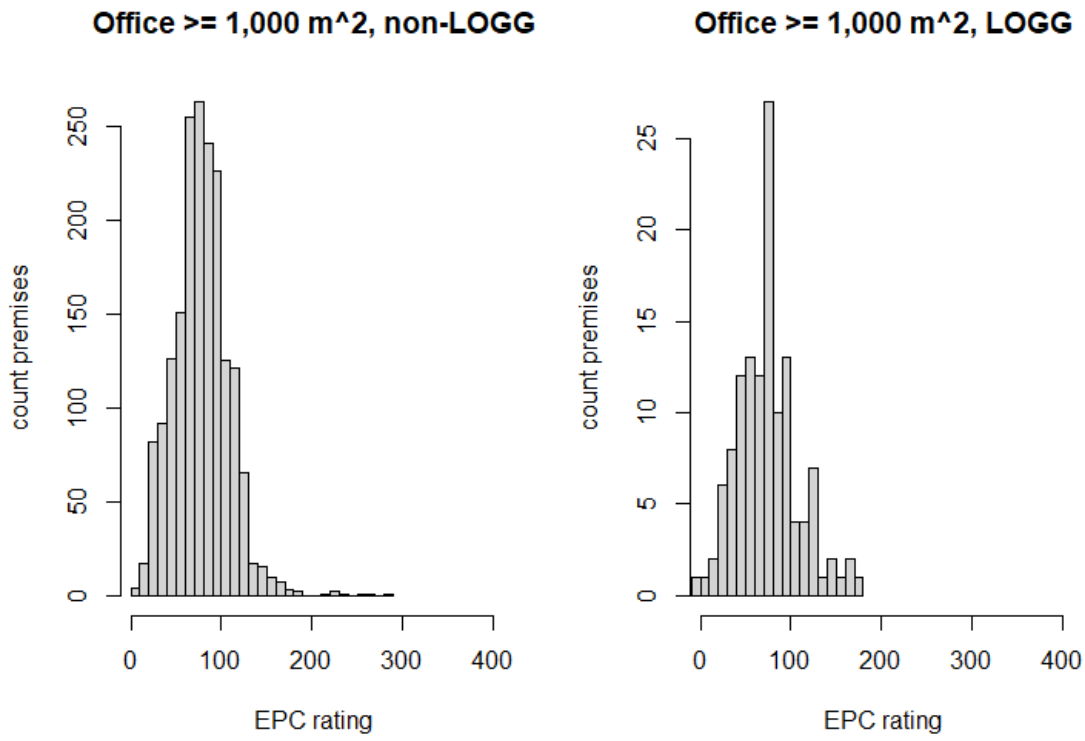


Figure 13 Distributions of Energy Performance Certificate ratings for LOGG and non-LOGG Factory premises.

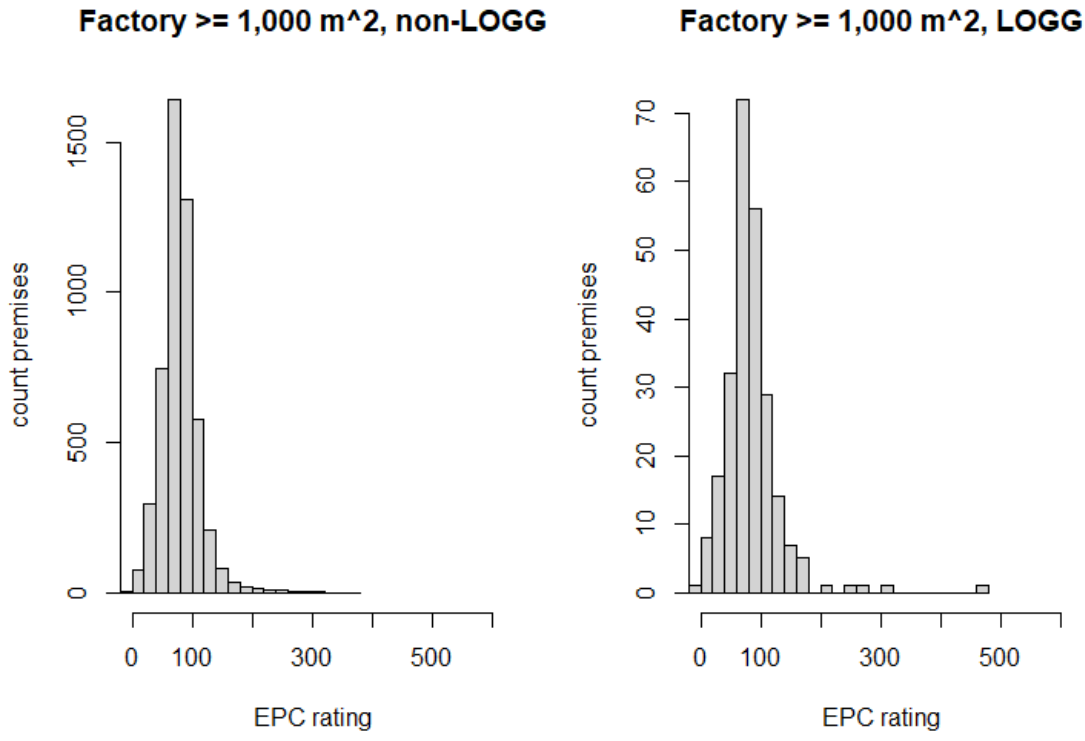
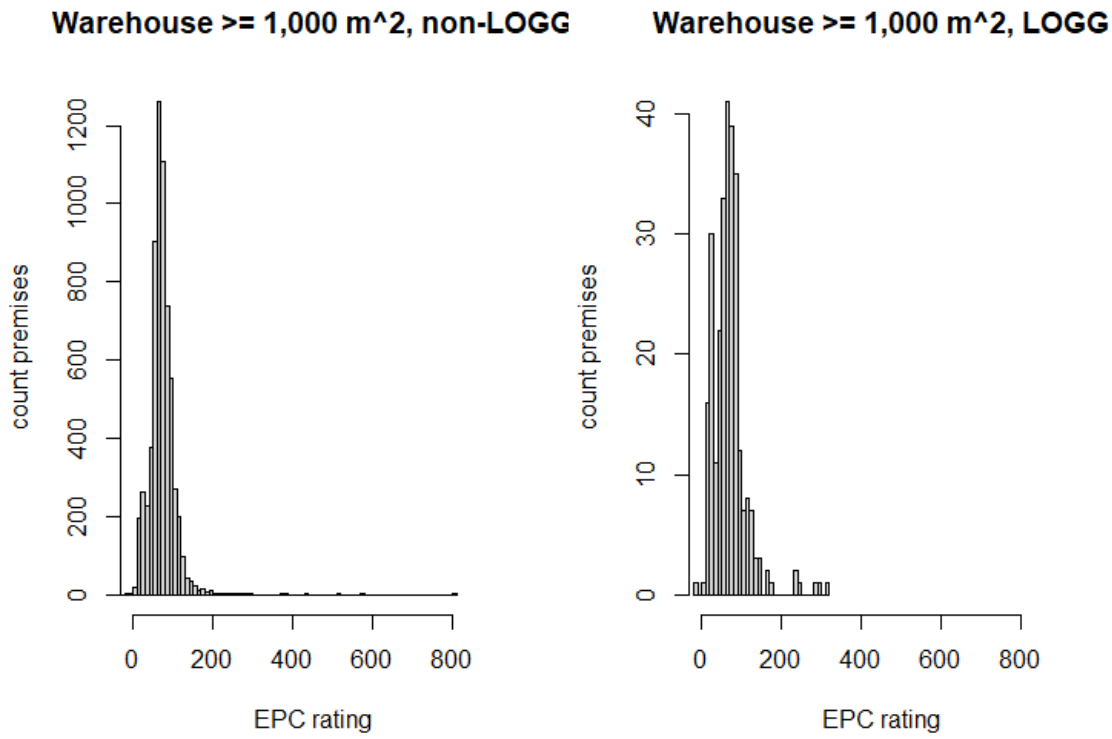


Figure 14 Distributions of Energy Performance Certificate ratings for LOGG and non-LOGG Warehouse premises.



LOGG and non-LOGG Display Energy Certificates

Display Energy Certificates (DECs) are only required for premises that are ‘public access’, such that they are occupied by services that are not generally considered to be commercial in nature; for example, local council premises, schools, hospitals, libraries and suchlike. This results in only very few premises in the Warehouse and Factory CaRB3 classes having a DEC, whilst Offices are more likely to have a DEC, as indicated in Table 13. The problem, here, is that there are so few DECs in the Shop, Factory and Warehouse classes of the LOGG and non-LOGG premises, that the results cannot be seen as reliable (in particular for Shops, in which the Mann-Whitney Wilcoxon statistical test informs us that accurate p-values cannot be calculated). Thus, in terms of deciding whether LOGG and non-LOGG premises are from the same population, only Offices can be seen as reliable, giving a p-value < 0.05 indicating that these are statistically separate populations.

Table 14 Analysis of main CaRB3 activity classes for presence and ratings of Display Energy Certificates for LOGG and non-LOGG premises >= 1,000 m²

CaRB3 Class	Shop		Office		Factory		Warehouse	
LOGG status	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG	LOGG	non-LOGG	LOGG
count	17,712	1,046	11,921	1,003	25,088	1,565	26,908	1,747
count with DEC	43	4	812	50	206	7	186	8
percentage with DEC	<1%	<1%	7	5	1	<1%	1	<1%
Mean	325	96	114	96	220	1,502	163	105
Std dev	1,511	33	494	35	980	3,747	727	38
Min	32	64	12	39	4	37	5	24
Q1	75	69	62	72	83	46	76	92
Median	94	94	78	86	108	92	102	119
Q3	115	121	103	121	136	148	137	126
Max	9,999	130	9,999	213	9,999	9,999	9,999	142
Mann-Whitney p-value	0.95340		0.02829		0.09831		0.86470	

* Very small counts of premises indicate that these p-values are unlikely to be reliable. See text.

To further display the DEC data, pairs of histograms for DEC ratings for LOGG and non-LOGG premises, per CaRB3 class, are provided in Figure 15 to Figure 18. Note that scales on these charts alter, due to the diversity in the counts and DEC ratings in each CaRB3 class and depending upon being LOGG or non-LOGG. These distributions highlight the unreliability of trying to determine similarities between the LOGG and non-LOGG premises in the Shop, Factory and Warehouses CaRB3 class premises, using statistics alone.

Figure 15 Distributions of Display Energy Certificate ratings for LOGG and non-LOGG Shop premises.

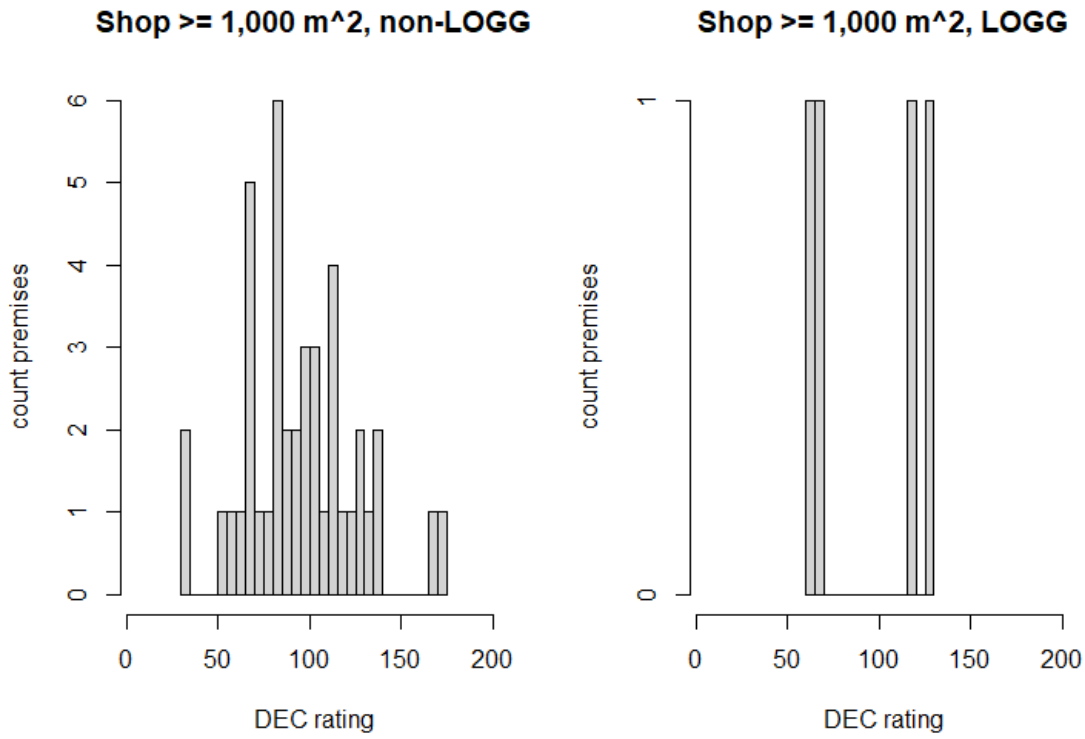


Figure 16 Distributions of Display Energy Certificate ratings for LOGG and non-LOGG Office premises.

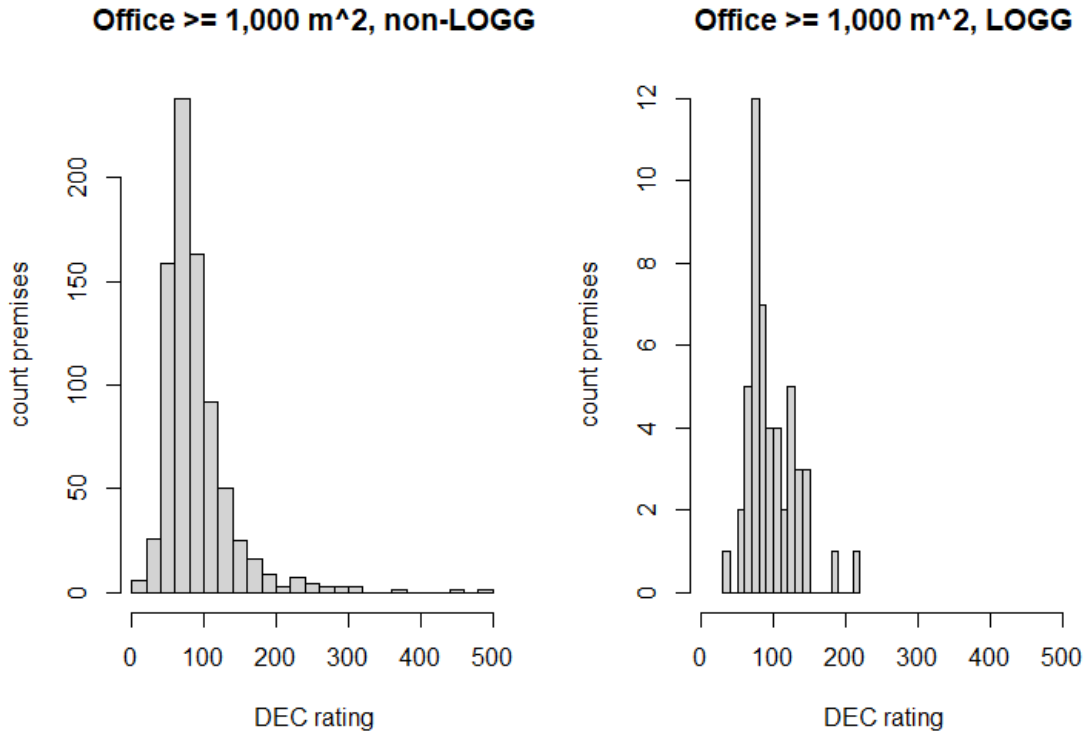


Figure 17 Distributions of Display Energy Certificate ratings for LOGG and non-LOGG Factory premises.

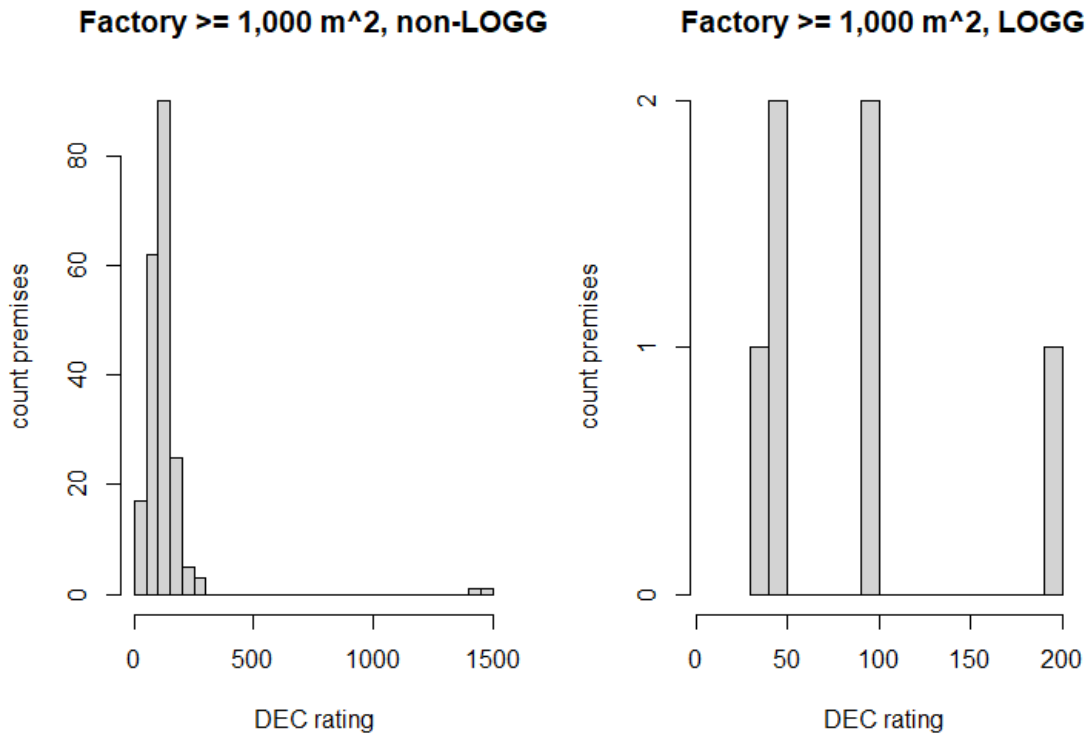
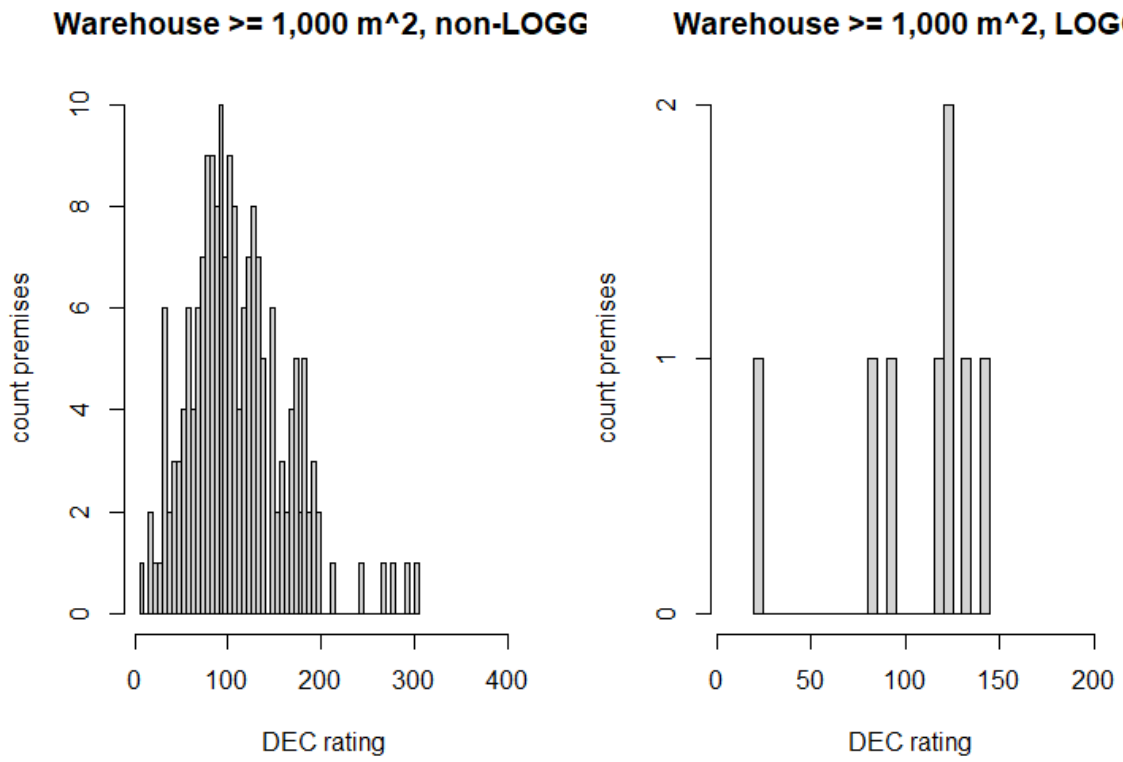


Figure 18 Distributions of Display Energy Certificate ratings for LOGG and non-LOGG Warehouse premises.



Surveys

Generation of survey sample

The need to tailor survey questions to each individual CaRB3 class, coupled with the low presence of LOGG premises in many classes, led to a decision to focus on the 4 dominant classes for the remote survey since these represented 92% of the stock by count (Factory 27%, Office 17%, Shop 18%, Warehouse 30%) and 95% of the stock by floor area (Factory 29%, Office 16%, Shop 14%, Warehouse 35%). The total pool of records from the 3DStock model, provided for data matching by a commercial provider, was 5,362. The number matched to IDBR was 1,782.

When supplied to the commercial provider, for appending contact details, the following guidelines on matching were supplied:

- If available, match using the IDBR name and address.
- If IDBR is not available, match using the VOA premises address and OSAB organisation name.
- Where an OSAB organisation name is available, match using the VOA premises address only (incl. postcode), without an organisation name.
- Finally, if none of the above are possible, match on the UPRN address for the remaining records.

For the remote surveys, all large off gas grid buildings in the database with the necessary contact information appended were released and contact attempted to enable fieldwork. The table below indicates the available sample by CaRB3 class.

Table 15 Final Sample by CaRB3 class, for fieldwork

CaRB3 class	Number in sample matched to contact details by commercial provider
Warehouses	530
Factories	613
Offices	197
Shops	442
TOTAL	1782

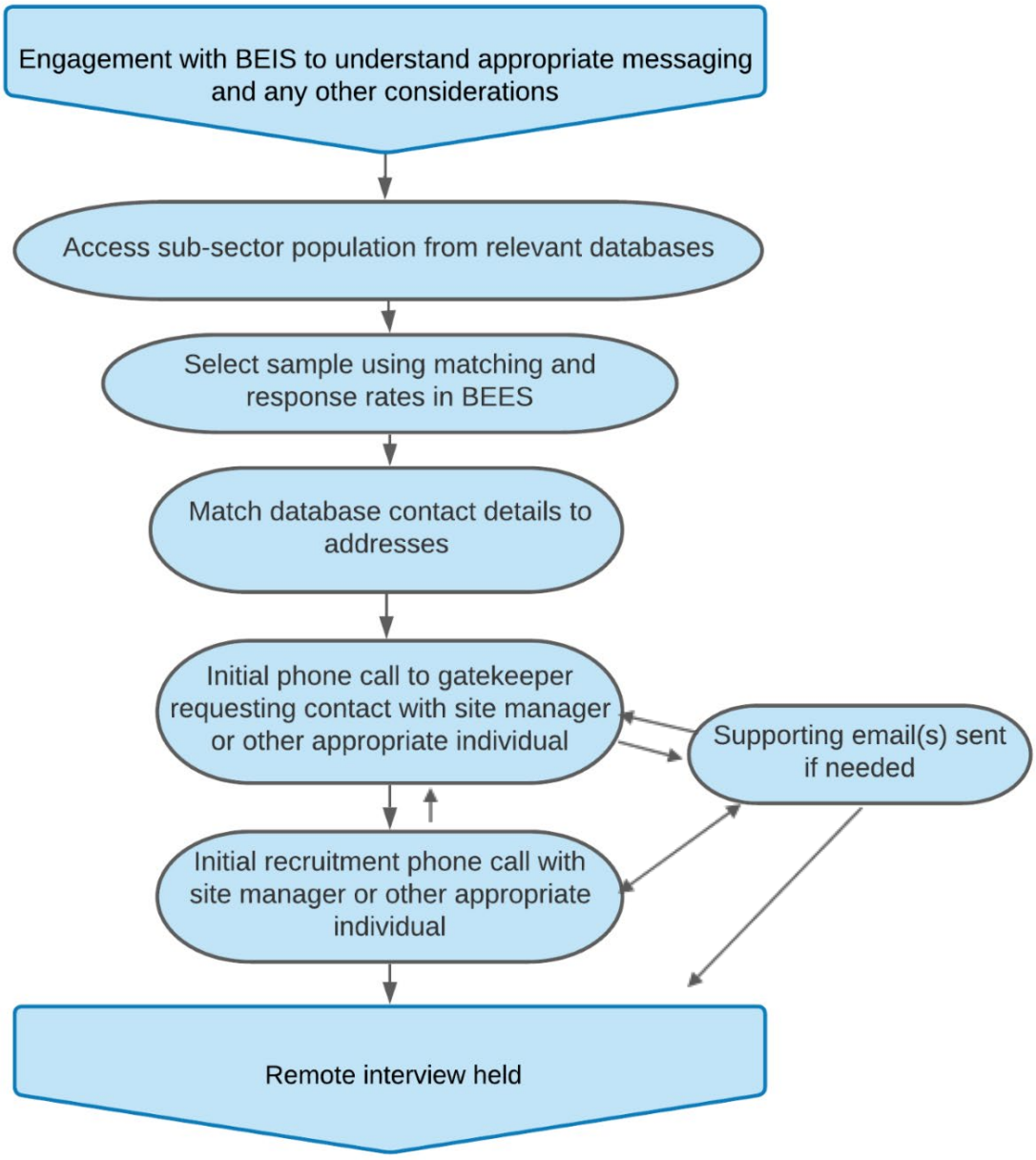
Sampling approach

For remote surveys, stratification, with quotas on CaRB3 classes, was used to ensure that there was adequate representation of all groupings of CaRB3 activities interviewed.

Recruitment

The recruitment process for the LOGG remote survey followed the process outlined in Figure 19, below.

Figure 19 Recruitment process



As indicated in Figure 19, the final three processes happened interchangeably and multiple times; e.g. the initial phone call would lead to a supporting email being sent, followed by another phone call, followed by an email, then either a booking via email or phone for an interview, then the interview was held.

Recruitment was challenging as detailed under the learnings below. To aid recruitment, the following actions were taken:

Direction of first enquiries to a site manager or energy manager, keeping information as brief as possible.

Inclusion of some policy questions relevant to the CaRB3 class to give participants an opportunity to express their views to government. These were on challenges and support need and helped in trying to reduce the survey feeling like a one-sided transaction with little immediate benefit for the respondent, who was giving up their time due to the very factual nature of the survey.

It is also important to offer flexibility in the timing of appointments to suit the respondent. This also meant having a long enough fieldwork period to accommodate respondent preferences and potentially to reschedule where necessary. Fieldwork for the remote survey ran between April and June. Those carrying out remote interviews were able to book appointments between 9am and 5pm, or if requested, before 9am and after 5pm to suit the respondent.

With organisations that were franchises or multi-site, difficulties were faced in reaching the head office, so the head office organisations were transferred to one person who could focus on asking one person, e.g. about all six of the organisations at once. Generally, chain/ multi-site organisations for LOGG were hard to reach because those at head office were less likely to understand the off-gas grid aspect of the building or could not/ would not take the call for the survey.

Sample Management

The sample for remote surveys was managed using a CATI system and observed the following principles:

Attempts to contact respondents were made across different days and times over at least two weeks before no further calls were attempted.

When a completed interview was not secured, a final call outcome was recorded in order to better understand response rates. These call outcomes included:

- Outright refusal.
- No suitable respondent – when a suitable respondent cannot be identified.
- No answer.
- Unfulfilled appointment – when a general appointment was booked that wasn’t kept.
- Invalid record – when the telephone number is not in use.
- Out of business.

Once an interview with a suitable respondent had been conducted (whether or not they could provide all the data required), the interview was considered complete.

Sample achieved: response rates and call outcomes

In total, 63 remote survey interviews were successfully completed for the remote survey, as shown in Table 15 this compares with the original target of 200 surveys.

Table 16 Number of interviews completed per CaRB3 class

CaRB3 class	Number in sample
Warehouses	15
Factories	36
Offices	7
Shops	5

Table 16 below details the call outcomes for the remote sample. The overall response rate was 4%.

Table 17 Call outcomes for LOGG remote survey

Completes	63
Refused personally	101
Gatekeeper – not allowed to speak to respondent	93
No suitable respondent – when a suitable respondent cannot be identified	59
Out of scope – not 1000 m²	5
Out of scope – did not occupy premises in 2019	1
Out of scope – not off the gas grid	32
Left message with gatekeeper	21
Out of business	5
Requires an email to arrange an appointment	92
Out of scope off gas grid but no energy supply at all to building	1
Over 7 calls made	103
Removed due to database provider requirements	23
Agreed to probe but not full interview	1
Busy signal	54
Duplicate	3
Unfulfilled appointment – when a general appointment was booked but was not kept	718
Left message on voicemail	8
No answer	293
Invalid record – when the telephone number is not in use	21
Not available until after fieldwork period	85

Reasons for refusal

Where people seemed initially reluctant to participate, as well as being offered flexibility in timing of interviews, they were encouraged using the following information:

- This is a national survey on behalf of the Department for Business, Energy and Industrial Strategy.
- This survey is to help understand building energy use so that policy to support those in LOGG premises can be developed.
- The government has a target of carbon net zero by 2030.

Nonetheless, 101 potential respondents refused to complete the survey, the majority noting they did not have the time (30 minutes) to spare or had bigger priorities to focus on currently than energy and building information (such as global supply chain delays, recovery from Covid-19).

Survey Population

The survey sample was ultimately dictated by willingness to participate. Initially, the full LOGG population, for which contact details had been obtained, was contacted. The characteristics of the actual respondents were compared with the characteristics of the overall LOGG population for the four dominant CaRB3 classes (Shop, Office, Factory, Warehouse) in which recruitment was undertaken.

Although quotas for each class were initially followed, the low participation rate meant these were relaxed towards the end of recruitment. Factories were over-represented in the sample, compared with Offices and Shops, as shown in Figure 20 and Figure 21.

Figure 20 LOGG population and survey sample distribution by count

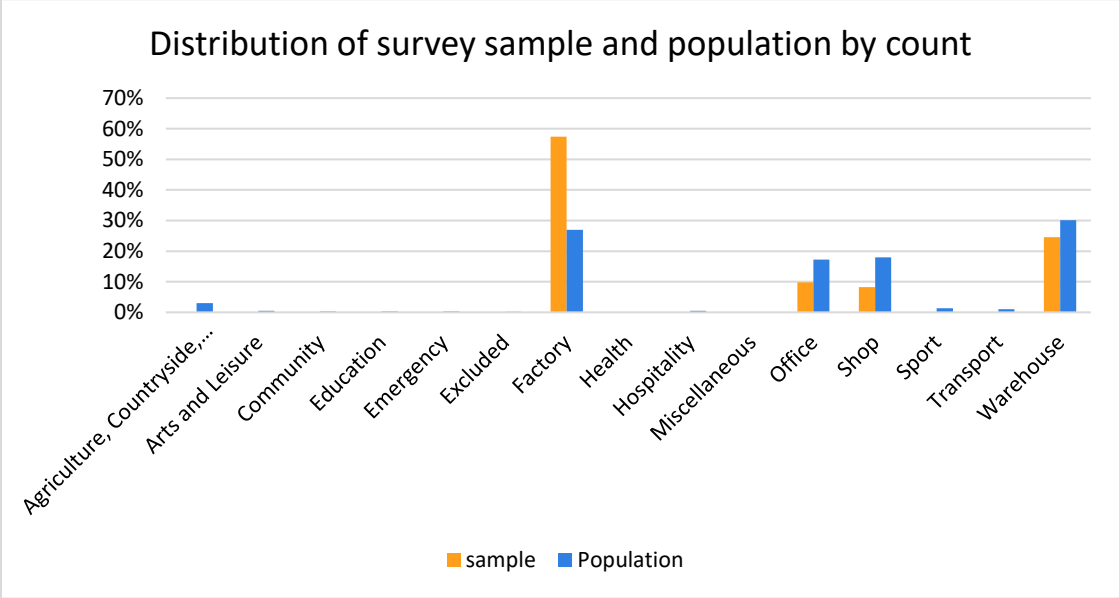
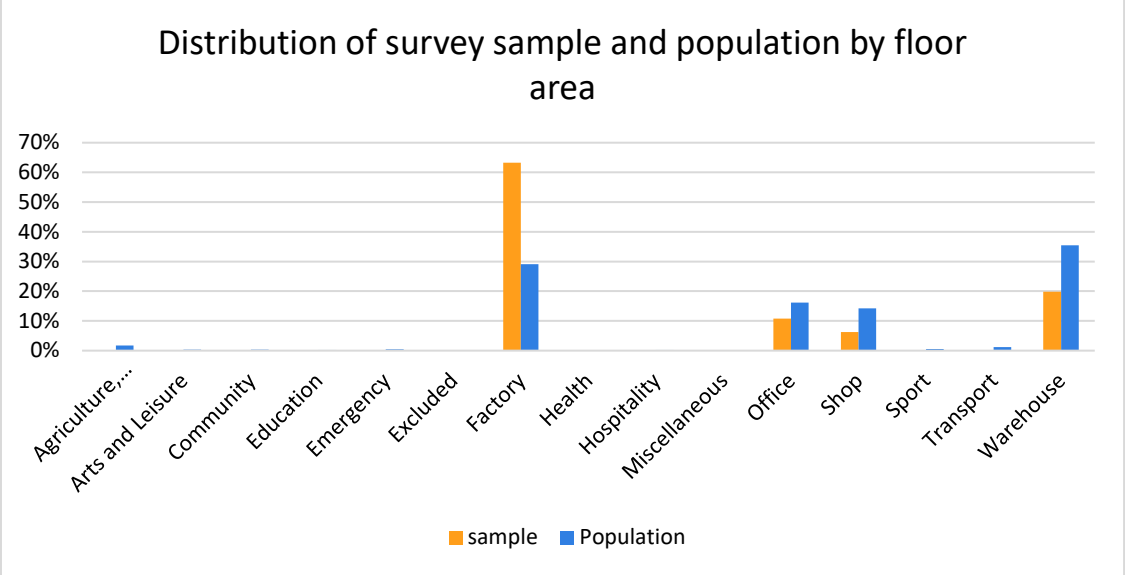
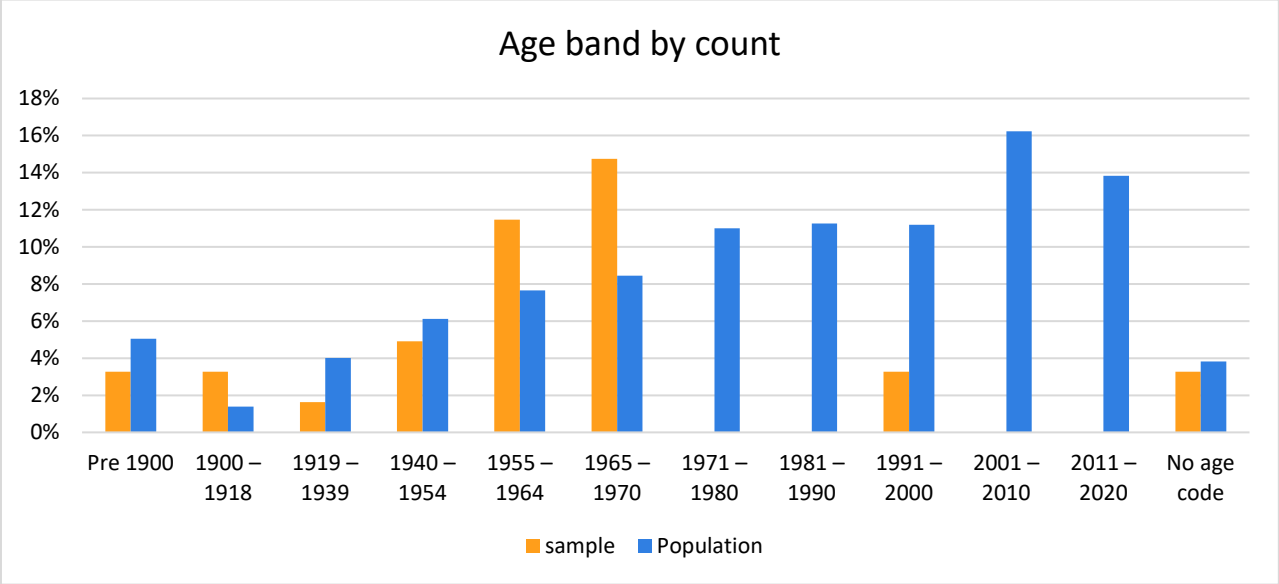


Figure 21 LOGG population and survey sample distribution by floor area



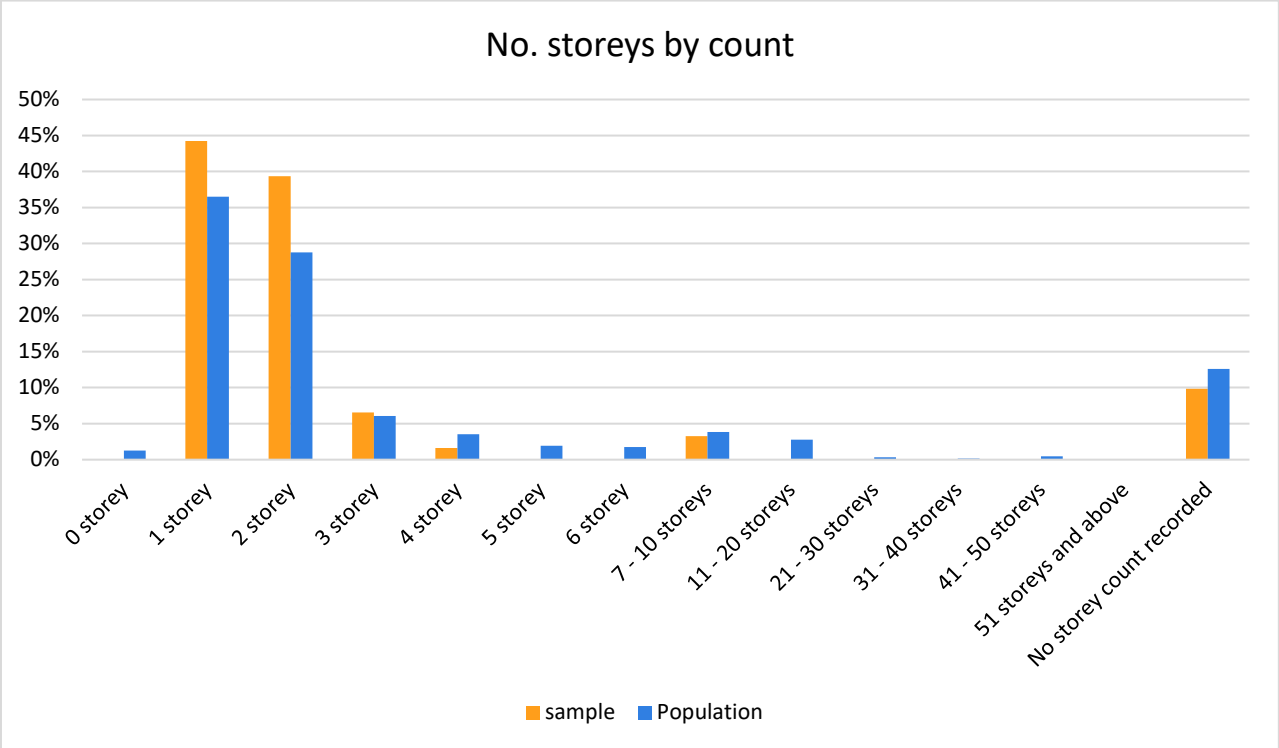
The LOGG survey sample of respondent premises was generally older than the overall LOGG population as shown in Figure 22, with the sample having particularly high representation of premises built between 1955 and 1970, compared to the same age bands in the LOGG population.

Figure 22 Distributions of Survey sample and LOGG population by age band



Both the survey sample and the LOGG population are dominated by one and two-storey buildings, with these two categories, in particular, having higher percentages in the sample than in the full LOGG population, as indicated by Figure 23, below.

Figure 23 LOGG population and sample distribution by number of storeys



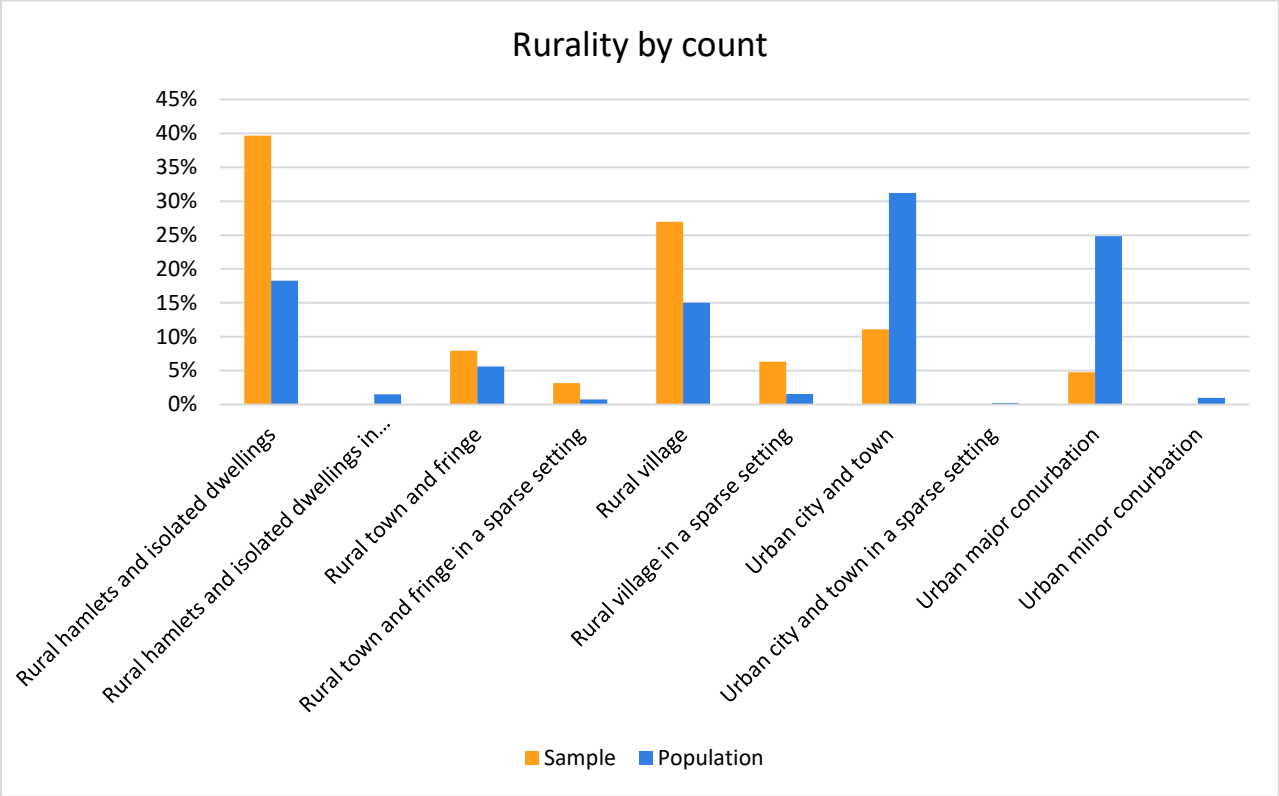
Overall, the survey sample had similar coverage of EPC certificates to the LOGG population (25% vs 23%). However, there were no EPC certificates for the Shops in the sample and thus relatively higher coverage rates for the remaining CaRB3 classes. Average EPC grades were lower (i.e. worse) than the LOGG population, which may reflect the relative age of the survey sample, or perhaps that these premises have had lower rates of change in occupier (occupier churn). However, the number of records in each case is very small; see Table 17.

Table 18 LOGG population and survey sample EPC coverage

CaRB3 class	EPC coverage (LOGG population)	EPC coverage (survey sample)	Average Grade (LOGG population)	Average Grade (survey sample)
Factory	16%	43%	D (86)	D (89)
Shop	0	0	n/a	n/a
Office	18%	26%	C (75)	D (80)
Warehouse	16%	30%	C (68)	F (142)

The survey sample contains a higher proportion of rural premises than the overall LOGG population, as indicated by Figure 24.

Figure 24 LOGG population and survey sample rurality



Survey methods

This section outlines the approach used for the remote survey and the verification surveys. A remote survey employing Computer Assisted Telephone Interviewing (CATI) was used and is recommended for any future work, because:

- Telephone contact provided an opportunity for persuasion to partake in the survey, unlike an email.
- Quality is better when compared to online options as highly skilled interviewers were able to:
    - Ensure that the data collected were as complete as possible,
    - clarify responses,
    - capture additional information that an online survey would not capture that helped both with understanding this classification of premises and capturing options that did not always fit into the established responses in the survey.
- A more representative sample was aimed for through careful sample management.
- CATI provided an opportunity to have conversations with organisations about which members of staff could best answer the questionnaire. It would have been difficult to identify the appropriate respondents through commercial databases alone, especially due to the outdated nature of the databases associated with the Large Off Gas grid buildings, in particular.
- The technical annex for the earlier BEES study[2] also noted that when the survey was split into two parts, telephone followed by online, there were difficulties securing a response to the online version.

The process of the remote interview was as follows:

- Identification of appropriate respondent and recruitment .
- Appointment setting, including guidance on interview content and preparation required.
- Interviews that were planned to last 30 minutes took place. In reality, these took up to 50 minutes, depending on knowledge, processes, CaRB3 class, and depth of information provided by respondents.
- Data checking and clarification call, where necessary.

[2] Department for Business, Energy and Industrial Strategy. (2016). Building Energy Efficiency Survey 2014-2015: Technical Annex.https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/566038/BEES_Technical_Annex_FINAL.pdf

Survey Instrument

Table 18 below provides an overview of the survey for the Large Off Gas Grid premises, the full survey instrument is included in Annex 2 – LOGG remote survey instrument

Table 19 Overview of LOGG remote survey

Section	Overview
Premises type and ownership	A set of questions to understand whether the organisation we spoke to occupied the whole building, a collection of buildings, or a premises within a building. The section went on to capture information on ownership and activity specific details for the premises (for example the % of space used for different purposes).
Occupancy, Running Hours	A set of questions to understand the number of individuals occupying the premises on a regular basis and the hours that the business operates. Either the term 'visitor' or 'customer' was used, depending on the activity class.
Energy supply and metering arrangements	Includes questions on energy metering, including any submetering, energy supplies to the building and energy consumption (using cost as a proxy, where necessary)
Energy using equipment	Three sets of questions to understand energy-using equipment and fuel type: Heating, cooling and ventilation Lighting Other energy-using processes and equipment
Industrial processes	A set of questions to understand on-site industrial processes, focusing on up to three industrial processes
Actors with responsibility for energy and energy efficiency measures installed	A section to understand who has ultimate responsibility for energy within the premises and to understand the energy efficiency measures that have been implemented and when. We also included a couple of bespoke policy questions. This gave participants an opportunity to express their views to government, for example, on challenges or support needs they have related to energy management.

The survey script was developed drawing on existing literature on the key drivers of energy consumption and questions used in existing research. Questions were edited to make them appropriate for the timescale we are reflecting. Some questions used during the BEES survey were excluded where we believe the information would not be captured easily through a remote survey mechanism. Additional questions were introduced for datapoints specific to this research. The survey instrument was reviewed by BEIS and updated to reflect feedback.

Throughout fieldwork some aspects of the questionnaire were monitored and issues to be considered in a national survey were noted, as indicated in Table 19.

Table 20 Future considerations, by questionnaire section

Section	Issue
B - Building	Wall structure – the questionnaire did not allow for wall types that were neither solid construction nor traditional cavity for example the typical 1930's construction involving a narrow cavity and wall ties. Some respondents also had a mix of wall types.
C – Occupancy and hours	Respondents found the questions around partial (20-50%) and full (50% or more) occupancy in terms of staffing a challenge resulting in overlap of answers. Respondents often answered as Monday to Friday occupancy and hours and Saturday or Sunday occupancy, so the questions were edited after the pilot to ask only about Monday to Friday, Saturday and Sunday rather than every day.
G-Equipment	Additional verbatim boxes were added to the questionnaire to capture information around equipment, such as glass and dishwashers that had different run times and frequencies.
H – Industrial processes	Whilst respondents could discuss these, they struggled with aspects such as floor space taken up and power rating of the processes.

Where respondents could give data, they were able to do so using the energy units provided by the questionnaire.

Within the script, questions were cited where edits were required for specific samples selected for the LOGG remote survey. An overview of these questions is included in Table 20 below.

Table 21 Overview of changes to amend the remote survey for specific sub-sectors

Section	Proposed changes to the core script
Types of visitors	In the BEES survey, types of visitors were specified for sub-sectors (roughly equivalent to CaRB3 activity classifications). This was also done here. For example, in Shops we discussed customers, but for Offices we used the term visitors.
Types of energy-using equipment	Questions on types of energy using equipment were tailored to those most likely to be present for the sector (Sections F and G). Questions have also been included in Section H to cover Industrial processes with Factories interviewed.

Quality protocol

The following quality procedures were used for the remote survey.

Training and supervision of interviewers

A comprehensive training plan was developed and conducted at the beginning of fieldwork. This covered the following elements:

- Background to the project, including: its aims, the client and supporting organisations, methodological background
- Number of target interviews and sample management rules
- Supervision procedures including how quality would be checked and the process for queries
- Identification of appropriate respondents
- A run through of all remote survey questions
- Explanation of technical terms – glossary provided for interviewers
- Interviewer questions
- Role play/dummy interviews. Before researchers interviewed 'real' respondents they were able to role-play interviews with each other to familiarise themselves with the questionnaire and anticipate how respondents might react to particular areas of questioning. This helped to ensure that interviewers were well prepared prior to the first interview.

A dedicated field manager was available throughout the fieldwork period to answer any queries arising from interviews. The field manager monitored:

- Individual interviewer productivity
- Overall response rates and refusal rates, weekly, to ensure that the sample was being worked effectively.

Quality monitoring of interviewer work

The quality of interviewers' work was monitored in two ways.

The first interview conducted by an interviewer was listened to by the field manager, alongside the checking of data entered into the system for that interview. In total, 14% of all interviews were monitored. If the listener considered it to be appropriate (e.g., on the basis of initial monitoring) the level of monitoring of individual researchers was increased.

Feedback from interviews was given to interviewers within one day and any further training was given, where required. If problems identified in monitoring were considered by the field team to be sufficiently serious, respondents may have been re-contacted to clarify data.

Each interview that was listened to was given a quality score based on consideration of:

- Identification of the right respondent
- Accuracy of data entry and categorisation, including verbatim responses
- Appropriate probing of responses
- Accurate delivery of questions
- General interviewing manner.

The project team had targets to ensure the average quality score was at a high level.

Before fieldwork commenced, the consultant responsible for drafting the remote survey produced a dataset checking guide. This covered a range of areas including ensuring that the respondent was correct, that all essential questions were asked and that the interviewer probed to gather a detailed response. This also included checking the quality of the numerical data collected (if and where applicable), as well as ensuring that data across an interview were consistent.

The field manager checked the write-ups from first interviews and provided feedback to the team. The overall data were then checked on a weekly basis. The project team met once a week to discuss the work.

If required, interviewers called back respondents to capture any data that might have been missed during an initial interview or that needed clarifying.

In some cases, the energy figures provided seemed to be outliers. For each of these, the interview recordings were checked and the documented figures were found to be an accurate representation of the respondent’s answers.

Assessing the quality of responses

The process included the following question in the questionnaire – asked of both respondents and interviewers respectively to gain their insight into the quality of the data collected.

“In terms of your responses given to questions where factual information is provided, how accurate do you think your responses have been?

- Mainly accurate
- Mix of some accurate and some guesswork
- Mainly guesswork but should be about right
- Don't know”

Of the 63 interviews included in the final dataset, the following assessments of accuracy were made, as shown in Table 21.

Table 22 Accuracy assessment

Accuracy	Respondents' self-assessment	Interviewer assessment
Mainly accurate	41	31
Mainly guesswork but should be about right	3	17
Mix of some accurate and some guesswork	19	15
Unsure	0	1

Before analysis, the data were reviewed for any gaps, potential data entry errors and any poor-quality records. Any changes to the raw data were logged against the data cleaning plan. The exact criteria for assessing the quality of records included:

- Screening records for outliers. This was based on metrics such as occupancy or energy usage. All outliers were verified through listening to interview recordings.
- The data from the first pilot set of interviews were reviewed by UCL/Verco. Feedback was then incorporated into questionnaire changes and/or further interviewer training. Lessons from this were incorporated into the data checking plan.

Piloting

Given the complex nature of the study, and the unique questionnaire-tailoring required for LOGG buildings, it was important to pilot the questionnaire to understand:

- Questionnaire length.
- Engagement and response of potential respondents.
- Any further tailoring of recruitment and the approach to identifying an appropriate respondent.
- Any difficulties with the main questionnaire.

In addition to the above, the proposed script for LOGG buildings overlaps with the remote survey developed for the pilot study of the Hospitality CaRB3 class, and therefore also underwent a phase of cognitive testing to ensure that questions were phrased appropriately and understood as intended by respondents.

Verification surveys

The verification survey work stream provided an independent verification of the data provided by telephone survey participants by sending an auditor to the site. Auditors repeated selected questions from the telephone surveys and undertook visual inspections to assess the accuracy of the data provided in answers to the telephone interviewers.

Telephone survey participants were asked at the conclusion of their phone survey if they would be willing to receive a verification visit. The contact details of those who agreed were transferred securely to the verification audit team who then re-established contact with the phone survey participant to organise the verification visit.

The results of the phone survey were provided via Secure File Transfer (SFT) to the verification auditor who then travelled to site and carried out the verification audit. The results of the verification audit were transferred back via SFT so that the telephone and verification audit results could be compared and any variances in answers given identified.

The verification audit team consisted of five UCL post-graduate students in technical building engineering disciplines and two members of the Verco energy engineering team. In preparation for the verification audits the students attended a one-day training course at UCL, where Verco provided training on, for instance: plant room familiarity and safety; asbestos awareness; confined spaces; lone working (not permitted during the project); technical plant familiarisation; data security protocols to be followed by the audit team at all stages. UCL attended and provided key insights to the audit team of the background and objectives of the verification work stream. The verification audit team members were issued with Personal Protective Equipment (PPE) identified as necessary by the workstream risk assessment.

In total, 8 verification audits were completed as part of the LOGG Verification workstream. This is significantly lower than the target of 20 but is actually higher than the 10% of remote surveys originally proposed. Hence the absolute total is mainly explained by the lower than expected success rate for remote surveys (63 vs 200 target). Other reasons for the low number of verification surveys are discussed in the sections below.

The participants by sector are given below:

- Office + Warehouse 1
- Shops 2
- Factories 3
- Warehouses 1
- Offices 1

Key learnings and considerations for future work

The CATI software platform selected for the telephone interviews met the needs of the telephone interviewers, however it had no offline functionality for the entering of verification data, as a result it was necessary to export the telephone survey data to Excel for transmission to the verification auditors. On arrival the data had to be processed to make it usable for the verification auditors. The transmitted data set contained answers to all questions in the survey script whether asked by the interviewer or not, to make this data set intelligible it was necessary to strip out all unused data points. This process required double handling, was time consuming and required quality assurance to ensure that data wasn't removed in error. After an on-site survey had been conducted the verification data had to be standardised and later uploaded to a summary workbook for all on-site surveys.

This shortcoming in the software increased the work required to accommodate telephone survey script changes part way through the program. Whilst these undoubtedly made the telephone survey more useful, the requirement to change the Excel formulae, built to identify questions requiring verification, added additional handling time and cost. These challenges could have been circumvented by the selection of a telephone interview software platform more suited to the remote verification needs of the project.

Any future project should use software able to provide abstracts of survey response data for offline verification surveys, with the ability to upload the verification data set on completion.

Lead generation and follow up

The total population of sites, for which a verification survey was an option, was de facto limited to the 63 sites for which a remote survey was achieved. The verification lead drop-out rate was high for this segment, with some participants of phone surveys contacted on 7 occasions before finally confirming they weren't interested in participating. It was decided to limit contact attempts to 5 per contact.

The verification audit team experienced a low conversion rate, from agreement during the phone survey to participating in a verification audit, to confirming a date for audit with the verification auditor; respondents claimed not to have been aware of anyone having given prior agreement to an onsite survey. It is believed this was either an excuse not to participate or a result, in many cases, of the contact person answering the phone survey questions not being the same contact person given for the site verification visit. This appears to have been so in the case of chain branches and where the phone respondent was an owner or manager of the responding business whilst the verification contact was a member of a different team. In any future study, efforts should be made to further qualify lead contact details, for instance to establish that the contact person has authorisation to book the site visit and will be made aware they will be contacted. An ideal solution would be to organise the site visit at the time of the telephone survey and confirm the visit prior to attendance with the same telephone respondent to minimise abandoned visits. This could be achieved by making auditor availability, viewable by the telephone interviewers, using online calendars for each verification auditor.

The participation drop-out could also have been affected by the lead time from remote survey to when the verification auditors received contact details and were able to commence booking arrangements. Initially, new leads came in a batch on an unspecified day of the week, as the project evolved and the structure changed to a weekly or bi-weekly leads update on Wednesday. This led to a quick follow-up call from the on-site surveyors, who were able to schedule contact calls and emails to when they knew contact details would become available. A more frequent update could be beneficial for audit confirmation rates, though too frequently would lead to a loss of the structure for the on-site surveyors. Therefore, a twice-weekly update on Monday and Wednesday, or Tuesday and Thursday, would be ideal.

Lead prioritisation

Challenges in booking verification visits were found to be exacerbated further where it was necessary to postpone a visit. This only happened due to a circumstance beyond the auditors' control, in one instance, for example the audit was cancelled due to a train strike. In these situations, it proved impossible to rebook a new date within a reasonable timescale. In one example, the audit team was asked to wait over a month before attending site, a date beyond the scheduled end of the project phase.

Future projects should have a clear priority set between verification audit types, in order to ensure resource is assigned to the highest priority verification audits first. This will help to ensure that survey segments with low response rates, as in this case with the LOGG sites, are allocated priority audit slots, thus minimising the chances of high priority site verification audits being delayed or cancelled.

Continuity of contact

Where the verification team experienced issues booking audit visits with site respondents through a lack of response to emails and phone calls, the audit was issued back to Winning Moves who then approached the respondent again to try and reengage them. This approach proved successful on a minority of occasions and verification audits were subsequently scheduled.

Grouping of surveys

Assigning verification candidate sites to clusters and attempting to book in more than one site in a cluster on the same day would improve the overall efficiency of the verification process. It would be possible under these circumstances to complete two surveys in one day, making better use of time and finances to achieve the result; albeit the program would have potentially been slowed down waiting for confirmed details of all sites within a cluster. This could have been achieved by structuring the on-site survey selection by location instead of when the corresponding remote survey had been performed. This would have enabled the surveyors to easily follow up on a cluster of leads in the same vicinity. Given the challenges completing the remote surveys, in this instance, this methodology may well have proved too challenging to implement effectively; however, it offers a potential alternative approach for any future projects.

Survey Results

This section of the report presents key findings from the survey process. Where verification surveys showed some disagreement between remote survey results and findings on site this is discussed in the relevant section.

It should be noted that since it was only possible to undertake 63 surveys, the results may not be representative of the wider population.

Key characteristics of LOGG premises

The majority of respondents in all CaRB3 classes indicated that they had authority to make fundamental changes to their premises (Factories 72%, Offices 85%, Shops 75% and Warehouses 100%). This reflects the tenure of the premises, as illustrated in Table 22; i.e. owner-occupiers have greater ability to initiate change and the format as shown in Table 23 with only 25% of Offices and 3% of Factories operating out of part of a building.

Numbers of staff on each site were generally low with median values ranging from 20 (Warehouses) to 106 (Shops). Factories were typically small (median 25 employees on site) with one exception with 2,100 employees, whilst Offices had a median of 100 employees on site.

Table 23 Tenure status of LOGG premises

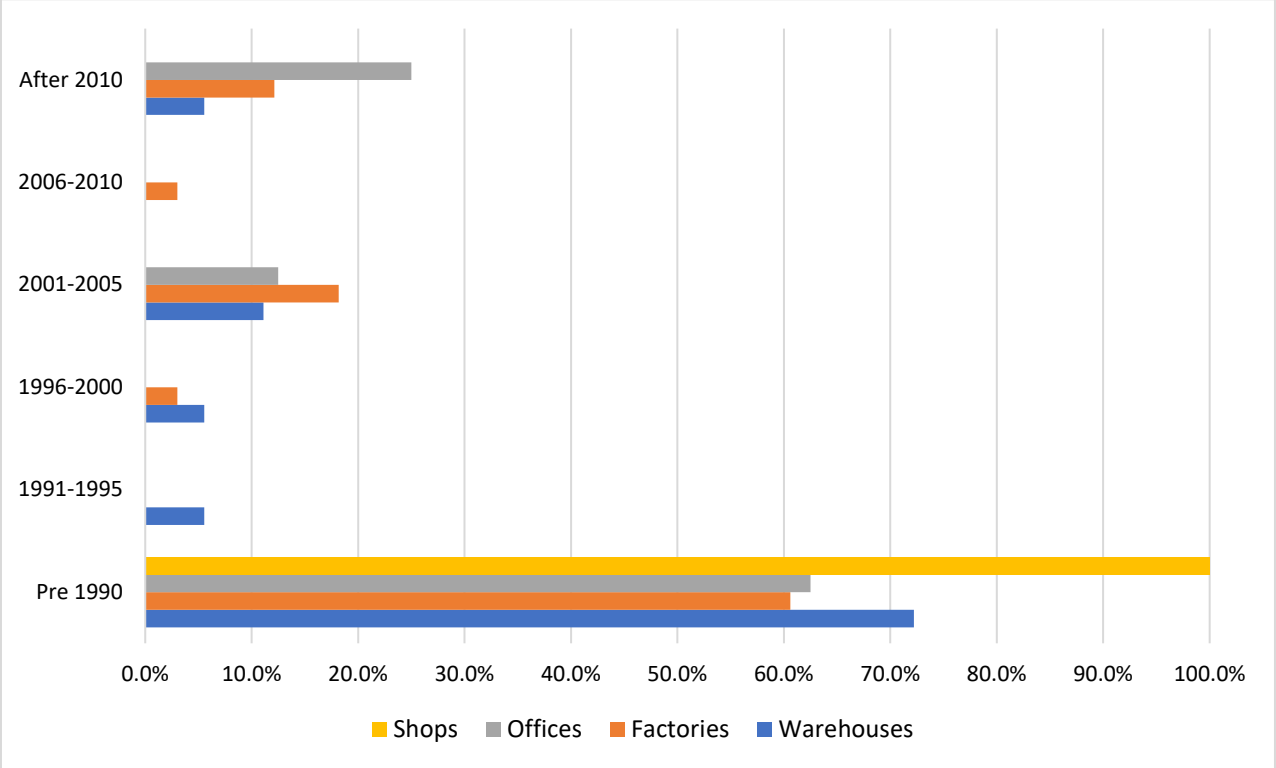
	Warehouses N=15	**Factories N=35**	**Offices N=7**	**Shops N=5**
Rented	27.8%	12.1%	25.0%	
Leased	11.1%	18.2%	12.5%	25.0%
Owned outright (include if mortgage has been paid off in full)	50.0%	51.5%	62.5%	75.0%
Owned - Mortgage	5.6%	6.1%		
Other - capture details		9.1%		
Unsure	5.6%	3.0%		

Table 24 Format of LOGG premises

	Warehouses N=15	**Factories N=35**	**Offices N=7**	**Shops N=5**
A collection of buildings	44.4%	57.6%	25.0%	25.0%
A whole building	55.6%	39.4%	50.0%	75.0%
Part of a building		3.0%	25.0%	

Respondents had typically occupied their premises for a long period with median occupancy periods of 20 years for Warehouses and Factories, 17 years for Offices and 50 years for Shops. Length of occupation is reflected in the age of the premises as shown in Figure 25 with the majority of premises in all CaRB3 classes being constructed before 1990. This is in contrast to the age of the population as a whole as shown in Figure 7.

Figure 25 Construction date for premises



The date of last significant investment varied by CaRB3 class, with Factories and Warehouses more likely to report never having had significant investment (44%, 40% respectively). All (100%) of the Offices and 60% of Shops reported some investment occurring since 2010.

Energy Supplies

Almost all respondents paid suppliers directly for energy (Shops 75%; Offices 75%; Factories 90%; Warehouses 83%). The majority of these payments were made directly by the site (Shops 60%; Offices; 71%; Factories 84%; Warehouses 87%). Where payments for energy used in communal areas were reported, these were made directly to the supplier.

Energy sources used at the sites are shown in Table 24, indicating that 6 Factories reported use of “other” energy sources (3 instances of biomass boiler, 1 of wood burner, 1 of solar panels and 1 of diesel generator).

Table 25 Energy Sources in LOGG premises

Energy Source	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Electricity	100%	100%	100%	100%
Oil	20%	58%	43%	40%
Coal	0%	3%	0%	0%
LPG	20%	17%	14%	20%
Smokeless fuel	0%	0%	0%	0%
Anthracite	0%	0%	0%	0%
Dual fuel appliances: mineral and wood	7%	8%	0%	0%
District heat	0%	0%	14%	0%
Other	0%	17%	0%	0%

Electricity was metered at all sites, but metering for other energy sources was limited to two Factories at which oil was metered; one at which dual fuels were metered and one at which biomass was metered. The Office which used district heat reported that this was metered.

Submetering was reported at a small number of sites (1 Office, 4 Factories, 2 Warehouses), but only four respondents (2 Factories and 2 Warehouses) reported using it for energy management purposes.

Heat recovery systems were in place at a small number of sites (1 Shop, 2 Offices, 4 Factories, 2 Warehouses). In half of these cases this was the main system for heating the building. In one Factory it was also the main system for heating hot water.

The main energy sources for heat were electricity and oil as shown in Table 25, whilst Table 26 shows the main energy source for water heating.

Table 26 Main energy source for space heating in LOGG premises

Energy Source	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Electricity	53%	33%	43%	40%
Oil	20%	36%	29%	40%
Coal	0%	0%	0%	0%
LPG	0%	6%	0%	0%
Smokeless fuel including coke	0%	0%	0%	0%
Anthracite	0%	0%	0%	0%
Dual fuel appliances- mineral and wood	0%	6%	0%	0%
District Heat	0%	0%	14%	0%
Unsure	20%	6%	0%	20%

Energy Source	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Other = biomass	0%	8%	0%	0%

Table 27 Main energy source for water heating in LOGG premises

Energy Source	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Electricity	67%	53%	57%	40%
Oil	7%	22%	14%	20%
Coal	0%	0%	0%	0%
LPG	0%	6%	0%	20%
Smokeless fuel including coke	0%	0%	0%	0%
Anthracite	0%	0%	0%	0%
Dual fuel appliances- mineral and wood	0%	3%	0%	0%
District Heat	0%	0%	14%	0%
Unsure	27%	8%	14%	20%
other = biomass	0%	6%	0%	0%

Respondents were asked to provide details of quantities of fuels used or costs incurred. These details are recorded in the raw data but not summarised here due to the small number of responses in each case.

Almost all respondents were able to report which of their equipment was responsible for the majority of electricity use, and the reported sources of demand are shown in Table 27. One Shop reported roller shutters as the primary energy demand.

Table 28 Main source of energy demand in LOGG premises

Main source of energy demand	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Industrial machinery	27%	14%	14%	0%
Air conditioning	0%	14%	14%	0%
Heating/cooling	0%	0%	0%	20%
Refrigeration	7%	0%	0%	0%
IT	0%	14%	14%	0%
IT & air-conditioning	7%	14%	14%	0%
Heating/cooling and IT	0%	14%	14%	0%
Lighting	47%	14%	14%	40%
Lighting cooling and kitchen equipment	0%	0%	0%	20%
Lighting and IT	7%	14%	14%	0%
Other	0%	0%	0%	20%

Heating, ventilation and air-conditioning systems

The majority of sites had (where present) dedicated systems for heating, ventilation and cooling (Shops 80%, Offices 71%, Factories 89%, Warehouses 80%). Electric heating systems varied by CaRB3 class, with electric room heaters more common in Factories than other classes. One Shop and one Warehouse reported the presence of an air-source heat pump. Although 8 Warehouses reported electricity as the main heating source, only two reported an electric heating system. Two Factories reported the presence of solar thermal heating whilst four Factories and one Warehouse were using biomass boilers.

Heat distribution systems were typically radiators or hot air systems, with some sites having both. The state of repair varied across CaRB3 classes, with Warehouses most likely to report that the system had never been replaced (73%). Approximately 40% of respondents in the other classes indicated that heating systems had been replaced since 2010. Repairs were more likely to have been carried out, since 2010, in Shops (60%) and Offices (57%), than in Factories (31%) and Warehouses (27%).

The median operating period for the heating system was 6 months for Shops and Factories, 7 months for Offices and 10 months for Warehouses. However, Warehouses were more likely to report that only part of the premises was heated (14% reported 60% of areas were heated), whilst for Shops this was 80%, for Offices 57% and for Factories 42%. The median operating period for the heating system each day was similar across all CaRB3 classes (Shops 8 hours; Offices 6 hours; Factories 7 hours; Warehouses 7 hours).

Ventilation systems (Table 28) varied by CaRB3 class, with 40% of Shops, 29% of Offices, 39% of Factories, and 53% of Warehouses being naturally ventilated. While all respondents could respond to the question of the method of ventilation, fewer were able to estimate the spatial coverage of the system (Shops 60%; Offices 71%; Factories 36%; and 40% for Warehouses). Respondents were more confident reporting the controls for ventilation systems, timing of repair/replacement and the type(s) of system.

Table 29 Mechanical ventilation systems

Type of mechanical ventilation system	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Supply and extract	20%	8%	29%	20%
Extract only	7%	47%	29%	40%
Displacement ventilation	13%	3%	0%	0%

Presence and coverage of air conditioning varied by CaRB3 class: the majority of Factories and Warehouses had no air-conditioning (61% for Factories and 60% for Warehouses), while 20% of Shops were mostly air-conditioned and 71% of Offices reported at least 60% of their building was air-conditioned.

Table 29 shows the distribution of different cooling systems across the survey sample, the type of system varied by CaRB3 class, with Offices having only central systems and Shops only local units. Factories and Warehouses reported both central and local systems with two Factories reporting both central and local systems.

Table 30 Types of cooling systems

Type of cooling system	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Central system - cold air distribution	7%	19%	0%	0%
Central system with chilled water distribution	7%	0%	29%	0%
Central system with refrigerant distribution (VRV)	0%	11%	29%	0%
Central system but unsure of type	13%	3%	29%	0%
Local units with refrigerant (DX split units)	13%	17%	0%	60%

Respondents reported that cooling systems were either replaced in 2010 onwards or not at all (Table 30). The lack of responses for periods prior to 2010 may reflect lack of knowledge. Offices are more likely to have had systems replaced since 2019 (29% compared with 11% for Factories, and 0% for both Shops and Warehouses). Although no Shops reported replacement of the cooling system after 2019, overall, they were most likely to have had a system replacement since 2010, this may be linked to the ease of replacement of individual local units compared with central systems. Table 30 shows repairs taking place more recently than replacement. Offices and Warehouses are most likely to have recent repairs.

Table 31 Timing of last replacement of cooling system

Last replacement of cooling system	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
After 2019	0%	11%	29%	0%
Between 2010 and 2019	7%	11%	14%	60%
Between 2005 and 2009	0%	0%	0%	0%
Pre-2005	0%	0%	0%	0%
Cooling system has never been replaced	13%	17%	29%	0%

Table 32 Timing of last repair of cooling system

Last repair of cooling system	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
After 2019	7%	19%	57%	20%
Between 2010 and 2019	0%	6%	14%	20%
Between 2005 and 2009	0%	0%	0%	0%
Pre-2005	0%	0%	0%	0%
Cooling system has never been repaired	13%	14%	14%	20%

Thermostatic temperature control is reported in all Offices, time controls and zoning controls are less prevalent as shown in Table 32.

Table 33 Types of cooling controls

Types of cooling controls	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Time controls switch off the cooling outside normal hours of use	27%	19%	57%	20%
Temperature control is efficiently set via thermostats	40%	22%	100%	60%
Cooling for zones with different hours of use is controlled separately	20%	17%	43%	20%

Table 34 Cooling practices

Cooling practices	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
The building suffers from heat gains due to the sun shining on the building	27%	22%	71%	40%
The building has external shading to prevent heating from the sun	13%	3%	14%	0%
The building regularly uses night-time ventilation in warm weather	7%	3%	43%	0%
Cooling is only used in very hot weather (top cooling)	20%	22%	29%	40%
Cooling is available 24h for special areas only (e.g. servers, control rooms)	27%	28%	71%	0%

The use of air-conditioning across the classes. All Warehouses who responded to the question reported using cooling year-round, while the median for Factories was 9 months per year, Offices 5 months and 4 months for Shops.

Low carbon and renewable technologies

Renewable and low carbon technologies were reported in 20% of Shops, 17% of Factories, and 20% of Warehouses, no renewable or low carbon technologies were reported in Offices. Table 34 shows the low carbon technologies reported by respondents. When respondents indicated that there were technologies other than photovoltaic panels and wind turbines present, they were asked to specify the technology.

Table 35 Low carbon technologies

Low carbon technologies	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Photovoltaic panels	0	2	0	1
Wind turbine	0	0	0	0
Other - air source heat pump	0	0	0	0
Other – heat pump with waste heat from refrigeration system to heat water	0	1	0	0
Other - solar thermal panels	2	2	0	0
Other - Wood burner (biomass?)	0	1	0	0

Hot water

The majority of premises reported using centrally heated hot-water for hot-water taps (Shops 60%; Offices 71%; Factories 83%; and Warehouses 67%). All of the Offices using centrally heated hot-water for taps also used it for showers, in contrast to other CaRB3 classes where only 3 Factories and 1 Warehouse used centrally heated hot-water for showers. Two Factories reported using centrally heated hot water for washing production equipment and machinery.

Point of use electric water heaters were reported in a majority of premises (Shops 40%; Offices 71%; Factories 61%; and Warehouses 53%). Most of these premises also reported using centrally heated water for hot water taps (1 Shop; 3 Offices; 19 Factories; and 7 Warehouses).

Lighting

The majority of all premises had LED lighting (Shops 100%; Offices 86%; Factories 81%; and Warehouses 60%). A mix of other lighting technologies were also reported, in many cases, alongside LED lighting as shown in Table 35.

Table 36 Lighting technologies

Lighting technologies	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
LED	60%	81%	86%	100%
Incandescent	13%	25%	0%	20%
GLS lamp	0%	3%	0%	20%
Compact fluorescent	27%	25%	57%	20%
Halogen	20%	17%	14%	20%
industrial, big light bulbs. warehouse one that lights up a big area.	7%	0%	0%	0%
Strip lights, very green lights in show	7%	0%	0%	0%
T5 fluorescent	0%	0%	14%	0%
uv lamps x 6	0%	3%	0%	0%

More sophisticated lighting controls (automatic switching and lighting management systems) were more likely to be found in Offices than in other classes as shown in Table 36.

Table 37 Lighting controls

Lighting controls	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Light switches that are easily accessible	93%	92%	86%	100%
Light switches that are hard to access	0%	3%	0%	20%
Automatic controls (daylight or presence detectors)	33%	39%	71%	40%
Lighting management systems	7%	3%	29%	0%

Most premises reported that lighting was switched off in unoccupied areas (Shops 80%; Offices 86%; Factories 75%; and Warehouses 80%). The use of artificial lighting when daylighting was sufficient varied: all Shops reported lighting being switched off when daylighting was sufficient, in contrast to 64% of Shops, 43% of Offices, and 73% of Warehouses.

Equipment

Table 38 Presence of equipment in LOGG sample premises

Equipment	Warehouses N=15	Factories N=35	Offices N=7	Shops N=5
Catering kitchen serving meals	0%	0%	14%	40%
Server supporting IT	53%	6%	100%	0%
Data centre	7%	0%	29%	0%
Swimming Pool/Jacuzzi/Hot tubs	0%	0%	0%	0%
Commercial refrigerated storage for food sales	0%	0%	14%	40%
Chilled drinks/ cellar/ bar facilities	7%	3%	29%	40%
Non-food refrigeration	0%	17%	0%	0%
Saunas/steam rooms	0%	0%	14%	0%
Lifts or escalators	13%	17%	57%	20%
Sound system	0%	0%	14%	40%
Hot drinks facilities	47%	53%	43%	80%
Automatic Conveyor Belt	7%	22%	0%	0%
Timber treatment plant	7%	0%	0%	0%
Industrial machinery	0%	42%	0%	0%
Compressors	13%	6%	14%	0%
Cold store	7%	0%	0%	0%
Forklifts	0%	3%	0%	0%
Vending machine	0%	0%	14%	0%

Three premises had catering kitchens (2 Shops, 1 Office) all serving predominantly reheated food. Between 40 and 400 hot meals a day and between 20 and 500 cold meals a day.

Industrial processes

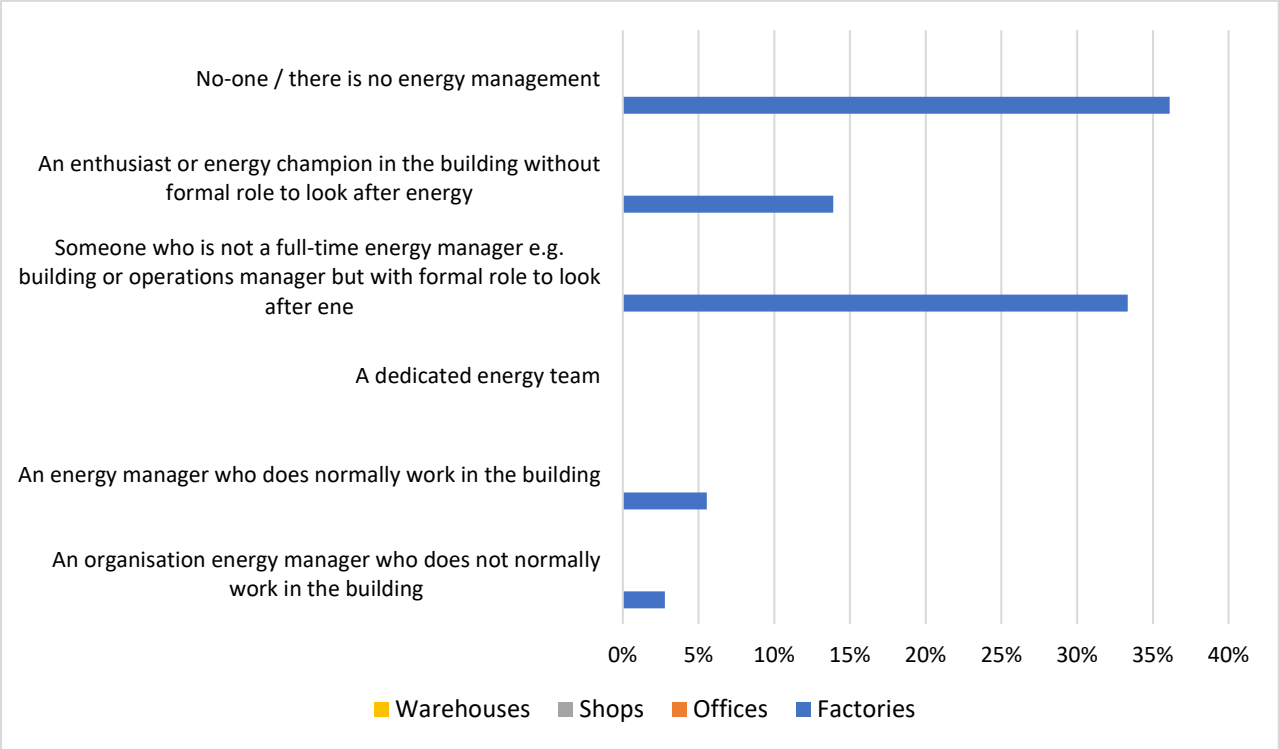
Three factories reported more than 80% of their electricity expenditure being due to industrial processes and one reported 60-80% of their electricity expenditure being due to industrial processes. One factory reported less than 40% of oil expenditure being due to industrial processes and two reported dual fuel expenditure due to industrial processes (60-80% and less than 40%, respectively). No other fuel expenditure was reported for industrial processes.

Four factories reported using processes which rejected large amounts of heat to the surrounding areas, all of these respondents reported having heat recovery systems in place. 10 factories reported using processes which required additional ventilation and air extraction.

Management

Factories was the only CaRB3 Class for which respondents provided details of responsibility for energy management. Dedicated resource for energy management was reported by 9% of respondents (n=3).

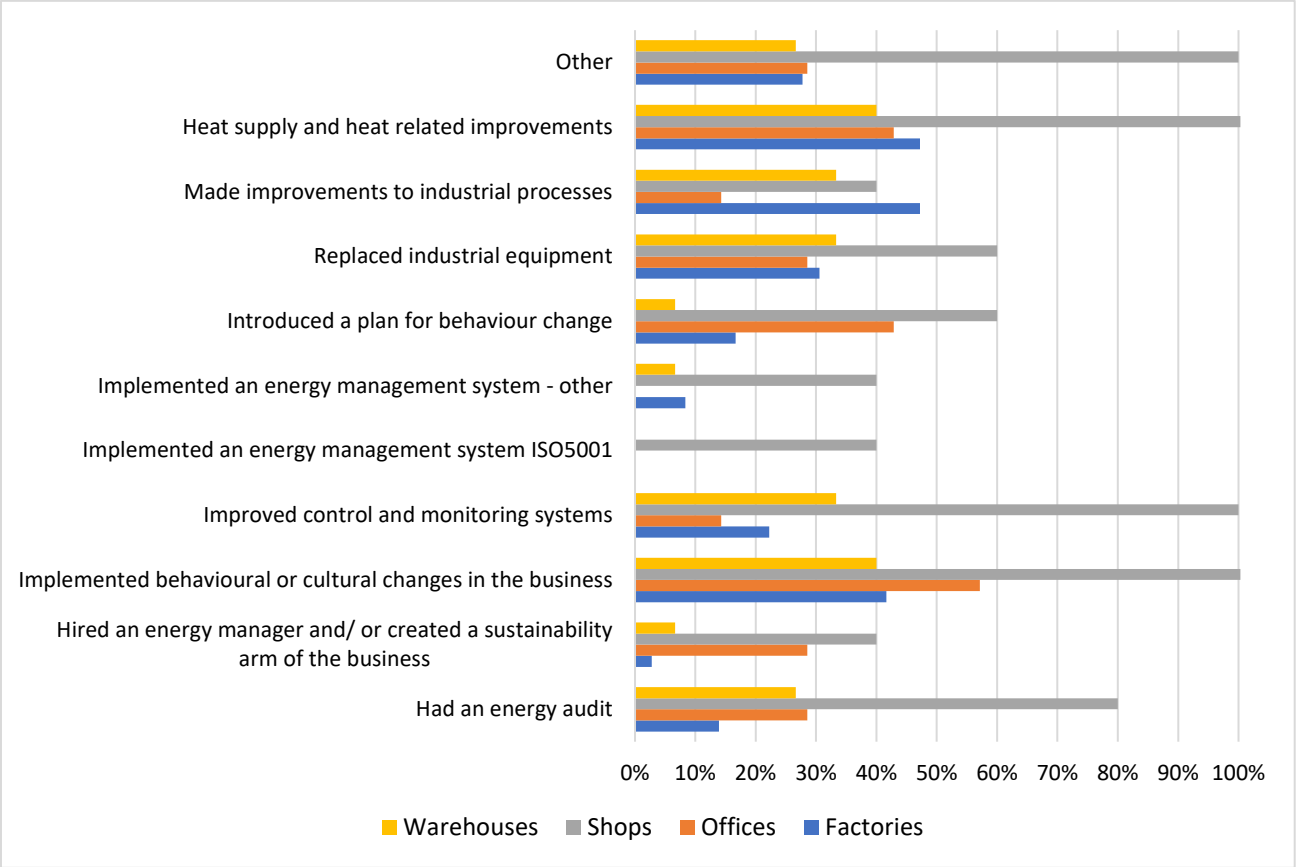
Figure 26 Energy management responsibility



Across all CaRB3 classes, 6% (n=4) of respondents had explored the potential to connect to the gas grid.

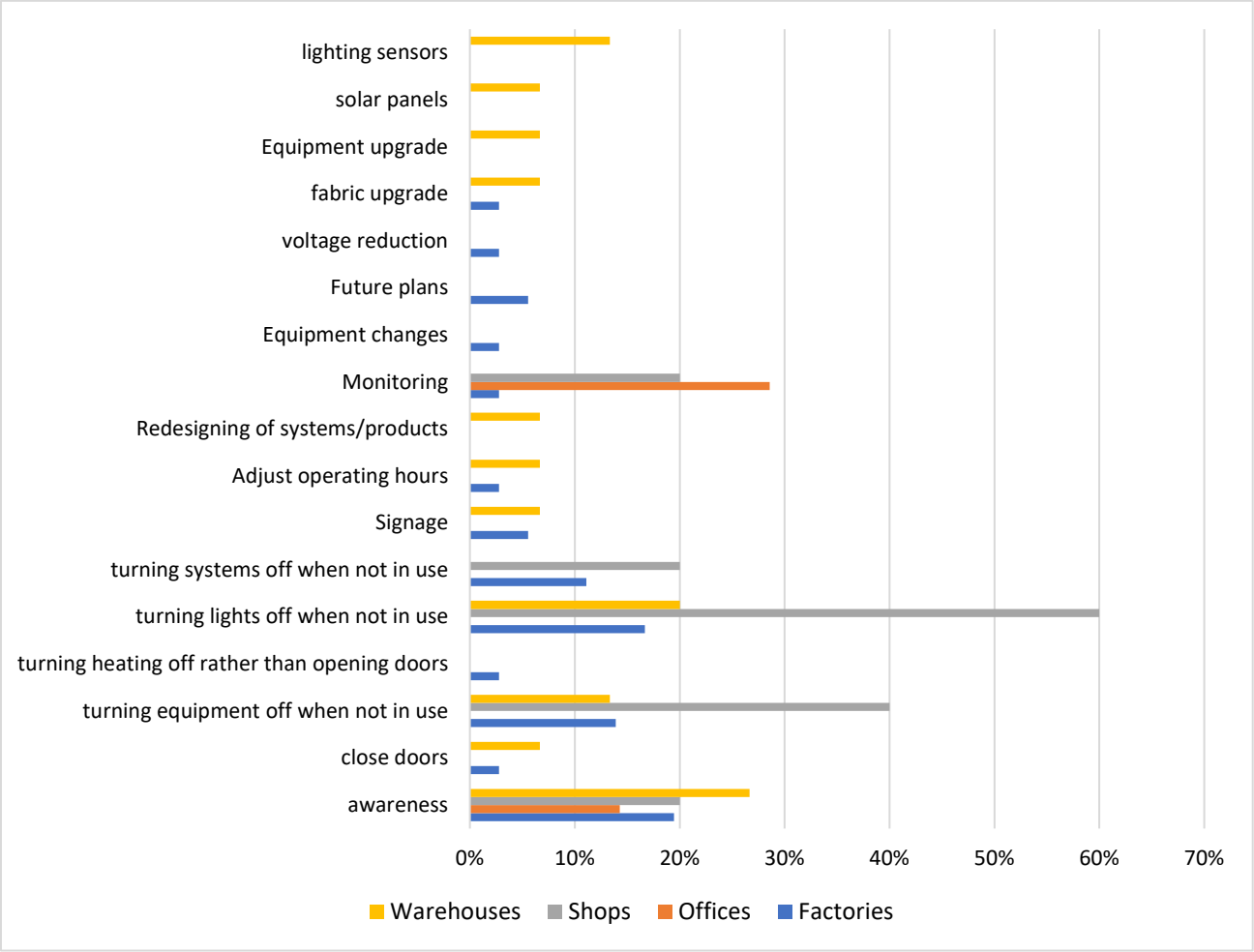
Across all CaRB3 classes the majority of respondents reported taking some form of action on energy management in the last 5 years (Factories 75%, Offices 86%, Shops 100% and Warehouses 80%). The range of actions is shown in Figure 26 Energy management actions in the last 5 years. All shops and at least 40% of respondents in the other CaRB3 classes reported making improvements to heat supply and related systems. 47% of factories reported making improvements to industrial processes.

Figure 27 Energy management actions in the last 5 years



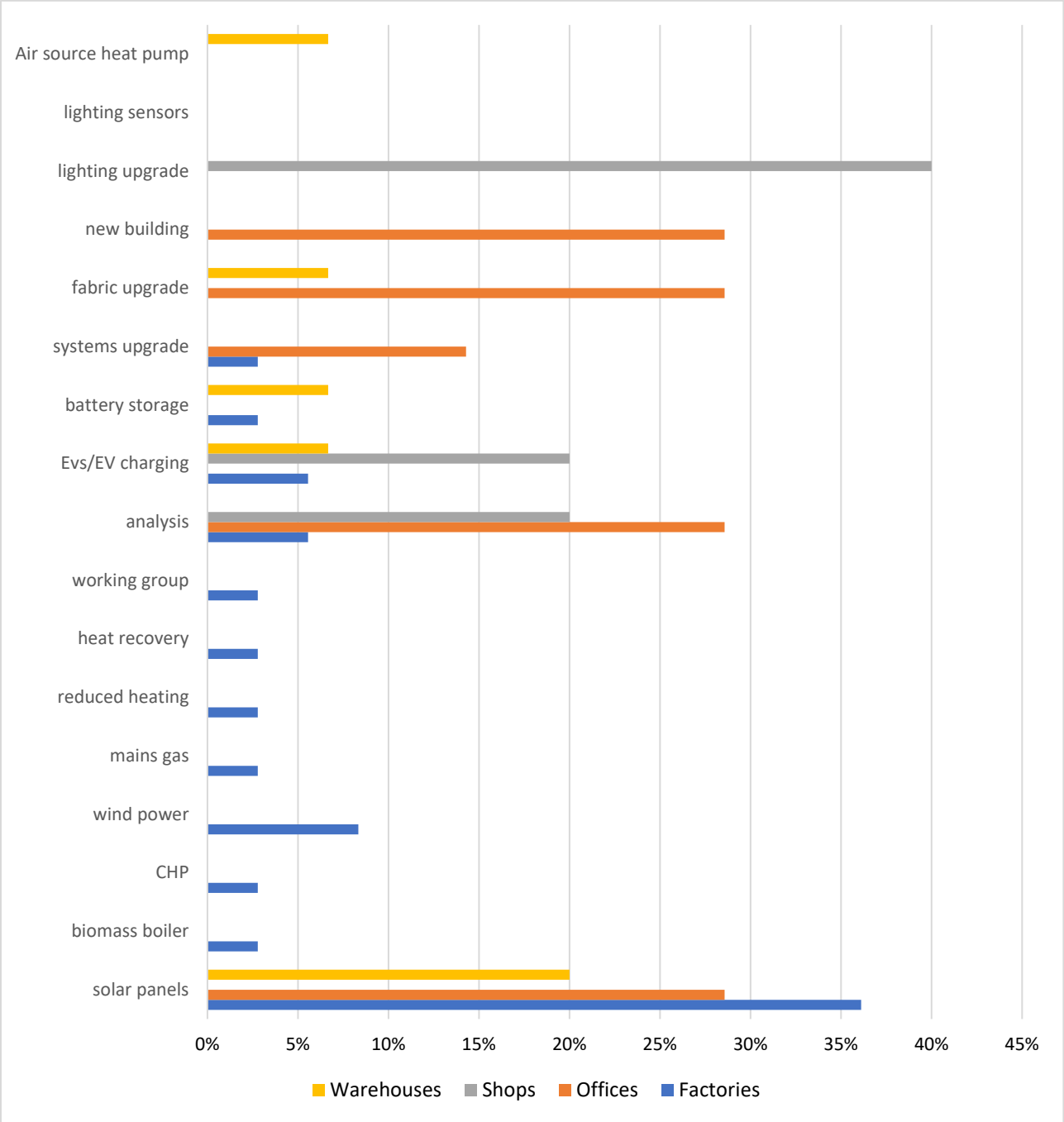
Across all CaRB3 classes 49% of respondents reported implementing some form of behavioural or cultural change action and 21% reported implementing a plan for behaviour change. When asked to specify these changes, respondents generally listed a wide range of changes, not all behavioural. Responses were recorded verbatim and subsequently categorised. The categorised responses are shown in Figure 27. Note that some respondents listed several actions and these were coded individually.

Figure 28 Changes implemented



Respondents were also asked what other changes they had investigated. Responses were recorded verbatim and later categorised and coded. Some respondents provided more than one response which have been coded individually. Results are shown Figure 28. 36% of factories had investigated installation of solar panels or other renewable generation options.

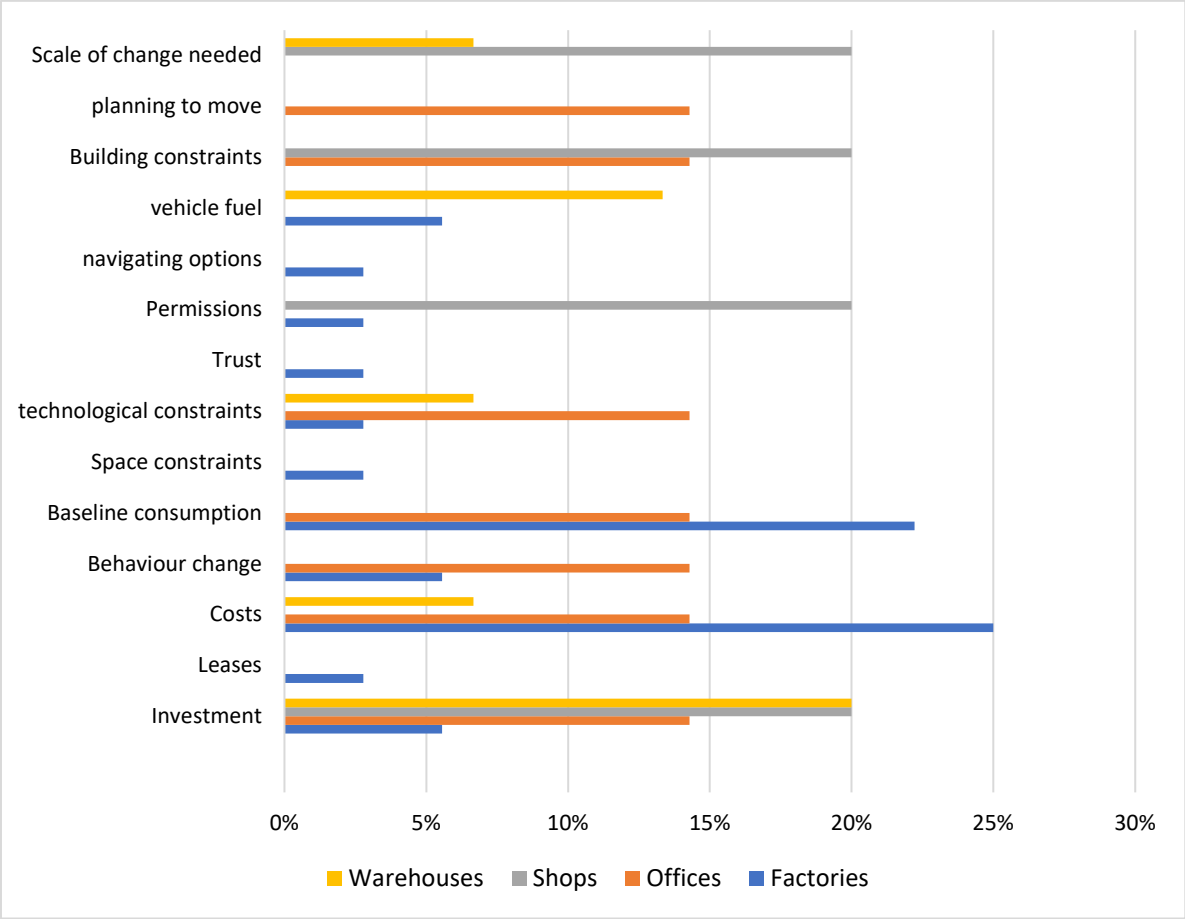
Figure 29 Other changes which have been explored



Challenges faced in lowering carbon emissions.

Respondents were asked what challenges they faced in lowering their carbon emissions and transferring to alternative energy efficient options. Responses were recorded verbatim and later categorised and coded. Some respondents provided more than one response which have been coded individually. Current energy costs were cited as a key challenge by 25% of Factories, 14% of Offices and 7% of Shops. 25% of Factories reported challenges with the baseline consumption needed for processes or the technological demands of the process which reduced options for switching to lower carbon options. Investment costs were a key concern for Warehouses and Shops (20% of respondents). Constraints of existing buildings were a challenge for one office and one shop with one office planning to move as a result.

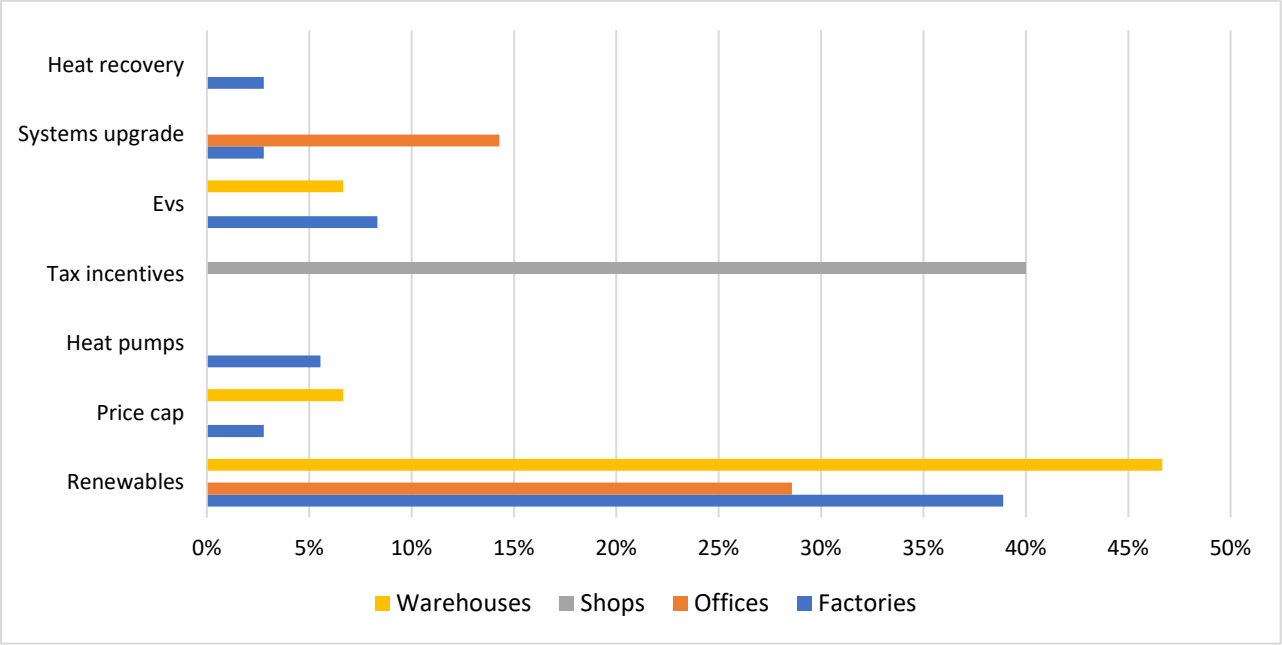
Figure 30 Challenges to lowering carbon emissions



Government support

Respondents were asked what funding support they would value from government. Responses were recorded verbatim and later categorised and coded. Some respondents provided more than one response which have been coded individually. Responses are shown in Figure 29 Government support - funding. For all CaRB3 classes except shops, the most common response was grant support for investment in renewables.

Figure 31 Government support - funding



Respondents were also asked to detail other forms of government support that might be valued. Responses were recorded verbatim and later categorised and coded. Some respondents provided more than one response which have been coded individually. Results are shown in Figure 30 Government support - other. For Warehouses and Factories the most common response was advice on available measures.

Figure 32 Government support - other

Probe Surveys

The Probe surveys are intended to build a picture of what is actually happening in the building stock, the survey process consists of:

- Pre audit booking data request and review, to ensure comprehensive data is available, as a minimum 24 months of energy and bulk fossil fuel consumption and a check that the site is still classified as LOGG. In some instances, it was found this was no longer the case.
- Pre audit data analysis, to understand the energy consumption patterns onsite, understand the apparent level of control over heating fuel use and correlation to weather conditions. Where provided details of building fabric and plant are also reviewed pre survey so the site team has a holistic understanding of the building ahead of the audit.
- A one day site survey is undertaken, during which the energy end uses, the fabric and plant, occupation patterns and controls are subjected to scrutiny with the objective of identifying the interventions necessary, in this case to firstly decarbonise heat and secondly align the asset to net zero specification.
- The survey is then written offsite by the survey team.

This approach facilitates analysis and understanding of the building as it is today and the interventions necessary to achieve the objectives of decarbonising heat and achieving net zero performance. Additionality is provided by the opportunity to engage with and understand the concerns of the occupiers and operators of the building and how the physical building characteristics influence their occupation of the site.

The sites captured in this series of audits were identified and recruited through three routes:

- · 5 recruited through specialist telephone research agency Winning Moves
- · 2 recruited through existing Verco client base
- · 1 recruited through contacts within other market participants

In total 8 sites were recruited for the audits, which took place between February 2022 and January 2023.

Target quota

The project brief set a target of 20 for the number of LOGG Probe audits to be undertaken. The number achieved fell short for many reasons, but we would particularly highlight the following:

- Limited sample: the final total sample of 1782 LOGG premises is a relatively small pool from which to obtain the commitment entailed for a Probe survey starting with a cold call
- The lag between the phone survey participant agreeing to have a LOGG audit and the audit team making contact led to some participants changing their minds in the interim, this could be prevented by providing the CATI operators access to the surveyors' diaries to book in appointments directly.

- The challenges in contacting the right person, described in the verification section, occurred again with the LOGG Probe audits.
- Occupier attention was demonstrably not focused on decarbonisation, other challenges were taking time and attention.
- A change in fuel use between the target period of 2019 for the CATI survey and the present day. For instance, one site had already installed an Air Source Heat Pump (retaining their LPG boiler as back up) and another had converted to wood chips, a waste product from their manufacturing process. This meant that whilst the sites qualified for the CATI portion of the project, they did not qualify for a LOGG Probe audit.
- Some participants wanted us to audit specific assets which were not their LOGG asset, one participant refused to assist us with access to their organisations LOGG site if we wouldn't also audit their non-LOGG asset for free, at the same time. Their cooperation with the conversation ceased at this stage, even when it was highlighted the principles were the same for both assets.

Audit methodology

The audit process consisted of:

- Pre-audit energy consumption data analysis and review of available building construction and location data.
- A one-day site visit including: extensive interview with site occupiers and facilities managers to understand how the building is operated; known issues with plant or internal conditions; known opportunities for performance improvement and other relevant considerations, for instance planning limitations. During site audits opportunities were sought to engage site occupiers and understand how effectively the building performs for them and, where it is a place of work, how comfortable they find working there, for instance, whether the work environment provided was thermally comfortable, well-lit and effectively ventilated for air quality.
- Analysing utility and sub-meter data, using half-hourly data, where available; checking building management systems (BMS) control settings for plant run times; observing energy using equipment and feedback from site personnel to create a picture of energy end use, such as space heating (SH) and cooling, hot water, pumps, fans, lighting, cooking, food refrigeration, lifts, IT, etc, over the year; reconciling and fine-tuning end use estimates against the 'truth' of measured annual energy use for each type of energy used.

The LOGG Probe audits have considered two distinct intervention strategies for each asset. The first, referred to as Strategy A examined the minimum engineering interventions necessary to replace on-site use of delivered fossil fuels (LPG, fuel oil, etc). Basic energy efficiency interventions were identified, where prudent, as preparation ahead of elimination of fossil fuel use.

The second strategy referred to as Strategy B identified the engineering interventions necessary to align the site to a so-called Net Zero Carbon energy performance level. The

objective here is both to eliminate the use of fossil fuel on site and to achieve a post intervention Energy Use Intensity (EUI) which is aligned with targets for the non-domestic building stock consistent with the UK's legislated requirement to reach net zero carbon by 2050. This approach is aligned with the net zero strategies for 2050 described by the Climate Change Committee[3] and National Grid[4], and advocated by the UK Green Building Council[5] (UKGBC), the Carbon Risk Real Estate Monitor (CRREM) initiative[6], the International Property Federation (IPF)[7] and the forthcoming UK Net Zero Carbon Building Standard[8].

The approach built on the heat decarbonisation fundamentals, described in previous research commissioned by BEIS[9], as well as case studies produced for BEIS under the Energy Systems Catapult programme[10].

Description of the LOGG Probe buildings

The headline descriptors of the 8 LOGG buildings, for which Probe surveys were undertaken, are shown in Table 17. The GIA for each site is presented in Figure 32.

[3] Committee on Climate Change (2019), Net Zero – Technical report May 2019, https://www.theccc.org.uk/publication/net-zero-technical-report/
[4] https://www.nationalgrideso.com/future-energy/future-energy-scenarios
[5] https://www.ukgbc.org/ukgbc-work/net-zero-carbon-energy-performance-targets-for-offices/ and for technical details: Cohen RR, Desai K, Elias J and Twinn R, "Net zero carbon: energy performance targets for offices", first published by BSER&T online 09 February, 2021
[6] From Global Emission Budgets to Decarbonization Pathways at Property Level, CRREM V2 Version 1.0, 11 January 2023
[7] Pathways to Net Zero Carbon Emissions in International Real Estate Investment (January 2022) https://www.ipf.org.uk/resourceLibrary/pathways-to-net-zero-carbon-emissions-in-international-real-estate-investment--january-2022--full-report.html
[8] https://www.nzcbuildings.co.uk/
[9] Evidence update of low carbon heating and cooling in non-domestic buildings, November 2022 https://www.gov.uk/government/publications/evidence-update-of-low-carbon-heating-and-cooling-in-non-domestic-buildings
[10] For example: A concept design for an integrated, decarbonised, energy system at HMP Risley, Modern Energy Partners, May 2021

Figure 33 LOGG sites GIA

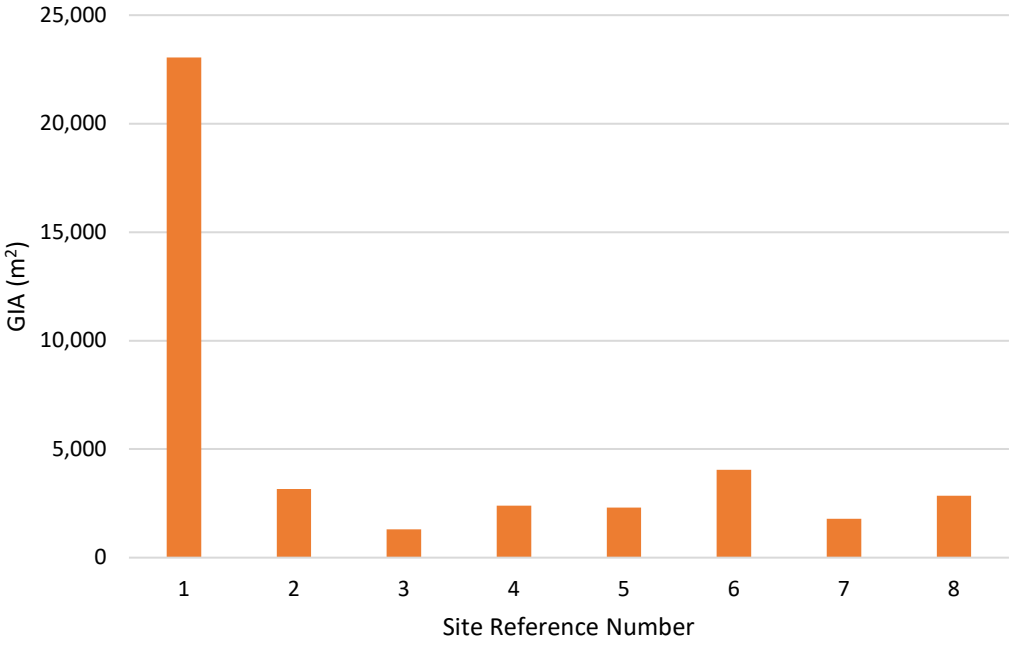


Table 39 Headline description of the 8 LOGG premises subject to Probe surveys

Site Ref No.	Sector	Floor space area m²	Location	Ownership/ Occupier	Description
1	Office	20,000 + GIA, 15,000 + NLA	South East England	Investor landlord, multi let	24-storey, multi let mid-century office tower
2	Office/ Call Centre	3,161	South Wales	Owner occupied	Two-storey call centre and office on a campus site
3	Warehouse	1,304	Northeast England	FRI Lease	Mid-century logistic warehouse on industrial estate
4	Warehouse	2,400	South Wales	FRI Lease	Mid-century retail warehouse on a South Wales industrial estate
5	Warehouse	2,300	Northwest England	FRI Lease	Mid-century retail warehouse on industrial estate
6	Office / Scientific Lab	4,000	South East England	Owner occupied	Late 19th century to mid-20th century campus site with multiple buildings
7	Garden Centre	1,785	North Wales	Owner occupied	Mid-20th century garden centre with restaurant, inside and outside retail spaces

8	Hotel	2,852	South West England	FRI Lease	21st century 71 room hotel, near arterial route, with electric heating but bulk fossil fuel domestic hot water generation

GIA refers to the Gross Internal Area of the building, that is the total floor area within the building.

NLA refers to the Net Lettable Area of the building, that is the floor plate which may be let to tenants.

FRI lease refers to the Full Repairing, Full Insuring lease type.

The buildings were predominantly found to be constructed between 1950 and 1990, with two exceptions. The main campus building of the space lab was estimated to be late 18th century/ early 19th century construction. Construction of building 8 concluded in March 2020.

Overall, the standard of plant and fabric maintenance at the sites was observed to be poor and many of the sites demonstrated protracted under investment in fabric upgrade to modern standards, evidenced by retention of extensive single glazing, poor insulation levels and out of date heating systems, lack of forethought and planning in change of space use planning and decision making and an overall lack of care with regards upkeep.

Current bulk fossil fuel consumption and how data is recorded

All sites were supplied via frequent deliveries and the audit teams were able to obtain consumption/ delivery data, albeit the quality and format of this data varied across the sites. There was no evidence of heat metering observed on any of the sites. Building 1 monitored the level of each of its several tanks and the combined level of all tanks to determine when to order a fuel delivery. Building 8 received bills derived from flow volume metering of its LPG supply which it received from a central tank farm serving its wider site.

In the case of building 8, the audit team determined that the quantity of energy being invoiced by the managing agent appeared to be incorrect, with the annual fee being based on litres of LPG rather than m^3. Therefore, the original consumption values used by the billing team were approximately 5 times smaller than they should have been.

Table 40 summarises, by building, the bulk fossil fuel used by each site, the volume used in a year and the kWh of energy this equates to. All the sites audited used either oil or LPG as their bulk fossil fuel. It was observed that all sites apart from building 8 were using electric panel heaters as a form of supplemental heating.

Table 40 Sites by activity, bulk fossil fuel type, annual consumption in volume and kWh

Site Reference Number	Activity	Type of Bulk Fossil Fuel	Annual Consumption (litres/year)	Annual Consumption (kWh/year)
1	Office	Oil	156,865	1,556,989
2	Office/ Call Centre	Oil	22,872	224,146
3	Warehouse	Oil	4,014	39,337
4	Warehouse	LPG	7,070	52,043
5	Warehouse	LPG	8,385	61,723
6	Office / Scientific Lab	Oil	55,148	585,120
7	Garden Centre	Oil + LPG	17,931 + 13,300	270,661
8	Hotel	LPG	15,164	109,184

Fuel conversion factor of 9.98 kWh/l used for Oil and 7.26 kWh/l for LPG from The Engineering Tool Box [11]

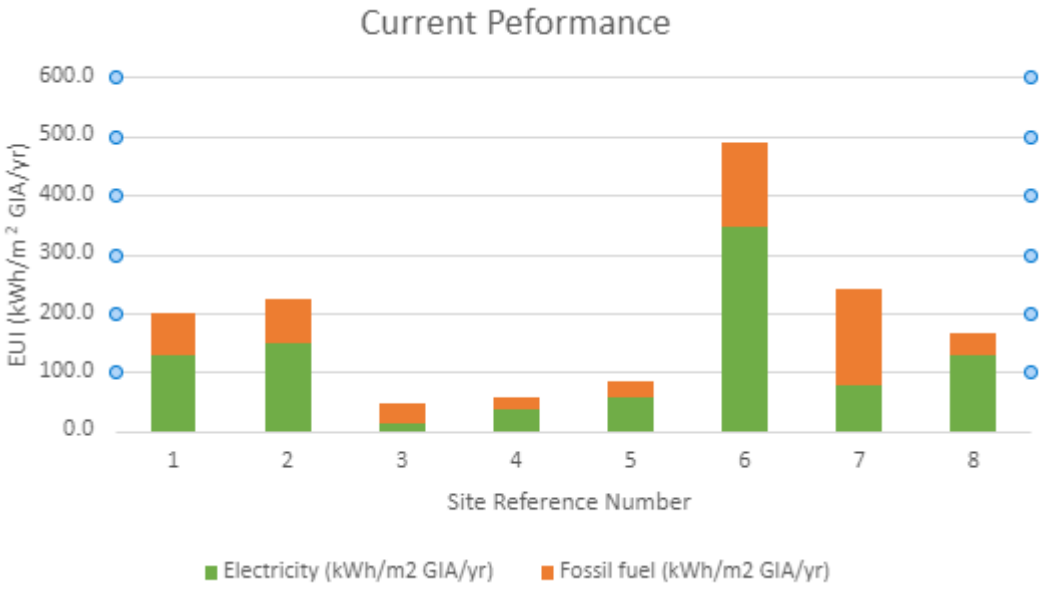
Table 41 quantifies the current measured energy use intensities (EUIs) for each building, showing the values for fossil fuel use and total electricity use separately.

Table 41 Current energy use intensity of each site

Site Ref No.	Activity	Fossil fuel use		Current fossil fuel EUI	Current electricity EUI	Total delivered EUI
		Fuel type	End use	(kWh/m² GIA/year)		
1	Office	Oil	SH +HW	68	129	196
2	Office/ Call Centre	Oil	SH +HW	71	148	219
3	Warehouse	Oil	SH +HW	30	14	44
4	Warehouse	LPG	SH +HW	22	36	58
5	Warehouse	LPG	SH +HW	27	58	85
6	Office / Scientific Lab	Oil	SH +HW	134	345	479
7	Garden Centre	Oil + LPG	SH +HW	158	78	235
8	Hotel	LPG	HW only	37	130	167

[11] https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html

Figure 34 Current electricity and fossil fuel usage of each site



Benchmarks for each site have been taken from CIBSE TM46 except site 8 which uses the typical value cited by BSRIA[12] and are shown in Table 42.

Table 42 EUI benchmarks

Site ref no.	Electricity Benchmark EUI	Fossil fuel Benchmark EUI
	kWh/m² GIA/yr	kWh/m² GIA/yr
1	95	120
2	95	120
3	35	160
4	70	170
5	70	170
6	95	120
7[13]	141	80
8	87	58

[12] Rules of Thumb Guidelines for building services (5th Edition) -https://www.bsria.com/doc/rQV5xn
[13] For site 7, TM46 benchmark was tailored for uses on the garden centre site

Figure 35 Current EUI against benchmarks

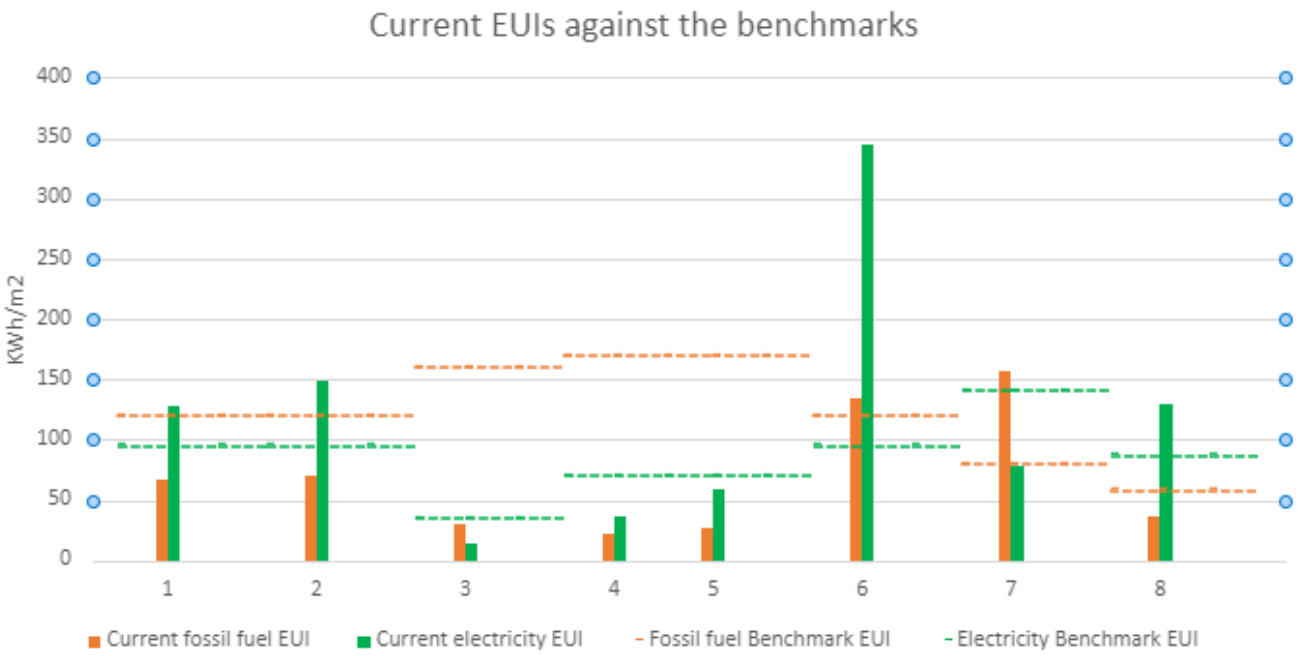


Figure 35 shows that most sites were typically below fossil fuel consumption benchmarks and above electricity benchmarks. In the case of site 6, this is likely because of the use of electric heating to replace inefficient or decommissioned oil based heating systems or to complement newer LPG based localised heating, providing additional electrical heating when required to maintain occupier comfort; there was a common pattern of low holistic investment in interventions, for instance sites 3, 4 and 5 demonstrated poor management of space air flow and heat retention, through failure to install internal walls and partitions and site 6 demonstrated an ad hoc approach to long term asset planning using temporary buildings, now fallen into extensive disrepair and repurposing of, for instance, aged accommodation blocks.

Specific key end uses and occupancy patterns

Sites all reported operating heating during core occupation hours, typically reflecting the working day, as detailed in Table 43. In the case of the warehouses on sites 4 and 5, this represented five and half days per week, in the case of building 1 five days per week plus Saturday mornings. Operating hours typically had a longer warm-up period on Monday mornings if the building was unoccupied on Sunday, for instance building 1. The hotel demonstrated two periods of the day that could be called “Core Hours”, this reflects the anecdotal evidence from the occupier that the site is typically busy in the morning, quiet over lunchtime and then busier in the later afternoon to evening as guests returned to their rooms and new guests arrived.

Table 43 Days and hours occupied

Site reference number	Days occupied	Hours occupied
1	Mon-Fri and Sat morning	12 hours a day and 6 hours a day on Sat
2	Mon-Fri (general office area) + every day of the week (contact centre area)	11 hours a day (general office area) and 24/7 (contact centre area)
3	Mon-Fri	10 hours a day
4	Mon – Fri and Sat morning	11.5 hours a day and 4 hours Sat
5	Mon – Fri and Sat morning	11.5 hours a day and 4 hours Sat
6	Mon-Fri	12 hours a day
7	Every day of the week	8.5 hours a day
8	Every day of the week	24/7

In the case of site 8, the fossil-fuel heating demand was specific to the generation of DHW only, with the requirement for space heating being met by existing variable refrigerant flow (VRF) units[14]. This heating requirement presented the challenges of maintaining sufficient supply of DHW to hotel guests with sufficient capacity to replicate the performance of the existing direct-fired LPG water heaters which supplied a 300 litre storage calorifier each, located underneath the water heater. It was observed that the DHW generation recovery rate to 60°C from the installed LPG fired water heaters was specified as 10 minutes. It was deemed necessary, to maintain guest comfort to replicate this refresh rate in the ASHP specification selected. If it were possible to negotiate, on installation of ASHP by the hotel operator, a slower refresh rate, for instance 30 minutes, the capacity of the ASHP could be proportionately reduced, saving cost and reducing demand on local distribution networks.

Warehouses demonstrated an evolution over their lifetime of which areas of their floor plate are heated and how. Sites 3, 4 and 5 demonstrated that as-built LPG or oil fuelled direct-fired air heating units, within the storage area, had been decommissioned and either replaced with localised LPG or electric heating or those spaces had become unheated, as is the case at site 3. This evolution of space use over time meant the solutions best able to meet the current occupation of the spaces did not reflect the solutions required to meet the occupier behaviours and intended uses when buildings were originally constructed.

For instance, if a space use changes from accommodating employees to accommodating storage, with employees only passing through to locate and retrieve stock, it no longer makes sense to heat the whole of the warehouse air volume. In this instance, installing electric radiative heaters over walkways would keep the employees comfortable whilst not heating the stock. In the case of site 6, however, the change of use from accommodation to office would

[14] Note VRF splits are a form of Air Source Heat Pump technology.

not be expected to have the same impact and the continuing use of space to accommodate employees means the whole space still needs to be heated.

Strategy A solution: Heat decarbonisation only

Table 44 shows the proposed system to enable the elimination of fossil fuel use on-site for each building under strategy A.

Table 44 Site decarbonised heat solutions

Site No.	Activity	Bulk Fossil Fuel Type	Low carbon heat solution
1	Office	Oil	ASHP
2	Office/ Call Centre	Oil	ASHP
3	Warehouse	Oil	VRF Splits
4	Warehouse	LPG	Radiant Heating
5	Warehouse	LPG	Radiant Heating
6	Office / Scientific Lab	Oil	ASHP
7	Garden Centre	Oil + LPG	ASHP
8	Hotel	LPG	CO2 HP

For five of the sites (1, 2, 6, 7, 8), the heat decarbonisation requirement was found to be best met by variations of ASHP technology which provided the right combination of cost effectiveness to install, sufficient operating temperatures and efficiency that their use was justified and considered practicably reasonable, rather than the cheaper to install but very expensive to run option of direct electric heating. For the other three sites (3 – 5), direct electric radiative heating was identified as most suitable given the large internal air volume and the fact the strategy did not include improved insulation or air leakage measures – radiative heaters heat the people in the space, not the air around them.

For all but one of the sites the requirement was to end the use of bulk fossil fuels (decarbonise) for both Domestic Hot Water (DHW), to supply for instance, taps and showers, and Low Temperature Hot Water (LTHW) for heating radiators. In the case of site 8, a modern hotel, bulk fossil fuels were in use for DHW only, which is likely a reflection of the perceived ease of use of combustion for the generation of DHW to meet peak demand.

Table 45 shows both the marginal and full CAPEX required to implement Strategy A. Marginal CAPEX is the additional CAPEX required to implement measures above and beyond that which is required to maintain a site in line with Business As Usual (BAU). The last two columns of the table show the predicted impact on building energy performance of the decarbonisation intervention: the total electricity EUI when the building has become an all-electric building and the reduction in the total delivered energy EUI.

Table 45 The cost and impact of identified heat decarbonisation pathways for each site under strategy A

Site ref no.	Marginal CAPEX	Cost	Total CAPEX	Cost	Electricity EUI after intervention	Achieved reduction in delivered EUI
	£	GIA/m²	£	GIA/m²	(kWh/m² GIA/year)	
1	£1,679,000	£73	£2,269,000	£98	117	80
2	£240,000	£134	£300,000	£169	171.2	-23.2
3	£150,000	£115	£186,000	£143	29	50
4	£15,334	£6	£75,000	£31	36	0.07
5	£44,000	£19	£44,000	£19	58	0.08
6	£678,000	£168	£678,000	£168	350	-5.24
7	£240,000	£134	£300,000	£169	170.8	-90.8
8	£286,040	£100	£286,040	£100	132.7	12

In all cases the auditors found that decarbonising heat without taking any measures to reinforce insulation, change the size of heat emitters or recover heat already generated from extract air led to the size of ASHP required being larger than where such measures were employed. In this scenario the supply capacity from the local distribution grid, contractual supply limit and load placed on local Distribution Network Operators (DNOs) and Transmission Network Operators (TNOs) would also be increased with potentially costly consequences.

Strategy A would therefore increase the requirement for electricity generation at peak load, except in the case of the Bodmin hotel as heating is already provided via Variable Refrigerant Flow Units (VRF), a form of ASHP technology.

Strategy B solution: Decarbonisation and energy efficiency (NZC alignment)

Under this scenario, for all but two of the sites the heat decarbonisation intervention under the more invasive Strategy B is the same as under Strategy A. The exceptions to this are warehouses 4 & 5 which under Strategy B are specified to install ASHPs. The difference is attributable to the complimentary interventions specified in Strategy B, such as reinforced insulation and installation of glass partitioning to create thermal barriers between the differently used areas on site. These complementary interventions have the effect of enabling ASHP installation by reducing the overall heating load to an extent that ASHP technology becomes practical.

It is worth noting that in one instance, site 6, no alternative option to ASHP was identified as being suitable, alternative direct electric heating options were considered too invasive to install relative to the requirements to install ASHPs. One alternative, to install electric irradiative heating to each of the rooms in the buildings would have required the installation of a reinforced electrical distribution system from scratch to accommodate the additional load, this installation process would have required the removal of the existing LTHW pipework and heat emitters, this being ruled out on the grounds the works required would be so invasive, disruptive to science and thus costly as to render the option impractical. The installation of electric boilers was ruled out on the ground of high operating costs.

Table 46 shows both the marginal and full CAPEX required to implement Strategy B.

Table 46 The cost and impact of Strategy B pathways for each site

Site ref no.	Marginal CAPEX	Cost	Total CAPEX	Cost	Electricity EUI after intervention	Achieved reduction in delivered EUI
	£	GIA/m²	£	GIA/m²	(kWh/m² GIA/year)	
1	£2,269,000	£98	£15,259,000	£688	55	141
2	£820,000	£451	£1,010,000	£559	117.5	30.5
3	£188,000	£144	£243,000	£18	0	44
4	£89,000	£37	£128,000	£53	45	-8.5
5	£38,000	£16.50	£69,000	£30	64	-5.9
6	£868,000	£215	£886,000	£219	379	-33.8
7	£820,000	£451	£1,010,000	£559	114.1	-34.1
8	£476,240	£167	£476,240	£167	69	76.2

Stranding risk

In most instances, the work necessary to achieve net zero aligned specification was not found to require major disruption to in situ occupiers, meaning an end to a lease or the temporary removal of a tenant would not be required to allow the measures to be implemented. However, in the case of the three retail warehouses and the garden centre, the occupier was already considering whether to upgrade the premises plant and insulation or relocate the business to an alternative premises. Consideration of these strategies which broadly align to Strategies A & B described in this report, were stated by the occupiers to be a reason they were likely to trigger the option of lease surrender. In these instances, the costs of upgrading fossil fuel plant would fall entirely upon the occupier and the possibility of no longer being able to use bulk

fossil fuels to generate heat and therefor to upgrade to an alternative would be seen by the occupier as prohibitively expensive.

The occupier of site 3 had already served notice on the landlord specifically because of the lack of maintenance of the warehouse and the inability of the installed heating system to maintain an acceptable working environment within the office area, whilst the cost of upgrade would fall to them under the terms of the lease.

In the case of sites 4 and 5, although moving to a new location was expensive and disruptive to business operations, relocation was still identified as a compelling option after being advised of the cost benefit analysis of both Strategies A & B. The projected sums necessary to remain in situ at the current location, to address the lack of insulation across the roof, were deemed prohibitive when compared to a move to an already upgraded unit becoming available locally.

The owner occupier of the garden centre, site 7, stated that they perceived the costs associated with both Strategies A & B as being so high as to warrant a full redevelopment of the site with a new thermally insulated main retail area and upgrades to the associated ancillary buildings.

This scenario would therefor make assets appeal to some occupiers/ owners/ investors more than others, for some the risk associated with redevelopment of the asset would be countered with the potential reward of increased asset value and rental income. For others, the need to substantially invest in sub-prime property would make the site unattractive and subject to stranding risk.

For some investors, the need to invest in a site to make it habitable, offers an opportunity to enhance its value and achieve a return on investment. For others, however, the risk of the investment not being rewarded with sufficient uplift in value is so great as to render the asset un-investable. Different perceptions of a site by market participants have the effect of driving arbitrage within the real estate market, such that some asset owners decide to dispose of assets or not buy them, whilst others will deliberately seek out assets requiring investment, depending on their strategy. A driver to retrofit non-fossil fuel based heating systems could therefore stimulate a transaction/ development/ occupation cycle, which would provide an economic benefit beyond that directly associated with the heat decarbonisation or net zero carbon retrofit.

Cost effective potential for energy efficiency improvement

Strategy B identifies maximum cost effective engineering potential for energy efficiency to arrive at a Net Zero carbon aligned solution for each site. In the case of Site 1 this involved the installation of 24 individual air handling units to the floors, a full retrofit of modern insulation to the external areas and an upgrade of the single glazing to high performance double glazing, also taking this opportunity to install solar PV integrated within the new glazing. This high specification, full cost effective technical potential strategy for site 1 was predicted to achieve an EUI of 95.7 kWh/m² NLA gross building energy use (not counting the contribution from PV) or 81.2 kWh/m² net energy use (allowing for the electricity generated by the PV) very

substantially reduced from the current 283 kWh/m² NLA, albeit for a marginal cost around £700/m² GIA or £15m in absolute terms.

In contrast for the site 3 warehouse, the forecast revised EUI of 17.3 kWh/m² NLA gross building energy use or 0 kWh/m² NLA net energy use (allowing for the contribution from PV whether used on site or exported) was achieved with far fewer measures and a much lower marginal spend requirement. In this instance, the achieved EUI is a reflection of two factors. Firstly, the site has a large, structurally sound roof on which it is possible to install an extensive solar panel array, capable of generating the entire energy requirement of the building. Secondly, the proportion of internal floorplate requiring heating is extremely small, relative to the overall floor plate. This reflects the evolution of the use of the space over time.

The evolution of the use of floor space was also observed at sites 4 & 5. A key difference for these two units being their roofs were not suitable for installation of solar PV arrays due to their construction from corrugated asbestos. The resulting pathway for warehouses 4 & 5 does not therefore include provision of solar PV, although were the roof to be replaced then solar PV would become a viable option in these two instances also.

Observations on building fabric characteristics

Low levels of insulation were apparent across the majority of LOGG Probe Sites, apart from site 8 which had fabric insulation to current regulations installed across the building and highly effective sound proofing, in particular the double glazing system, providing high thermal insulation and low levels of noise transmission. This relatively high specification was clearly a reflection of the building's age and makes the site an outlier.

Insulation is an important factor in the assessment and sizing of Net Zero aligned, decarbonised heating sources such as ASHPs; a lack of insulation, such as cavity wall fill, blown or sheeting, creates inefficiencies through over sizing when specifying heating systems, over sizing being required to compensate for rate of heat loss due to lack of insulation. Extensive use of single glazing was observed, in particular site 1 had single glazing across all 24 stories of glazed facade and almost no insulation installed in the exposed floorplates and ceilings. The high ratio of exposed floorplate and roof area, lack of insulation and single glazing made this measure a key intervention in net zero alignment. Similarly, the warehouses demonstrated a systematic lack of insulation, in particular of their roofing, this made their internal areas that much more challenging to heat effectively. There was some evidence of limited double glazing retro fit, i.e., some parts of buildings were upgraded to double glazing but not an entire site, in particular at sites 3, 4 and 6.

Figure 36 Breakdown of glazing type across all LOGG Probe survey sites

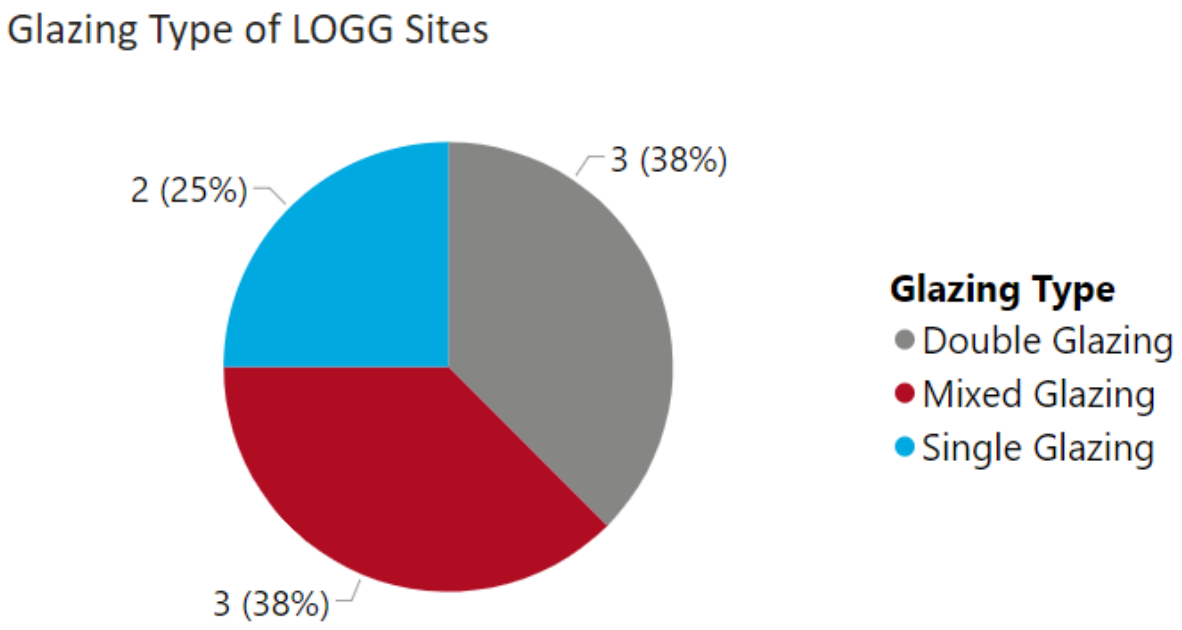


Figure 36 makes clear that the type of glazing used across the sites varies significantly, the most prominent scenarios being that of mixed and double glazing. This may reflect a lack of space use planning and/or coordinated investment in sites over time by landlords and occupiers.

Installation of insulation, glazing and air permeability measures within Strategy B had the effect of reducing the size of heat pump required, the size of distribution grid connection necessary, contract capacity agreements, DNO, TNO and generation required to meet peak demand. EUI Impact of these measures was calculated using spreadsheet calculations based on relative R values of insulation, they were not calculated using dynamic simulation modelling.

Table 47 Impact of insulation as a proportion of EUI reduction and cost

Site Reference Number	% EUI reduction of Strategy B for fabric measures	% cost of Strategy B for fabric measures
1	12%	30%
2	N/A	N/A
3	22%	12%
4	36%	6%
5	2%	11%
6	21%	18%
7	60%	66%
8	N/A	N/A

Embodied carbon is an ever-growing area of research in the field. A whole life carbon approach, accounting for the carbon required to manufacture any retrofit measures identified captures the whole life carbon impact of a retrofit program. Whilst this area of research is developing apace, it is sufficient to say here that the selection and specification of retrofit measures in the future will pay ever greater attention to the whole life carbon and embodied carbon impact of each measure.

Unused spaces were typically found to be left with their services “live” adding to overall heat demand for little practical benefit beyond condensation prevention. Mechanical and electrical systems were not well maintained and decommissioned systems were left in situ. Sometimes these decommissioned systems have been replaced in a cost focused "oh that'll do" manner, rather than in a well thought through, specified and comprehensive process, i.e. internal partitioning not added between retail areas and office areas. An exception to this is the water to VRF retrofitted heating and cooling partially installed within Site 1.

On investigation the gas grid has been found to extend to areas nearby the LOGG sites; in 4 out of the 8 buildings surveyed the gas grid was demonstrably close by. Whilst typically these sites are within 100 meters of local gas infrastructure ease of connection has been difficult to judge from the surface as the site audit did not cover assessment of overall local gas grid capacity. For the building owner is it possible that despite the gas grid being nearby, the cost of connection would be disproportionately high relative to the benefits of connection, making a transition to electricity more likely.

Simultaneously, there is a realistic chance these buildings would be connected to the mains gas grid, continuing the reliance on fossil fuels for heating, thus negating the benefit of any initiative to remove bulk fossil fuels. It is possible therefore that the outcome of a future heat source choice between mains gas or mains electricity could come down to which is the cheaper option, to connect too and potentially extend the local gas or electricity distribution.

Description of Landlord/ Tenant Agreements

The single storey warehouses (sites 3, 4 & 5) were found to have a single tenant in occupation, under Full Repairing and Insuring Leases (FRI) whereas the laboratory (6), hotel (8), garden centre (7) and call centre (2) were all owner occupied.

The office (1) was unique as it was let to multiple tenants and owned by a separate institutional investor landlord responsible for the upkeep of the communal parts, all be it the costs recharged to the tenants through the service charge mechanism.

Site (8) the hotel, whilst having a single party as both its owner and operator was located within a dual carriage way service station, thus service charges and ground rent were payable to this third party landlord. Of interest to this study, it was confirmed that the hotel paid for the LPG used on a metered volume basis to the landlord of the service station, though there was no ongoing requirement to pay for the use of LPG if the hotel stopped using it; equally it seems that the hotel was obliged to purchase its LPG from this one source from convenience due to the presence of an existing LPG tank farm.

The question of commercial energy purchasing arrangements would warrant further consideration in the decarbonisation of LOGG sites; some commercial property structures, such as commercial airports, require tenant energy to be purchased from themselves rather than direct from DNO's/ suppliers, potentially at a considerable price premium. Consequently, there may be a contractual penalty or prohibition from moving to other sources of energy, even if physically possible. This additional premium may prove prohibitive for the decarbonisation of heat.

The warehouses (sites 3,4 & 5) being let on a Full Repairing and Insuring (FRI) lease were maintained at the occupier's expense and any changes to the plant installed onsite, for instance the installation of an ASHP would, strictly speaking, fall to the occupier under the terms of their lease.

Site 1 was the only site maintained through a communal service charge mechanism contributed to quarterly by the tenants in proportion to their leased floor plate; the hotel (8), the call centre (2), the garden centre (7) and the space lab (6) were maintained by the owner occupier. In the majority of cases specialist maintenance provision was outsourced, for instance provision of annual boiler maintenance.

Sites 2, 6, 7 & 8 are located on campus style sites of multiple buildings, whereas the other sites were all single self-contained unit plots.

Table 48 Ownership, maintenance and utilities payment arrangements for Probe survey sites

Site Reference Number	Occupier structure	Maintenance delivery model	Payment by
1	Multiple tenants	Third party outsourced	Service charge
2	Owner occupied	Third party outsourced	Owner occupier
3	FRI lease	Occupier	Occupier
4	FRI lease	In house FM, outsourced maintenance	Occupier
5	FRI lease	In house FM, outsourced maintenance	Occupier
6	Owner occupied	Owner occupier	Owner occupier
7	Owner occupied	Owner occupier	Owner occupier
8	Owner occupied	Owner occupier	Owner occupier

The warehouses (sites 3, 4 & 5) appeared to have been less effectively maintained over time than the other sites audited. Fabric elements of warehouses 4 & 5 had become a potential liability, their roofs being constructed of corrugated asbestos sheeting. It should be noted that the tenant of warehouse 3 had decided the historic protracted lack of repair and maintenance to the fabric and plant prior to their purchasing the business holding the tenancy was sufficient reason for their seeking a new location for their business, they had served notice on the third party landlord for precisely this reason.

The standard of maintenance at site 8 was observed to be very high, with a dedicated maintenance engineer on site. Site 8 was owned by a Property Company (PropCo), whilst the hotel business was operated through an Operating Company (OpCo), the PropCo developed the site with the hotel brand and received rent from the OpCo which is a franchise of the hotel brand. Both the PropCo and the OpCo were owned and managed by the same people but operated as separate legal entities with obligations to each other. The site team expressed a real desire to understand how to effectively decarbonise their heat and reduce their ongoing running costs. In this instance the OpCo would pick up the cost of the upgrade to ASHP but any potential asset value increase would be attributable to the PropCo. In this case then the delineator between who paid for and who benefited from interventions on site was nuanced through legal entity, ultimately it was the same people making decisions on both sides of the interaction between landlord and tenant.

The apportionment of costs for Strategies A and B would likely vary across the sites audited. The simplest scenario to describe is that of the owner occupier. In this use case, the costs of both strategies would fall to the owner occupier. In the case of the FRI warehouses, the costs according to a standard lease will fall in their entirety to the lease holder as per normal maintenance and repair works, especially where the existing plant is end of life as in all three examples. An alternative cost apportionment may be negotiated between the landlord and the occupier where the existing plant is not beyond end of life cycle. This may have a bearing on the removal of bulk fossil fuels if owners or occupiers were compelled to replace plant ahead of life cycle expiry.

In the case of the multi-let office, site 1, the service charge mechanism allows the landlord to recover from the tenants all the operating costs of the building, including where plant is replaced at end of life, however, there is a nuanced requirement that installed plant must replace the existing plant on a like for like basis or be of a modern equivalent; for instance, LED lighting would typically be service charge recoverable as it is the modern equivalent of older lighting technologies such as incandescent or halogen lamps. In the case of ASHPs, this clear delineation between technologies is less defined and so there exists a potential challenge to the recovery of costs through service charge mechanisms. As the delineation between technologies becomes more pronounced recovery may become less controversial. This is an area worthy of further consideration and study in preparation for the delivery of net zero targets.

The lab buildings (6) demonstrated multiple phases of occupation, with portacabins used as short term accommodation initially, then having become more permanent later. Now in disrepair, plans were being made to replace them, potentially with another “temporary” structure. It was noted that the use of space within the space lab campus had also evolved over time with one accommodation block having been retrofitted to an office and lab block for example.

Across all sites, except the hotel (8), there was evidence that maintenance was being carried out to a budget rather than to deliver the maintenance required to maintain building comfort and services. This lack of investment having a bearing on the relative costs required to achieve strategies A or B. This is now starting to drive occupancy decisions of some of the building

occupiers: some sites will be redeveloped (sites 1 & 7), some sites will be vacated and handed back to the landlord (3 and potentially 4 & 5), some sites requiring continued occupation are having plans developed to secure their future (6). In the case of warehouse 3, the tenant has surrendered the lease due to the protracted historic lack of maintenance. In the case of warehouses 4 & 5 maintenance, reroofing and operating costs were so high as to be root causes of ongoing discussions regarding relocating to a different site. In these instances, heat decarbonisation costs will add to these costs and alter the perception of the occupier/ landlord accordingly. In the case of sites 1 (office) and 8 (hotel) heat decarbonisation is seen by the owners as a necessary step in responsible asset stewardship and investment. In the case of building 1 these were viewed as a positive investment to help drive up asset value.

A consequence of historic under investment is the extent and associated cost of the interventions needed for both Strategy A and B to be implemented. The CAPEX associated with both strategies reflects the extent and value of previously deferred upkeep and maintenance spend, for instance the failure to correctly compartmentalise the retail spaces or to replace the asbestos roof proactively means deferred expenditure will need to be committed at once, artificially increasing the extent and cost of interventions necessary to achieve both strategies.

In the case of site 1, the purchase price in part reflected the state of repair of the asset, this value was sufficiently low that the investment necessary for either Strategy A or B are seen by the institutional investor as attractive further investment opportunities to enhance the building specification and value. The building post intervention will be able to attract sufficiently higher rents and these materially increase the asset's value. Whilst costs associated with Strategies A and B were not always perceived as a negative by those on whom they fell, in the case of the three warehouses the costs were the driving factor in one lease surrender decision and were being actively weighed in the decision-making process of retaining the other two warehouses. In the case of site 7, the garden centre, the costs of Strategies A or B were so high as to be perceived as a driver to redevelop the whole site rather than redevelop certain retained elements.

Across all sites, it was apparent that the tenants and owner occupiers were responsible for ongoing active energy management. Site 1 had a nuance in this regard as the communal parts, such as stairwells, lifts, lobbies and lavatories fell within the remit of the managing agent, acting on behalf of the landlord/ institutional investor. It should be noted though that any costs associated with energy use or energy management within these communal parts were recoverable by the landlord from the tenants under the service charge mechanism.

In all instances the costs of any heat decarbonisation initiative would fall to the tenant/ owner occupier as part of the lease agreement, although in the case of site 1 tenants could potentially make the case they were only responsible for the cost element equivalent to upgrading on a like for like basis, for instance the cost equivalent to replacing oil boilers with oil boilers and that any additional marginal cost should fall to the landlord. This argument would rest on the proviso that the marginal cost element was providing an upgrade to the specification of the site, upgrades not being service charge recoverable.

Current engineering solution

Site 1 had retrofitted VRF units to the temperate loop on 17 of the floors, this had been completed on a rolling basis as floors had gone void or in some cases tenants had been relocated into a “swing space” to facilitate works access, then returned to their original demise. The temperate loop has been used for the retrofit of VRF units on all but 7 floors, suggesting it is in a reasonable condition and can continue to be used.

This case study suggests that multi-tenant buildings may introduce more opportunities for gradual decarbonisation interventions, due to changing tenants and therefore floors going void, providing opportunities for intervention works access. These incremental retrofit works had been carried out over 5 years, this graduated program had reduced the cost of the works necessary in any one year although the basebuild oil boilers had not been replaced at the point of audit. In multi let sites then, where Strategies A or B can potentially be implemented gradually, the cost in any one year may be less than where all interventions are required at once, however, this rolling implementation is likely to work out more expensive over the longer term given the requirement for multiple projects to deliver all interventions.

All sites apart from the hotel (8) reported common use of electric panel heaters to supplement their base build heating solution, likely as a quick fix measure of occupier complaints without the need of serious upgrade, this was common to all three warehouses in particular which also experienced a second common problem of heat loss between areas designated for different end uses, again this suggests previous interventions to space use and heating had been implemented in isolation rather than as part of an informed, holistic plan.

Aside from site 1, all the other audited sites are let to a single tenant on an FRI basis, or are owner occupied. At these sites, responsibility for the set points and other controls of heat raising plant were (obviously) the responsibility of the sole occupier.

At site 1, with its multiple tenants, the responsibility for set points and controls within the tenant demise fell to the tenants, whereas the landlord assumed responsibility for settings controlling the landlords areas and for communal plant, i.e. the temperate loop and oil boilers. When considering the overall energy efficiency of the whole building, this split of responsibility for heating and cooling control between landlord and tenants is unhelpful at best and potentially disastrous. Gross inefficiencies can arise where arrangements are not in place to avoid 24/7 operation of central plant just in case any tenant seeks heating or cooling outside normal working hours and/or a call for tenant heating or cooling arises due to a fault in the tenant system, such as a stuck valve, which for the landlord BMS is indistinguishable from a genuine call for service. The split responsibility for control arrangement often is also accompanied by the tenants having responsibility for maintenance of HVAC equipment in their demise and this meaning it ends up being done less diligently, with consequent impacts on the HVAC efficiency of the whole building. Returning whole building HVAC control to landlords is one of the steps the NABERS UK scheme advocates to improve base building ratings.

The age of the sites audited meant that Asbestos Containing Materials (ACMs) were a likely fabric component and ACMs were observed directly at sites 1, 3, 4, 5 and 6. ACMs in themselves do not pose a barrier to the decarbonisation of heat, though they do add additional

cost and risk to any heat decarbonisation or net zero programme. End uses observed were firstly as linings for pipe work joints connecting boilers to LTHW distribution systems, secondly in insulative lagging on LTHW pipework, thirdly as a fire-retardant component in suspended ceilings, and in addition as insulation, paint finishes and other cosmetic fabric finishes and finally as a raw construction material for roofing.

Conclusions

Implementation of Strategy A, minimum engineering interventions, costs less to achieve but conversely locks in higher ongoing operating costs through the need to overcome heat losses through insufficient insulation, air tightness, glazing and controls. This higher EUI requirement will place greater demands on local distribution, transmission and generation infrastructure.

Implementation of Strategy B addresses the shortcomings of Strategy A but at significantly higher costs to owners and occupiers. The measures required are disruptive and invasive. Investment in insulation, air tightness, glazing and controls measures allows for lower capacity, less expensive low carbon heat generation.

Air Source Heat Pumps are an adaptable, relatively easy to deploy technology which can achieve the removal of bulk fossil fuels at scale. They are not a perfect technology however, in particular they become progressively less efficient as the set point they are required to achieve increases. To operate efficiently at lower temperatures, the measures under Strategy B are required to minimise overall heating demand.

The decarbonisation of DHW is a particular challenge, especially where the hot water volume required at short notice is high. CO2 heat pumps offer an effective technology solution to this challenge when combined with closed loop storage vessels to ensure a low water supply temperature. The impact of and alternatives to current Legionella risk management strategies in commercial buildings should be investigated further to better align the requirements with the capabilities of ASHPs.

The audits demonstrated that a protracted lack of maintenance, upkeep and holistic space use decisions are common across building types. This will likely impact the cost of any statutory decarbonisation measures. To achieve economically affordable end state EUIs, it will be necessary to invest in complementary measures more aligned to Strategy B than purely those aligned to Strategy A, though for some stakeholders the costs associated with Strategy B will no doubt be prohibitive.

Historic under investment and obsolete fabric were demonstrated in 4 instances to be either forcing relocation decisions or playing a significant part in their deliberation. Therefore any requirement for further investment to achieve decarbonised heat due to a removal of bulk fossil fuel supply can be reasonably expected to influence landlord and tenant ownership and lease decisions.

There is no clear-cut market wide cost delineation pattern that can be accounted for in the decision-making process. This area requires further research, in particular the cost impacts on owners and occupiers where replacements are being installed in advance of the end of the

expected life cycle of the current plant. The impact of service charge code needs to be understood in this regard.

Where observed plant areas were found to be of sufficient size and construction to accommodate decarbonised heat generation, in particular accommodating ASHP external condensers did not appear to present an insurmountable problem at the sites audited, though access challenges at building 1 were noted, given the location of the plant room on level 23.

There is a material risk that compulsory removal of bulk fossil fuels will force some owner occupiers to connect their building to the mains gas grid, deferring heat decarbonisation. In these instances, there are potentially two sets of costs attributable to the removal of bulk fossil fuels: the initial cost to connect to the gas grid and any subsequent cost to decarbonise grid gas based heating further down the line. A holistic policy and incentive environment would partially mitigate the risk of sites connecting to the gas grid in response to a removal of bulk fossil fuels.

Campus style sites pose a challenge for understanding the impact of policy changes as several self-contained units of accommodation can be located at the same address and postcode, their fuel supply arrangements where from a communal tank farm will mean that removal of bulk fossil fuels will impact several occupiers at the same time in one location.

Key learnings and considerations for future work

This segment of the non-domestic stock proved challenging to engage with, at the time of the audit phase respondents stated that decarbonisation was not a key priority for their business in the context of increasing import/ export challenges, economic head winds and price inflation. Any further research in this area should take this into account when describing the benefits to participants; in particular, an emphasis on ongoing energy cost reductions would be beneficial.

The Probe audits have provided valuable insights into the “operational” phase of a premises life cycle and in-use energy consumption.

Electrical heating energy was observed as a means to make up any shortfall in comfort achieved through ageing heating systems, further PROBE audits in other sectors can help to build a picture of whether this is a general trend in the building stock.

Further PROBE audits should also focus on the evolution of space use within premises across the lifespan of the building/premises. The warehouses, in particular, demonstrated that space use at building design and construction can change over time. For instance, the installation of offices, the addition of internal partitions, and the change of use of different areas over time, all have an impact on the type and quantity of energy used over the life cycle of the building/premises. A reduction or increase in the percentage of floor area requiring heating and lighting will have a marked impact on future energy use intensities.

Annex 1 – Understanding ‘floor areas’ in the Valuation Office Agency data

This annex refers to all non-domestic premises, subject to business rates in England and Wales, as defined by the Valuation Office agency (VOA). The annex does not solely refer to large off gas grid (LOGG) premises.

Within the VOA data, for all rateable premises in the whole of England and Wales, there are many instances of premises with activities that are not given a taxable value based on floor area. The principal CaRB3 classes in which this situation occurs are: Hospitality (mostly pubs, hotels and self-catering accommodation); Education (mostly state schools); Health (mostly NHS hospitals); Utilities; MoD. However, there are also many instances where premises that would normally be given a taxable value based on floor area are valued in some other way and these premises may be identified by a lack of floor area record. In summary, there are 269 different CaRB3 activities, spread through 16 CaRB3 classes, accounting for more than 177,000 premises where there is no record for a ‘floor area’. However, there are also instances where the VOA uses the ‘floor area’ field to record metrics that are not necessarily directly related to floor area, such as the existence of a ‘golf course’ or the number of bedrooms in a guesthouse.

The ‘missing’ floor area records, and the ‘non-area’ records in the field allocated to floor area, are not necessarily anomalies so far as the VOA is concerned. However, the mixing of the record types causes problems when attempting to discover the actual floorspace in each CaRB3 activity and class population. The knock-on effect of this is felt in the calculation of energy use intensities, which rely on accurate and appropriate measurements of floor area in each premises. Thus, when based solely on VOA data, the sum of ‘floor areas’ in the Hospitality, Education, Health, Utilities and MoD CaRB3 classes are certainly an under-estimation. Similarly, this lack of floor area data reduces the sample size of calculated annual energy use intensities (EUI, kWh/m²) for these classes, in particular.

From the above, it is clear that the EUIs for these classes, when solely based on VOA ‘floor area’ data should be treated with a degree of caution. On the other hand, when the data are analysed according to the CaRB3 activity of premises (i.e. not aggregated to the class), the analyses are more robust, because the majority of premises, per CaRB3 activity, will be valued by the VOA using the same method. For example, no ‘Hotel (4 star and above, or major chain)’ premises have a floor area record, whilst almost all ‘Cafes’ have a floor area record, but both fall within the Hospitality CaRB3 class. This demonstrates problems that can arise when trying to simplify the data through aggregations.

Annex 2 – LOGG remote survey instrument

The table below outlines the full survey script.

A number of sources were used in the preparation of suitable questions including:

BEES: Building Energy Efficiency Survey (BEES) – GOV.UK (www.gov.uk)

Energy Efficiency in Industry: Not published online

Social research looking at non-domestic consumers off-gas grid: Social research with non-domestic consumers in buildings in off gas grid areas of England and Wales (publishing.service.gov.uk)

Evaluation of the Energy Savings Opportunity scheme: Energy Savings Opportunity Scheme (ESOS): evaluation of the scheme – GOV.UK (www.gov.uk)

Research into Energy Ratings for Non-Domestic Buildings: Not published online

Section A – Confirm respondent and business details

A_1NAMECH
If confirmed as part of introduction then do not ask. Select yes and continue. **To begin I have a few questions on your business activity and size….. Can I check that the organisation occupying the premises is called <busname>? If NO - is it the same address as <ADDR>?**

Choices	
Yes	1
NO AND NOT SAME ADDRESS- Thank and close	2
No but is same address	3

A_22019CH

If confirmed as part of introduction then do not ask. Select yes and continue.

Can I confirm, did <busname> occupy <Addr> in 2019?

Choices		
Yes	1	
No - Thank and close	2	

A_3

If confirmed as part of introduction then do not ask. Select yes and continue.

As part of your role, can I confirm whether you are involved in dealing with energy use at <ADDR> (e.g. you have knowledge of the energy costs and uses on your premises) and would be able to answer questions about <busname> energy usage at this address?

Choices		
Yes	1	
No	2	

A_4

Who would be the most appropriate person to speak to regarding energy use in your premises or building at this address? Can you put me through to them?

Choices		
Yes can provide contact and put us through – CONTINUE AND RECORD NEW RESPONDENT NAME	1	
Can provide contact but can't put us through -(take contact details) CLOSE CALL	2	O

AND TRY AND ARRANGE A DATE AND TIME TO RESUME THE INTERVIEW WITH THE NEW CONTACT	
Don’t know alternative contact – THANK AND CLOSE INTERVIEW	3
Don’t wish to provide an alternative contact – THANK AND CLOSE INTERVIEW	4

A_5

Do you / your organisation have the authority to make fundamental changes to the building heating system(s) at <ADDR>? For example, to change from an oil boiler to a new technology.

Choices	
Yes	1
No	2
Unsure	3

A_6SUBSECTOR

If confirmed as part of introduction then do not ask. Select correct subsector.

I have a few further questions on your business activity and size.. Could I confirm that the main category of your business is <Subsector>?

Choices

Warehouses	1
Factories	2
Offices	3
Shops	4
No the business is not one of the above - THANK AND CLOSE	5

A_7

Can I confirm, is your building/ the building you occupy connected to the main gas grid?

Choices	
Yes- THANK AND CLOSE	1
No	2
Unsure	3

A_7A

Can I can confirm, is your building solely off the gas grid or does it have any gas supplied from other buildings that are on the gas grid?

Choices	
It is entirely off the gas grid	1

It has gas supplied from other buildings on the gas grid	2
unsure (DO NOT READ)	3

A_7B

Does this off the gas grid building have its own meter or is the energy used captured on a meter in the mains gas grid building?

Choices	
off the gas grid building has its own meter	1
it uses the mains gas grid building's meter	2

A_7C

Do you own/ have use of both buildings, or is there an arrangement with the other building that is owned/ leased by another organisation?

Choices	
own/ lease both buildings	1
mains gas building is owned/ leased by someone else	2

A_7D

Is the gas supply from the other building a feed of hot water rather than an actual gas supply?

Choices		
Hot water feed	1	
gas supply	2	
other- what	3	O
unsure (DO NOT READ)	4	

A_7E

Can you tell me (or interviewer capture) any other information about this gas supply arrangement

Choices	
(Capture info eg how it works, put NA if nothing additional to add)	1

A_8EMPS

How many people does your organisation employ? If required: If your organisation is part of a wider group please provide employees for just <busname>?

Choices		
Can give a figure (number) - enter Full Time Equivalent	1	O
Don't know	2	
Prefer not to say	3	

A_9EMPS2

How many of these employees operate out of <addr>?

Choices		
Can give figure (number) - enter Full Time Equivalent	1	O
Don't know	2	
Prefer not to say	3	

Section B- Premises type and ownership

B_1BUILD

I´d now like to capture some information on the premises your business occupies at <addr>. For some of these questions, we will ask you to give us an answer thinking about how things stood for your business pre-Covid-19 and so the questions are asking you to think about 2019. Which of the following best describes the premises at <addr> in 2019 - Did your organisation have full use of…? (prompted; single response)

Choices	
A collection of buildings	1
A whole building	2
Part of a building	3

B_2BUILDSWAP

And, has this changed since 2019?

Choices	
Yes	1
No	2
Unsure	3

B_3OVER1000A

Approximate is fine, 1000m2 is size of an office for 50-80 people, a small primary school, a small hotel,

Are any of your buildings over 1000m2 in size?

Choices	
Yes	1
No- thank and close	2
Don’t know	3

B_3OVER1000

Capture number - Enter 999 for don't know

How many buildings over 1000m2 were there on this site in 2019? [Interviewer note: Approximate answer is fine. 1000 m2 is the size of an office for 50-80 people, a small primary school or a small hotel; portacabins should not be included?]

B_4

Interviewer just needs to read & click next

Please select the building/ one of the buildings on the site that is at least 1000m2 if possible please choose a building where you occupy the whole building. Please base all your following responses on this building

B_5NAME

What is the name of this building or how should we refer to this building for the rest of our conversation?

Choices		
Capture verbatim	1	DO

B_5OCCUPY

And do you occupy:

Choices	
The whole building	1
Part of the building	2

B_6PERCENT

Interviewer to probe to help respondents approximate. Enter 999 for don't know

What percentage of the building did <busname> occupy in 2019? [Capture percentage of floor area]

B_7

Prompted, single response

Is the building your business occupies/ the building your premises is in over 1000m2 in size? (Interviewer note: Approximate is fine. 1000m2 is the size of an office for 50-80 people, a small primary school or a small hotel)

Choices	
Yes	1
No	2
Unsure- do not read out	3

SECTIONB8A

We would now like to ask a series of questions relating to the whole building.

SECTIONB8B

We would now like to ask a series of questions relating to <B_5name:o>.

SECTIONB8C

We would now like to ask a series of questions relating to the premises you occupy within the building.

B_8LONG

Enter 999 for don't know

How long has your business occupied this building / part of the building? Capture years

B_9PAY

Prompted, single response

Which of the following best describes how your organisation typically pay for this building / part of the building?

Choices		
Rented	1	
Leased	2	
Lease purchase	3	
Owned outright (include if mortgage has been paid off in full)	4	
Owned - Mortgage	5	
Other - capture details	6	O
Mixture - capture details	7	O
Unsure - DO NOT READ OUT	8	

Don't want to say - DO NOT READ OUT	9

B_10RENT

Enter 999 for don't know

When does your rental or tenancy agreement for this building / part of the building end? Capture year

B_11BUILT

Prompted, single response

When was the building / the building your premises occupies originally built?

Choices	
Pre 1990	1
1991-1995	2
1996-2000	3
2001-2005	4
2006-2010	5
After 2010	6
Unsure - DO NOT READ OUT	7

B_12WALLS

Prompted, single response

Which of the following best describes the construction of the walls for the building/ the building your premises occupies?

Choices		
Solid masonry construction e.g. brick or stone	1	
Cavity wall construction	2	
Concrete walls	3	
Panel construction e.g. wood or steel frames with wood, metal or other cladding	4	
Unsure - DO NOT READ OUT	5	

B_13INVEST

When was the last time significant investment was made, by you or your landlord, on refurbishing or repairing the building/the building your premises occupies? [By significant investment we mean -replacement of major items such as boilers, chillers, air handling units, or lighting - or introduction of new control systems such as a Building Management Systems -or fabric improvements such as replacing windows which go beyond standard maintenance and upkeep]

Choices		
Capture year	1	O
Significant investment has never been made	2	
Unsure	3	

B_13INVESTB

Prompted, single response

Are you able to estimate if it was.....

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure - DO NOT READ OUT	5

B_14REFURB

Thinking back to 2019, did you consider the building/the building your premises occupied to be in need of refurbishment?

Choices	
Yes	1
No	2
Unsure	3

B_15ENTRY

Prompted, multiple response

In 2019, did the main entrances and exits to the building/the building your premises occupies have any of the following?

Choices	
Revolving doors	1

Motorised doors	2	
Draught lobbies	3	
Over door heaters or air curtains	4	
Open door policy (door is always open during opening hours)	5	
None of the above	6	X

Section C – Occupancy and running hours

SECTIONCA

We would now like to ask a series of questions relating to the whole building. For the following questions please answer considering how your business operated in 2019 (i.e. prior to the Covid-19 pandemic). If you are unsure we can ask about how the business operates now, but would prefer to take an approximate answer for 2019…..

SECTIONCB

We would now like to ask a series of questions relating to <B_5name:o>. For the following questions please answer considering how your business operated in 2019 (i.e. prior to the Covid-19 pandemic). If you are unsure we can ask about how the business operates now, but would prefer to take an approximate answer for 2019…..

SECTIONCC

We would now like to ask a series of questions relating to the premises you occupy within the building. For the following questions please answer considering how your business operated in 2019 (i.e. prior to the Covid-19 pandemic). If you are unsure we can ask about how the business operates now, but would prefer to take an approximate answer for 2019…..

C_1EMPSA

Approximately, how many employees of <busname> were based in the building/ the part of the building you use on a typical working day in 2019?

Choices	
Can give figure for 2019	1
Unsure - ask about now	2
Don't know	3

C_1EMPSB

Number of employees

C_2M

Thinking about 2019, please can you indicate if employees in <BUSNAME> typically worked in the building/the part of the building you use on the following days?

Monday to Friday

Choices	
Yes	1
No	2
Unsure	3

C_2S

Thinking about 2019, please can you indicate if employees in <BUSNAME> typically worked in the building/the part of the building you use on the following days?

Saturday

Choices	
Yes	1
No	2
Unsure	3

C_2SU

Thinking about 2019, please can you indicate if employees in <BUSNAME> typically worked in the building/the part of the building you use on the following days?

Sunday

Choices	
Yes	1
No	2
Unsure	3

C_3M

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use reasonably occupied? (I.e. at least 50% of staff present)?

Monday to Friday

C_3S

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use reasonably occupied? (I.e. at least 50% of staff present)?

Saturday

C_3SU

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use reasonably occupied? (I.e. at least 50% of staff present)?

Sunday

C_4M

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use partly occupied? (I.e. at least 20-50% of staff present)?

Monday to Friday

109 C_4S

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use partly occupied? (I.e. at least 20-50% of staff present)?

Saturday

C_4SU

capture number of hours for each day Enter 999 if unsure

And on each of these days how many hours was the building/ part of the building you use partly occupied? (I.e. at least 20-50% of staff present)?

Sunday

C_5WEEKSA

Number 52 or less. Enter 999 for don't know

In 2019, how many weeks per year was the building/the part of building you use closed e.g. business holiday periods?

Number of weeks in 2019

C_5WEEKSB

Number 52 or less. Enter 999 for don't know

If unsure - capture number of weeks as of now

C_6SHOPM

Enter 999 for don't know

In 2019, approximately how many customers were in the building/ the part of the building you use on each of the days employees worked in the building?

Monday to Friday

C_6SHOPS

Enter 999 for don't know

In 2019, approximately how many customers were in the building/ the part of the building you use on each of the days employees worked in the building?

Saturday

C_6SHOPSU

Enter 999 for don't know

In 2019, approximately how many customers were in the building/ the part of the building you use on each of the days employees worked in the building?

Sunday

C_6OTHERSM

Enter 999 for don't know

In 2019, approximately how many visitors were in the building/ the part of the building you use on each of the days employees worked in the building?

Monday to Friday

C_6OTHERSS

Enter 999 for don't know

In 2019, approximately how many visitors were in the building/ the part of the building you use on each of the days employees worked in the building?

Saturday

C_6OTHERSSU

Enter 999 for don't know

In 2019, approximately how many visitors were in the building/ the part of the building you use on each of the days employees worked in the building?

Sunday

Section D- Energy supply and state of metering

DINTROA

WHOLE BUILDING

Please answer the following questions for the whole building you occupy...

DINTROB

A COLLECTION - refer to specified name

Please answer the following questions for <b_5name:o>

DINTROC

PART OF A BUILDING

Please answer the following questions for the part of the building your business uses... Thinking about the premises you occupy, EXCLUDING any communal areas shared with other premises or businesses....

D_1PAYA

Prompted list; single response

How do you pay for your energy supply

Choices	
Payment made directly to your energy supplier	1
Energy costs included within rent paid to a landlord	2
A combination of the above	3
Unsure (DO NOT READ OUT)	4

D_1PAYB

For payments made directly to the energy supplier, is this done directly by this site or paid for by another part of your organisation (e.g. a head office, university central services etc)

Choices	
Paid by this site	1
Paid by another part of the organisation	2
Unsure (DO NOT READ OUT)	3

D_1PAYC

For energy costs included within rent paid to a landlord, is this

Choices	
A fixed cost	1
A variable cost	2
Unsure (DO NOT READ OUT)	3

D_31A

Prompted list; single response

Thinking about communal areas how do you pay for energy supply in these spaces?

Choices	
Payment made directly to your energy supplier	1

Energy costs included within rent paid to a landlord	2
A combination of the above	3
Do not pay for communal areas	4
Not applicable/ no communal areas	5

D_31B

For payments made directly to the energy supplier, is this done directly by this site or paid for by another part of your organisation (e.g. a head office, university central services etc)

Choices	
Paid by this site	1
Paid by another part of the organisation	2

D_31C

For energy costs included within rent paid to a landlord, is this

Choices	
A fixed cost	1
A variable cost	2

D_2SUPPLY

Prompted, multiple response

Which of the following supplies did the building receive in 2019?

Choices		
Electricity	01	
Oil	02	
Coal	03	
LPG	04	
Smokeless fuel including coke	05	
Anthracite	06	
Duel fuel appliances- mineral and wood	07	
District Heat	08	
Other - what?	09	O

D_2METER

And which of these supplies were directly metered?

Choices		
Electricity	01	
Oil	02	
Coal	03	
LPG	04	
Smokeless fuel including coke	05	
Anthracite	06	

Duel fuel appliances- mineral and wood	07	
District Heat	08	
Other - what?	09	O
Unsure	10	XF
None of these	11	XF

D_3RECOVERY

Did the building have a heat recovery system in 2019?

Choices	
Yes	1
No	2
Unsure	3

D_3A

Was the heat recovery system the main energy source for heating the building or heating the hot water?

Choices	
Yes- heating the building	1
Yes- heating the hot water	2
No	3

D_4MAINBUILD

Prompted single response

Which one of the supplies you received was the main energy source for heating the building?

Choices		
Electricity	01	
Oil	02	
Coal	03	
LPG	04	
Smokeless fuel including coke	05	
Anthracite	06	
Duel fuel appliances- mineral and wood	07	
District Heat	08	
Other - what?	09	O
Unsure	10	XF

D_5MAINWATER

Prompted single response

Which one of the supplies you received was the main energy source for heating water in the building?

Choices		
Electricity	01	
Oil	02	
Coal	03	
LPG	04	
Smokeless fuel including coke	05	

Anthracite	06	
Duel fuel - mineral and wood	07	
District Heat	08	
Other - what?	09	O
Unsure	10	XF

D_6DHFUEL

Prompted, single response

What was the fuel used to generate the heat for the district heat system?

Choices	
Oil	1
Coal	2
LPG	3
Smokeless Fuel inc. Coke	4
Anthracite	5
Dual Fuel Appliances (Mineral + Wood)	6
Other	7
Unsure	8

D_6B

Is your district heat bill calculated from a meter?

Choices

Yes	1
No	2
Unsure (DONT READ)	3

D_6C

Do you have a set payment for your allocation?

Choices	
Yes	1
No	2
Unsure (DO NOT READ)	3

D_6D

In 2019, do you know approximately how much you paid for district heat?

Choices	
Yes	1
No	2
Unsure (DO NOT READ)	3

D_6E

Enter 999 if unsure

Capture annual DISTRICT HEAT spend in £s

D_6F

Do you know how much you currently spend per year?

Choices	
Yes	1
No	2
Unsure	3

D_6G

Enter 999 if unknown

Capture DISTRICT HEAT spend annual currently

D_6H

Are you able to give an approximate average per month or per quarter?

Choices	
Per month capture £	1
Per quarter capture £	2
Unsure	3

D_7SPEND1

In 2019, do you know approximately how much you spent in total on ELECTRICITY?

Choices	
Yes	1
No	2

Unsure	3

D_7SPEND2

Enter 999 for don't know

Capture annual 2019 ELECTRICITY spend in £'s

D_7SPEND3

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_7SPEND4

Enter 999 for don't know

Capture 2019 ELECTRICTY spend per month/quarter in £'s

D_7SPEND5

Do you know how much you currently spend per year on ELECTRICITY?

Choices	
Yes	1
No	2
Unsure	3

D_7SPEND6

Enter 999 for don't know

Capture current annual ELECTRICITY spend in £'s

D_8EXTRA

Which of these supplies accounted for less than 20% of your total energy usage for the building/ part of the building in question?

Choices		
Electricity	01	
Oil	02	
Coal	03	
LPG	04	
Smokeless fuel including coke	05	
Anthracite	06	
Duel fuel appliances- mineral and wood	07	
District Heat	08	
Other - what?	09	O
Unsure	10	XF
None of these	11	XF

D_8DELIVER1

Thinking about your use of OIL in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2

Enter 999 for don't know

Capture litres of OIL for the year

D_8DELIVER3

Are you able to give an approximate amount used for a month or per quarter of OIL

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4

Enter 999 for don't know

Capture OIL per month/ per quarter

D_8DELIVER5

Do you know how much OIL you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6

Enter 999 for don't know

Capture OIL used in current year

D_9DELIVER

Can you tell me how many deliveries of OIL you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2

Enter 999 for don't know

Capture how many deliveries of OIL

D_10SPEND1

And can you estimate how much you spent on OIL for the year 2019?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND2

Enter 999 for don't know

Capture OIL £s for the year

D_10SPEND3

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPEND4

Enter 999 for don't know

Capture OIL spend per month/quarter in £'s

D_10SPEND5

Do you know how much you currently spend per year on OIL

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND6

Enter 999 for don't know

Capture current annual OIL spend in £'s

D_8DELIVER1A

Thinking about your use of COAL in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2A

Enter 999 for don't know

Capture tonnes of COAL for the year

D_8DELIVER3A

Are you able to give an approximate amount used for a month or per quarter of COAL

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4A

Enter 999 for don't know

Capture COAL per month/ per quarter

D_8DELIVER5A

Do you know how much COAL you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6A

Enter 999 for don't know

Capture COAL used in current year

D_9DELIVERA

Can you tell me how many deliveries of COAL you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2A

Enter 999 for don't know

Capture how many deliveries of COAL

D_10SPENDA1

And can you estimate how much you spent on COAL for the year 2019?

Choices	
Yes	1
No	2
Unsure	3

D_10SPENDA2

Enter 999 for don't know

Capture annual 2019 COAL spend in £'s

D_10SPENDA3

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPENDA4

Enter 999 for don't know

Capture 2019 COAL spend per month/quarter in £'s

D_10SPENDA5

Do you know how much you currently spend per year on COAL?

Choices	
Yes	1
No	2
Unsure	3

D_10SPENDA6

Enter 999 for don't know

Capture current annual COAL spend in £'s

D_8DELIVER1B

Thinking about your use of LPG in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2B

Enter 999 for don't know

Capture litres of LPG for the year

D_8DELIVER3B

Are you able to give an approximate amount used for a month or per quarter of LPG

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4B

Enter 999 for don't know

Capture LPG per month/ per quarter

D_8DELIVER5B

Do you know how much LPG you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6B

Enter 999 for don't know

Capture LPG used in current year

D_9DELIVERB

Can you tell me how many deliveries of LPG you had in the year?

Choices	
Yes	1
No	2

Unsure	3

D_9DELIVER2B

Enter 999 for don't know

Capture how many deliveries of LPG

D_10SPEND1B

And can you estimate how much you spent on LPG for the year 2019?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND2B

Enter 999 for don't know

Capture annual 2019 LPG spend in £'s

D_10SPEND3B

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2

No	3

D_10SPEND4B

Enter 999 for don't know

Capture 2019 LPG spend per month/quarter in £'s

D_10SPEND5B

Do you know how much you currently spend per year on LPG?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND6B

Enter 999 for don't know

Capture current annual LPG spend in £'s

D_8DELIVER1C

Thinking about your use of SMOKELESS FUEL in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2C

Enter 999 for don't know

Capture tonnes of SMOKELESS FUEL for the year

D_8DELIVER3C

Are you able to give an approximate amount used for a month or per quarter of SMOKELESS FUEL

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4C

Enter 999 for don't know

Capture SMOKELESS FUEL per month/ per quarter

D_8DELIVER5C

Do you know how much SMOKELESS FUEL you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6C

Enter 999 for don't know

Capture SMOKELESS FUEL used in current year

D_9DELIVERC

Can you tell me how many deliveries of SMOKELESS FUEL you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2C

Enter 999 for don't know

Capture how many deliveries of SMOKELESS FUEL

D_10SPENDC1

And can you estimate how much you spent on SMOKELESS FUEL for the year 2019?

Choices	
Yes	1
No	2
Unsure	3

D_10SPENDC2

Enter 999 for don't know

Capture annual 2019 SMOKELESS FUEL spend in £'s

D_10SPENDC3

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPENDC4

Enter 999 for don't know

Capture 2019 SMOKELESS FUEL spend per month/quarter in £'s

D_10SPENDC5

Do you know how much you currently spend per year on SMOKELESS FUEL?

Choices	
Yes	1
No	2
Unsure	3

D_10SPENDC6

Enter 999 for don't know

Capture current annual SMOKELESS FUEL spend in £'s

D_8DELIVER1D

Thinking about your use of ANTHRACITE in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2D

Enter 999 for don't know

Capture tonnes of ANTHRACITE for the year

D_8DELIVER3D

Are you able to give an approximate amount used for a month or per quarter of ANTHRACITE

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4D

Enter 999 for don't know

Capture ANTHRACITE per month/ per quarter

D_8DELIVER5D

Do you know how much ANTHRACITE you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6D

Enter 999 for don't know

Capture ANTHRACITE used in current year

D_9DELIVERD

Can you tell me how many deliveries of ANTHRACITE you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2D

Enter 999 for don't know

Capture how many deliveries of ANTHRACITE

D_10SPEND1D

And for 2019 can you estimate how much you spent on ANTHRACITE for the year?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND2D

Enter 999 for don't know

Capture annual 2019 ANTHRACITE spend in £'s

D_10SPEND3D

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPEND4D

Enter 999 for don't know

Capture 2019 ANTHRACITE spend per month/quarter in £'s

D_10SPEND5D

Do you know how much you currently spend per year on ANTHRACITE?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND6D

Enter 999 for don't know

Capture current annual ANTHRACITE spend in £'s

D_8DELIVER1E

Thinking about your use of DUAL FUEL in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2E

Enter 999 for don't know

Capture tonnes/litres of DUAL FUEL for the year

D_8DELIVER3E

Are you able to give an approximate amount used for a month or per quarter of DUAL FUEL

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4E

Enter 999 for don't know

Capture DUAL FUEL per month/ per quarter

D_8DELIVER5E

Do you know how much DUAL FUEL you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6E

Enter 999 for don't know

Capture DUAL FUEL used in current year

D_9DELIVERE

Can you tell me how many deliveries of DUAL FUEL APPLIANCES you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2E

Enter 999 for don't know

Capture how many deliveries of DUAL FUEL APPLIANCES

D_10SPEND1E

And can you estimate how much you spent in 2019 on DUAL FUEL APPLIANCES for the year?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND2E

Enter 999 for don't know

Capture annual 2019 DUEL FUEL spend in £'s

D_10SPEND3E

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPEND4E

Enter 999 for don't know

Capture 2019 DUEL FUEL spend per month/quarter in £'s

D_10SPEND5E

Do you know how much you currently spend per year on DUEL FUEL?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND6E

Enter 999 for don't know

Capture current annual DUEL FUEL spend in £'s

D_8DELIVER1G

Thinking about your use of <D_2SUPPLY:09> in 2019, do you know how much you had delivered for the year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER2G

Enter 999 for don't know

Capture tonnes/litres of <D_2SUPPLY:o> for the year

D_8DELIVER3G

Are you able to give an approximate amount used for a month or per quarter of <D_2SUPPLY:09>

Choices	
Yes- per month	1
Yes- per quarter	2
Unsure	3

D_8DELIVER4G

Enter 999 for don't know

Capture <D_2SUPPLY:09> per month/ per quarter

D_8DELIVER5G

Do you know how much <D_2SUPPLY:09> you will use in the current year?

Choices	
Yes	1
No	2
Unsure	3

D_8DELIVER6G

Enter 999 for don't know

Capture <D_2SUPPLY:09> used in current year

D_9DELIVERG

Can you tell me how many deliveries of <D_2SUPPLY:09> you had in the year?

Choices	
Yes	1
No	2
Unsure	3

D_9DELIVER2G

Enter 999 for don't know

Capture how many deliveries of <D_2SUPPLY:09>

D_10SPEND1G

And can you estimate how much you spent in 2019 on <D_2SUPPLY:09> for the year?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND2G

Enter 999 for don't know

Capture annual 2019 <D_2SUPPLY:09> spend in £'s

D_10SPEND3G

Are you able to give an approximate average per month or per quarter?

Choices	
Yes - per month	1
Yes - per quarter	2
No	3

D_10SPEND4G

Enter 999 for don't know

Capture 2019 <D_2SUPPLY:09> spend per month/quarter in £'s

D_10SPEND5G

Do you know how much you currently spend per year on <D_2SUPPLY:09>?

Choices	
Yes	1
No	2
Unsure	3

D_10SPEND6G

Enter 999 for don't know

Capture current annual <D_2SUPPLY:09> spend in £'s

D_11SITE

Is the building located on a site i.e. a collection of buildings?

Choices	
Yes	1
No	2
Unsure	3

D_12METEREL

Single response

Was the total ELECTRICITY supplied to the building sub-metered in 2019? (E.g. you have a meter or meters which are not the utility suppliers meter)?

Choices	
Yes	1

No	2
Unsure	3

D_13TYPEEL

Single response

What type of meter did you have for ELECTRICITY in 2019? · Basic meter (These meters need to be read at the site of the meter, and are used by the utility company for billing purposes. These meters are very basic and are similar to those used in domestic buildings. They can have digital displays.) · Automatic meter reading or ``advanced´´ meter (AMR or advanced meters provide a company with the ability to read a meter remotely, automatically and at frequent intervals. For example, meter readings could be displayed real-time on a control panel/control room, providing much more accurate and `up to date´ energy usage data (than available through monthly or quarterly bills). This type of meter also reduces the need for manual readings and provides access to the information via internet `portals´, for example) · Smart meter (A 'smart' meter allows meter readings to be displayed off-site (for example, to a utility company or aggregator) on a frequent basis (e.g. half-hourly). A `smart´ meter may also allow the utility company to both remotely read and instruct the meter and therefore allows a number of additional operations such as updating the metering tariff.)

Choices	
Basic meter	1
Automatic meter reading or “advanced” meter	2
Smart meter	3
Unsure	4

D_14ELEND

Single response

Do you have any metering in place that allows you to break down your ELECTRICITY bill by the end use (e.g. space heating, hot water, cooking)

Choices		
Yes	1	
No	2	
Unsure	3	

D_14ELENDA

And do you use this information in managing your energy use?

Choices		
Yes	1	
No	2	
Unsure	3	

D_15ELEQUIP

Do you know what equipment in your premises is responsible for most of your ELECTRICITY use?

Choices		
Yes - what equipment uses most energy (capture verbatim)	1	O
No	2	

Section E: Energy using equipment – heating, cooling and ventilation

E_1BSP

Single response

Please answer the following questions thinking about how you heated the building/part of the building you use in 2019….. Did the premises you occupy have its own dedicated building services plant (e.g. heating, and ventilation or cooling if present) or is this provided from central systems serving the whole building?

Choices	
All heating, cooling etc. is dedicated to our premises & is our responsibility	1
All heating, cooling etc is provided centrally by the landlord & is their responsibility	2
Some services are dedicated and some are provided centrally	3
Not sure	4

E_2HEATSYS

Prompted, multiple response

In 2019, did you have any of the following electric heating systems in your building/premises?

Choices	
Electric boiler	1
Individual room electric heaters	2

Ground Source Heat pump	3	
Air Source Heat Pump	4	
None of the above (DO NOT READ)	5	X
Unsure (DO NOT READ)	6	X

E_3HEATSYS

Prompted, multiple response

Did you have any of the following heating systems in 2019?

Choices		
Solar Thermal	1	
Biomass Boiler	2	
Neither (DO NOT READ)	3	X
Unsure (DO NOT READ)	4	X

E_4HEATDIST

Prompted, multiple response

In 2019, did you use any of the following to distribute your heating?

Choices		
Radiators	1	
Underfloor heating	2	
Hot air system	3	

None of the above (DO NOT READ)	4	X
Unsure (DO NOT READ)	5	X

E_5REPLACEA

When was the last time you/your landlord replaced your heating system?

Choices

Capture year	1	O
Heating system has never been replaced	2	
Unsure	3	

E_5REPLACE

Prompted, single response

Are you able to estimate if it was…..

Choices

After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure - DO NOT READ OUT	5

E_6REPAIRA

And when was the last time you/your landlord made repairs to the current heating systems in the building/premises?

Choices		
Capture year	1	O
Heating system has never been repaired	2	
Unsure	3	

E_6REPAIR

Are you able to estimate if it was.....

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure - DO NOT READ OUT	5

E_7RUN

Number 12 or less. Enter 999 for don't know

How many months of the year did you typically have the heating running in 2019?

Capture months

E_8THERMO

Was the heating controlled by a thermostat in 2019?

Choices	
Yes	1
No	2
Unsure	3

E_9HEATA

On a typical working day in 2019, where the heating is running, how much of the building/premises would be heated? For hotels, boarding houses and hostels please answer this question for the areas that are controlled by central management.

Choices	
None	1
Special areas only - less than 20%	2
Some - 20% to 40%	3
About half - 40%-60%	4
Most - 60-80%	5
All - more than 80%	6
Unsure	7

E_10HEATB (I)

On a typical day in 2019, where the heating is running, how much of the building/premises would be heated? For hotels, boarding houses and hostels please answer this question for the areas that are controlled by central management.

Quiet day

Choices	
None	1
Special areas only - less than 20%	2
Some - 20% to 40%	3
About half - 40%-60%	4
Most - 60-80%	5
All - more than 80%	6
Unsure	7

E_10ONA

Number 24 or less. Enter 999 for don't know

And in 2019, (in a typical working day) typically how many hours would your organisation have the main heating system switched on?

E_11ONB (I)

Number 24 or less. Enter 999 for don't know

And in 2019, typically how many hours would your organisation have the main heating system switched on?

Quite day

E_11VENT

Prompted

I´d now like to understand a little more about the ventilation in your building in 2019… Which one of the following types of ventilation did you have 2019?

Choices	
Openable windows EVERYWHERE	1
Openable windows in MOST areas, PLUS extract fans in special areas (e.g. kitchens or toilets)	2
Ventilation from a CENTRAL SYSTEM in MOST or ALL of your areas	3
Unsure	4

E_12VENTUSE

Prompted

Approximately how much of the building used mechanical ventilation in 2019? [If required: mechanical ventilation is where fans supply or extract air to/from the internal spaces through pipes or ducts to grilles in the roof or floor, rather than opening windows to supply fresh air]

Choices	
None	1
Special areas only - less than 20%	2
Some - 20% to 40%	3
About half - 40%-60%	4
Most - 60-80%	5
All - more than 80%	6

Unsure	7
Heating and ventilation are all one unit so same usage	8

E_13MECHVENT

Prompted, single response

What type of mechanical ventilation was most commonly in use in 2019?

Choices	
Supply and extract	1
Extract only	2
Displacement ventilation	3
Unsure	4

E_14VENTCONT

Prompted, multiple response

What types of ventilation controls did you have in the building in 2019

Choices	
Variable speed drive fans vary the ventilation rate according to time controls	1
Variable speed drive fans vary the ventilation rate according to demand e.g. using CO2 sensors	2
Time controls switch off the ventilation outside normal hours of use	3
Ventilation to zones with different hours of use is controlled separately	4

Unsure	5	X
None of these	6	X

E_15A

When was the last time you/ your landlord replaced your ventilation system?

Choices		
Capture years	1	O
Ventilation system has never been replaced	2	
Unsure	3	
It is the same as the heating unit	4	

E_15B

Are you able to estimate was it?

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre-2005	4
Still unsure	5

E_15C

And when was the last time you/ your landlord made repairs to the ventilation systems in the building/ premises?

Choices		
Capture years	1	O
Ventilation system has never been repaired	2	
Unsure	3	
It is the same as the heating unit	4	

E_15D

Are you estimate if it was?

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure	5

E_15MECHUSE

Prompted, single response

In 2019, how much of the building had a mechanical cooling or air conditioning system? (If required: this is areas where you can adjust the temperature to keep the space comfortably cool when it is hot outside or it is too hot inside a room)

Choices		
None	1	
Special areas only - less than 20%	2	
Some - 20% to 40%	3	
About half - 40%-60%	4	
Most - 60-80%	5	
All - more than 80%	6	
Unsure	7	
Heating ventilation and air conditioning are all one system so same usage	8	

E_16COOL

Multiple response

What types of cooling systems did you have in the building in 2019?

Choices		
Central system - cold air distribution	1	
Central system with chilled water distribution	2	
Central system with refrigerant distribution (VRV)	3	
Central system but unsure of type	4	
Local units with refrigerant (DX split units)	5	
Unsure (DO NOT READ)	6	X
None of the above (DO NOT READ)	7	X

E_17REPLACEA

When was the last time you/your landlord replaced your cooling system?

Choices		
Capture year	1	O
Cooling system has never been replaced	2	
Unsure	3	
It is the same as the heating unit AND OR ventilation unit	4	

E_17REPLACE

prompted, single response

Are you able to estimate if it was…..

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure - DO NOT READ OUT	5

E_18REPAIRA

And when was the last time you/your landlord made repairs to the cooling systems in the building/premises?

Choices		
Capture year	1	O
Cooling system has never been repaired	2	
Unsure	3	
It is the same as the heating unit AND OR ventilation unit	4	

E_18REPAIR

prompted, single response

Are you able to estimate if it was...

Choices	
After 2019	1
Between 2010 and 2019	2
Between 2005 and 2009	3
Pre 2005	4
Still unsure - DO NOT READ OUT	5

E_19CONTROL

Multiple response

What cooling controls did you have in the building in 2019? For hotels, boarding houses and hostels please answer this question for the areas that are controlled by central management.

Choices		
Time controls switch off the cooling outside normal hours of use	1	
Temperature control is efficiently set via thermostats	2	
Cooling for zones with different hours of use is controlled separately	3	
Unsure (DO NOT READ)	4	
None of these (DO NOT READ)	5	

E_20COOL

Prompted, multiple response

Which of the following applied to your building in terms of cooling in 2019?

Choices		
The building suffers from heat gains due to the sun shining on the building	1	
The building has external shading to prevent heating from the sun	2	
The building regularly uses night-time ventilation in warm weather	3	
Cooling is only used in very hot weather (top cooling)	4	
Cooling is available 24h for special areas only (e.g. servers, control rooms)	5	
Unsure (DO NOT READ)	6	X
None of these (DO NOT READ)	7	X

E_21MONTHS

Number up to 12. Enter 999 for don't know

In 2019, how many months per year did you switch on your cooling system?

E_22LOWCARB

Were there any low carbon or renewable energy technologies supplying the building other than <compheat1>, <compheat2>, <compheat3>, <compheat4> in 2019?

Choices		
Yes	1	
No	2	
Unsure	3	

E_23TECH

Which low carbon or renewable technologies did you have dedicated to the building in 2019?

Choices		
Photovoltaic panels	1	
Wind turbine	2	
Other - what?	3	O
Unsure	4	X

E_24WATER

Prompted, multiple response

Thinking about hot water in the building, what uses does centrally heated hot water have in your building?

Choices		
Hot water taps	1	
Hot water showers	2	
Other - what?	3	O

E_25WATER2

Do you have any under sink/wall mounted electric water heaters?

Choices	
Yes	1
No	2
Unsure	3

E_25WATER3

Enter 999 for don't know

How many under sink/wall mounted electric water heaters do you have?

Section F: Energy using equipment - Lighting

F_1LIGHTS

Prompted, multiple response

Think now about the lighting... Which of following lighting types did the building have in 2019?

Choices		
LED	1	
Incandescent	2	
GLS lamp	3	
Compact fluorescent	4	
Halogen	5	
Other - what?	6	O
Unsure	7	X

F_2CONTROLS

Prompted, multiple response

What controls were present to control lighting in the building?

Choices	
Light switches that are easily accessible	1
Light switches that are hard to access	2
Automatic controls (daylight or presence detectors)	3
Lighting management systems	4

Unsure (DO NOT READ)	5	X

F_3ALIGHTS

Which of the following best describes how lighting controls were used in the building in 2019?

Lighting is usually off in unoccupied spaces

Choices	
Yes	1
Sometimes	2
No	3

F_3BLIGHTS

Which of the following best describes how lighting controls were used in the building in 2019?

Lighting is usually off where and when daylight is sufficient

Choices	
Yes	1
Sometimes	2
No	3

Section G: Other energy using processes and equipment

SECTIONGA

Please continue to answer the following question on energy using equipment and processes in relation to the whole building for the year 2019

SECTIONGB

Please continue to answer the following question on energy using equipment and processes in relation to <B_5name:o> for the year 2019

SECTIONGC

Please continue to answer the following question on energy using equipment and processes in relation to the premises you occupy within the building for the year 2019

G_1EQUIPSHOP

Prompted, multiple response

Which of the following, if any, did you have in your building in 2019?

Choices		
Catering kitchen serving meals	01	
Server supporting IT e.g. computer network or tills	02	I
Data centre	03	I
Swimming Pool/Jacuzzi/Hot tubs	04	I
Commercial refrigerated storage for food sales	05	
Chilled drinks/ cellar/ bar facilities	06	
Non-food refrigeration e.g. medical uses	07	I
Saunas or steam rooms	08	I

Lifts or escalators	09	
Sound system	10	
Hot drinks facilities	11	
Automatic Conveyor Belt	12	I
None of the above (DO NOT READ)	13	X
Other high energy equipment - what?	14	O

G_1EQUIPOFF

Prompted, multiple response

Which of the following, if any, did you have in your building in 2019?

Choices		
Catering kitchen serving meals	01	
Server supporting IT	02	
Data centre	03	
Swimming Pool/Jacuzzi/Hot tubs	04	
Commercial refrigerated storage for food sales	05	
Chilled drinks/ cellar/ bar facilities	06	
Non-food refrigeration	07	I
Saunas/steam rooms	08	
Lifts or escalators	09	
Sound system	10	
Hot drinks facilities	11	
Automatic Conveyor Belt	12	I
None of the above (DO NOT READ)	13	X

Other high energy equipment - what?	14	O

G_1EQUIPFACT

Prompted, multiple response

Which of the following, if any, did you have in your building in 2019?

Choices		
Catering kitchen serving meals	01	I
Server supporting IT	02	I
Data centre	03	I
Swimming Pool/Jacuzzi/Hot tubs	04	I
Commercial refrigerated storage for food sales	05	I
Chilled drinks/ cellar/ bar facilities	06	I
Non-food refrigeration	07	
Saunas/steam rooms	08	I
Lifts or escalators	09	
Sound system	10	I
Hot drinks facilities	11	
Automatic Conveyor Belt	12	
None of the above (DO NOT READ)	13	X
Other high energy equipment - what?	14	O

G_1EQUIPWARE

Prompted, multiple response

Which of the following, if any, did you have in your building in 2019?

Choices		
Catering kitchen serving meals	01	I
Server supporting IT	02	
Data centre	03	
Swimming Pool/Jacuzzi/Hot tubs	04	I
Commercial refrigerated storage for food sales	05	I
Chilled drinks/ cellar/ bar facilities	06	I
Non-food refrigeration	07	
Saunas/steam rooms	08	I
Lifts or escalators	09	
Sound system	10	I
Hot drinks facilities	11	
Automatic Conveyor Belt	12	
None of the above (DO NOT READ)	13	X
Other high energy equipment - what?	14	O

G_2CATERING

Do you know approximately, how many hot meals does the catering facility produce in a typical day

Choices	
Yes	1
No	2
Unsure	3

None	4

G_2A

Enter 999 for don't know.

Approximately how many hot meals does the catering facility produce in a typical day?

G_3PROPBOUT

Number 100 or less. Enter 999 for don't know

What proportion of hot meals served are:

Bought in chilled and reheated

G_3PROPSCRAT

Number 100 or less. Enter 999 for don't know

What proportion of hot meals served are:

Prepared from scratch

G_4COLDA

Enter 999 for don't know. Enter 0 for none.

Approximately, how many cold meals does the catering facility produce in a typical day

G_5TYPE

Prompted, multiple response

What type of meals does your catering kitchen serve?

Choices		
Breakfast served in a set time-period	1	
Lunch served in a set time-period	2	
Dinner served in a set time-period	3	
Food is served all day	4	X

G_6ENERGY

Which of the following do you use for cooking in your kitchen?

Choices		
All electric	1	
Other- what?	2	O
Unsure	3	

G_7GLASS

Enter 999 for don't know

How many glass/dishwashers do you operate?

G_8GLASS

Enter 999 for don't know. Enter 0 for none.

On average how many times do you run your glass/dishwasher

G_9SERVERIT

Which of the following best describes your server room?

Choices	
Local (serves workstations in this building only)	1
Regional (also serves workstations outside this building)	2
Unsure DO Not READ OUT	3

G_10DATA

CAPTURE m2 enter 999 if unknown

What is the approximate floor area of your data centre?

G_11SWIM

Enter 999 for don't know. Enter 0 for none.

How many of the following did you have in 2019?

Swimming pools

G_11B

Enter 999 for don't know. Enter 0 for none.

How many of the following did you have in 2019?

Jacuzzis or Hot tubs

G_12SWIM1L

Enter 999 for don't know

I'd like to understand the size of your swimming pools How big is swimming pool 1?

What is the length in metres?

G_12SWIM1W

Enter 999 for don't know

How big is swimming pool 1?

What is the width in metres?

G_12SWIM1D

Enter 999 for don't know

How big is swimming pool 1?

What is the depth in metres?

G_12SWIM2L

Enter 999 for don't know

How big is swimming pool 2?

What is the length in metres?

G_12SWIM2W

Enter 999 for don't know

How big is swimming pool 2?

What is the width in metres?

G_12SWIM2D

Enter 999 for don't know

How big is swimming pool 2?

What is the depth in metres?

G_13SWIM1

Was swimming pool 1 heated in 2019?

Choices	
Yes	1
No	2
Unsure	3

G_13SWIM2

Was swimming pool 2 heated in 2019?

Choices	
Yes	1
No	2
Unsure	3

G_14JAC1

Enter 999 for don't know

I´d like to understand more about the size of your jacuzzi/s and/or hot tub/s How many people could fit in jacuzzi / hot tub 1?

G_14JAC2

Enter 999 for don't know

I´d like to understand more about the size of your jacuzzi/s and/or hot tub/s How many people could fit in jacuzzi / hot tub 2?

G_15FRIDGE1

Enter 999 for don't know

Thinking about refrigeration ..How many of each of the following did you have in 2019?

Refrigerators

G_15FRIDGE2

Enter 999 for don't know

How many of each of the following did you have in 2019?

Freezers

G_16FRIDGE3

Did customers have access to your refrigerator(s)?

Choices	
Yes	1
No	2

G_16FRIDGE4

Enter 999 for don't know

How many did they have access to?

G_17FRIDGE5

Did customers have access to your freezers?

Choices		
Yes	1	
No	2	

G_17FRIDGE6

Enter 999 for don't know

How many did they have access to?

G_18FRIDGE

In 2019, were all your refrigerators a similar age?

Choices		
Yes	1	
No	2	
Unsure	3	

G_19FRIDGAGE

Can you estimate how old your refrigerator/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_19FRIDGAG2

Can you estimate on the following scale

Choices		
Less than 5 years	1	
5 to 10 years	2	
10 to 15 years	3	
15 to 20 years	4	
20 years or more	5	
Still unsure (DO NOT READ)	6	

G_20AGE1

Can you estimate how old on average your refrigerator/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_20AGE1B

Can you estimate on the following scale on average how old the fridges were in 2019?

Choices		
Less than 5 years	1	
5 to 10 years	2	
10 to 15 years	3	

15 to 20 years	4	
20 years or more	5	
Still unsure (DO NOT READ)	6	

G_21FREEZE

In 2019, were all your freezers a similar age?

Choices		
Yes	1	
No	2	
Unsure	3	

G_22FREEZAGE

Can you estimate how old your freezers/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_22FREEZAG2

Can you estimate on the following scale

Choices		
Less than 5 years	1	
5 to 10 years	2	

10 to 15 years	3	
15 to 20 years	4	
20 years or more	5	
Still unsure (DO NOT READ)	6	

G_23AGE1

Can you estimate on average how old your freezer/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_23AGE1B

Can you estimate on the following scale on average how old your freezers were in 2019?

Choices	
Less than 5 years	1
5 to 10 years	2
10 to 15 years	3
15 to 20 years	4
20 years or more	5
Still unsure (DO NOT READ)	6

G_24BARA

Enter 999 for don't know

How many of each of the following do you have?

Draught pumps

G_24BARB

Enter 999 for don't know

How many of each of the following do you have?

Real ale pumps

G_24BARC

Enter 999 for don't know

How many of each of the following do you have?

Flash Coolers

G_24BARD

Enter 999 for don't know

How many of each of the following do you have?

Remote coolers

G_24BARE

Enter 999 for don't know

How many of each of the following do you have?

Cellar A/C units

G_24BARF

Enter 999 for don't know

How many of each of the following do you have?

G_24BARG

Enter 999 for don't know

How many of each of the following do you have?

Ice making machines

G_25GLASS

Enter 999 for don't know

How many glass/dishwashers do you operate?

G_26GLASSA

Enter 999 for don't know. Enter 0 for none.

On average how many times do you run your glass/dishwasher

G_26GLASSB

Enter 999 for don't know. Enter 0 for none.

On average how many times do you run your glass/dishwasher

G_27NONFOOD

Enter 999 for don't know

How many of each of the following non-food refrigeration did you have in 2019?

Refrigerators

G_27NONFOODA

Enter 999 for don't know

How many of each of the following did you have in 2019?

Freezers

G_28

In 2019, were all your non-food refrigerators a similar age?

Choices	
Yes	1
No	2
Unsure	3

G_29A

Can you estimate how old on average your non-food refrigerator/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_29B

Can you estimate on the following scale on average how old your non food refrigerators were in 2019?

Choices		
Less than 5 years	1	
5 to 10 years	2	
10 to 15 years	3	
15 to 20 years	4	
20 years or more	5	
Still unsure (DO NOT READ)	6	

G_31

In 2019, were all your freezers a similar age?

Choices		
Yes	1	
No	2	
Unsure	3	

G_32

Can you estimate how old your freezer/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_32A

Can you estimate on the following scale

Choices		
Less than 5 years	1	
5 to 10 years	2	
10 to 15 years	3	
15 to 20 years	4	
20 years or more	5	
Still unsure (DO NOT READ)	6	

G_33

Can you estimate how old on average your freezer/s were in 2019?

Choices		
Capture age in years	1	O
Unsure	2	

G_33A

Can you estimate on the following scale on average how old your freezers were in 2019?

Choices	
Less than 5 years	1
5 to 10 years	2

10 to 15 years	3
15 to 20 years	4
20 years or more	5
Still unsure (DO NOT READ)	6

G_34SAUNA

Enter 999 for don't know

How many of each of the following do you have:

Saunas

G_34STEAM

Enter 999 for don't know

How many of each of the following do you have:

Steam room

G_35LIFTA

Enter 999 for don't know

How many of each of the following do you have:

Escalators

G_35LIFTB

Enter 999 for don't know

How many of each of the following do you have:

Passenger lifts

G_35LIFTC

Enter 999 for don't know

How many of each of the following do you have:

Goods lifts

G_36LIFTD

Enter 999 for don't know

How many of each of the following do you have:

Platform lifts

G_36SOUND

Enter 999 for don't know

In 2019, how many hours on a typical working day would the sound system be running?

G_37DRINKA

Enter 999 for don't know. Enter 0 for none.

In 2019, approximately, how many hot drinks did you serve on a typical working day?

G_38BELT

Enter 999 for don't know.

How many automatic conveyor belts do you operate?

G_39OUTSIDE

I´d now like to understand more about outside space use in 2019…. Which of the following types of outdoor area did you have in 2019?

Choices		
Car Park	1	
Other outdoor area - please describe	2	O
None	3	X

G_39CPA

Are any of these car parks associated exclusively with the building?

Choices	
Yes	1
No	2

G_39CP2

And are these car parks for your organisation's sole use?

Choices	
Yes	1
No	2

G_39OTHA

Are any of these other spaces associated exclusively with the building?

Choices	
Yes	1
No	2

G_39OTH2

Are any of these other spaces for your organisation's sole use?

Choices	
Yes	1
No	2

G_40CARPARK

Enter 999 for don't know

How many parking spaces do you have? [if unknown ask for estimate for example does it accommodate a few staff, most staff, staff and visitors]

G_41LIGHT

When is car park lighting on?

Choices

Mornings/evenings when required (e.g. switched on in winter)	1
At all times outside daylight hours	2
At all times, but automatic controls reduce lighting when not needed	3
There is no lighting	4

Section H: Industrial processes

H_1

We would like to understand more about the industrial processes that were run from this building in 2019. What do you think are the top three energy consuming industrial processes in your businesses? If you do not have three processes, please list all industrial processes. For each please tell me how the process is powered (e.g. electricity, LPG, oil, coal).

1

Choices		
Capture process one inc how powered	1	DO

H_1B

Leave blank if only 1

We would like to understand more about the industrial processes that were run from this building in 2019. What do you think are the top three energy consuming industrial processes in your businesses? If you do not have three processes, please list all industrial processes. For each please tell me how the process is powered (e.g. electricity, LPG, oil, coal).

2

Choices		
Capture process one inc how powered	1	O

H_1C

Leave blank if only 2

We would like to understand more about the industrial processes that were run from this building in 2019. What do you think are the top three energy consuming industrial processes in your businesses? If you do not have three processes, please list all industrial processes. For each please tell me how the process is powered (e.g. electricity, LPG, oil, coal).

3

Choices		
Capture process one inc how powered	1	O

H_2

Please could you tell me what equipment is used in <H_1:o> ?

Choices		
	1	DO

H_3

Are you able to tell me the power rating for <H_2:o>?

Choices		
	1	DO

H_4

If can’t get % use scale

What proportion of this building's floor area was taken up by <H_2:o>?

Choices		
Capture %	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Unsure (DO NOT READ)	6	

H_2A

Please could you tell me what equipment is used in <H_1B:o> ?

Choices		
	1	DO

H_3A

Are you able to tell me the power rating for <H_2a:o>?

Choices		
	1	DO

H_4A

If can’t get % use scale

What proportion of this building's floor area was taken up by <H_2a:o>?

Choices		
Capture %	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Unsure (DO NOT READ)	6	

H_2B

Please could you tell me what equipment is used in <H_1C:o> ?

Choices		
	1	DO

H_3B

Are you able to tell me the power rating for <H_1C:o>?

Choices		
	1	DO

H_4B

If can’t get % use scale

What proportion of this building's floor area was taken up by <H_1C:o>?

Choices		
Capture %	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Unsure (DO NOT READ)	6	

H_5

Are you able to split out your energy costs for industrial processes versus other energy uses?

Choices	
Yes	1

No	2	==> H_7
Unsure	3	==> H_7

H_6

What proportion of your annual ELECTRICTY cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6A

What proportion of your annual OIL cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6B

What proportion of your annual COAL cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6C

What proportion of your annual LPG cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6D

What proportion of your annual SMOKELESS FUEL cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6E

What proportion of your annual ANTHRACITE cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
Less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6F

What proportion of your annual DUAL FUEL cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O

Less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6G

What proportion of your annual DISTRICT HEATING cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
Less than 40%	2	
40-less than 60%	3	
60-less than 80%	4	
Greater than 80%	5	
Not sure	6	

H_6H

What proportion of your annual <D_2SUPPLY:o> cost is on industrial processes?

Choices		
Capture % - if unsure use scale?	1	O
Less than 40%	2	
40-less than 60%	3	

60-less than 80%	4
Greater than 80%	5
Not sure	6

H_7

Are there any equipment or processes releasing a significant amount of cooling to the premises that would require additional space heating to compensate? (For example, warm air supplied to cold processing area for maintaining temperature comfort for staff)

Choices	
Yes	1
No	2
Unsure (DONT READ OUT)	3

H_8

Enter 999 if don't know

How many months a year is additional heating required?

H_9

Are there any equipment or processes releasing a significant amount of heat to the premises that would require additional cooling to compensate? (For example air conditioning required to offset the heat from equipment on a production line to ensure staff can work comfortably)

Choices

Yes	1
No	2
Unsure (DONT READ OUT)	3

H_10

Enter 999 if unsure

How many months a year is additional cooling required?

H_11

Do you have a heat recovery system in place for these industrial processes?

Choices	
Yes	1
No	2
Not sure (DO NOT READ)	3

H_12

Are there any processes that would require additional ventilation and air extraction from the building?

Choices	
Yes	1
No	2
Not sure (DO NOT READ)	3

Section I: Actors with responsibility for energy and energy efficiency measures installed

I_1RESP

Prompted, single response

This final set of questions looks to understand responsibilities for energy for [your building/ the building your premises is in] and whether you have made any changes over the past 2 years. Who is responsible for energy management in your building?

Choices	
An organisation energy manager who does not normally work in the building	1
An energy manager who does normally work in the building	2
A dedicated energy team	3
Someone who is not a full-time energy manager e.g. building or operations manager but with formal role to look after energy	4
An enthusiast or energy champion in the building without formal role to look after energy	5
No-one / there is no energy management	6

I_2

Have you ever looked into how much it would cost your business to connect to mains gas?

Choices	
Yes	1
No	2
Unsure (DO NOT READ)	3

I_2A

Capture £s

Can you tell me how much you think it would cost?

I_3

Over the past five years, has your business done anything to improve your energy efficiency?

Choices	
Yes	1
No	2

I_4IMPA

Which of the following have you done since 2017?

Had an energy audit

Choices	
Done between 2017 and now	1

2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPC

Which of the following have you done?

Hired an energy manager and/ or created a sustainability arm of the business

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPK

Which of the following have you done?

Implemented behavioural or cultural changes in the business

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPD

Which of the following have you done?

Improved control and monitoring systems

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPE

Which of the following have you done?

Implemented an energy management system ISO5001

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPF

Which of the following have you done?

Implemented an energy management system - other

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPG

Which of the following have you done?

Introduced a plan for behaviour change

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPH

Which of the following have you done?

Replaced industrial equipment

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPI

Which of the following have you done?

Made improvements to industrial processes

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPJ

Which of the following have you done?

Invested in building improvements

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPP

Which of the following have you done?

Heat supply and heat related improvements

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPL

Which of the following have you done?

Other

Choices		
Done between 2017 and now	1	
2020	2	I
2019	3	I
2018	4	I
2017	5	I
Not done	6	

I_4IMPM

You mentioned that you made behavioural and cultural changes in the businesses - what were these?

Choices		
Capture verbatim	1	DO

I_4IMPN

You mentioned that you introduced a plan for behaviour change - could you please describe this?

Choices		
Capture verbatim	1	DO

I_4IMPOTH

You mentioned that you made other changes - what were these?

Choices		
Capture verbatim	1	DO

I_5

Have you looked into any further options your business could take to improve your energy efficiency or reduce your carbon footprint in future?

Choices	
Yes	1

No	2	
Unsure (DO NOT READ)	3	

I_5A

What further options have you looked into?

Choices		
Capture verbatim	1	O

I_5B

Did you look into how much it would cost your business to make these improvements?

Choices	
Yes	1
No	2
Unsure (DONT READ)	3

I_5C

What is the cost estimate for these changes?

I_6CHALLENG

What are the main challenges for you / your business in lowering your carbon emissions and transferring to alternative energy efficient options?

Choices		
Capture verbatim	1	DO

I_7SUPP

Is there any support from government (including policy change) that you would value in helping the business lower your carbon emissions and transferring to alternative energy efficient options?

Choices		
Yes, funding - what this would be used for?	1	O
Yes, other - please describe	2	O
No	3	X

ACCA

In terms of your responses given to questions where factual information is provided, how accurate do you think your responses have been?

Choices	
Mainly accurate	1
Mix of some accurate and some guesswork	2
Mainly guesswork but should be about right	3
Unsure	4

RECONTACT

Thank you for your time. Would it be possible to call you back if we need to check anything?

Choices		
Yes	1	
No	2	

VISIT

We will be contacting some organisations to request a site visit that could take between 1 and 2 days to complete. This will enable us to source data from physical meters and equipment. As a thank you we are offering a short report giving advice on energy saving measures and showing how your organisation compares with on-gas peers. Would you be happy for us to contact you again in the future to explain more about what is involved and see if you would be willing to help? If yes, when is best to visit (capture potential days, dates that could work/ dates unavailable and make clear if dates are those that they are free or not!)

Choices		
Yes	1	O
No	2	

WYORKS2

We are aware of business support available in the West Yorkshire area to help businesses reduce their carbon emissions and operate more sustainably. Would

you like to give consent for us to pass your contact details (name, email, telephone number) to them in case they may be able to support you with future projects to work towards net zero?

Choices	
Yes	1
No	2

CONTACTA

What would be the best email

CONTACTB

and what would be the best phone number

CALLR

Finally, would you like to take Winning Moves number or the Market Research Society freephone number just in case you wanted to check something about the company or the work we are doing? That's all that I was hoping to cover with you today so thank you for your time.

Choices	
Winning Moves - 0121 285 3800	1
Market Research Society freephone - 0800 975 9596	2
None	3
Both	4

ACCB

DO NOT ASK - INTERVIEWER TO CODE

In terms of the responses given by the respondents, how accurate do you think their responses have been? (capture open end and code)

Choices		
Capture your open end	1	DO
Mainly accurate	2	
Mix of some accurate and some guesswork	3	
Mainly guesswork but should be about right	4	
Unsure		

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