August 2021

Energy Audit Recommendation Report

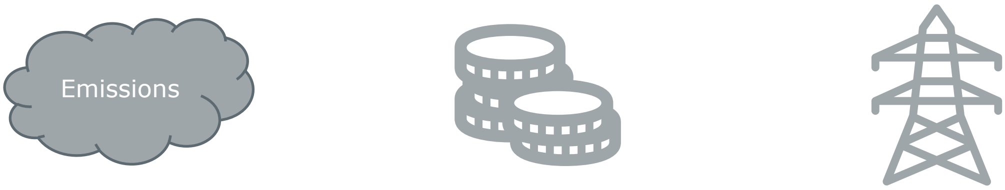
Contents

[redacted]

1 Executive Summary

1.1 Existing Emissions

[redacted]

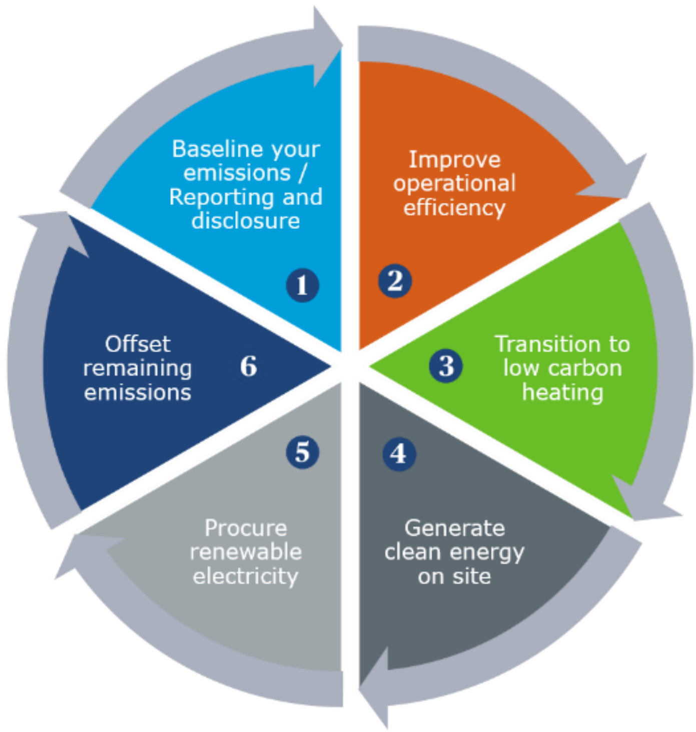


47.5 tCO_2e	£33,400	171,400 kWh

[redacted]

1.2 [redacted] Journey to a Net Zero Office

This report sets out six simple steps [redacted] will need to take to operate their building at net zero operational carbon, analyses their progress to date, and sets out actions they will need to take in order to progress their net zero ambitions.



Step		Status	Actions
1	Measure and report energy consumption and emissions		
2	Operate the building as efficiently as possible, with minimal energy waste		
3	Transition to low carbon sources for heating and hot water systems		
4	Generate clean energy on site		
5	Procure renewable electricity		
6	Offset emissions		

1.3 Energy Saving Opportunities

Six opportunities have been identified that can be implemented within a reasonable timeframe.

Opportunities 1-3 are low-to-zero-cost. Opportunities 4 and 5 will require a combined capital expenditure of approximately £31,100. Opportunity 6 revolves around strategic future decision making. Combined, opportunities 1-5 could reduce the office’s energy use by 28%, resulting in savings of £9,380 per year (using 2019 cost data) and 10.9 tCO_2e (in 2022) as summarised in the following table.

Measure	Estimated savings			% energy savings	Lifetime carbon savings *	Cost	Payback period **
	Energy saving (kWh/yr)	Cost saving (£/year)	Carbon saving (tCO_2e) (year 1)	% kWh saving	tCO_2e	£	years
1. Ensure server room cooling temperature setpoint is suitable							
2. Encourage staff to adopt sustainable energy practices							
3. Ensure HVAC controls are suitably adjusted to office usage patterns							
4. Install LED lighting with intelligent controls***							
5. Install a solar PV array (details in step 4)							
6. Develop policies to ensure sustainability is considered in all procurement							
Measures 1-5 combined							

*Accounts for decarbonisation of the electricity grid, as set out in Appendix 1.1.
**Inflation is applied to future energy cost calculations, as set out in Appendix 1.2.
*** The costs noted in the table are for LED tube replacements, not replacement of fittings.
Note these are estimates based on the auditor’s observations and are not guaranteed savings.

2 Introduction

2.1 Aims of this project

2.2 Scope of the project

2.2.1 Business Climate Challenge

2.2.2 Site

This report covers energy use and emissions at the following site:

Address:

Floor area:

Occupancy:

Tenure:

Year of latest refurbishment:

Date of survey:

2.2.3 Emission Scopes

The scope of this study only covers emissions from the **building use only**, which in this instance is emissions from purchased electricity (scope 2).

For the whole business to become a net zero business, additional steps will need to be undertaken to address emissions from scope 1 and scope 3 activities. For more information of the Greenhouse Gas Protocol emission scopes, see [Compare Your Footprint](#).

2.2.4 Display Energy Certificate

[1] Net Zero Operational Carbon document (LETI, https://b80d7a04-1c28-45e2-b904-e0715cface93.filesusr.com/ugd/252d09_0f7760d9a2ba4ab8920f69f8cee3e112.pdf

3 Background Information

3.1 Carbon dioxide equivalent measurements

CO_2

vs

CO_2e

There are seven main greenhouse gases (GHGs) that contribute to climate change, as covered by the Kyoto Protocol. These are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). Different activities emit different gases.

Each of the GHGs has different properties, a different global warming potential (GWP) and, as such, each has a different impact on climate change.

A standardised unit is used to enable a comparison between all GHGs.

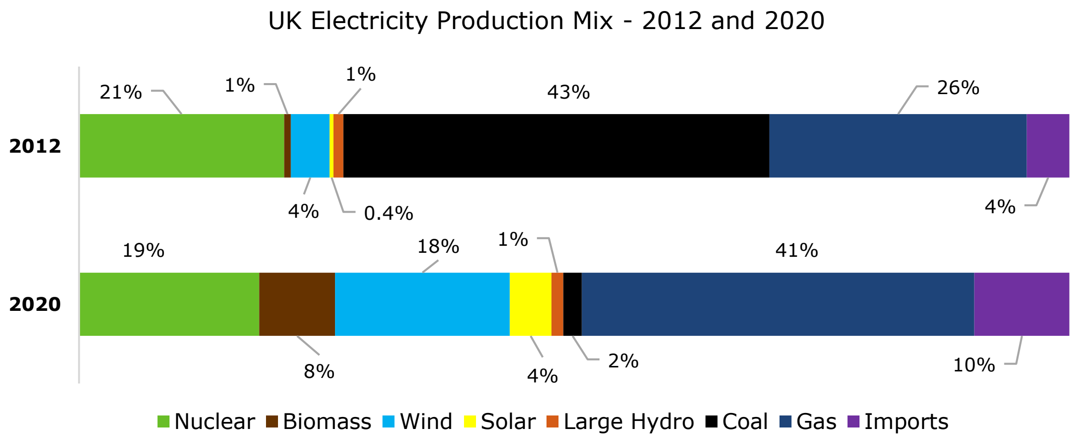
Carbon dioxide equivalent, CO_2e, is the universal unit of measurement to indicate the GWP of GHGs, expressed in terms of the GWP of one unit of carbon dioxide.

Carbon dioxide equivalent is regularly misinterpreted or misreported as "carbon" or "carbon dioxide" – whereas it is likely that most of the time, the measure being referred to is CO_2e. This is the unit that is being used in this report.

3.2 The decarbonisation of the electricity grid

Electricity in the UK comes from multiple sources, some of which are 'clean', and some of which rely on the combustion of fossil fuels.

The UK's energy mix has changed substantially in recent years, becoming noticeably more reliant on clean energy sources and much less reliant on polluting and carbon emitting fuels such as coal. This is reflected in the following chart, which shows that around 6% of the UK's grid was generated from renewable energy in 2012, compared to 31% in 2020.[2]



This increase in renewable energy generation has resulted in a decrease of the carbon intensity of electricity.

[2] Data from https://www.mygridgb.co.uk/historicaldata/

3.3 Climate Change and Climate Emergencies

The Intergovernmental Panel on Climate Change has made it clear that limiting global warming to 1.5°C is necessary to prevent a sustained environmental and public health catastrophe.

189 countries signed the Paris Climate Change Agreement in 2015/16, signing up to a legally binding commitment to limit global temperature rise to 1.5°C by the middle of this century.

In December 2018, the London Assembly declared a Climate Emergency, shortly followed by the Mayor of London, who in 2020 set a target for London to be net zero carbon by 2030. To date, 26 of the 33 London boroughs have also made Climate Emergency declarations.

3.4 Net Zero Carbon Buildings vs Carbon Neutral Buildings

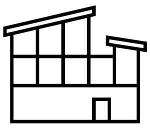
The terms *carbon neutral* and *net zero* are subtly different, easy to confuse and widely misreported.

Despite the term *net zero* proliferating in political, corporate, and academic discussions, there is still not one commonly agreed definition of *net zero*.

This report is solely focusing on building operational emissions and does not consider other emissions from the organisation's activities, such as travel and procurement.

The following table provides an outline of definitions relevant to building operation.

Net Zero Building



Perhaps the most relevant definition for building assets was outlined in a recent definition report by LETI, RIBA & WLCN:

> *A 'Net Zero Carbon – Operational Energy' asset is one where no fossil fuels are used, all energy use has been minimised, [the building] meets the local energy use target (e.g. kWh/m2/year) and all energy use is generated on- or off- site using renewables that demonstrate additionality. Any residual direct or indirect emissions from energy generation and distribution are 'offset'.*

Other definitions recommend that any emission offsetting/compensation should be restricted to only certified methods of greenhouse gas removal to ensure carbon is permanently sequestrated.

The UK Green Building Council (UKGBC) have developed a framework definition for net zero carbon buildings in the UK, with the following definition:

> *"A building that is highly energy-efficient and fully powered from on-site and/ or off-site renewable energy sources".*

Carbon Neutral Building

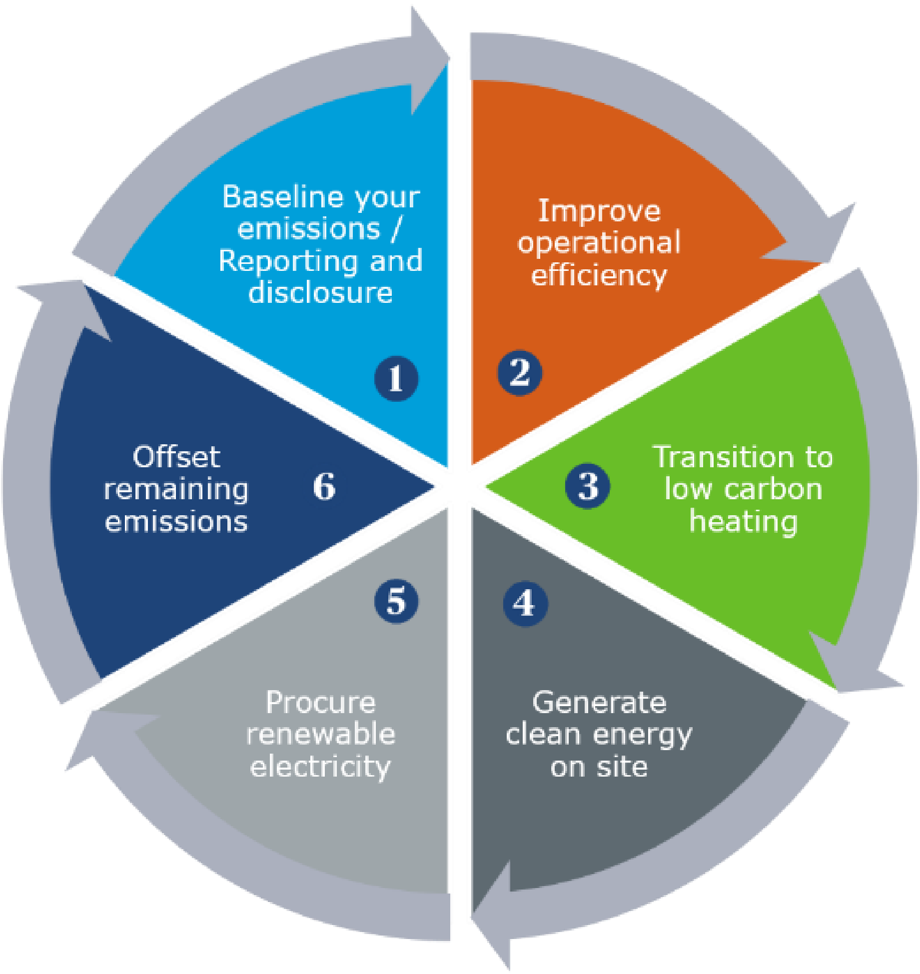
Carbon neutral is defined as a when an organisation offsets 100% of their emissions through avoidance and/or removal projects, with no reduction in emissions. Where emissions continue, they must be offset by absorbing an equivalent amount from the atmosphere, for example through carbon capture and reforestation that is supported by carbon credit schemes (BSI PAS 2060:2010)

Put simply, to be carbon neutral, any emissions released into the atmosphere must be balanced by an equivalent amount being removed.

The fundamental difference between the two is that to operate a net zero building, the organisation must first minimise their energy use as much as possible. In contrast, organisations can become carbon neutral tomorrow with minimal effort, by simply purchasing offsets (which is less favourable). For more information on offsetting, see section 6.6.

3.5 Steps to Operate a Net Zero Building

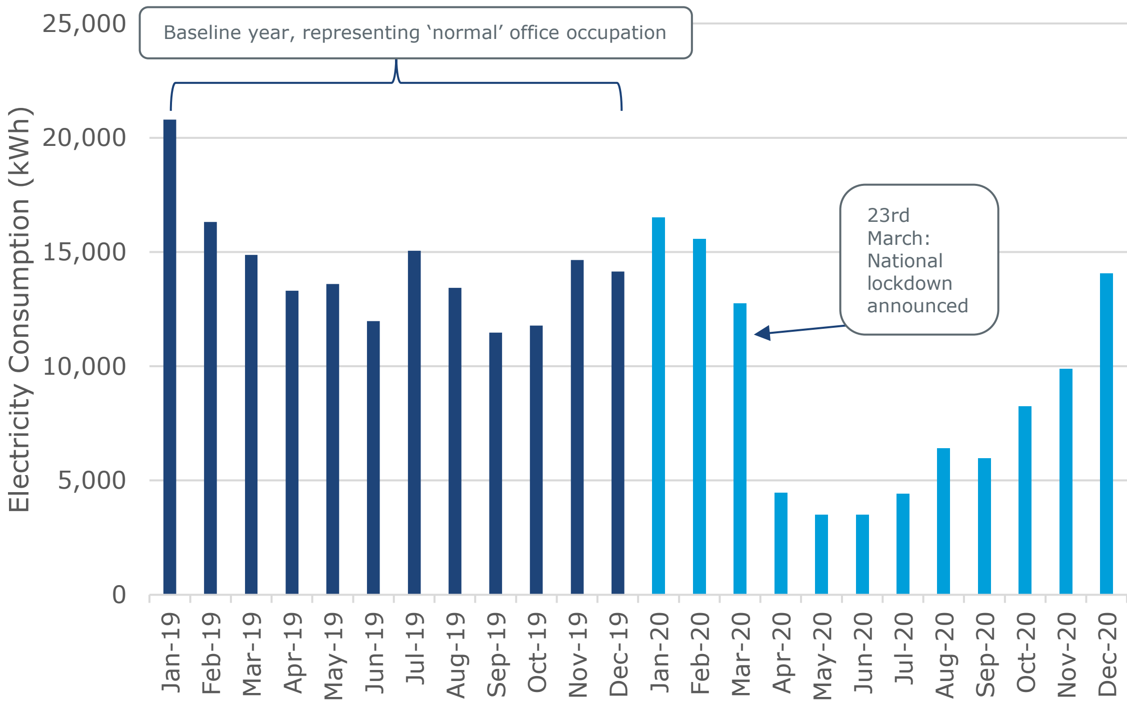
The following graphic sets out six simple steps any organisation will need to take to operate their building at net zero operational carbon.



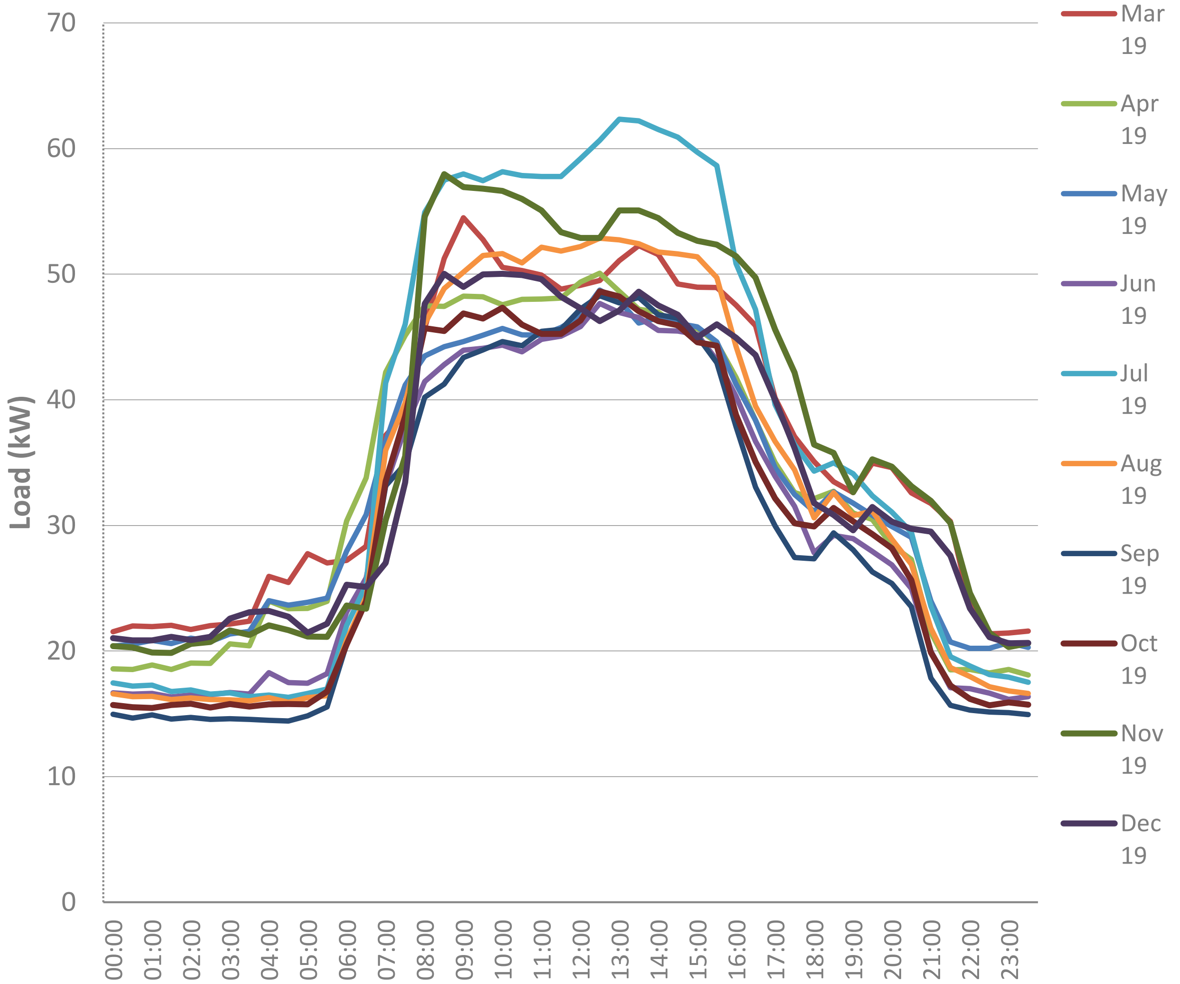
A more detailed description of each step is set out in section 6.

4 Energy Review

4.1 Energy baseline

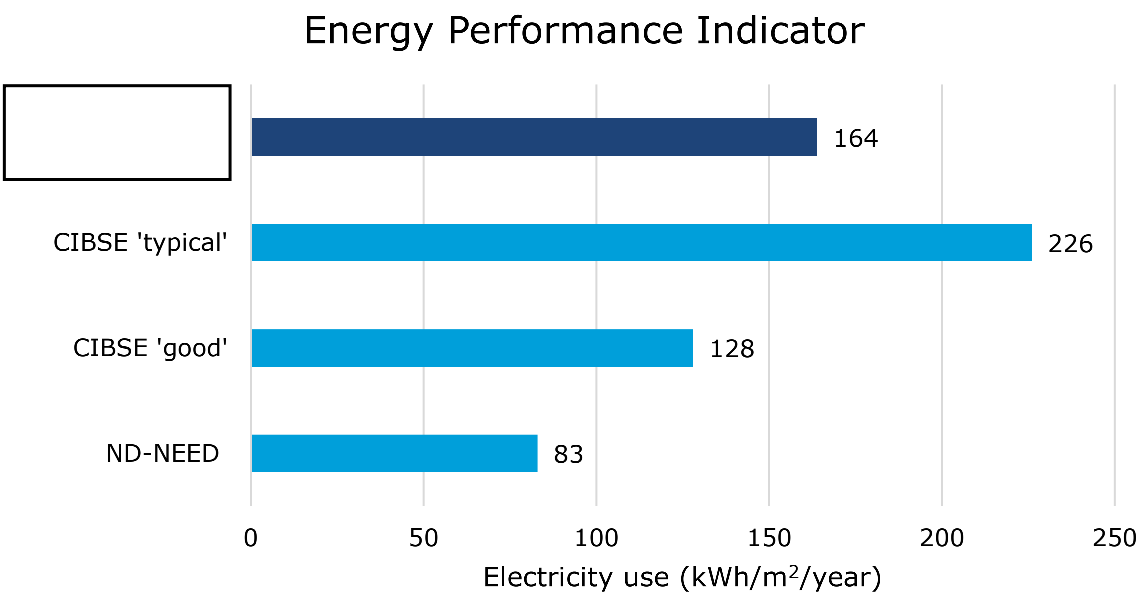


Average half hourly electricity load (whole building)



4.2 Site Energy Performance

To assess the energy performance of the building, its energy use per unit floor area has been compared to published benchmarks for air-conditioned office space in the UK.[3]

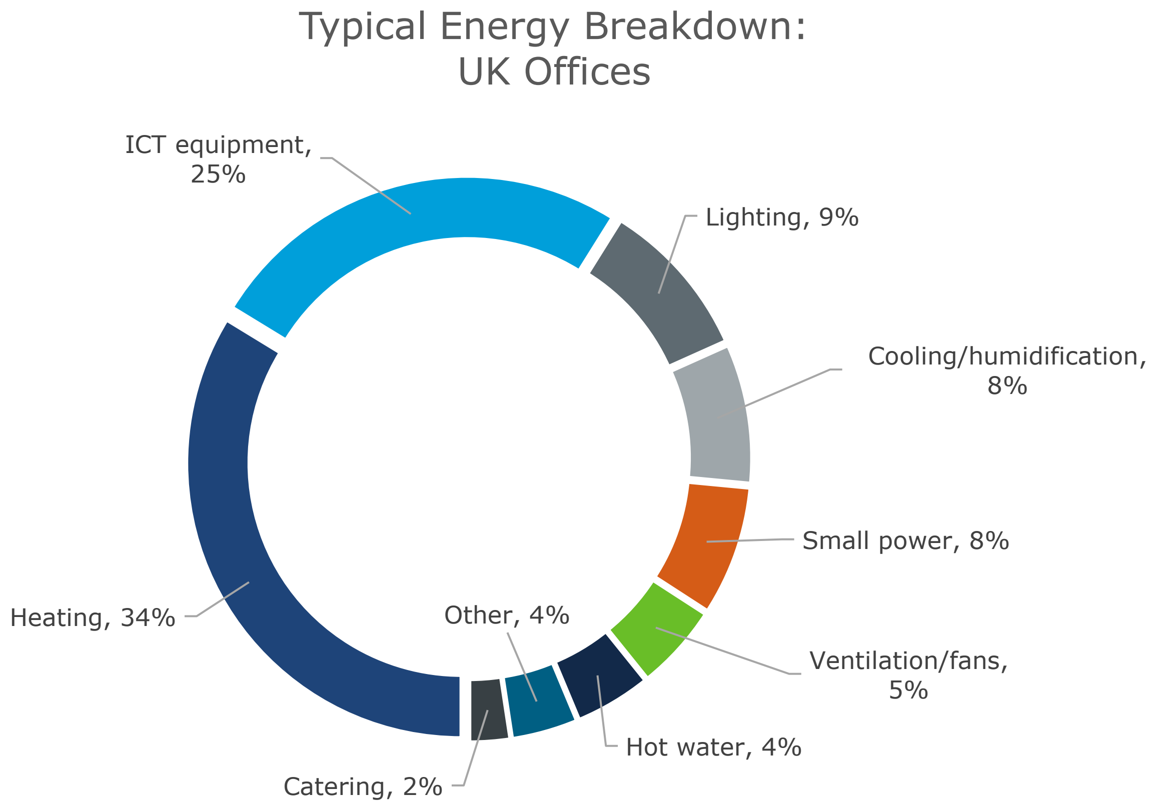


[redacted]

[3] DECC Non-Domestic National Energy Efficiency Data, Energy Statistics 2006-12 (2015). Figure quoted is for "Offices 500-1,000m^2." (The next available category is 1,000 – 5,000m^2 and therefore it was decided that as the building is only marginally greater than 1,000m^2, this would be a more reflective benchmark).
CIBSE, Guide F, Energy Efficiency in Buildings (2012). Table 20.1, offices, air conditioned, standard.

4.3 Breakdown of Energy by End Use

The graph below shows a typical breakdown of energy by end use in offices in the UK, using data collected as part of the BEIS Energy Efficiency Survey conducted in 2016.



Normally an auditor would attempt to estimate how much energy is being used by various pieces of equipment at the site to provide a comparison. However, as the office was only partly occupied on the day of the site visit, it was not possible for the auditor to make an accurate assumption of the site's energy breakdown that could be described as a 'typical' day.

These data should, nonetheless, give [redacted] a reasonable indication of the breakdown of energy use at the site and therefore highlight potential areas to focus on reducing energy demand.

5 Analysis of Existing Site Energy Use

The following sections outlines the auditor's observations of current practices for various building services and outlines typical best practice to progress to net zero.

Note any observations made during the energy audit were based on a 'snapshot' of time (a few hours on site) and may not reflect how the building is typically operated on a daily basis, or a pre-pandemic basis.

5.1 Building Fabric

The building's date of construction is unknown, although it's known that the building was refurbished between 2016-17. Due to this refurbishment, it is expected that the building complies with the 2013 Part L Building Regulations and therefore benefits from reasonably good levels insulation in the walls, floors and ceilings. The windows are metal-framed double-glazed windows.

What Best Practice Looks Like[4]	Do [redacted] Align with Best Practice?	
Well insulated building	Yes	
Double/triple glazed windows	Yes	
Options installed to reduce heat loss/gain, such as solar blinds and solar film	Window blinds installed	

5.2 Heating, Ventilation and Air Conditioning

[redacted]

Heating, ventilation, and air conditioning (HVAC) is provided by several Mitsubishi PURY reversible heat pumps (located externally) connected to a series of ceiling-mounted fan coil units (FCUs) (pictured left), which then supply treated air to the office space via a ducted system. This is an effective way of heating/cooling/ventilating the space.

Space heating/cooling is also provided by a number of individual split direct expansion (DX) units in other areas where required.

All units were installed in 2017 and appear well specified for their purpose.

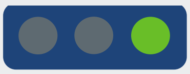
[redacted]

Control

The units are controlled centrally by a master building management system (BMS), which controls:

- On/off times
- Standard temperature setpoint parameters, ventilation rates and deadband settings

There are local controllers throughout the space, but these only allow users to turn the units on/off and control small temperature changes within that space, and make minor adjustments to the ventilation. It is believed these units are overridden by the master BMS.

What Best Practice Looks Like	Do [redacted] Align with Best Practice?	
Low carbon heating source (e.g. heat pumps)	Yes	
Temperature setpoints on controllers limited to sensible temperatures for UK offices (e.g. 18 – 24°C).	Yes	
Temperature sensors in suitable locations (e.g. ~1.5m high, located on an internal wall where possible, not in proximity to air supply louvres, no solar gain. Alternatively they could be located within the return air ducts)	Yes	
Suitable deadband settings (e.g. ±3°C). A deadband is a temperature range where a system neither heats nor cools. For example, if a system was set to 21°C with a ±3°C deadband, the system wouldn't start cooling until the room is 24°C and wouldn't start heating until 18°C. This prevents the units from reacting to small temperature fluctuations and 'cycling' on and off unnecessarily.	Assumed to be in use	
On/off times set to organisation's operating hours	BMS operating hours are 'wide' to allow for the system to reach temperature, and to ensure the cleaners are not cold. There are opportunities to optimise this.	
Fans able to self-regulate based on demand	It is believed this function is active	
Regularly maintained (e.g. annually) system	Yes – service plan in place	

5.3 Lighting

The existing office lighting consists predominately of a selection of T5 fluorescent luminaires. T5 lamps were once the most energy efficient types of lamp available; however, they have been succeeded by LED lighting technology, which typically delivers energy savings of ~20-50% over T5 office lighting.

The lighting in the office and meeting rooms is switched using presence detection technology, which is good practice. The ground floor is manually switched, which is not good practice.

What Best Practice Looks Like	Do [redacted] Align with Best Practice?	
High-efficiency LED lighting	No, T5 lighting installed	
Switching wired 'in parallel' (this is where the lights near to the windows share the same switches/sensors, so these can be turned off on brighter days separately to the other lighting in the office)	No	
Presence/absence detection sensors (often known as passive infrared sensors, or PIR)	Yes	
Daylight sensors that can dim the lighting based on requirements	No	

5.4 Server Room

There is a server room on site, which contains ICT servers and a cooling unit.

What Best Practice Looks Like	Do [redacted] Align with Best Practice?	
High efficiency ICT equipment	Unknown	
Free cooling opportunities utilised and prioritised	No evidence of this. Unlikely to be feasible on this site.	
Cooling system temperature setpoints at a suitable temperature for the installed equipment	There is scope to increase the temperature setpoint	
Cooling system fan speed able to self-regulate based on demand	Yes	
Heat recovery	No evidence of this. Difficult to retrofit without major replacement of plant equipment	

5.5 Hot Water

Hot water is provided by individual electrical point-of-use (POU) water heaters underneath each sink. Boiling water in the kitchens is provided by a coffee machine. and showers are served by instant electric showers, which is also good practice.

What Best Practice Looks Like	Do [redacted] Align with Best Practice?	
Electric instant point of use water heaters with tap aerators	Yes	
Electric showers	Yes	
Small ancillary equipment (coffee machines) deactivated automatically out of hours (e.g. 7-day plug switch timer)	Unknown. Recommended a 7-day plug timer is utilised	

5.6 Small Power

Computers, monitors, screens, and printers are all relatively modern and likely to be reasonably energy efficient.

Monitors and TVs were turned off when not in use and printers were in sleep mode.

What Best Practice Looks Like	Do Align with Best Practice?	
Highly efficient ICT equipment	Yes	
Equipment set to enter 'sleep'/'standby' modes during periods of inactivity	Yes, for printers and screens. Unknown for other equipment such as laptops.	
Equipment deactivated automatically out of hours (e.g. 7-day plug switch timer on equipment such as TVs, etc.)	Unknown	

6 Recommendations to Progress Toward Net Zero

The following section sets out the potential steps [redacted] can take to reduce the emissions associated with the operation of their building. It is made up of six simple steps as outlined in the diagram in section 3.5.

As the scope and funding for this project was weighted toward short-term energy savings, a greater emphasis has been put on the second step.

1 Measure and report energy consumption and emissions

At present, [redacted] review the sub-meters on each floor (including the floors that are rented out) on a monthly basis, which is good practice. However, whilst monitoring of energy use is clearly taking place regularly, there appears to be limited action to address increases in electricity use (for example, December 2019 electricity use was significantly higher than January 2019).

It is possible to connect the sub-meters to the Mitsubishi building management system (BMS) to monitor the sub-meters on a half hourly basis. Activating this function of the BMS will not save any energy in its own right, but will allow for much closer monitoring of electricity consumption, helping to identify excess energy use, which could lead to savings. It will also allow for monitoring, targeting and verification of savings which is a key part of progressing toward net zero goals.

In addition to the sub-meters, there is a half hourly electricity meter on the incoming electricity supply that monitors the whole building. This captures electricity consumption data in real time and transmits it live to a cloud server to allow analysis. Unfortunately, due to the way this is set up, this does not provide a split of the electricity use by floor, so it is difficult to assess which organisation is responsible for excess energy use.

Recommendations:

- Continue to collect sub-metered data.
- Connect the sub-meters to the existing Mitsubishi BMS, to enable half hourly sub-metering. Indicative costs for this are in the region of £1,500 – £2,500. This will allow for much closer monitoring of electricity consumption, helping to identify excess energy use, which could lead to savings.
- Closely monitor fluctuations in energy consumption and investigate excess energy consumption. For example, it is clear energy use increased throughout 2019, but it’s not clear if any action was taken to identify the cause of this and rectify it.

2 Operate the building as efficiently as possible, with minimal energy waste

A series of recommendations have been made to enable [redacted] to operate their part of the building as efficiently as possible. It is recommended all measures are implemented as soon as reasonably possible.

Energy efficiency recommendations at a glance

Zero cost measures:	**1. Ensure server room cooling temperature setpoint is suitable**
	2. Encourage staff to adopt sustainable energy practices
	3. Ensure HVAC controls are suitably adjusted to office usage patterns
Capital cost measures:	**4. Install LED lighting with intelligent controls**
	5. Install a solar PV array
Future planning:	**6. Develop policies to ensure sustainability is considered in all procurement**

Recommendation 1: Ensure server room cooling temperature setpoint is suitable				
Estimated annual savings			Implementation cost	Payback period

Details

- There is an on-site server room, which requires cooling 24/7 in order to maintain the temperature of server equipment.
- The server room was inspected on the day of the site visit and the cooling unit was set to 19°C, which is cooler than necessary. This temperature setpoint could be increased.
- The design and environmental performance of ICT equipment has improved substantially in the last 10+ years. As a result, servers and other IT equipment have become much more tolerant and resilient across a wider range of temperatures and humidity.
- This is reflected in the 2011 ASHRAE Thermal Guidelines for Data Processing Environments, which is summarised below:

Class	IT Equipment type	Recommended operating range	Allowable operating range	Maximum dew point	Environmental control
A1	Enterprise servers, storage products	18º to 27ºC	15 to 32ºC	17ºC	Tightly controlled
A2	Volume servers, storage products, personal computers, workstations	As above	10 to 35°C	21°C	Some control
A3	Volume servers, storage products, personal computers, workstations	As above	5 to 40°C	24°C	Some control
A4	Volume servers, storage products, personal computers, workstations	As above	5 to 45°C	24°C	Some control

Benefits

- Zero cost energy and carbon savings.

Risks

- Undesirable effects such as increased fan operation in the IT equipment, warnings / alarms from IT equipment operating at or beyond recommended levels.

	▪ These risks can be managed through incremental increases in temperature set-points and monitoring of performance.
Next steps	▪ **Review the IT equipment class**, **cooling system performance and current set-points** with an IT specialist. ▪ Assuming no barriers are identified, **incrementally increase the setpoint**, perhaps weekly, and monitor the effects. ▪ Ensure you **do not exceed the upper limit of the ASHRAE recommended operating range** for the installed equipment. ▪ **Make changes by increasing the temperature setpoint** on the wall-mounted or handheld controller.
Calculations	▪ As a 'rule-of-thumb', every 1ºC increase in the cooling set-point typically delivers a 2-4% reduction in energy consumption. ▪ It's been assumed the cooling unit is a 5kW unit operating 24/7 at 25% utilisation. It has been assumed the existing temperature setpoint is 19ºC and could be increased to 23ºC. A 3% saving per degree (compounded) will result in a 14% reduction in energy use from the server cooling unit.
Other considerations	▪ Many organisations choose to outsource their server requirements. This is often viewed as beneficial from an energy-saving point of view, as large data centres benefit from economies of scale with regard to cooling, and are often designed to exploit energy conservation measures such as free cooling.

Recommendation 2: Encourage staff to adopt sustainable energy practices

Potential annual savings (based on 5% reduction of selected equipment)			Implementation cost	Payback period
4,683 kWh/year	£910/year	1,080 kg CO_2e/year	Internal staff time	Instant
Details	▪ When staff use the office, they use energy. Whilst electrical equipment such as laptops and monitors are not large energy users in their own right, lots of small energy users adds up to a surprising amount. ▪ Often people do not notice energy waste until it is brought to their attention. For example, when leaving a meeting room many people will turn off the lights as they present a visual reminder – but it's easy to forget to turn off the air conditioning because you can't see it. Raising awareness of this can help people to adopt more sustainable practices. ▪ During the audit it was not possible to gain a proper understanding of current energy management practices. However, it's understood that the management team are actively making efforts to encourage staff to minimise their energy use. ▪ Improving energy management efforts through notices, targets and procedures, staff awareness and engagement efforts, will help reduce levels of avoidable energy wastage occurring through equipment being used unnecessarily. ▪ The Carbon Trust publish useful guides to employee engagement surrounding energy and carbon awareness, which can be downloaded from their website. Other guides are widely available to empower staff to take a greater interest and control over their emissions, both work-related and outside of work.			
Benefits	▪ Reduction in emissions and energy use at zero cost. Encouraging staff to adopt sustainable practices is likely to be one of the most cost-effective solutions to reducing energy use and emissions in the office.			
Risks	▪ There is a marginal risk that some members of staff may not be fully engaged. However, studies have shown the majority of employees want to assist their employer to be more environmentally friendly.			
Next steps	▪ Affix **'switch it off' labels** near light switches and heating/cooling controls. ▪ **Involve staff in identifying and developing ways to reduce energy use on site** – this helps to secure their 'buy-in'.			

	▪ Create an **end of day 'walk around' procedure for the last member of staff** to check that all energy-consuming equipment is turned off. ▪ **Set laptops/PCs to automatically sleep or hibernate** after a certain period. Sleep functions use around 80% less power than normal, and a computer in hibernation uses no power. ▪ **Use the sub-metered data to monitor changes to energy use**.
Energy Saving Calculations	▪ It's not uncommon for measures of this nature to reduce energy use by 10% or more. However, a conservative potential saving of 5% has been calculated for energy use relating to HVAC and small power (e.g. PCs, TVs) energy use. No savings have been attributed to lighting as PIR sensors are in use.

Recommendation 3: Ensure HVAC controls are suitably adjusted to office usage patterns				
Estimated annual savings			**Implementation cost**	**Payback period**
Details	▪ Heating, cooling and ventilation typically account for more than 50% of an office building's energy use (BEIS Energy Efficiency Survey, 2016). ▪ The HVAC equipment installed is suitably specified for its purpose, although there are some changes that could be made to its controls to optimise energy use. It is recommended that the time controls, override functions and temperature thresholds are checked. Setting these correctly will ensure that excess energy use will be minimised. ▪ The installed Mitsubishi system has an 'optimised start' function, which uses a self-learning algorithm to enable the system to calculate how long it takes it to reach temperature depending on outside air temperature and adjust its warm-up time as appropriate. This function will start the units 5 to 60 minutes prior to the scheduled start time to reach the set temperature with the building at the scheduled start time for the day, based on the operation data in the past. At present, this function is not being used, but instead the HVAC is set to start at 07:00 to heat the space to 24ºC, which will be resulting in energy waste. The HVAC system is set to be operational for 12 hours per day, but the office's main use is only 8 or 9 hours. ▪ CIBSE Guide A (Environmental Criteria for Design) suggests limiting the temperature setpoint range to 21-24ºC would be suitable (21-23ºC in winter and 22-24ºC in summer). Ideally, seasonal commissioning would be suitable to match outdoor conditions (e.g. on a cold day, people are likely to dress warm). A 1°C reduction in heating setpoint can reduce energy use by as much as 8%, and a 1ºC increase in the cooling set-point typically delivers a 2-6% reduction in energy consumption.)				
Next steps	▪ The following setup is recommended:			

	▪ The HVAC equipment operating times should align with the office opening times (e.g. approx. 08:30 – 17:30), with minimal operation at weekends. The ‘optimum start’ function should be utilised. ▪ If possible, local controllers (pictured right) should provide an override facility that resets daily. For example, if somebody is working late in the office, they should be able to manually activate heating/cooling at the local controller, but this should revert to its normal settings daily. ▪ Additionally, **carry out routine visual inspections of all external pipework** to check that the pipework insulation is present and in a good condition (it is currently in a very good condition with no immediate action required). Where pipework insulation is damaged/missing (e.g. due to age, wear and tear, birds damaging it for nesting, etc.) it should be replaced to ensure the equipment is able to operate as efficiently as possible.
Calculations	▪ Calculations have been undertaken conservatively to ensure savings are not being overestimated. The savings calculated assume the existing HVAC activation times are reduced from 07:00 – 19:00 to 08.00 – 18.00. This represents a reduction of 520 hours per year, which could potentially save £2,490/year and 2.9 tCO_2e.
Other considerations	▪ These units were installed in 2017 and have a typical lifespan of 15-20 years, so are expected to last beyond 2030.

Recommendation 4: Install LED lighting with intelligent controls				
Estimated annual savings			**Implementation cost**	**Payback period**
Details	▪ Lighting has been conservatively estimated to account for around 12% of energy use at the site, costing ~£4,500/year and causing the emission of around 6.5tCO_2e per year. ▪ The existing lighting system is made up predominantly of T5 lamps and LED fittings. Whilst the T5 lamps were once considered the most efficient technology available, they have been proceeded by more efficient LED lighting technology. ▪ Good quality LED lighting can offer superior illumination, energy performance, colour temperatures and control over the existing lighting types. LED technology has improved substantially in recent years and offers a lifespan exceeding 50,000 hours (to L70B10). ▪ There are two options for replacement of the T5 lamps: 1. The existing T5 fluorescent tubes can be removed and replaced with LED tubes (cheaper option on which this proposal is based), or; 2. The entire T5 light fittings can be removed and replaced by a new LED lighting (more expensive option). ▪ The existing presence detection sensors should be utilised to ensure that lighting is only switched on in areas where people are working. ▪ Lighting should be wired in parallel to the windows, which means that all lighting near windows will be controlled by the same control gear. This means that lighting in proximity to windows can be switched off if there is adequate natural light.			

Rationale	▪ Installing LED lighting will reduce lighting energy consumption by a calculated 34%. Further savings will be available through incorporation of parallel switching. ▪ Based on experience with similar installations in commercial premises, the estimated 'all-in' cost to install at this site is as follows: 1. **£6,100** for replacement of 244 nr. fluorescent tubes with LED equivalents (this assumes a cost of £20 per tube (market rate) plus a London-rate electrician at 10 tubes per hour). 2. **£10,300** for replacement of 144 nr. fittings (this assumes a cost of £2,800/kW installed based on data from previous installations in London). Note the costs given throughout this report are for option 1 (tube replacement) as this presents a more favourable financial scenario with less intrusive works required.
Benefits	▪ Energy and carbon savings. ▪ Improved working environment. ▪ Reduced maintenance / lamp replacement requirements.
Risks	▪ Care must be taken to ensure that emergency lighting is not compromised by any changes being made. ▪ Some LED modules are prone to failure, so ensure the specified lighting is sourced from a reputable manufacturer. ▪ Some office downtime/disturbance may be required to install lighting.
Next steps	▪ **Obtain three quotations from suppliers and choose a suitable installer.** The Carbon Trust's Green Business Directory is a good resource to find reputable suppliers in London.
Calculations	▪ Calculations are based on the power consumption (Watts) of existing lighting units compared to the power consumption of replacement LED tubes. ▪ Note the costs noted in the table header are for LED tube replacements, not replacement of the entire fittings. 

Recommendation 5: Install a rooftop solar PV array

Estimated annual savings	Implementation cost	Payback period
[redacted]		

Details	▪ Currently [redacted] purchases all their electricity from the electricity grid and pays per unit of energy used. The unit rate of [redacted] is moderately high, but not unexpected for London. However, installing a solar PV array will allow the site to generate and use its own electricity. ▪ The building has a large flat roof. Satellite imagery has been analysed to identify the opportunity to install solar photovoltaic (PV) panels on the roof to generate clean, emission-free electricity. ▪ As the site houses two ICT servers, the building has a high weekend baseload and uses electricity 24/7. ▪ Solar PV works by absorbing ultraviolet energy released from the sun. It absorbs the energy and turns it into direct current (DC) electricity. An inverter then turns this into 230V alternating current (AC) electricity that can be fed into the building's main power supply. ▪ It does not have to be a sunny day for the PV array to generate electricity – it works on cloudy days too, although the power output is slightly reduced. ▪ All energy generated and used on site will equate to cost and carbon savings from purchased energy. Energy prices are likely to rise, so savings are often greater than they appear. [redacted]
Options	▪ There is space to install around 78 panels (23.4kWp) on the usable part of the roof (~300m^2 of usable space). ▪ However, based on an observed typical whole-building weekend baseload of 18kW per hour, 60 panels (18.0kWp) would typically match the building's demand throughout the months with high solar radiation. ▪ 60 panels will generate around 15,500 kWh per year, worth >£3,000, and will ensure that 100% of energy generated will be used on site.

	▪ Based on experience with similar installations in commercial premises in central London, the estimated 'all-in' cost to install this is £25,000, providing a 6.3 year payback.
Benefits	▪ Significant annual carbon and cost savings. ▪ 6.3-year payback for a technology with a 25+ year lifespan. Once paid off, the panels will generate more than £73,000 worth of additional electricity during their lifespan (not accounting for inflation/price increases), with **25-year carbon savings of >62 tCO_2e.**
Risks	▪ Potential difficulty with planning permission, although most developments of this size will meet permitted development rights (most installers will apply for planning if required). ▪ A bi-annual clean will be required.
Next steps	▪ **Obtain three quotations from suppliers and choose a suitable installer.** The Carbon Trust's is a good resource to find reputable suppliers in London.
Calculations	▪ Calculations are based on the MCS certified methodology using the London Irradiance dataset assuming: ▪ Roof orientation of 10 degrees from south ▪ Panels located at 10 degrees angle on weighted frame or similar ▪ ~300m^2 of usable space (measured from satellite imagery) ▪ 60x 300W solar panels installed (1.0 x 1.6m) ▪ 100% of power will be used on site by a combination of [redacted] and the other tenant (due to 24/7 server requirements)

Recommendation 6: Develop policies to ensure sustainability is considered in all procurement	
Details	▪ Targeting energy efficient equipment at procurement stages reduces the requirement for expensive retrofitting and/or replacement of functional equipment to improve energy efficiency. ▪ For example, for most high efficiency equipment, the additional purchase cost is offset by the reduction in energy cost to operate the equipment over its lifetime. One example is fan motors, where the purchase cost of the motor typically is around 1-3% of its total energy cost to operate it over its lifetime.

Next steps	▪ It is recommended policies are developed to ensure all equipment procured going forward is specified to the highest energy performance rating available. Examples may include:
	    ▪ "Laptops must have ENERGY STAR 5.0 rating"
	    ▪ "Fridges must be A+ Energy Efficiency standard or above"
	    ▪ "Printers must have an A+ Energy Efficiency standard or above"
	    ▪ "Energy-efficient options shall be evaluated for all major capital purchases (such as replacement HVAC equipment)"
	    ▪ "Battery-powered equipment (such as keyboards and mice) should not be purchased/used to reduce the use of batteries (which use valuable earth metals)".

Summary of Energy Saving Measures

Measure	Estimated savings			% energy savings	Lifetime carbon savings *	Cost	Payback period **
	Energy saving (kWh/yr)	Cost saving (£/year)	Carbon saving (tCO_2e) (year 1)	% kWh saving	tCO_2e	£	years
1. Ensure server room cooling temperature setpoint is suitable							
2. Encourage staff to adopt sustainable energy practices							
3. Ensure HVAC controls are suitably adjusted to office usage patterns							
4. Install LED lighting with intelligent controls***							
5. Install a solar PV array (details in step 4)							
6. Develop policies to ensure sustainability is considered in all procurement							
Measures 1-5 combined							

*Accounts for decarbonisation of the electricity grid, as set out in Appendix 1.1.
**Inflation is applied to future energy cost calculations, as set out in Appendix 1.2.
*** The costs noted in the table are for LED tube replacements, not replacement of the entire fittings.

3 Transition to low carbon sources for heating and hot water systems

Heating

Each floor has a Mitsubishi inverter-controlled variable refrigerant flow heat pump serving fan coil units, which provide heating, ventilation and cooling to the building's occupants. The building is not connected to the natural gas network.

Heat pumps like these are efficient methods of heating a space and are often the recommended solution for decarbonising heat in many buildings.

They are powered by electricity, which means that the site's heating will decarbonise in line with the decarbonisation of the electricity grid. These units are compatible with a low carbon future and therefore it's recommended that no changes are made to the units themselves until replacement is required (the previously described changes to controls should be considered though).

Heat pumps typically have a 15-20 year life expectancy. The installed units were manufactured in 2017, and therefore should be expected to last beyond 2030. When replacement is required, consideration should be given to utilising heat pumps with low global warming potential (GWP) refrigerants such as CO_2 or ammonia (occasionally, these units can develop leaks and will leak gases into the atmosphere, therefore a low-GWP gas is preferable to an ozone-damaging gas).

Hot water

Hot water (tap water) at the site is currently provided by point-of-use instant domestic hot water (DHW) heaters which is best practice, and showers are served by instant electric showers, which is also good practice.

[redacted]

4 Generate clean energy on site (where possible)

[redacted] have freehold ownership of the building, and are therefore well placed to install solar panels on the roof to generate electricity. See recommendation 5 (above) for full details.

Other forms of renewable energy generation such as wind or hydro are not suitable at this location.

5 Procure renewable electricity

1[redacted] Current Electricity Supply

[redacted]

2. Background to Renewable Energy Procurement

Energy suppliers market certain products as '100% renewable electricity'. In theory, purchasing electricity with a Renewable Energy Guarantees of Origin (REGO) certificate should mean that the share of electricity procured was produced from renewable resources.

However, these claims can easily be misleading/manipulated, and this is common practice. REGOs (the certificates) can be bought and sold freely by energy suppliers on a secondary market. Suppliers can legally source all their energy from fossil fuel sources, then buy REGOs last-minute to market it as 'green electricity'.[5,6]

This means that, in some circumstances, purchasing 'renewable electricity' does not mean your business is actually using green electricity.

However, there are ways to improve the environmental credentials of electricity procured. The latest best practice guidance on green electricity procurement from the UK Green Building Council recommends procuring electricity from a supplier that 'demonstrates additionality'. This means that buying electricity from them will lead to new, additional renewable electricity generation.

At present, Turner & Townsend are unaware of any mainstream organisations or comparison sites that specifically help with finding tariffs that demonstrate additionality. EnergyBillKill claim to

[5] Additional information available from https://www.there100.org/sites/re100/files/2020-09/RE100%20Making%20Credible%20Claims.pdf
[6] Additional information available from https://www.cibse.org/getattachment/Networks/Groups/Energy-Performance-Group/Carbon-Bites/51st-CB_L-Pemble_FINAL.pdf

provide this service, although [redacted] have no first-hand experience of this. Therefore, this exercise may require some research (or could be outsourced to a broker).

Procuring a fully renewable electricity tariff from a supplier that demonstrates additionality does not mean that the building no longer generates emissions. For example, on an overcast, windless day when renewable electricity generation is minimal, the site will still be receiving electricity, and it’s likely that this will be coming from the combustion of fossil fuels.

3. Renewable Electricity Carbon Accounting

The carbon intensity of electricity generation (kgCO_2e/kWh) reduces annually as more and more green electricity generation is commissioned. This reduction in the carbon intensity of electricity is reflected annually in changes to the BEIS carbon emission factors (see Appendix 1.1 for details).

If an organisation like [redacted] was to procure a 100% renewable electricity tariff and then state their electricity carbon footprint as 0 tCO_2e, this would effectively result in the double counting of this green energy generation as the reduction in carbon intensity has already been applied to the electricity grid factor. Additionally, renewable electricity still suffers from power loses associated with the distribution and transmission of electricity.

4. Recommendation

Despite the aforementioned limitations to renewable electricity tariffs, it is still recommended that a tariff the demonstrates additionality is procured, as this contributes to the continual decarbonisation of the electricity grid. Therefore, **it is recommended that, when re-procurement of electricity tariff is due, [redacted] obtain a renewable electricity tariff from a supplier that ‘demonstrates additionality’.**

Note offsetting of emissions from electricity should still be undertaken regardless of the electricity tariff produced.

6 Offset any remaining emissions

To ensure the building can fully achieve net zero, offsets can be purchased through certified greenhouse gas removal methods to ensure carbon is permanently sequestered and not simply ‘offset’ elsewhere.

A range of offsets are available to purchase on the open market. It’s recommended that carefully consider the credibility of the carbon removal methods they choose to procure.

The price of offsets ranges widely – at present, offsets are priced from £18 – £150 per tonne of carbon sequestered, and typical costs in London are in the region of £70-90 per tonne at present.

Whilst the cost of this may seem reasonable at present, the price of purchasing carbon removal credits will vary, especially on the approach to 2030 when demand is expected to increase exponentially. This should be considered as a risk and should be managed with care, and the risk further strengthens the importance for reducing emissions rather than relying on offsets.

Example of questionable offsetting:

Information about how carbon is offset is rarely published in detail. For example, one aviation provider, who claim to offset every single flight mile, notes that the steps they are taking include:

- “Prevention of deforestation”
- “Working with local communities in developing countries to encourage emission reduction”

There is no doubt that these actions are important parts of the net zero journey. However, it’s argued that these emission reductions need to be done regardless, and do not therefore provide a free pass to generate emissions. To truly be net zero, the carbon emissions from the flight should be directly removed from the atmosphere through GHG removal methods (e.g. carbon capture and storage)

Quantifying offsets

To achieve a net zero building, organisations need to reduce their energy use to a minimum and then purchase offsets equivalent to their minimised energy use.

Typically, this can be calculated by multiplying annual fuel usage by the Greenhouse Gas Emission Reporting Factor[7] (or ‘emission factor’) for that fuel published for that year. Further details are given in Appendix 1.1.

[7] See https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

7 Conclusion and Next Steps

7.1 Actions to Progress to a Net Zero Office

This report has set out six steps [redacted] will need to take to operate their building at net zero operational carbon. The following table outlines the actions required to complete each step.

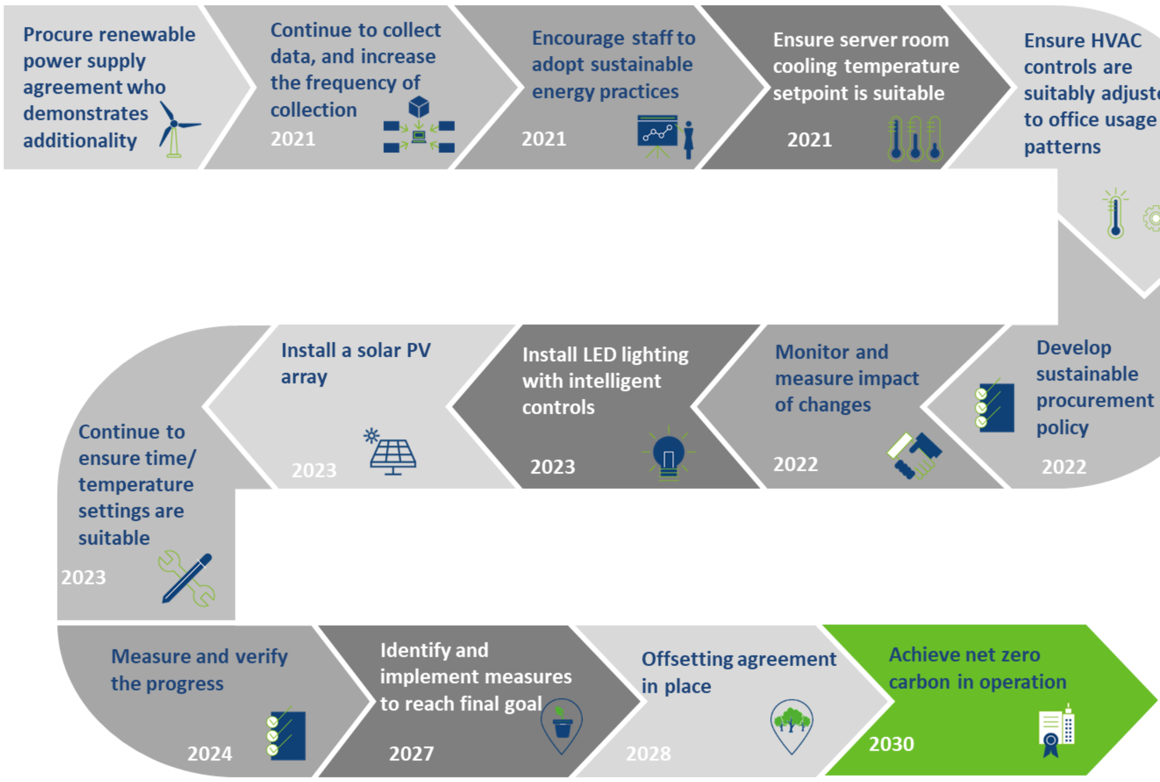
Step		Status	Actions
1	Measure and report energy consumption and emissions	[redacted]	
2	Operate the building as efficiently as possible, with minimal energy waste		
3	Transition to low carbon sources for heating and hot water systems		
4	Generate clean energy on site		
5	Procure renewable electricity		

6

Offset emissions

7.2 Roadmap to Net Zero Building

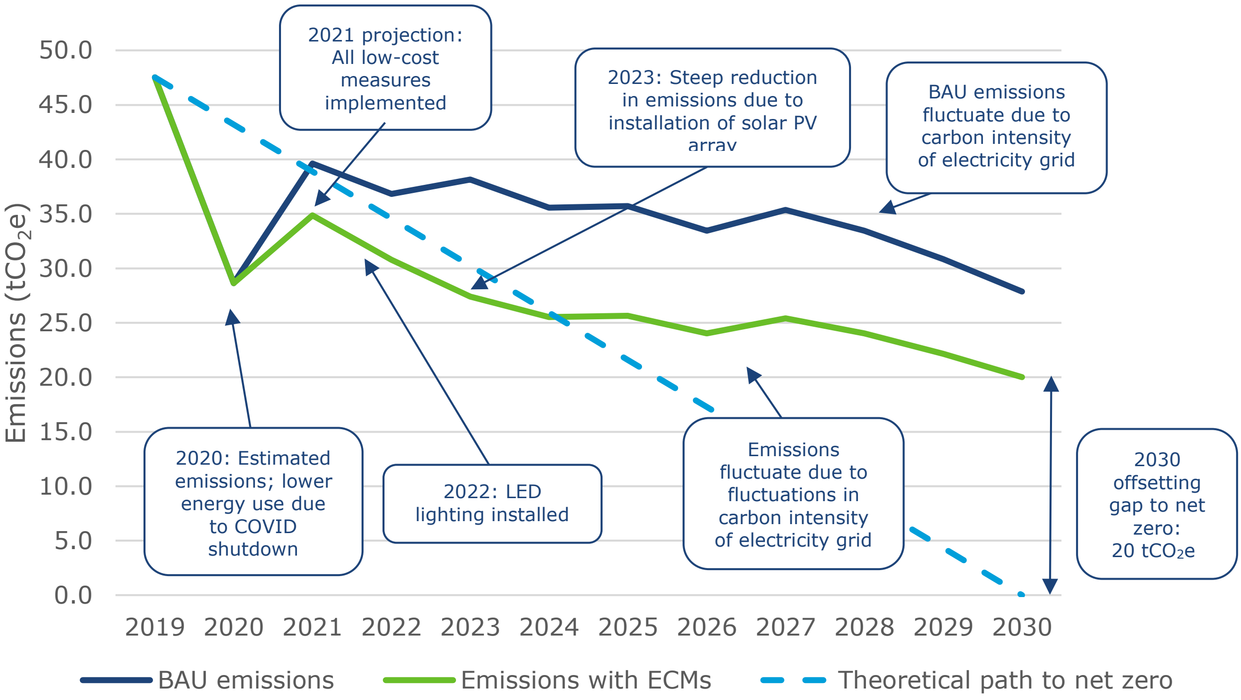
The following chart shows an approximate timeline for [redacted] transition to a net zero carbon office.



The timeline should be considered as a step-by-step guide to decarbonising the office.

The dates are suggested based on a realistic timescale for implementation but measures could be fast-tracked if possible. In this instance, most of the measures are not interdependent, and therefore the order of implementation can be changed if required.

7.3 Net Zero Emissions Profile



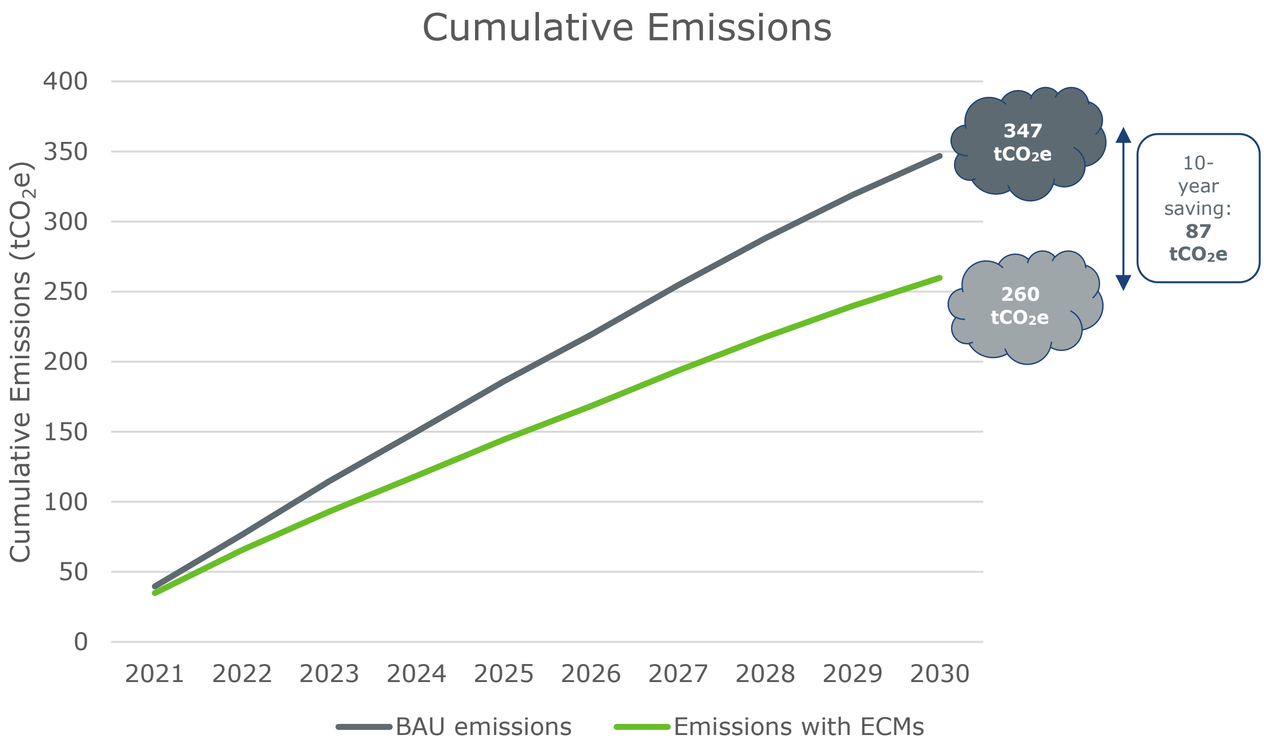
* BAU – Business as Usual. ECMs – Energy Conservation Measures.

In total, it is projected that by 2030, carbon emissions from the office could have reduced to 20tCO_2e, which is a 58% reduction over the 2019 baseline.

7.3.1 Cumulative Emissions

The following chart shows the cumulative emissions from the office in two scenarios:

- Business as usual
- Projection if energy conservation measures are implemented as per the suggested timeline



* BAU – Business as Usual. ECMs – Energy Conservation Measures.

It shows a reduction of around 87 tCO_2e over the next nine years if the measures are implemented as per the suggested timeline.

8 Glossary of Key Terms

Glossary	
Carbon neutral	When an organisation offsets 100% of their emissions through avoidance and/or removal projects, with no reduction in emissions. Where emissions continue, they must be offset by absorbing an equivalent amount from the atmosphere, for example through carbon capture and reforestation that is supported by carbon credit schemes (BSI PAS 2060:2010)
Carbon negative (and carbon positive)	When the balance of carbon emissions exceeds zero, indicating the process of absorbing more CO_2 than is emitted. There is no official definition, and the term "carbon positive" is confusingly sometimes used to mean "carbon negative" where corporate communications attempt to avoid the use of the word "negative".
Carbon offsetting	A carbon offset allows organisations to compensate for emissions they cannot reduce. By funding an equivalent saving in carbon emissions elsewhere, residual emissions can be balanced.
Decarbonisation	Reducing and ultimately eliminating related carbon emissions from upstream, operational, and downstream activities.
GHG Protocol Standard	This Greenhouse Gas (GHG) Protocol Corporate Standard provides standards and guidance for companies and other types of organizations preparing a GHG emissions inventory. It covers the accounting and reporting of the six greenhouse gases covered by the Kyoto Protocol — carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).
Low carbon	Technology, energy, sources and services that yield minimal output of greenhouse gases.
Low carbon heat	Heat that originates from sources that do not require direct combustion of scope 1 fossil fuels. This includes heat pumps, solar thermal heating, and biomass.
Net zero	A state where there is no incremental addition of GHGs to the atmosphere. This means all avoidable emissions have been reduced and thus residual emissions have to be removed from the atmosphere

Scope 1 Emissions	Direct emissions of an organisation, including combustion of fuels and fugitive emissions.
Scope 2 Emissions	Indirect emissions of an organisation, including purchased electricity and heat.
Scope 3 Emissions	Other indirect emissions associated with an organisation, including the supply chain, transport and distribution, business travel and commuting, use of products, waste, investments and other leased assets or franchises.

[redacted]

9 List of Abbreviations

Abbreviations	
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BAU	Business as Usual
BEIS	UK Government Department for Business Energy and Industrial Strategy
BMS	Building Management System
BSI	British Standards Institution
CAPEX	Capital expenditure
CIBSE	Chartered Institute of Building Services Engineers
DEC	Display Energy Certificate
DHW	Domestic hot water
ECM	Energy Conservation Measure
FCU	Fan Coil Unit
GHG	Greenhouse gas
GLA	Greater London Authority
GWP	Global Warming Potential
HVAC	Heating, ventilation and air conditioning
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
LED	Light-emitting diode lighting
LETI	London Energy Transformation Initiative
[redacted]	
ND-NEED	Non-Domestic National Energy Efficiency Data
NZC	Net zero carbon

OPEX	Operational expenditure
PIR	Passive infrared (sensor)
POU	Point of use (water heaters)
PPM	Planned preventative maintenance
REGO	Renewable Energy Guarantees of Origin
RIBA	Royal Institute of British Architects
Solar PV	Solar photovoltaics
T&T	Turner & Townsend
UKGBC	UK Green Building Council

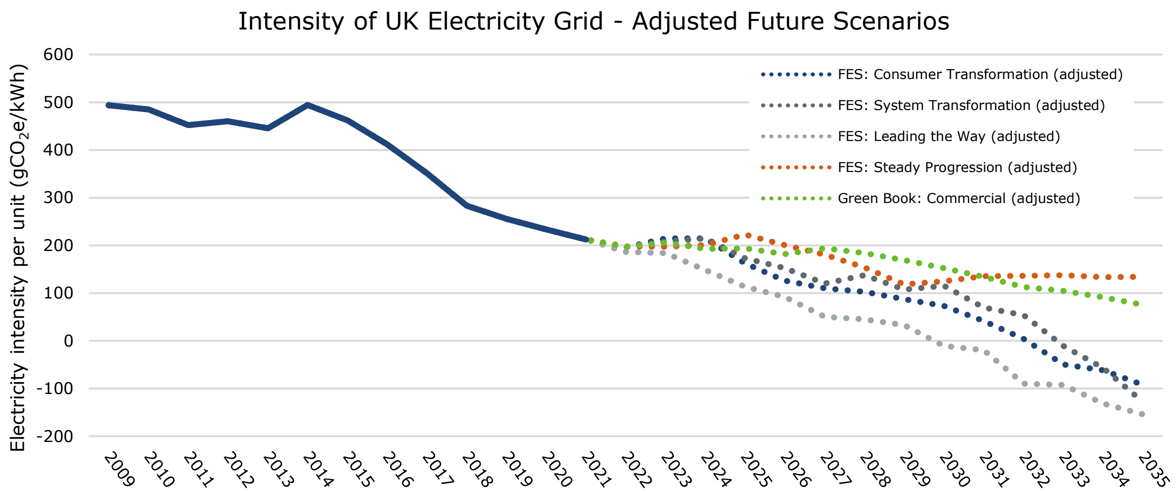
10 Appendices

10.1 Decarbonisation of the Electricity Grid

Electricity in the UK comes from multiple sources, some of which are 'clean', and some of which rely on the combustion of fossil fuels.

The UK's energy mix has changed substantially in recent years, becoming noticeably more reliant on clean energy sources and much less reliant on polluting fuels such as coal. This increase in renewable energy generation has resulted in a decrease of the carbon intensity of electricity. The following graph shows outlines the historical carbon intensity of the electricity grid, and five projected scenarios to 2035.[8]

There is typically a 3-4 year delay before the projected emission factors are reflected in the published UK greenhouse gas emission factors. As a result, the projections have been 'adjusted' to account for this by applying the projected year-on-year percentage change to the most recent UK grid emission factor.



In all emissions scenarios, a general reduction in the emission intensity of the UK electricity grid is expected.

The selected emissions scenario used in future calculations in this report was an adjusted version of the Treasury's Green Book Commercial projection. This was chosen as it represents a relatively conservative/realistic trajectory and was also the projections used in Public Sector Decarbonisation Scheme. The following emission factors were used.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Carbon factor (gCO_2e/kWh)	256	233	212	197	206	192	194	182	194	184	169	153

[8] Historical data from https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting. Forecasts from https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal and https://www.nationalgrideso.com/future-energy/future-energy-scenarios and adjusted to account for the performance gap between estimated and actual data.

10.2 Inflation

To reflect changes to the value of commodities and the pound, a cost inflation scenario was applied to account for future increases in the price of utilities.

The percentage changes to commodity prices applied are the most recent BEIS Energy Commodity Projections[9]. The following figures were used:

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Percentage change	-	0.4%	2.1%	2.1%	0.0%	-0.2%	0.6%	2.7%	-3.4%	-1.4%	0.7%	-0.9%
Cost (£/kWh)	£0.1948	£0.1955	£0.1995	£0.2037	£0.2036	£0.2033	£0.2045	£0.2100	£0.2028	£0.2000	£0.2014	£0.1996

[9] BEIS Updated Energy & Emissions Projections 2019 - Annex M: Growth assumptions and prices https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2019

10.3 Assumptions Used

Opportunity	Cost assumptions	Saving Assumptions
Access to half hourly energy consumption data and more frequent monitoring	£1,500 per data logger installed, plus access to website	No direct savings, savings will come from identified wasted energy, typical payback of two years
1. Ensure server room cooling temperature setpoint is suitable	All costs internal	Assumed existing temperature setpoint is 19^{0}C and could be increased to 23^{0}C. A 3% saving per degree (compounded) will result in a 14% reduction in energy use from the server cooling unit.
2. Encourage staff to adopt sustainable energy practices	All costs internal	5% reduction in human-controlled energy use (e.g. PCs, TVs, HVAC)
3. Ensure HVAC controls are suitably adjusted to office usage patterns	All costs internal	Savings include reduction in heat pump operation hours, and reduction from 24^{0}C to 22^{0}C setpoint in the mornings
4. Install LED lighting with intelligent controls	Cost for 254 new LED tubes at £20, plus electrician labour in London on the assumption of 10 tube changes per hour.	Based on the power consumption (W) of existing lighting units compared to the power consumption of replacement LED panel lighting / downlighting.
5. Install a solar PV array	Observed typical fully commissioned cost in central London through other studies: £1,050/kWp. Flat roof area: ~300m^2 Weekend baseload identified by analysing half hourly data: typically 18kW per hour. 60nr. 300W panels equates to 18.0kWp.	Followed MCS Generation Scheme Methodology. Irradiance zone: London Kk value of 864kWh/kWp/year based on roof angle of 10 degrees from south and panels on a 10 degree angle self-weighted frame. Approximate solar generation = 20,218kWh/year

10.4 Net Zero Carbon vs Carbon Neutral

Net Zero

The Intergovernmental Panel on Climate Change (IPCC) defines net zero as:

> *"a state where there is no incremental addition of GHGs to the atmosphere. This means all avoidable emissions have been reduced and thus residual emissions have to be removed from the atmosphere."*

On the path to pursuing this target, companies should:

- Set a net zero target based on science with interim milestones on how to get there, consistent with a 1.5ºC mitigation pathway.
- Show how they can reduce emissions across their value chain in line with climate science.
- Be carbon / climate neutral by financing projects to further avoid and remove emissions (aka offsetting) throughout their journey towards net zero
- Eventually neutralise unavoidable residual emissions with carbon removals to achieve net zero emissions.

Net zero is reached when the amount of GHGs added is no more than the amount taken away.

Carbon Neutral

Carbon neutral is defined as a when an organisation offsets 100% of their emissions through avoidance and/or removal projects, with no reduction in emissions. Where emissions continue, they must be offset by absorbing an equivalent amount from the atmosphere, for example through carbon capture and reforestation that is supported by carbon credit schemes (BSI PAS 2060:2010)

Put simply, to be carbon neutral, any emissions released into the atmosphere must be balanced by an equivalent amount being removed.

Key differences include:

- *Net zero* requires organisations to minimise their emissions as much as possible. In contrast, organisations can become *carbon neutral* tomorrow with minimal effort, by simply purchasing offsets.
- *Net zero* typically encourages targets in line with the Science-based Target Initiative (SBTi).
- Some definitions of *net zero* encourage greenhouse gas removal (typically via certified methods to ensure carbon is permanently sequestered) rather than simply offsetting emitted carbon elsewhere. (Carbon offsets have been criticised by some as ineffective and simply a means to continue unsustainable practices).

10.5 Display Energy Certificate