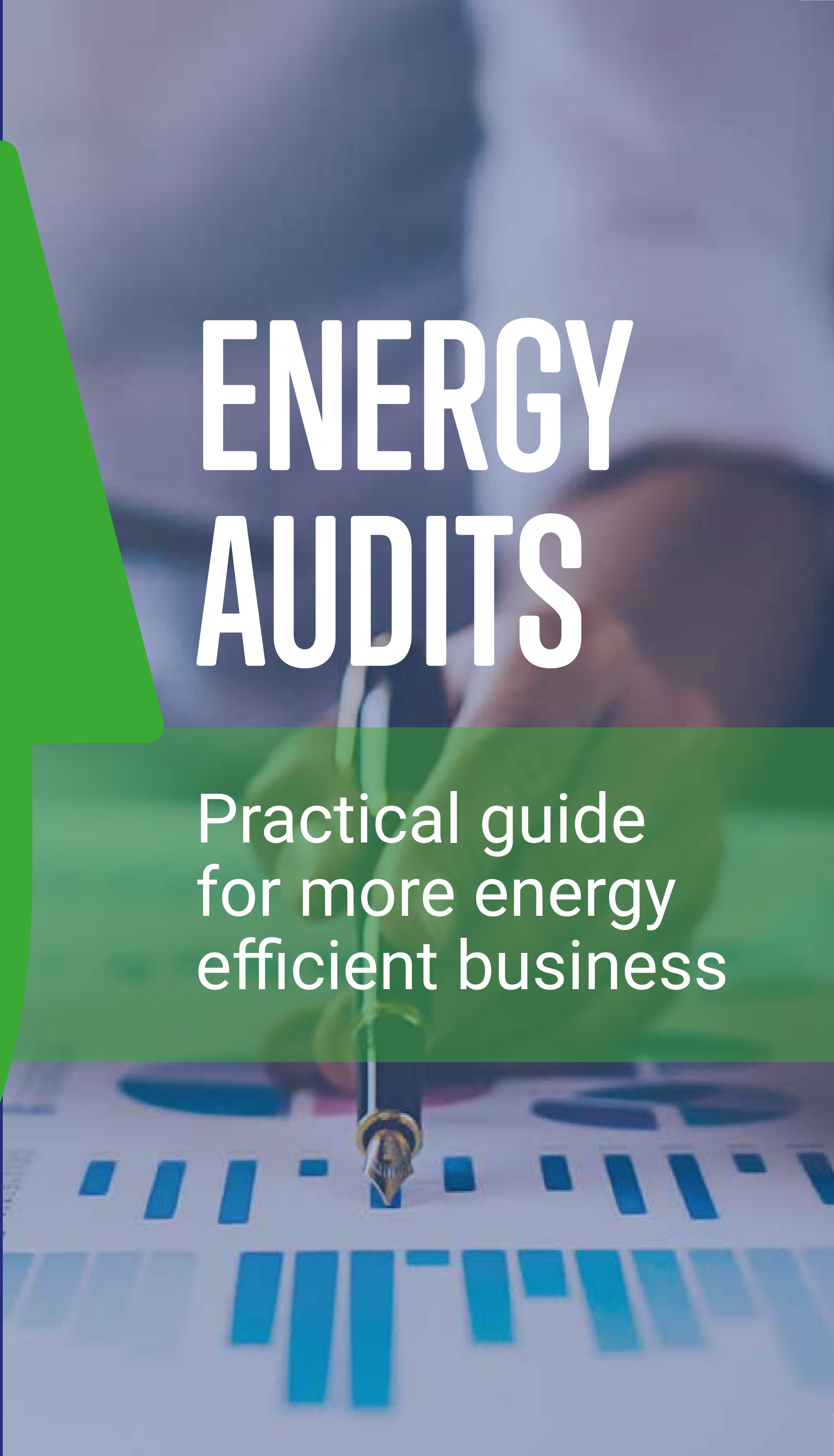

ENERGY AUDITS

Practical guide for more energy efficient business

LEAP4SME

ENERGY AUDIT POLICIES TO DRIVE ENERGY EFFICIENCY

This booklet has been developed by the LEAP4SME project. Bringing together nine national energy agencies, LEAP4SME aims to support European countries in establishing or improving effective policies for SMEs to undergo energy audits and implement cost-effective, recommended energy-saving measures through identifying the barriers for unlocking energy efficiency measures, mobilising private stakeholders, and proposing effective solutions to realise both energy and non-energy benefits.

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SMALL BUSINESSES AT THE HEART OF THE ENERGY TRANSITION

Welcome to this energy audit handbook. This is a practical guide on how energy audits can help small and medium-sized businesses (SMEs) become more energy efficient – making them more sustainable, more profitable, and better prepared for the future.

In Europe there are 25 million SMEs representing 99% of European businesses. They are the backbone of the EU economy. They employ around 100 million people, account for more than half of Europe's GDP, and provide two out of every three jobs. Almost a quarter of SMEs in Europe already enable the energy transition by offering green products or services.

As energy price volatility and uncertainties hamper SMEs' growth, becoming more energy efficient can help alleviate these risks and make businesses more resilient moving forward.

One of the key enablers of energy efficiency transformations in businesses are **energy audits.**

WHAT IS AN ENERGY AUDIT?

An energy audit is a 'systematic procedure' with the purpose of obtaining adequate knowledge of the existing energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy savings opportunities, and reporting the findings.

Undertaking an energy audit ensures the reduction of energy use, leading to lower energy bills. It also aids the reduction of any carbon footprint and improves overall energy efficiency by continuously finding new ways to conserve energy.

Energy audits can potentially bring significant benefits:

Financial benefits which contribute to a reduction in operating costs and an increase in the profits of an organisation (these must be assessed against the cost of implementation of the energy efficiency measures). It will also effectively 'green' a business, thus increasing market competitiveness.

Operational benefits that assist the management of an industrial site or building, improving the comfort, safety, and productivity of its occupants or simply improve its general operation.

Environmental benefits with the reduction of CO_2 or other greenhouse gas (GHG) emissions. On a wider scale they can lead to the reduction of national energy demand and the conservation of natural resources.

HOW DOES AN ENERGY AUDIT WORK?

The European standard EN 16247-1 (2012) provides the framework for efficient energy audits and is acknowledged as the baseline for information on them.

The goal of an energy audit is to identify energy flows and the potential for energy efficiency improvements. The next step is to assign a monetary value to various measures through investment and economic efficiency studies, so that companies can quickly see which investments pay off over time.

The usual energy audit process is comprised of the following steps:

STEP 1
PRELIMINARY CONTACT

STEP 2
START-UP MEETING

STEP 3
DATA COLLECTION

STEP 4
FIELD WORK

STEP 5
ANALYSIS

STEP 6
REPORTING

STEP 7
FINAL MEETING

STEP 1 - PRELIMINARY CONTACT

The energy auditor must set the framework of the consultancy with the client organisation. In particular, the goals and expectations of the consultancy must be defined, as well as the criteria which will be used to measure energy efficiency.

STEP 2 - START-UP MEETING

The data to be supplied, the requirements for measurements and procedures for installing the measuring equipment are defined. Concrete agreements about the practical performance of the energy audit should also be made. This includes the company nominating a person responsible for assisting with the energy audit.

Preliminary analysis of relevant data provided by the client organisation can help the auditor to carry out more effective on-site work, as it can highlight potential areas for further investigation. Such areas might include periods with spikes in energy use or any particularly regulatory considerations. These will help identify the measurements that need to be taken.

STEP 3 - DATA COLLECTION

The energy auditor will collect information and data such as:

Electricity bills, other fuel bills, meter registration system operator (MRSO) data, gas point registration number data, or access to online billing data. The energy billing information should span a minimum of one year but ideally should include the previous three years, or a full operating cycle.

Energy monitoring software and data sets, copies of building layout drawings, piping and instrumentation diagram/drawings, site plans, asset or equipment lists, process diagrams, and activity metrics data such as production output or occupancy weather data.

Historic energy performance information, such as previous energy audits. Known opportunities for energy efficiency improvements may also be beneficial at this stage.

STEP 4 - FIELD WORK

The energy auditor must inspect the facility to be audited to assess the energy use and investigate those areas and processes where additional data is required. Workflows and user behaviour and their influence on energy consumption and efficiency need to be assessed. This is the basis for the first recommendations for improvement. Measurements should be taken under real conditions and should be reliable.

MEASUREMENT PLANNING AND REQUESTED MEASURING INSTRUMENTS

During the energy audit, portable or fixed measuring instruments are used for data collection. Some of them have the capability to give an electrical output signal, which allows a PC to monitor measurements and collect data.

Table 1 shows the appropriate measuring equipment for various systems that could be tested during an energy audit.

Table 1 Instrument Types

Electrical Systems	Temperature Measurement	Exhaust gases measurements	Compressed Air
• Ammeter • Voltmeter • Watt-meter • Cos-Phi meter • Multi-meter • Power analyser	• Resistance Thermometer Detectors (RTD) • Thermocouples • Thermistors • Infrared thermometers	• Gas analyser	• Ultrasonic leak detectors

Flow measurements	Air humidity	Other necessary measurement
• Differential pressure meters (of perforated diaphragm, Venturi or Pitot tube type). • Interference meters (of variable cross section, positive shift, eddy or vortex metering type). • Non-interference meters (of ultrasonic or magnetic meter type). • Mass meters (of Coriolis or angular momentum type).	• Dry and wet bulb thermometers • Psychrometer • Lithium chloride cell • Humidity meter with ion exchange resin sensor (pope type) • Digital humidity meter • Thermo-hydrograph	• Luminance level measurements • Measurements of the Total Dissolved Solids (TDS) in the boiler's water • Pressure measurements • Measurements for monitoring the steam-traps' condition

ANALYSIS OF CURRENT AND PAST PERFORMANCE

Analysis of information supplied by the client, site visit observations and metering results help the auditor gain a thorough understanding of energy usage profiles across the site. It also helps to develop a better understanding of the processes carried out and the types of technologies used and to determine specific areas on which the audit should concentrate.

The billing information and, possibly, energy metering information should be analysed to determine if there are any trends in consumption patterns, as well as if any unnecessary charges have occurred. The historical meter data provided on request by the MRSO can be instrumental in conducting a high-level analysis of organisational consumption and trends.

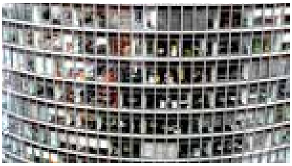
The energy consumption profiles identified from bills or the energy monitoring systems can be further analysed using statistical analysis techniques such as regression analysis. This may be used to gain greater insight into what is driving changes in the facility's energy consumption.

SITE VISIT

The purpose of the site visit is to collect the information needed to conduct an appropriate energy analysis, including sufficient information to inform an energy model and financial analysis.

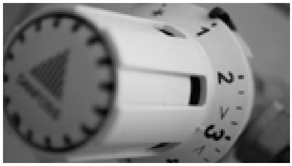
During the site visit the energy auditor records the existing processes, takes measurements and, finally, elaborates on the collected data. The auditor also has a discussion with the company's managerial staff, so that possible energy efficiency interventions may be assigned.

IDENTIFYING ENERGY CONSUMERS

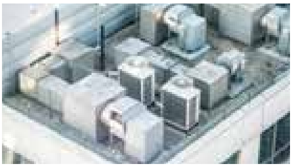


Buildings

Lighting



Heating and boilers



Heating, ventilation and air conditioning (HVAC)

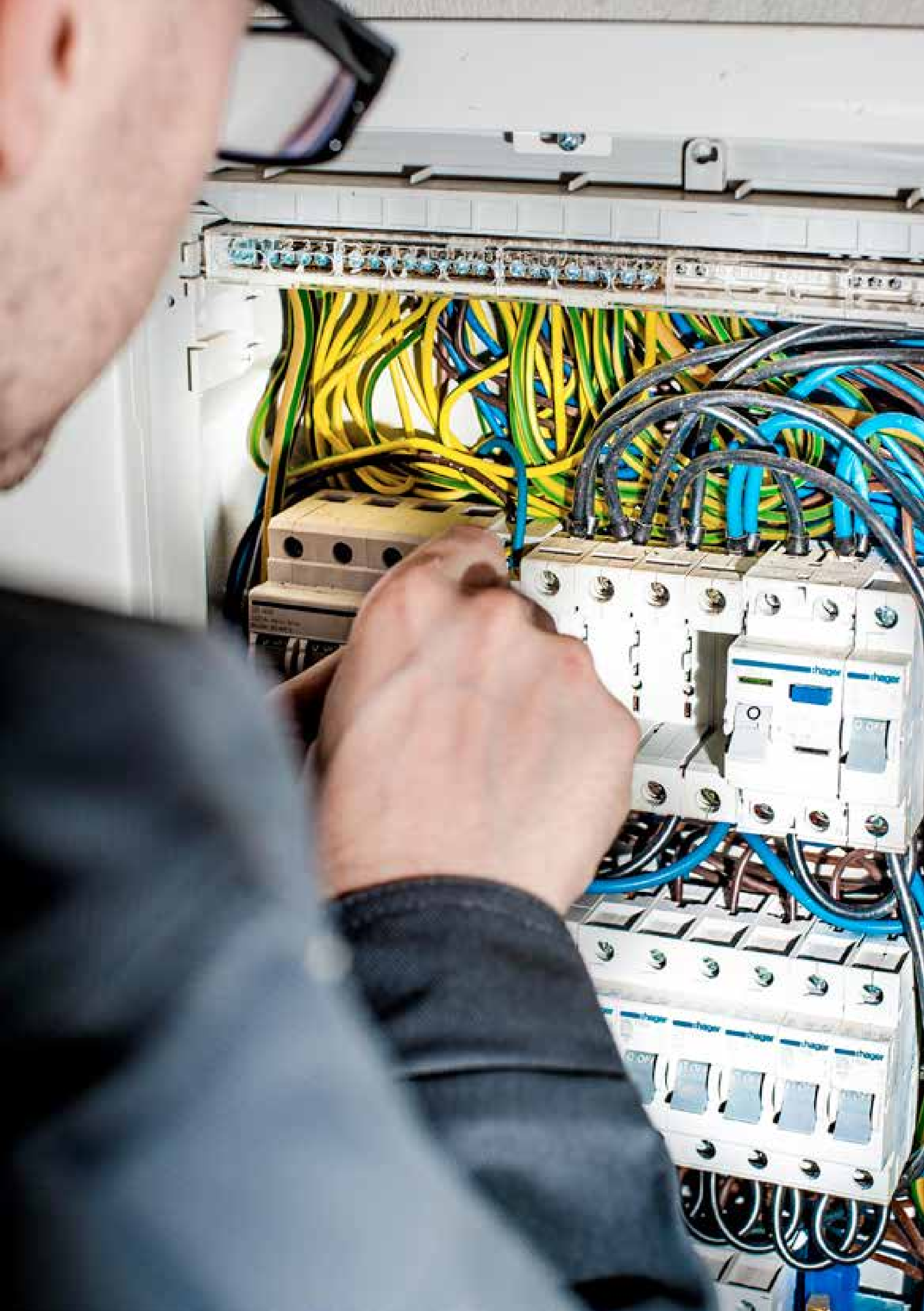
Pumps

Refrigeration and cooling

Industrial processes

Compressed air

Transport



BUILDINGS

Residential and commercial buildings consume a large amount of energy. Energy efficiency improvements can reduce the cost for energy, the GHG emissions and improve the quality of both living and working conditions.

What to check	Typical opportunities
• The building shell for inadequate insulation, thermal bridges or hot spots • Doors and windows if they remain open during cold weather • Doors for their size and if they remain open in heated or air-conditioned spaces • Windows for leaks and type of glazing, single or double etc. • Building equipment such as HVAC, ventilation and lighting systems, for opportunities for energy efficiency improvements • Poorly utilised space	• Sealing of building leakages and replacing damaged insulation • Installing window shading, window films and/or high-performance windows • Correcting air/water flow rate • Closing of doors, windows • Switching off lifts and escalators during off peak period • Adopting natural or mechanical ventilation when possible • Identifying over heating/cooling of areas • Reducing heating system activity during unoccupied periods • Installing additional switches and controllers • Installing or improving use of the building management system • Using energy efficient office equipment • Installing occupancy and daylight sensors

LIGHTING

Lighting accounts for a significant portion of the energy use in buildings or facilities. In addition, heat generated by lighting contributes to the thermal load to be removed by the cooling equipment.

What to check

- Lighting level too high
- Lighting along window areas turned on during daylight hours
- Lighting remains on outside the office area, for unoccupied areas and/or where its use is redundant
- Manual control for lighting
- Use of incandescent lamps
- Not enough lighting control switches
- Dirty lighting

Typical opportunities

- Disconnecting power supply to some fittings
- Turning off perimeter lightings
- Installing time switches
- Installing occupancy sensors
- Removing unnecessary lighting
- Installing occupancy sensors
- Installing more switches
- Lowering lighting levels for areas where it is too bright
- Cleaning lighting
- Reducing lighting operational hours
- Using reflective lighting shelves to transmit light inside
- Establishing correct quantity and quality of light
- Increasing luminaire efficiency

HEATING AND BOILERS

Another significant energy cost comes from heating systems, such as high-temperature fluids (e.g. thermal oil), steam and hot water systems, and those used for space and process heating in buildings.

It is essential to identify areas of inefficiency and opportunity. An energy audit will include the analysis of extensive use of flow, pressure, temperature, and fuel consumption.

What to check	Typical opportunities
• Air-fuel ratios • Oxygen level in flue gas • Specific fuel consumption • Waste heat recovery • Thermal insulation of boilers/ furnaces	• Selecting correct rating of blower as per manufacturers' recommendation • Placing blower near to the furnace to avoid transmission loss • Regular maintenance of blower impeller • Regularly planned maintenance of boilers/furnaces (measurements, adjustments, cleanings) • Replacing old boilers with new ones with higher efficiency • Installing a separate boiler for domestic hot water • Check for the possibility of combined heat and power (CHP) systems in large installations

HEATING, VENTILATION AND AIR CONDITIONING (HVAC)

HVAC systems maintain and control air temperature and humidity levels to provide an adequate indoor environment for people activity or for processing goods.

The cost of operating an HVAC system can be significant in commercial buildings and in some industrial facilities. It is important for auditors to recognise some of the characteristics of the HVAC systems and determine if any retrofits can be recommended to improve their energy consumption.

What to check

- Equipment operating beyond their economic life expectancy
- Inefficient air-cooled chillers
- Outdated control systems
- Air flow controlled by inlet guide vanes
- No blinds or blinds not being closed
- Overcooled spots due to improper air/water balancing
- Lack of individual control
- Poorly maintained systems
- Doors or windows left open when AC is on
- Too cold in summer or too hot in winter
- Excessive pressure drops across filters
- Excessive ventilation

Typical opportunities

- Reminding the last person to turn off AC, or installing time switches and occupancy sensors
- Closing doors and windows
- Re-setting thermostats
- Cleaning filters
- Disabling manual control
- Adjusting fresh air dampers
- Installing or closing blinds
- Adding dampers/valves if required and balance the system
- Adding controller
- Improving maintenance procedures
- Replacing with energy efficient equipment

PUMPS

The main function of pumps is to convert energy of a prime mover (usually electricity) into kinetic energy.

Pumps are one of the largest consumers of electricity. Energy audits can provide valuable information about the operation of the pumping equipment in buildings, industrial processes and water and wastewater treatment.

What to check	Typical opportunities
• The peak flow and head requirement and its duration • The most common flow and head requirement and its duration • Design specification, commissioning sheets and maintenance records • Current requirements compared with what the pump was originally designed to handle • If a VSD is fitted, whether a speed adjustment could deliver better kWh/m3 • Are any valves throttled? • Is the liquid velocity within the typical range? • Any parallel pumps with different commissioned values and/or running performance • Evidence of operational problems – cavitation, noise, overheating of fluid, leaking check valves, liquid hammer, suboptimal pump running due to lack of repair to normal pump • Motors overheating and/or unclean	• Replacing old pumps with energy efficient pumps • In multiple pump operations, combining the operation of pumps to avoid throttling • Checking suction, discharging heads and ensuring proper maintenance of the pump • Reducing consumption • Reducing leaks • Lowering pumping system flow rate and/or operating pressure if it is possible • Operating the system for less time each day • Turning off the system when not needed

REFRIGERATION AND COOLING

The amount of energy used in a refrigeration system is largely determined by the overall temperature difference that must be overcome (difference between condensing and evaporating temperature), and the size of the load that must be cooled.

What to check	Typical opportunities
• Potential to use 'free cooling' • Is the capacity of the plant appropriate for the current load? • Does the plant operate at part load for a large portion of the time? • If the condensing and cooling medium temperature difference is appropriate for the plant, according to the design conditions • If the set-points are ideal for the intended application under all conditions • Evidence of maintenance issues and/or difficulties in achieving temperatures • Insulation levels and condition including moisture ingress • Short-cycling of the plant • High pressure drops in liquid circuits • Air leakage into cold spaces due to poor housekeeping or maintenance • Fouling (or icing) of evaporators, condensers, or heat exchangers	• Using free cooling where the process temperature required is higher than the ambient • Reducing condensing temperature when ambient conditions are lower • Minimising auxiliary loads such as circulation pumps, depending on load requirements • Running more condenser fans to reduce condensing temperature when the load is lower • Maximising cooled space or medium and evaporating temperatures • Reducing air leakage through use of a fast-acting door, air curtains, strip curtains, dedicated personnel doors • Optimising defrost cycles • Optimising time controls for plant operation • Installing Variable Speed Drives (VSD) • Splitting plant to serve loads at different temperatures • Replacing equipment with more efficient options • Using a heat pump to provide cooling and heating process water simultaneously

INDUSTRIAL PROCESSES

The industrial sector uses more delivered energy than any other end-use sector, consuming about one third of the world's total delivered energy.

Energy is used in the industrial sector for a wide number of industrial processes, with many opportunities for savings and increase energy efficiency.

What to check	Typical opportunities
• General plant information • Furnace data • Fixtures, trays, conveyors, etc. • Wall surface heat losses • Water or air cooling (internal) • Atmosphere or makeup air • Flue gases • Radiation losses from openings • Power use by electric motors and other devices • Other heat loss or generation separation processes • Process control and energy management • Process integration and process intensification • Refrigeration • Heat pumps, transformers and organic Rankine cycle • High-temperature CHP • Combustion techniques	• Installing pipeline insulation • Reducing set point pressure • Utilising energy-efficient belts and other improved mechanisms • Controlling excess air ratio • Installing VSD motors • Turning off unused equipment • Recovering heat from compressed air systems and/or exhaust (flue) gas • Optimising power factor for a facility

COMPRESSED AIR

Compressed air is another large energy user in industry, but, due to its ease of use, it is often used inappropriately.

What to check	Typical opportunities
• The location of the compressor and the quality of air drawn by the compressors • Ensuring dust-free air intake • Identify leaks • Compressor lubrication • Pressure drops: inadequate pipe size, choked filter elements, improperly sized couplings and hoses	• Locating the compressor away from heat sources and other items of equipment that radiate heat. The compressor should be located such that it draws cool • Avoiding any moisture in the inlet air to the compressor as this will affect its performance adversely. The compressor should be placed away from equipment which may add moisture to the atmosphere, for example, rinsing lines, cooling towers, dryer exhaust, etc. • Cleaning inlet air filters at regular intervals to minimise pressure drops • Avoiding air leaks and associated energy losses and conduct leakage tests regularly to remove air leaks in the compressed air system • Changing the oil and oil filter regularly • Minimising the pressure drop in the line between the point of generation and the point of use • Don’t allow the compressors to run with loose or vibrating belt

TRANSPORT

The final energy consumption of transport is very important as it consumes final energy at an almost equal level to the building sector.

In the transport sector, it is often relatively easy through simple management measures to generate significant energy savings.

What to check	Typical opportunities
• Energy consumption or hours of operation of each vehicle • Share of each means of transport in the transmission line • Composition of the fleet and vehicles (e.g., permissible maximum weight, fuel consumption, fuel type, and for trucks the size and the European class (Euroclass) of the engine • Possibility to optimise routes • Maintenance plans, control sheet documents for inspections, approvals, and maintenance • Training of drivers or training programmes for other staff or partners to reduce energy consumption and monitor the impact of saving measures. • Energy-related guidance for vehicle procurement • Energy efficiency codes in the transport sector (regarding fuel consumption and CO_2 emissions) • Energy-efficient travel management • Fuel leakage	• Improving maintenance programmes • Instructions for the procurement of vehicles related to energy and CO_2 emissions • Regularly verified driver training and route planning optimisation • Energy consumption and emission reduction measures and technologies • Consumption measurements/ estimates based on efficient indicators and baselines • Alternative business travel management • Alternative staff mobility management

STEP 5 - ANALYSIS

IDENTIFYING & PRIORITISING OPPORTUNITIES

Opportunities may be identified at any stage during the planning and completion of the audit report, however it is useful to record what the client's significant energy users are as early in the process as possible. This helps to ensure that the opportunities identified are focused on those areas that will have the most substantial impact on energy use, carbon emissions, and cost. When the significant energy users have been identified, the drivers for energy use can also be identified.

When generating a register of opportunities, it is useful to look at various types of opportunities. These could be classified as behavioural, organisational and technical.

Methods used in the audit to identify energy savings opportunities may include some, or all of the following:

- Checking energy performance
  - Against manufacturers performance specification handbook
  - Against best practice data
  - Against theoretical minimum energy needed
  - For periods of poor performance against periods of good performance
  - At part load
- Checking energy use during quiet periods, e.g., when the building is closed, at night-time and weekends, or low production times
- Reviewing methods to reduce loads
- Reviewing controls behaviour
- Reviewing feedback/input from maintenance and operations personnel
- Reviewing energy savings opportunities identified by analysis of bills

All identified opportunities should be included in the register, along with any sources and assumptions for calculations of savings and costs of implementation.

The energy savings opportunities should be divided into two prioritised categories: technically feasible recommendations and financially feasible recommendations. Such prioritisation can be based on the main reasons for carrying out the audit – for example, generating the largest possible CO_2 savings, largest kWh of primary energy savings, shortest payback period, highest Net Present Value (NPV), or highest Internal Rate of Return (IRR).

Typically, the main considerations are the:

- Scale of the savings
- Cost of the measures
- Ease of implementation
- Interdependent nature of opportunities and their impact on savings.

FINANCIAL ANALYSIS

Financial analysis of opportunities for energy efficiency improvements is a key step in the audit process. The level of financial analysis depends on the type of opportunity, the size of the investment and the level of risk associated with the various opportunities.

A range of financial analysis tools can be employed at this stage, such as simple payback, net present value, internal rate of return and life cycle cost analysis.

For many of these tools, software applications are available online, which can save time when generating projections for the planned upgrade.

STEP 6 - REPORTING

The exact content of the report of the energy auditor will reflect the scope, aim and thoroughness of the energy audit.

The report of the energy audit should contain:

a. An executive summary ranking the energy efficiency improvement opportunities and including the suggested implementation programme.

b. The background of the audit process (general information of audited organisation, the methodology used, the context, etc.)

c. Energy audit description

d. Energy efficiency improvement opportunities

e. Appropriate profitability analysis

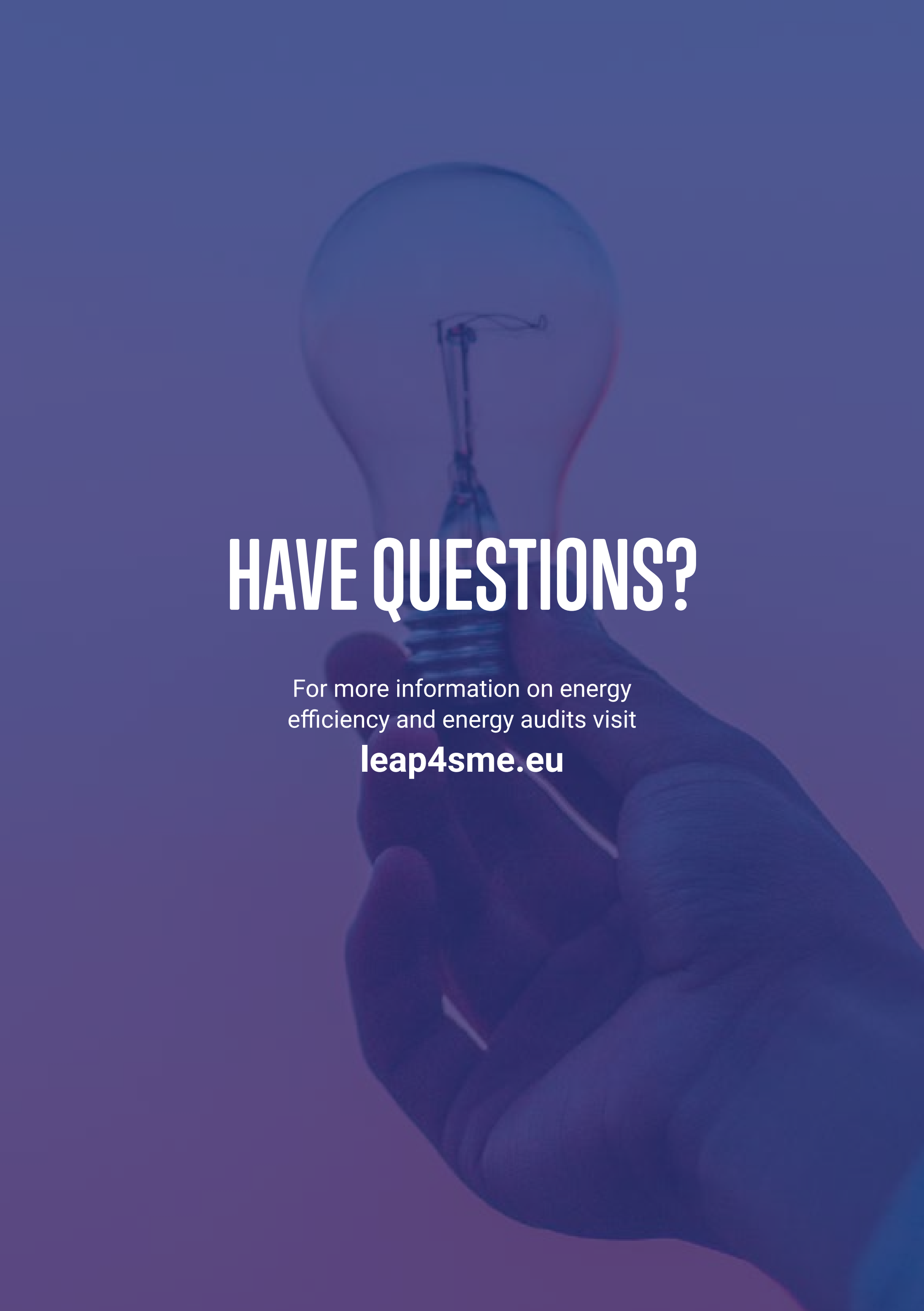
f. Conclusions

STEP 7 - FINAL MEETING

During the final meeting the output of the audit process is presented to the client.

The energy auditor shall:

- Hand over the report on the energy audit,
- Present of the audit findings and conclusions in such a manner that they are understood and acknowledged by the auditee's management,
- Present any related or relevant post-audit activities (e.g., implementation of corrective actions, audit complaint handling, or appeals process).



HAVE QUESTIONS?

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