north east & yorkshire NET ZERO HUB

ENERGY AUDITING GUIDANCE

North East & Yorkshire Net Zero Hub

Public Sector Estate Decarbonisation Programme

OUR PARTNERS

Hull & East Yorkshire LEP, North East LEP, South Yorkshire Mayoral Combined Authority, Tees Valley Combined Authority, West Yorkshire Combined Authority, and York & North Yorkshire LEP

Contents

1 Introduction

1.1 Purpose

This guide sets out to help offer a better understanding of how to undertake an energy audit. This guide has been developed as part of the North-East and Yorkshire Net Zero Hub's Public Sector Estate Decarbonisation programme.

Turner & Townsend are working with the Hub to deliver a suite of training programmes and guides to build capacity and upskill the public sector to deliver decarbonisation projects in their buildings.

1.2 What is energy auditing?

An energy audit is used to understand how energy is being used on site, identify how energy use can be optimised without compromising day-to-day operations and assess how carbon emissions can be reduced on site.

2 Conducting an audit

This section covers what to consider when conducting an energy audit.

When planning your energy audit, think about:

- What information do you already have about your building?
- What information will you need to collect and how?
- Who are the people you will need to liaise with (for example, IT colleagues) to get the full picture of your building's energy consumption?
- Do you have access to all of the areas you will need to survey (for example rooftops)?
- Document all of your calculation methodologies and assumptions made in your assessment.
- Can you link up any identified measures with planned maintenance regimes?
- Who is the audience for your report (e.g. senior staff looking to sign off a programme of work)?

Figure 1 below provides an indicative process for carrying out an energy audit. This process may change depending on your site-specific circumstance, your intended outcomes and audiences.

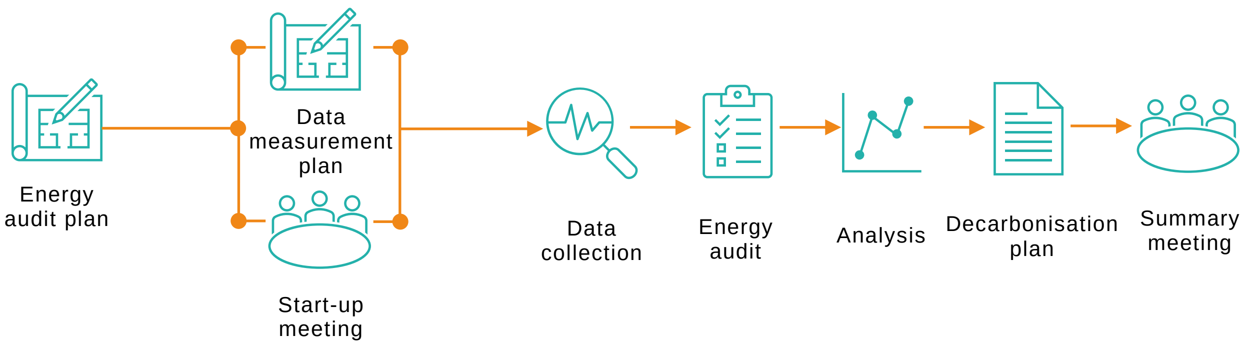

Figure 1: General process for conducting an energy audit

2.1 Planning your audit

2.1.1 Review of existing information

Before auditing a site, the auditor must collect as much useful information as possible, and review it, as it can often guide what measures are more appropriate, and highlight issues that can be investigated further on site,

It is recommended that you use an energy audit data collection form/sheet which entails but not limited to the following information:

- Building name
- Gross internal floor area (m2)
- Main heating fuel (e.g. natural gas).
- Consumption data (e.g. half-hourly).

All information collected is used to evaluate the different uses of energy within the process and to establish a breakdown of the energy consumed.

Building data				2021/2022 Consumption													
			Building Type	Electricity				Natural gas				District Energy				Oil	
Building name	Floor area - (m2)	Main heating fuel	CIBSE	kWh	£	£/kWh	tCO_2	kWh	£	£/kWh	tCO_2	kWh	£	£/kWh	tCO_2	litre	£
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Figure 2: Example audit data collection form

2.1.2 Benchmarking

A helpful method to understand how your building is performing is to compare it to recognised benchmarks. The Chartered Institute of Building Service Engineers (CIBSE) has developed the most comprehensive list of benchmarks in the UK in its Guide F. These benchmarks compare the electrical and thermal intensity of buildings (kWh/m^2). CIBSE have developed an online benchmarking tool[1] with up to date building benchmarks. An example graph showing comparison between benchmarks and a public building is shown below, clearly showing the site is performing well both thermally and electrically.

Consumption data is sometimes difficult to find as some older buildings may have older, analogue meters which require manual readings however digital, half hourly meters can automatically provide you with buildings consumption every half hour direct to the user to analyse. There is also an option to install additional submeters to provide granularity on consumption by service i.e. LED lighting, cooling, etc.

[1] https://www.cibse.org/knowledge-research/knowledge-resources/knowledge-toolbox/benchmarking-registration

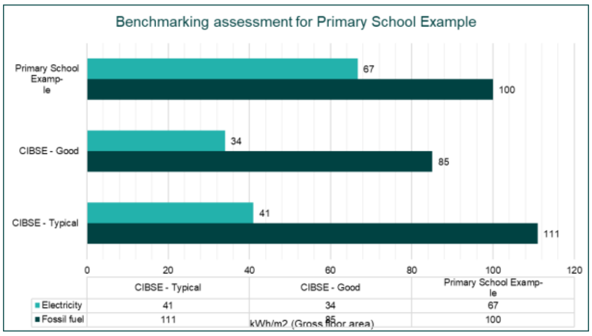

Figure 3: Benchmarking example using CIBSE benchmarks

Projected below, is the average energy consumption during the day (weekdays only) each month of 2021. This can be reviewed before attending site to query if building operations require heating to come on between 04:00 – 07:00 as it could likely be pushed to a later time to reduce energy use making the building more energy efficient, as the building is generally not occupied until 06:30 at the earliest.

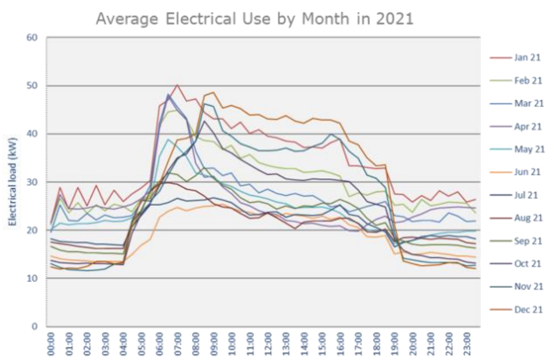

Figure 4: Half-hourly meter data example

2.1.3 Typical information required for audits

As well as the information above, an energy audit will be simpler if the energy auditor has access to layout drawings and any asset registers. Additionally, greater understanding can be gained if auditing the site with an experienced person that knows the site well such as a building manager or janitor.

2.1.4 Concerns such as care areas or asbestos

Care must be taken when arranging an energy audit as the auditor may put themselves at risk of harmful areas. One key concern is asbestos as it is often present in older plantrooms hence an up-to-date asbestos register should be received and reviewed before attending site.

Additionally, attention must be taken to what type of building is being audited as a healthcare building may have some areas with specific care areas, a defence building some classified areas, or schools with additional support needs which all may require additional security clearances.

2.2 Conducting the audit

2.2.1 Building fabric

The temperature of air will always try to equalise and therefore heat needs to be pumped in to match the heat that is escaping. Upgrading the building fabric of a building will decrease the heat loss of the building thus lowering the energy required to heat the building.

The building age can be a good representation of the building fabric as they are likely constructed to the fabric levels outlined in the standards available at the time of construction.

If the building is constructed from brick, you can also make an assumption of if the building has cavity wall insulation, see

Figure 5 below. As well as cavity wall insulation a more intrusive but greater benefit option is to provide external wall insulation which provides an additional layer of fabric on the external façade of a building.

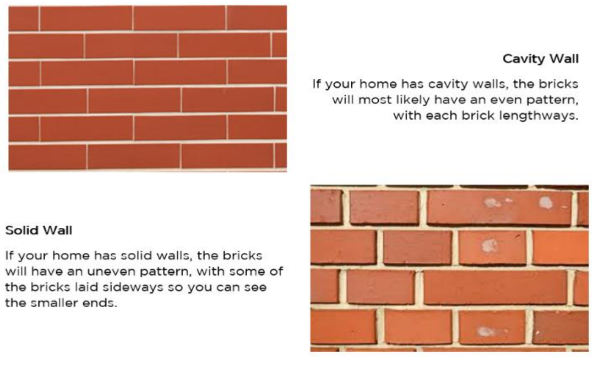

Figure 5: Cavity wall identification

Another important part of building fabric is any insulation that is installed in the roof space, internal wall or false ceiling. The main opportunities are ensuring that floors, ceiling and walls are insulated to good levels, and drafts are blocked wherever possible.

Finally, the level of glazing in the building should be reviewed to see if it can be upgraded to double or triple glazing. Some listed buildings may result is excessively expensive costs to keep in line with the status of the building however secondary glazing is another option that can be explored.

Figure 6: Ceiling insulation example

2.2.2 Heating, ventilation & cooling

Heating can come in a variety of sources be it gas, oil or biomass boilers, electric heating, split units and a number of other methods, all requiring different infrastructure to supply heat to a space.

Cooling follows similar pattern, typically from split units mounted externally, with varying types of emitters internally.

All buildings will have ventilation, whether it is a full mechanical ventilation system with air handling units, or simple extract fans. The key information that needs to be captured is set out below:

- Output of equipment
- Efficiency of equipment (referred to Coefficient Of Performance (COP) for heat pumps)
- Age of heating equipment
- Time, temperature and ventilation settings
- Any applicable ‘dead bands’ of heating & cooling (temperature range at which heating & cooling is allowed to be before firing)
- Infrastructure suitably insulated

Worked example: Gas boiler to air source heat pump

When calculating the energy implications moving from a gas boiler to a heat pump, you need to consider the following information:

- The current annual consumption of fossil fuel (kWh).
- The cost per unit of fuels (p/kWh)
- The proportion of this consumption that will be impacted by the upgrade.

- The heating demand of the site (kWh).
- The efficiency of the gas boiler (%).
- The coefficient of performance for the heat pump (COP).

Example primary school has an annual gas consumption of 150,000 kWh attributed to the provision of heating at a cost of 7p/kWh. The current gas boilers are at end of life with a rated efficiency of 85%.

The heating demand can therefore be calculated as 150,000 kWh × 0.85 =127,500 kWh.

The new heat pump is estimated to achieve a COP of 3.5 with a cost of electricity of 22p/kWh.

Considering heat demand remains the same, the consumption of the new heat pump can be estimated as 127,500 kWh ÷ 3.5 = 36,429 kWh.

Applying emissions factors[2] and cost of fuel, we can assume that the installation will save £2,486 per annum and 19.6 tonnes of CO_2e/kWh.

2.2.3 Lighting

Lighting can come in a variety of different sizes and wattages however the most common are fluorescent tubes. The greatest efficiency for lighting is to change to LED and reduce the operating hours through smart controls. Although difficult to determine the type of light fittings by eye, normally building managers will have spare fittings with all details.

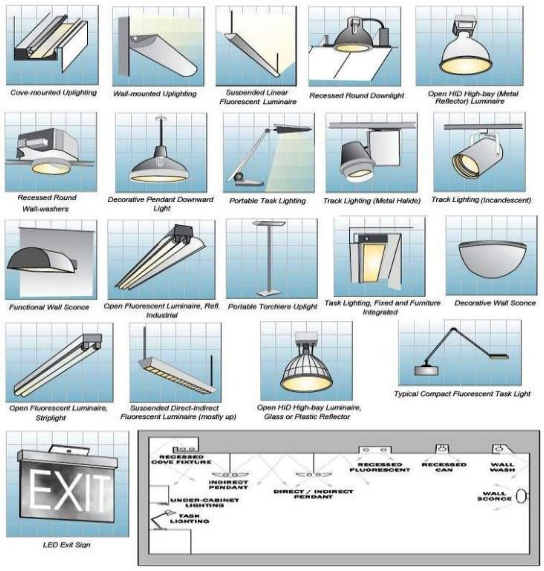

Figure 7: Types of lighting

As well as conventional lighting controls via switches, smart controls include Passive Infra-Red (PIR)s which turn lighting on when movement is detected, along with daylight control which can turn off lighting when natural daylight provides sufficient lux levels.

Worked example: Lighting upgrade including PIR controls

When calculating the energy implications of upgrading lighting, you will need to consider the following information:

- The current fitting types (e.g. T8) and the rated consumption (W).
- The replacement fitting type (e.g. LED) and the rated consumption (W).
- The number of fittings of each type.[3]
- The operational hours of the lighting.
- The unit price of electricity (p/kWh).

A primary school is looking to upgrade its T8 fluorescent lighting consuming 65W per unit to

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[2] Emissions factor for gas of 0.182 $kgCO_2e$/kWh and 0.211 $kgCO_2e$/kWh for grid electricity including transmission and distribution losses.

[3] Note that this is operational hours of when the lighting is switched on. This is not necessarily the same as the opening hours for a building, especially if users follow good practice and switch lighting off when not in use.

energy efficient LED lighting which consumes 30W. They pay 22 p/kWh for electricity.

There are 250 fittings to convert and the lighting is left switched on for 1,800 hours per year.

The current lighting annual consumption is calculated to be 65W × 250 × 1,800h = 29,250 kWh[4]

The replacement lighting annual consumption is calculated to be 30W × 250 × 1,800h = 13,500 kWh.

This would mean an annual energy consumption saving of 15,750 kWh (54%) which equates to a cost saving of £3,465 and 3.3 tonnes of CO_2e.

2.2.4 Renewable technology

In order to become more self-sufficient and ultimately net zero, some form of renewable generation would be required for the site. Renewable generation covers a variety of technology, the most common of which is solar generation but also includes tidal, and wind power. Generally tidal power will not be applicable for a building and wind turbines are unlikely to be applicable for any buildings in a city/town centre hence only solar is detailed further below. Sites should be reviewed with any potential for solar generation in mind, whether roof or ground mounted, looking for available space that is free from shading, etc.

Figure 8: Roof-mounted solar PV installation

Worked example: roof-mounted solar PV installation

Once you have appropriately sized your solar PV to meet the specific demand for your site, calculating the energy implications for solar PV, you will need to consider:

- The installed peak capacity of the array (kWp).
- Slope of the array (°).[5]
- Azimuth of the array (°).[6]
- System losses (%).

A primary school located in the south east of England has identified the potential for a 5kWp solar array on a roof space facing due south east (-45°).

The system losses are 14%. And the slope of the array is 35°.

Using freely available information from the EU Science Hub's PVGIS tool[7], it is estimated that the array could generate up to 5,039 kWh per annum, saving up to £1,108 per annum.

[4] Note that dividing Wh by 1,000 calculates kWh.
[5] This is the angle of the PV modules from the horizontal plane, for a fixed (non-tracking) mounting.
[6] he azimuth, or orientation, is the angle of the PV modules relative to the direction due South. -90° is East, 0° is South and 90° is West.
[7] https://re.jrc.ec.europa.eu/pvg_tools/en/

Locogen

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