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Hub guide

Greater South East Energy Hub

Hub Guide 11 - Energy Audits

1. Introduction

This guide is designed to explain the process and rationale for an energy audit and to describe the key areas of energy consumption that should be analysed. It has been written to assist anyone wishing to undertake an energy audit of a building or site. It explains how to prepare for an audit of a building or site, create a high-level profile of its energy consumption and make recommendations for specific energy-saving measures from the information gathered.

The methodology outlined in this guide reflects the approach and methodology used by compliance initiatives such as the Energy Savings Opportunities Scheme (ESOS) and the international management system standards ISO5001 and ISO14001.

To obtain clear, accurate recommendations, a specialist consultant should be engaged to undertake the audit itself.

2. Why Do an Energy Audit?

Energy audits can be undertaken to identify areas of significant energy consumption, profile energy usage (i.e. identify how much energy is being used, by what and when), identify specific recommendations for energy, carbon and financial savings, or adhere to specific compliance, including quality or safety standards.

Funding is available to the public sector to support the implementation of energy audit recommendations. Salix Finance provides interest-free government funding to public-sector organisations, to help them reduce their energy costs through the installation of energy efficient technologies. The loan can be repaid using the cost savings that the energy efficiency measures achieve, which then continue to save money. Over 100 technology types are currently supported by Salix funding programmes. This includes energy-management systems for buildings, cavity-wall insulation, combined heat and power systems, evaporative cooling, heat recovery systems, LED lighting, lighting controls, loft insulation, pipework insulation, server virtualisation and variable speed drives. Salix funding covers all types of public sector estate. This includes schools, higher and further educational institutions, emergency services, hospitals and leisure centres.

Many local authorities across the UK have declared climate emergencies as a response to the Intergovernmental Panel on Climate Change (IPCC) special report, on the impacts of global warming of 1.5°C above pre-industrial levels. In May 2019, the UK Parliament passed a resolution declaring an environmental and climate emergency and set a target for the UK to become climate neutral by 2050. Many local authorities have committed to achieve this sooner, in some cases as early as 2028.
Local authorities and other public-sector organisations can respond positively to these declarations and help to meet these targets, by improving the energy efficiency of their own estate.

3. Approaching an Energy Audit

The approach taken to an energy audit should be informed by its objectives. An essential element of the audit is to review what energy data is currently available and how it is currently used. This may ultimately need to be modified or enhanced. Good data management is essential for good energy management. The theory is, if it can be measured, it can be monitored, and, if it can be monitored, it can be managed. This is illustrated in figure 1 below.

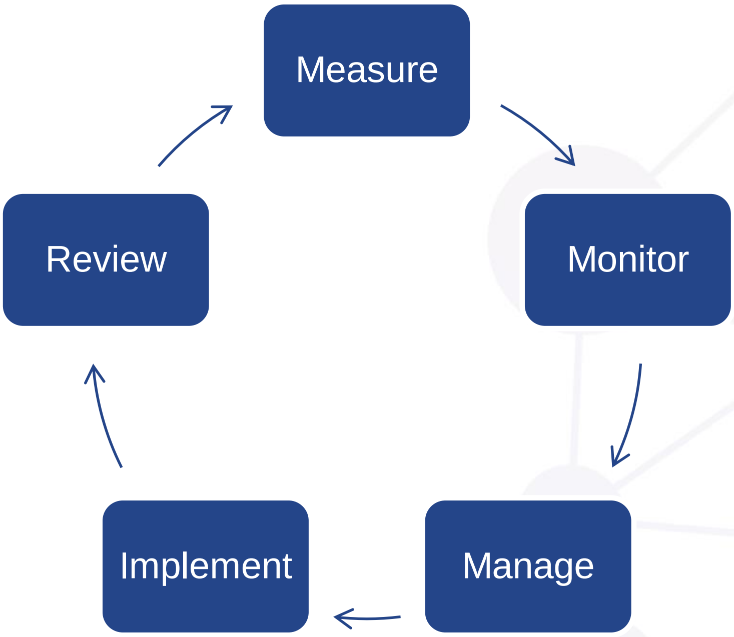

Figure 1: Energy Monitoring Process Cycle

Something that is properly managed will run more efficiently. In energy terms, this means reduced usage and lower costs. This is illustrated in more detail by the Energy Hierarchy principle, as illustrated in figure 2 below.

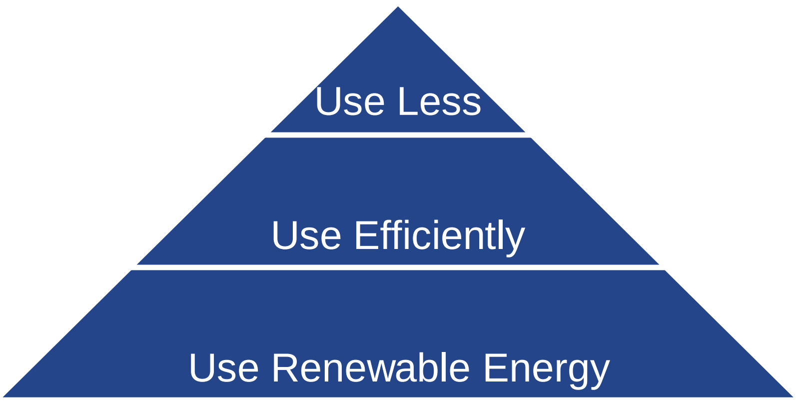

Figure 2: Energy Hierarchy

Stage One (Use Less) of the Energy Hierarchy means minimising demand for energy and reducing it where necessary, such as switching off equipment when not in use. Having achieved this, the focus moves to Stage Two (Use Efficiently) where consumption should be minimised by the using energy-efficient equipment such as LED lighting, and ensuring that any building is fully insulated. Stage Three (Use Renewable Energy) focuses on ensuring that energy consumed is from renewable sources, such as solar photovoltaic (PV), battery storage and wind power.

To follow the Energy Hierarchy, an energy audit should identify a series of priorities for investment. These will range from quick wins that are easy to implement at a minimal cost, through to longer-term interventions that require a more significant financial resource. The latter may require investment-grade proposals to confirm their cost and return on investment (ROI). If the right quality of information is obtained, the energy use of a building or site can be profiled, and recommendations made. This can help to determine how an energy priority will fit within an organisation's budgets and timeframes, whether it is suitable for financial support, and move it to an investment-ready stage.

4. Profile Building

This section focuses on establishing a profile of energy use. This is achieved by analysing available consumption data, understanding the short, medium and long-term plans for the building or site's use, identifying the activities undertaken on site, and reviewing any relevant studies and documentation. The purpose of these steps is to identify how energy can be Used Less and Used Efficiently, as corresponds to Stage One and Two of the Energy Hierarchy. Start by identifying the areas with the highest energy consumption. If multiple energy sources such as gas and electricity are used, focus on the one with the highest consumption. Alongside this, start to develop a profile, by categorising the activities and specific information on each building, or each specific area of a building.

4.1 Energy Data

When undertaking an audit, energy-consumption data will help to establish a baseline against which any improvements can be measured. Any data on electricity and fuel use, including gas, oil and liquid petroleum gas (LPG) should be gathered.

Energy data can be collected from a variety of sources, each with benefits and drawbacks. The table in figure 3 below provides an overview of the types of data that may be available and covers the advantages and disadvantages of using them to undertake an energy audit. In addition, many public-sector organisations may have their own energy brokers and managers from whom specific reports relating to energy consumption may be available.

DATA TYPE	OVERVIEW
Metered Data	• Provides historic and real-time consumption information to build a profile of use and enables energy-use patterns to be viewed in real time. • Includes data from Half Hourly (HH) meters (which record energy use in half-hourly intervals and are mandatory for any user which consumes more than 100kW in a half-hour period), sub-metering (which records actual energy use of specific locations or equipment), Energy Management Systems (EnMS), or Building Management Systems (BMS). • HH data can be used to establish daily profiles and helps to identify anomalies. • Reports and data from an EnMS or BMS will help to provide an enhanced level of information. • Being able to see energy data and be alerted to over-consumption has now become a mainstream requirement.
Billing Data	• Known as Non-Half Hourly (NHH) meters. • Provides top-level consumption data from individual meters over a set period, usually monthly or quarterly. • Depending on the meter type, it can provide a breakdown per meter for peak (day) and off-peak (night) usage. • The energy consumption data can include both estimated and actual use. • NHH data can be used to identify seasonal patterns of use if energy bills for a full year or more are provided, with more detailed patterns likely to be identified from monthly bills, as opposed to quarterly bills. • Profiles of usage can be created when more than one NHH meter is present, depending on the location of each meter and the specific area(s) covered.
Benchmarking Data	• Relates to any specific reports produced where benchmarking of energy use may have already taken place. • Reports which contain this information include specific compliance information such as the Carbon Reduction Commitment (CRC), ISO14001, ISO50001, Energy Strategies, and Sustainability Reports. • Any previous reports, proposals or quotes undertaken for specific energy-efficiency measures, such as solar PV or LED lighting, may have relevant consumption data and provide a benchmark to revisit and review the viability of those proposals (if not already implemented) as part of an energy audit.

	• If not already sub-metered, an inventory of equipment on site, if available, may be used to analyse significant areas of energy consumption. • As the data from reports will be historic, there will be limitations based on its validity when considering current energy use. This is particularly the case if, since the data was produced, there have been any specific changes that have resulted in changes to energy usage levels and patterns.
Associated Data	• Non-energy data that will help to support analysis of actual energy data to help build a profile of energy usage. • Such data is likely to include staff occupancy, general operation hours/days, productivity (e.g. visitor numbers to leisure centres or public venues), or building data (e.g. floor area and construction type) • It is essential to ensure that this data is of good quality. For example, if data about building occupancy is profiled against data about energy use, both sets of data must cover the same time periods.

Figure 3: Types of Available Data

4.2 Site or Building Details

It is important to understand what the site or building is used for and the building type(s) present. The type of building, especially its construction, plus available land use, can determine the opportunities for any energy-related improvements, including specific technologies. For example, if there is a flat roof, there may be an opportunity for solar PV, or if land use is available, this may determine opportunities for electric vehicle charge points or battery storage. Understanding site or building details may also highlight any limitations, such as if a building is listed or in a conservation area, which could restrict the use of energy technologies or improvements if they have an impact on the physical character of the building. This also applies to changes in ownership or use. For example, if there are plans for an organisation or activity to relocate in the future, this may impact on any specific energy efficiency recommendations, depending on the timescale and how firm the plans are.

Obtaining and reviewing any previous energy-related reports may also provide valuable information for anyone conducting an audit to understand the energy performance profile. This could include:

- Reviews of compliance activity, such as ISO14001, ISO50001 and ESOS
- Energy certification, such as Energy Performance Certificates (EPCs) and Display Energy Certificates (DECs)
- Property information, including Operation & Maintenance (O&M) reports, property management records and Facilities Management (FM) complaint logs

- Technology feasibility reports, such as for solar PV or LED lighting, which may themselves be supported by cost quotations and other information. These may be contained in site or building-layout plans. Such information may provide useful insights into opportunities or limitations for specific technology-related recommendations.

4.3 Activities

Understanding what site activities are undertaken is a key consideration, since these will have an impact on energy use. This could include office work, civic functions, health treatment and refuse-vehicle maintenance. Therefore, any recommendations for energy saving would need to take these activities into consideration.

When considering current and future energy requirements, it is important to understand what could change, for example, occupation levels, or the type of machinery or other equipment and how it is used, which may impact on energy use in the short, medium and long-term.

5. Areas of Energy Consumption

Once the overall profile of energy use has been established, the next stage will be to examine specific areas of energy consumption. This will help to identify a list of priorities for improvement, on which a more detailed cost-benefit assessment for investment can then be based.

The main outcome of this work is to help identify areas under Stage One and Stage Two of the Energy Hierarchy where energy can be Used Less and Used Efficiently. Initial consideration can also be given to Stage Three, Use of Renewable Energy, although such measures would be subject to a more detailed survey, and specific technologies will be covered in further Hub guides.

Quick wins for energy savings often relate to behaviour change, which is directly applicable to Stage One (Use Less) of the Energy Hierarchy. Behaviour change involves staff taking responsibility for areas of use where energy is consumed and the operation of it manually controlled, such as lighting, heating and cooling, computers, and other office equipment. There is evidence to suggest a positive link between behavioural change and energy savings. For example, turning off equipment at night can reduce consumption by around 60%. The promotion of energy efficiency through simple changes in behaviour amongst employees can also result in other benefits, such as a more comfortable working environment and higher staff retention.

5.1 Lighting

To align with the Energy Hierarchy, the initial focus for energy reduction in lighting should be to Use Less, as per Stage One. This includes removal of lighting from over lit areas (e.g. where use has changed), maximising natural lighting (e.g. window, sky light or luminaire cleaning) and use of reflectors and better diffusers. As a following step, lighting controls can be introduced to suit building use (e.g. installing automated lighting controls such as movement sensors). According to the Carbon Trust, movement sensors can reduce lighting consumption by 30% and daylight sensors can reduce it by 40%.

Once all opportunities to Use Less lighting have been identified, the next focus is on Stage Two of the Energy Hierarchy, to Use Efficiently. This will involve swapping to more energy-efficient lighting alternatives. Depending on the operation hours and subsequent usage, payback on lighting schemes can often be around one-year or less. In terms of energy savings, energy use reductions of over 60% can be achieved in some cases. In parallel with this, further savings can be realised by complimentary interventions under Stage One of the Hierarchy, such as installation of PIR (passive infrared) and daylight sensors. General maintenance savings will also be achieved in relation to replacement of tubes and lamps, given that more energy-efficient lighting has a significantly longer burn rate.

When auditing a site or building to examine lighting consumption, the information to be collected will include the (approximate) number and type of lamps and/or florescent tubes, with the wattage details of each. This information can be found via existing building or site plans. Any previous quotes received to upgrade the lighting may also help to establish the lighting profile.

Further information on lighting and potential savings is available from the Carbon Trust in their lighting overview guide.

5.2 Heating, Cooling & Ventilation

Heating, including hot water, can account for up to 60% of energy use in some buildings, especially high energy users such as leisure centres. The decarbonisation of heat is a key part of meeting climate-emergency targets and delivering a low carbon economy.

Heating and cooling use and demand will depend on which activities are taking place. For example, in offices, there may be heating, ventilation and air conditioning (HVAC) equipment, wall-mounted electric heaters, and gas or oil-fired central heating. This equipment is sometimes supplemented by desk fans and space heaters. Larger energy users such as leisure centres may have Combined Heat & Power (CHP) and larger gas or oil-fired boilers, due to the need to heat water for swimming pools and changing rooms.

Ventilation helps to provide fresh air and protect against issues such as damp and condensation. However, unnecessary ventilation can waste energy and money. For many organisations, air conditioning is a vital part of day-to-day operations. For example, hospitals require it for the comfort of patients and large offices need it due to the heat generated by IT equipment. Some such organisations are developing their own cooling strategies to offset the impact of air-conditioning use, by maximising the installation of renewable energy on site.

To align with the Energy Hierarchy, the initial focus should be to Use Less, as per Stage One. According to the Carbon Trust's heating, ventilation and air conditioning guide, heating, ventilation and air conditioning can account for the majority of money spent on energy; and the usage of energy can increase by up to 30% if heating and cooling systems and equipment are not maintained properly. The Carbon Trust's guide also provides tips and advice on how to reduce the need for equipment to be used. Some examples are set out in figure 4 below.

MEASURE	OVERVIEW
Passive Heating, Ventilation & Cooling	• This is the control of heat from the sun along with ventilation in order to benefit a building and avoid discomfort. • Making the most of natural heat and ventilation is a simple and cost-effective way of achieving big savings.
Reduce Overheating	• Before installing cooling equipment, always identify where the excess heat is coming from – sunlight, equipment and refrigeration are often main sources. • The more energy efficient equipment is, the less heat it produces – installing low-energy lighting and keeping equipment operating at peak efficiency reduces cooling costs.
Zoning	• Many buildings have problematic areas with different time and temperature requirements where only one overall heating or cooling control system exists. • A solution is to 'zone' the building, by installing separate time and temperature controls for individual areas, this helps to provide better conditions.
Daylight Blinds	• Help natural light to enter the space by re-directing it onto the ceiling; this will alleviate any discomfort felt by the occupants from direct daylight.
Night Cooling	• An established technique where cool "night air" is passed through the building to remove heat that has accumulated during the day. This enables the building to absorb more heat the following day. • The movement of cool night air may be natural, or fan assisted.
Behaviour	• Staff should receive guidance on recommended operating temperatures and how to set heating or cooling units correctly. • This includes understanding on how to use controls effectively.

Figure 4: Carbon Trust Recommended Measures to **Use Less** Heating & Cooling

Once all opportunities to Use Less have been identified, the next focus is to Use Efficiently, in line with Stage Two of the Energy Hierarchy. This involves ensuring that there is enough insulation, and the installation of thermostatic radiator valves and air-curtains to minimise any heat loss where doors are open. Other measures are dependent on the types of heating present. Some suggested interventions are outlined in figure 5 below, and further information may also be found in the Carbon Trust's heating, ventilation and air conditioning guide.

MEASURE	OVERVIEW
Temperature Control	• Ensure that air conditioning only operates above 24°C, and that heating and cooling systems do not compete. • This can be addressed by keeping a temperature gap, known as a *deadband*, between the heating and air conditioning temperatures.
Variable Speed Drives	• These can vary the output of an air conditioning system to meet the required cooling needs, while not producing more cooling than is required. • This can reduce the energy required for heating as well as cooling.
Free Cooling Coils	• Use outside air as a source of cooling for air-conditioning systems. This reduces the energy required to produce cooling. • While the effectiveness of free cooling coils is dependent on the outside temperature, according to the Carbon Trust, there is a good opportunity to use them in the UK, due to our temperate climate.
Motors	• High-efficiency motors can save up to 5% on energy costs.

Figure 5: Recommended Measures to **Use** Heating & Cooling Equipment **More Efficiently**

Recommendations to Use Renewable Energy to address heating, as per Stage Three of the Energy Hierarchy, would be subject to a more detailed survey. Specific technologies will be covered in further Hub guides, including Low Carbon Heat Projects and Heat Networks.

5.4 Computers, Office Equipment & Appliances

Information relating to office-equipment use, such as computers, printers and other equipment and appliances needs to be collected in order to identify potential savings in this area. This includes an estimate of the hours each day the equipment and/or appliances are in operation. In office buildings, computers are likely to be a significant source of energy consumption, and the cooling required for any server room(s) on-site will also add to the attributed energy consumption. In relation to Stage One (Use Less) of the Energy Hierarchy, simple measures can be undertaken to reduce energy consumption associated with computers and other office equipment, by switching them off when not in use.

In any buildings with canteens or catering facilities such as schools, hospitals, leisure centres or large office buildings, the use of catering appliances is likely to have a significant impact on energy use. This will include equipment such as ovens and other cooking appliances. There may be opportunities for efficiency linked to Stage Three (Use Renewable Energy) of the Energy Hierarchy. For example, renewable technologies could be used to meet the energy demands of these appliances, or, if there is an existing heat source, there is potential for that heat to be captured and deployed elsewhere.

Smaller appliances such as kettles, microwaves and domestic refrigeration units will also be present, although these usually constitute a small percentage of overall energy use. However, as part of Stage One (Use Less) of the Energy Hierarchy, it is still important to ensure these are used as efficiently as possible. This may translate into interventions such as ensuring the amount of water boiled in a kettle is only the amount needed.

5.5 Building Energy Management System (BEMS)

A Building Energy Management System (BEMS) helps to ensure that energy efficiency is maximised through monitoring and controlling services, such as lighting, heating, cooling and ventilation. It can be a solution to address issues relating to the management and control of the types of energy consumption listed in this section. However, to determine the suitability of a BEMS, there are several points to consider, linked to both the capital cost of installation and the day-to-day running of a BEMS once installed:

- Do you have a significant energy bill and control over your premises, which would justify the outlay on a BEMS?
- Do you have the resources, in terms of staff time and expertise, to properly run and maintain the system?
- Would staff benefit from integrated controls? Would you save on your energy bill overall?
- What else could be done with the energy data the BEMS gives you? Might this be useful?

If there is a Building Management System (BMS) on site, it is important to remember that a BMS can only be effective if managed properly. When used correctly, a BMS can reduce total energy costs by 10% and increase comfort. Accordingly, a BMS system should be regularly maintained to ensure maximum optimisation and potential ongoing savings. Therefore, when auditing a site or building which has an operational BMS, it is important to establish how any BMS is currently utilised and what the limitations and coverage of the BMS are across the building or site.

6. Presenting Findings

Once the energy audit has been completed, the next stage will be to present the findings. This will enable the material to be used, to set and develop further improvements.

6.1 Energy Profiling

Once the energy data described in section 4.1 has been analysed by your energy auditor, depending on the level of detail available and data sets, it may be possible to develop profiles of energy usage. If half-hourly data is used, specific profiles can be produced as per the example in figure 6 below.

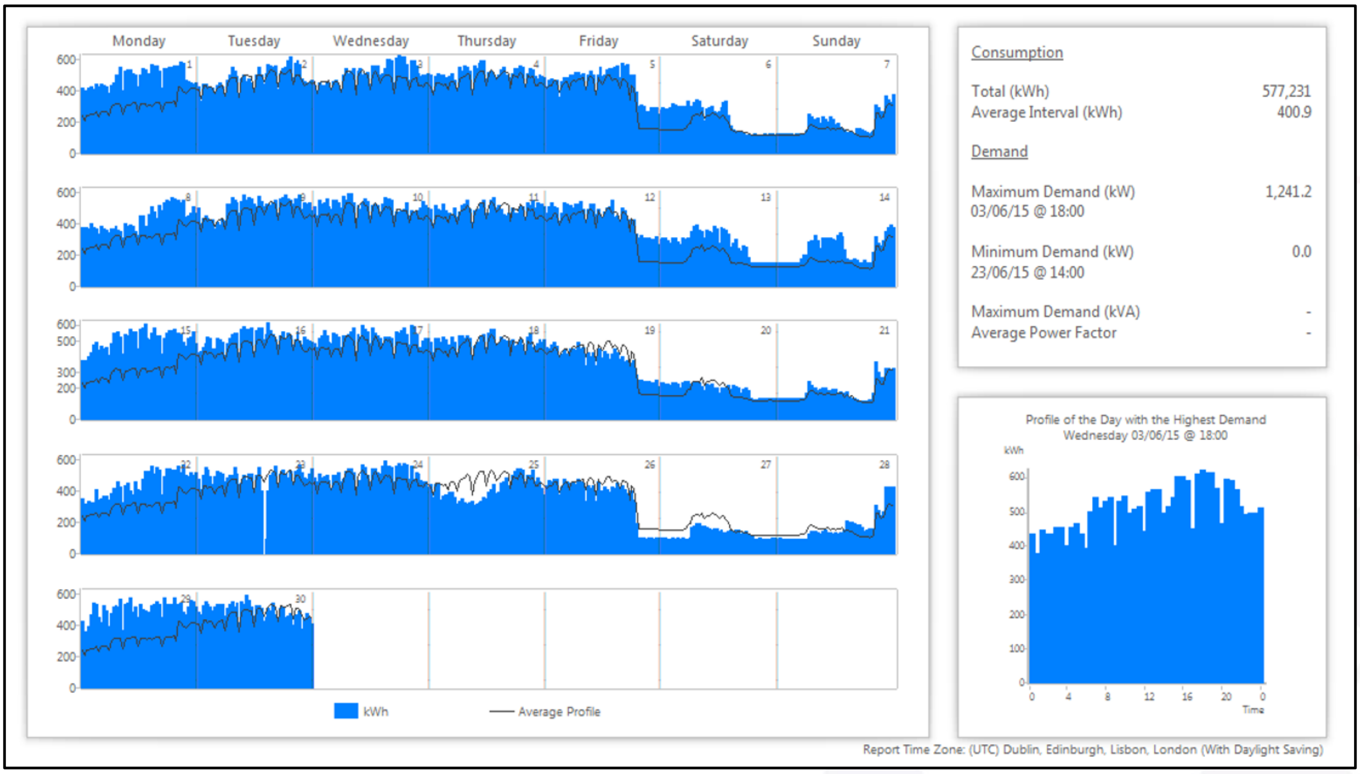

Figure 6: Monthly Profile of Electricity Consumption Based on HH Data

Figure 6 shows that from the data obtained, patterns of usage can be clearly seen. This example has a regular fall in consumption at the weekend, due to peak activity only taking place between Monday and Friday. By analysing this, it should be possible to identify any spikes in usage at the weekend, such as on Sunday 14th as per the example above. This may indicate an issue, such as equipment being left on when it should have been switched off. If an issue is identified, this helps to build the case for intervention relating to Stage One (Use Less) of the Energy Hierarchy.

Having profiled activities and equipment against energy consumption, it is then possible to create a top-level profile. This highlights how energy is consumed, based on the equipment and activities that result in the highest proportion of consumption. The Carbon Trust's energy benchmark tool is a useful toolkit to assist with this process. A consultant engaged to undertake an energy audit will be able to create a profile, having analysed the energy consumption and completed the audit.

Figure 7 below shows how a profile can be presented, based on electricity consumption. In this example, lighting accounts for the highest proportion of energy use. A profile can help to build the case, in this instance, for reducing energy consumption by replacing the lighting (depending on the lighting types present). This may not necessarily mean there are any energy efficiency issues, rather it may be that lighting accounts for the highest level of consumption, due to the nature of activity on the site.

SERVICE	KWh Annual Consumption (Est.)	% Annual Consumption (Est.)
Lighting	74,598	78%
Computers and Office Equipment	3,295	3%
Appliances	1,909	2%
Heating, Cooling & Processes	15,412	16%
Total Annual Energy Consumption	95,215	

Figure 7: Electricity Consumption Profile

6.2 Recommendations

Assuming there is an opportunity to replace the lighting based on figure 7, then an initial top-level calculation can be produced and presented like the example in figure 8 below. Proposals for installing PIR sensors and making use of natural light, which relate to Stage One (Use Less) of the Energy Hierarchy, will be the first consideration here. However, a case for Stage Two (Use Efficiently) can also be built, based on the recommendation for more energy-efficient lighting. Although this may be then be subject to a more detailed survey by a lighting specialist or funder, the calculation shows the initial savings that could be realised, including electricity (kWh), financial and overall payback. To create more detailed cost savings and calculations, an additional cost may be incurred to produce an investment-grade proposal, which is needed for some measures. However, having an initial calculation, such as that shown in figure 8 below, will help to build a business case. It is also worth mentioning that the figures below do not include any additional savings such as maintenance, given that upgraded lights may not need to be replaced as often.

	Annual Lighting Consumption per Annum (kWh)	Annual Lighting Cost per Annum (£)	Annual Savings (kWh)	Annual Savings (£)	Net cost of Initiative only (£)	Payback Period (Years)
Current Lighting Scheme	74,598	£7,460				
Replace with LED Lighting	23,767	£3,327	50,832	£4,132	£4,744	1.1

Figure 8: Potential Savings Based on a Lighting Upgrade

There will be further Hub guides produced on specific technologies, which will provide more information to support the implementation of renewable energy-efficiency measures as indicated by Stage Three (Use Renewable Energy) of the Energy Hierarchy.

While lighting upgrades can be undertaken with minimal payback periods, for a measure like the installation of solar PV, the payback period is often significantly longer, usually around ten years at the time of writing. However, when blended with other measures and technologies, it may be possible to reduce this payback period and make the technology more viable from an investment perspective. This is illustrated in figure 9 below, where the payback on solar PV can be reduced from 9.3 to 6.9 years, if blended with a lighting upgrade, automatic meter reading and HVAC controls.

	Cost (£)	Saving (£)	Saving (kWh)	PayBack (Years)	Saving (tCO2)
Lighting	£1,430	£753	3,389	1.9	1.5
Automatic Meter Reading	£17,480	£14,953	148,853	1.2	60.6
HVAC Controls	£2,800	£1,431	16,457	2.0	7.0
Solar PV	£389,000	£42,051	512,000	9.3	96.0
TOTAL	£410,710	£59,188	680,699	6.9	165.1

Figure 9: Potential Savings Based on Blended Measures

Legal Disclaimer

While the Greater South East Energy Hub has made every attempt to ensure that the information obtained in this guide is accurate, it is not responsible for any errors or omissions, or for the results obtained from the use of this information. All information is provided as is, with no guarantee of completeness, accuracy, or timeliness.

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