International Standard

ISO 50002-1

Energy audits —

Part 1: General requirements with guidance for use

Audits énergétiques —

Partie 1: Exigences et recommandations de mise en œuvre

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 301, *Energy management and energy savings*.

This first edition cancels and replaces ISO 50002:2014, which has been technically revised.

The main changes are as follows:

— the terms and definitions have been aligned with ISO 50001:2018;

— new principles have been added;

— decarbonization options have been included in improvement opportunities (renewable energy and achievement of net zero);

— energy auditor competencies have been clarified.

A list of all parts in the ISO 50002 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

0.1 Background

An energy audit comprises multiple yet interlinked activities and processes ranging from establishing the scope of the energy audit, collecting and measuring the appropriate data, analysing the energy performance of an organization, building(s), equipment, system(s) and/or process(es), site observations and using the information to draw conclusions about energy performance improvement actions (EPIAs). The intended result of energy audits is to use a structured and planned process to identify and prioritize EPIAs, which will help reduce wasted energy and can obtain related environmental benefits.

Audit outputs include information on current energy use and performance, and they provide ranked recommendations for improvement that are relevant and practicable. The benefits of carrying out an energy audit include:

— reduced energy consumption;

— economic and financial benefits;

— reduced CO_{2e} emissions and greenhouse gas (GHG) reduction arising from energy use;

— related environmental benefits (e.g. air quality, water reduction);

— distribution of energy use and GHG emissions among various energy systems;

— benchmarking of energy use;

— assessment of energy performance of specific energy systems;

— other benefits (e.g. production efficiencies, maintenance, training).

0.2 ISO 50002series

The ISO 50002 series was revised using ISO 50002:2014 and EN 16247-1:2022 as the starting point. It allows for differences in approach and in terms of scope, boundary and audit objective, and seeks to harmonize common aspects of energy auditing in order to enhance clarity and transparency.

The ISO 50002 series includes the following parts:

— This document provides the principles and defines the common set of requirements for conducting energy audits for buildings, equipment, processes, systems, transport and other applications needed to identify opportunities to improve energy performance. The energy audit process is presented as a simple chronological sequence, but this does not preclude repeated iterations of certain steps.

— ISO 50002-2 provides guidance for using this document when conducting an energy audit of a building or a portfolio of buildings.

— ISO 50002-3 provides guidance for using this document when conducting an energy audit involving processes. This applies to any process that converts an input of an organization into saleable outputs such as a manufacturing process or industrial process.

The ISO 50002 series benefits organizations, energy auditors, and stakeholders worldwide by providing clarity and consistency for designing, developing, conducting and reporting energy audits. Specifically, the use of the ISO 50002 series:

— enhances the credibility and transparency of energy auditing activities;

— promotes a common understanding and expectations between the organization and the energy auditors on the energy audit processes and the roles and responsibilities of each parties;

— facilitates the development and implementation of EPIAs that provide credible and tracible analysis;

— facilitates the ability to track performance and progress of the energy audit activity;

— facilitates the design of energy audit services by organizations providing energy auditing services;

— supports sustainable development and the actions needed to achieve a low-carbon economy.

The applicability of this document to other International Standards is given in Annex B.

0.3 Usingthis document as part of an ISO 50001energy review

An energy audit can be used as part of an ISO 50001 energy review or part of other associated organizational initiatives (e.g. environmental management, sustainability, net zero initiatives). It can also be conducted independent of the organization's other initiatives.

Some organizations implementing an ISO 50001 energy management system can require additional support to implement the technical elements of an ISO 50001 energy review. Using this document as part of an ISO 50001 energy review enables the organization to:

— organize, plan and resource the energy review activities;

— ensure that the activities are carried out by competent energy auditors;

— be able to monitor and track its progress.

Clause B.1 gives additional guidance on how to structure an energy audit as part of an ISO 50001 energy review.

If an energy audit is going to be part of a wider EnMS, the energy auditor can be required to have competence in ISO 50001.

Energy audits —

Part 1:
General requirements with guidance for use

1 Scope

This document specifies:

— the principles of carrying out energy audits;

— the process requirements for carrying out an energy audit in relation to energy performance;

— the roles and responsibilities of the organization and the energy auditor;

— deliverables for energy audits.

It gives guidance on determining and/or evaluating the competence of the energy auditor.

This document is applicable to any organization regardless of its size, complexity, geographical location, organizational culture or the products and services it provides, irrespective of the quantity, use or types of energy used.

This document does not apply to selecting and evaluating the competence of bodies providing energy audit services.

It also does not apply to auditing an organization's energy management system (EnMS), as this is described in ISO 50003.

Additional documents provide information guidance on applying the energy audit process to buildings (see ISO 50002-2), processes (see ISO 50002-3) and other applications or uses.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
audit objective
purpose of an *energy audit* (3.4) agreed between the *organization* (3.18) and the *energy auditor* (3.6)

3.2
boundary
physical and/or organizational limits as agreed between the *organization* (3.18) and the *energy auditor* (3.6) for the purpose of conducting an *energy audit* (3.4)

EXAMPLE A process, a group of processes, a site, multiple sites under the control of an organization, an entire organization.

Note 1 to entry: The boundary of an energy management system can be different from the boundary of an energy audit.

Note 2 to entry: The energy audit can include one or more boundaries.

[SOURCE: ISO 50006:2023, 3.1.2, modified — "virtual" deleted and "as agreed between the organization and the energy auditor for the purpose of conducting an energy audit" replaced "as defined by the entity for a stated purpose". Example added. Notes to entry replaced.]

3.3
energy
electricity, fuels, steam, heat, compressed air and other similar media

Note 1 to entry: For the purposes of this document, energy refers to the various types of energy, including renewable, which can be purchased, stored, treated, used in an equipment or in a process, or recovered.

[SOURCE: ISO 50001:2018, 3.5.1]

3.4
energy audit
systematic analysis of *energy use* (3.16), *energy balance* (3.7) and *energy consumption* (3.9) within a defined *energy audit scope* (3.5) and time frame, in order to identify, quantify and report on the opportunities for improved *energy performance* (3.12)

Note 1 to entry: "Energy audit" is the normal expression in English. There are other expressions for the same concept, e.g. "diagnosi" in Italian and "diagnóstico" in Portuguese.

Note 2 to entry: In industry, "energy audits" and "energy assessment" are both commonly used terms. An assessment deals primarily with examining adherence to a set of concepts and principles and evaluating the outcome through both quantitative and qualitative data. In contrast, the focus of an audit is primarily on procedures and processes that are to be followed.

3.5
energy audit scope
extent of *energy use* (3.16) and related activities to be included in the *energy audit* (3.4), as defined by the *organization* (3.18) in consultation with the *energy auditor* (3.6), which can include several *boundaries* (3.2)

EXAMPLE Organization, facility/facilities, equipment, system(s), process(es).

Note 1 to entry: The energy audit scope can include *energy* (3.3) related to transport.

3.6
energy auditor
individual or team of people conducting an *energy audit* (3.4)

Note 1 to entry: Energy audits can be conducted by the *organization* (3.18) using internal resources or external resources, such as energy consultants and energy service companies.

Note 2 to entry: An energy auditor, whether internal or external, needs to work with internal personnel relevant to the defined *energy audit scope* (3.5).

[SOURCE: EN 16247-1:2022, 3.2, modified — "or team of people" replaced "group of people or body", Note 1 to entry deleted.]

3.7
energy balance
accounting, by energy type and/or *energy use* (3.16), of energy input and energy output of an energy-using system, considering energy storage and energy loss

Note 1 to entry: Energy storage is considered within energy supply or energy use. If included in the *energy audit scope* (3.5), an energy balance needs to include energy storage and feedstock variation, as well as wasted energy or energy content in material flows.

Note 2 to entry: An energy balance reconciles all *energy* (3.3), goods and products that enter the system *boundary* (3.2) against the energy, goods and products leaving the system boundary.

3.8
energy baseline
EnB
value providing a basis for comparison of *energy performance* (3.12)

[SOURCE: ISO 50006:2023, 3.1.4, modified — Notes 1 and 2 to entry deleted.]

3.9
energy consumption
quantity of *energy* (3.3) applied

Note 1 to entry: Energy consumption can be represented in volume (e.g. litres of fuel), mass, weight units or energy units (e.g. GJ, kWh).

[SOURCE: ISO 50006:2023, 3.1.5]

3.10
energy efficiency
ratio or other quantitative relationship between an output of process and an input of *energy* (3.3)

EXAMPLE Conversion efficiency, energy required/energy consumed, theoretical energy used to operate/energy used to operate.

Note 1 to entry: The output of a process can be products, services or energy.

Note 2 to entry: Both input and output should be clearly specified in terms of quantity and quality and should be measurable.

[SOURCE: ISO 50006:2023, 3.16, modified — Example revised.]

3.11
energy flow
description or mapping of processes for transfer of *energy* (3.3) or conversion of energy within the defined *energy audit scope* (3.5)

3.12
energy performance
measurable result(s) related to *energy efficiency* (3.10), *energy use* (3.16) and *energy consumption* (3.9)

[SOURCE: ISO 50001:2018, 3.4.3, modified — Notes 1 and 2 to entry deleted.]

3.13
energy performance improvement
improvement in measurable results of *energy efficiency* (3.10) or *energy consumption* (3.9) related to *energy use* (3.16), compared to a baseline

[SOURCE: ISO 50001:2018, 3.4.6, modified — “a baseline” replaced “the energy baseline”.]

3.14
energy performance improvement action
EPIA
action or measure or group of actions or measures implemented or planned within an *organization* (3.18) intended to achieve *energy performance improvement* (3.13) through technological, managerial or operational, behavioural, economical or other changes

[SOURCE: ISO 50015:2014, 3.5]

3.15
energy performance indicator
EnPI
measure used to quantify *energy performance* (3.12)

Note 1 to entry: If the EnPI is used for the demonstration of *energy performance improvement* (3.13), it refers to *energy efficiency* (3.10) or *energy consumption* (3.9).

Note 2 to entry: The EnPI is defined by the *organization* (3.18).

Note 3 to entry: EnPI(s) can be calculated by using an energy model.

[SOURCE: ISO 50006:2023, 3.1.10]

3.16
energy use
energy end-use
application of *energy* (3.3)

EXAMPLE Ventilation, lighting, heating, cooling, transportation, processes, data storage.

Note 1 to entry: Energy use is based on "what the energy is used for" as compared to *energy consumption* (3.9) which is based on "how much energy is used".

Note 2 to entry: The application can be from any energy type including renewables.

[SOURCE: ISO 50006:2023, 3.1.7]

3.17
normalization
process to enable analysis under equivalent or standard conditions

Note 1 to entry: Normalization can be used for the purpose of comparison of *energy performance* (3.12) or *energy performance improvement* (3.13), which accounts for the changes in *relevant variables* (3.19).

[SOURCE: ISO 50006:2023, 3.1.13]

3.18
organization
person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives, and that has the authority to control its *energy use* (3.16) and consumption

Note 1 to entry: The concept of an organization includes, but is not limited to, sole-trader, company, corporation, firm, enterprise, authority, partnership, charity or institution or part or combination thereof, whether incorporated or not, public or private.

Note 2 to entry: The person or an organization requesting an *energy audit* (3.4) can be called a "client". The subject of the energy audit can be called an "auditee". Their roles and responsibilities in the energy audit can be different.

[SOURCE: ISO 50001:2018, 3.1.1, modified — "and that has the authority to control its energy use and consumption" added to the definition. Note 2 to entry added.]

3.19
relevant variable
quantifiable factor that significantly impacts *energy performance* (3.12) and routinely changes

Note 1 to entry: Significance criteria are discussed and agreed between the *energy auditor* (3.6) and the *organization* (3.18).

EXAMPLE Weather conditions, operating conditions (indoor temperature, light level), working hours, production output.

[SOURCE: ISO 50006:2023, 3.1.15, modified — "determined by" replaced "discussed and agreed between the energy auditor and" in Note 1 to entry. Note 2 to entry deleted.]

3.20
risk
effect of uncertainty

Note 1 to entry: An effect is a deviation from the expected – positive or negative.

Note 2 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.

Note 3 to entry: Risk is often characterized by reference to potential "events" and "consequences", or a combination of these.

Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated "likelihood" of occurrence.

[SOURCE: ISO 50001:2018, 3.4.11]

3.21
sampling
method of studying from representative selected audited objects, instead of the entire number of objects

Note 1 to entry: The selection is called a "sample".

Note 2 to entry: The principle of sampling is to analyse the samples selected in order to issue recommendations that will be valid for all audited objects.

3.22
significant energy use
SEU
energy use (3.16) accounting for substantial *energy consumption* (3.9) and/or offering considerable potential for *energy performance improvement* (3.13)

Note 1 to entry: Significance criteria are discussed and agreed between the *energy auditor* (3.6) and the *organization* (3.18).

Note 2 to entry: SEUs can be facilities, systems, processes or equipment.

[SOURCE: ISO 50001:2018, 3.5.6 — "discussed and agreed between the energy auditor and" replaced "determined by" in Note 1 to entry.]

3.23
static factor
identified factor that significantly impacts *energy performance* (3.12) and does not routinely change

Note 1 to entry: Significance criteria are discussed and agreed between the *energy auditor* (3.6) and the *organization* (3.18).

EXAMPLE Facility size, design of installed equipment, number of weekly shifts, range of products.

[SOURCE: ISO 50015:2014, 3.22, modified — "significantly" added to the definition. Note 1 to entry added. Example 1 modified. Example 2 deleted.]

4 Principles of energy auditing

4.1 General

An energy audit is characterized by reliance on a number of principles. These principles help to make the energy audit an effective and reliable tool in support of management decisions and controls by providing information on which an organization can act in order to improve its energy performance.

Adherence to these principles provides a consistent approach to an effective energy audit that enables energy auditors, working independently from one another, to reach similar conclusions in similar circumstances.

Clauses 5 and 6 are based on the principles outlined in 4.2 to 4.8.

4.2 Competency

The energy auditor should undertake the energy audit if suitably competent to do so within the agreed energy audit scope, boundaries and audit objectives. The energy auditor should also plan to conduct the energy audit ethically, truthfully and accurately. The minimum level of competence required for an energy auditor is described in Clause 6.

4.3 Confidentiality

The confidentiality of the audit deliverables should be agreed upon by the organization and the auditor prior to the start of the energy audit. Energy audit information shall not be used inappropriately for personal gain by the energy auditor or in a manner detrimental to the legitimate interest of the organization.

NOTE This concept includes the proper handling of sensitive or confidential information and data.

4.4 Objectivity

The energy auditor should act independently, in an impartial manner and with due professional care. Conflicts of interest (personal, financial or other) should be identified and disclosed to the organization in a timely manner.

If the organization intends to carry out an energy audit using internal personnel, every effort should be made to remove bias and encourage objectivity.

4.5 Access to equipment, resources and information

For completion of the energy audit based on the defined energy audit scope and boundaries, access is required to:

a) the organization, site(s), asset(s), equipment, system(s) and energy-using process(es);

b) personnel (engineering, operations, maintenance, etc.), their equipment vendors, contractors and others to collect information pertinent and useful to the energy audit and analysis of data;

c) other information sources, such as drawings, manuals, test reports, historical utility bill information, monitoring and control data, electrical equipment panels and calibration records.

4.6 Evidence-based approach

The energy audit should be based on representative data drawn from typical operation, measurements and observations collected. On-site measurements should be obtained based on a traceable, accurate and repeatable manner. Identified energy performance opportunities should be analysed and quantified using appropriate data and technical and economic analysis.

NOTE Appropriate analysis is consistent with the energy audit scope and sufficiently detailed to allow for effective decision-making.

4.7 Risk-based approach

The risk should substantively influence the planning, conducting and reporting of energy audits in order to ensure that audits are focused on matters that are significant for the audit client, and for achieving the audit programme objectives.

When an organization conducts an energy audit, they should consider the energy performance risks to the organization and the opportunities to improve its energy performance towards a defined intended outcome.

4.8 Communication

Clear lines of communication are essential for the energy auditor, both among the team and with the organization. Communication channels and methods necessary to facilitate the audit should be established in a timely manner.

5 Performing an energy audit

5.1 General

The energy audit process consists of the following stages, as illustrated in Figure 1. The extent to which the stages are applicable, the inclusion of new stage(s), the sequence or repeated iterations depends on the objectives and scope of the energy audit agreed between the organization and the energy auditor:

a) planning (see 5.2);

b) opening meeting (see 5.3);

c) data collection (see 5.4);

d) measurement plan (see 5.5);

e) site visit (see 5.6);

f) analysis (see 5.7);

g) reporting (see 5.8);

h) closing meeting (see 5.9).

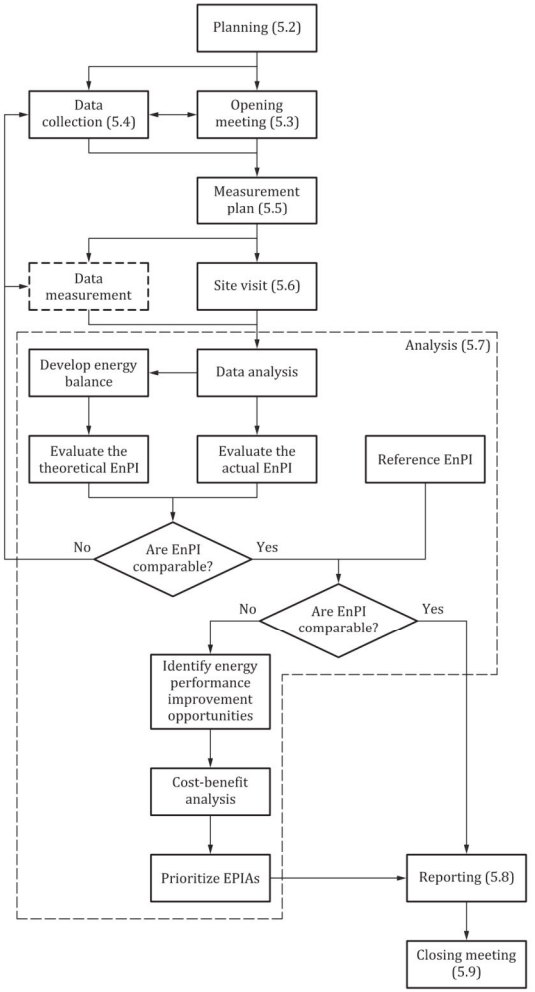

Figure 1 — Energy audit process flow diagram

5.2 Planning

Planning activities are essential to define the energy audit scope and objective(s), and to gather preliminary information from the organization to understand the organization structure and operations, and to plan for the energy audit.

In order to develop the energy audit scope and ensure an effective energy audit is conducted, the following applies:

a) the energy auditor and the organization shall agree on:

   1) the energy audit scope, boundaries and objective(s);

   2) needs and expectations to achieve the audit objectives;

      EXAMPLE 1 Comply with legal requirements, contractual obligations, voluntary obligations, the organization's aspirations towards climate change mitigation, adaptation and net zero goals.

   3) the level of detail required;

      NOTE 1 Annex A provides guidance that can be useful at the planning stage, including the three indicative levels of audit described in A.2.1.

      NOTE 2 Legal requirements can supersede the lower level(s) of energy audit.

   4) the energy audit schedule and agenda;

   5) criteria for evaluating and ranking opportunities to improve energy performance;

      EXAMPLE 2 Return on investment; potential energy performance improvement over time; life cycle costing; incremental cost analysis for replacement with more energy efficient equipment over the current equipment; simple payback period.

      NOTE 3 Opportunities for improving energy performance can include non-energy benefits and non-energy costs when applicable.

   6) time commitments and other resources from the organization;

   7) relevant data to be made available prior to the start of the energy audit;

      EXAMPLE 3 Drawings; plant layout; process and/or activity description; historical energy consumption; utility and other bills when appropriately verified; equipment manuals and other technical documentation, including planned measurement and/or inspections to be made during the energy audit.

   8) expected deliverables and report format;

   9) whether a draft of the final report shall be presented to the organization for comment;

   10) the organization's representative responsible for the energy audit process;

   11) roles, responsibilities and authority of the energy auditor, organization, and, if applicable, guides and observers;

      NOTE 4 Annex A provides guidance on the typical roles and responsibilities during an energy audit.

   12) the process for agreeing on any change in the objective(s), energy audit scope and data collection;

b) the energy auditor shall request information that can affect the outcome of the energy audit, including, as applicable:

   1) legal requirements and other requirements or constraints affecting the scope or other aspects of the proposed energy audit;

   2) strategic plans that can affect the organization's energy performance;

      EXAMPLE 4 Asset management plans; changing product mix; expansion plans; planned projects; outsourcing facilities management or equipment maintenance.

   3) management systems, such as environmental, quality, energy management or others;

   4) access to equipment, resources, systems, processes, services and information related to the energy audit scope;

5) factors or special considerations that can change the energy audit scope, process and conclusions;

6) any considerations, even subjective ones, including existing opinions, ideas and restrictions relating to potential energy performance improvement measures;

c) the energy auditor shall inform the organization of:

1) commercial or other interests which can influence their conclusions or recommendations;

2) any other conflict of interest issues;

d) the auditee should inform the auditor of any specific access, security requirements, and health and safety preparations within the scope and boundary of the audit (these requirements should be applied and adhered to throughout the audit process);

e) the energy auditor shall determine the feasibility of the energy audit to provide reasonable confidence that the audit objectives can be achieved.

5.3 Opening meeting

The purpose of the opening meeting is to review the energy audit objectives, energy audit scope, boundaries and methods, introduce the energy auditors and the arrangements for the energy audit (e.g. site safety inductions, access, security).

NOTE A meeting can include telephone calls, teleconferencing and other electronic/remote contact methods.

The energy auditor shall request that the organization:

a) assigns personnel or appropriate individuals constituted as a team to assist the energy auditor: these individuals shall have the necessary competences and authority to request or carry out direct operations on processes and equipment, and support the defined energy audit scope and objectives;

b) informs the appropriate personnel and other interested parties about the energy audit, their roles, responsibilities, cooperation and any requirements placed on them;

c) ensures the cooperation of affected parties, leveraging the experience of the energy auditor and the knowledge of the organization;

d) confirms any unusual conditions that can affect the energy audit or energy performance, i.e. maintenance work, special visits (customer, regulatory, etc.), significant changes in production volumes and others.

Where the energy auditor is not an individual, a member of the energy auditing team shall be nominated as lead energy auditor.

The energy auditor shall agree with the organization on:

— arrangements for access, as required by the defined energy audit scope for the energy auditor;

— requirements for health, safety, security, and emergency rules and procedures;

— availability of resources, including energy data and the need for additional metering;

— applicable non-disclosure agreements;

— requirements for any special measurements, if needed;

— procedures to be followed for installation of measuring equipment, if needed.

5.4 Data collection

Where available, the energy auditor shall collect and collate the appropriate energy data subject to the energy audit objectives and energy audit scope. This should include the following information, as applicable:

a) a list of energy consuming systems, processes and equipment;

b) detailed characteristics of the energy uses within the defined energy audit scope, including relevant variables and how the organization believes they impact energy performance;

c) historical and current energy performance data, including:

   1) energy types;

   2) energy use and consumption;

   3) relevant variables and static factors (if applicable);

   4) relevant related measurements;

      EXAMPLE 1 Equipment or system load measurements; results from a thermographic or compressed air survey.

      EXAMPLE 2 Operational characteristics such as shift timings, labour rate to be used in implementation analysis, equipment capacities and "nameplate" information, waste streams with energy content to consider as alternative fuel feedstock, process description, purchased energy streams such as steam and compressed air.

   5) operational history and past events that have potentially affected energy consumption in the period covered by the data collected;

d) methods used for normalization of energy performance indicator (EnPI) value(s) and their corresponding energy baselines (EnBs) where the organization has data which indicate that relevant variables significantly affect energy performance;

e) monitoring equipment, configuration and analysis information;

   EXAMPLE 3 Local gauges, distributed control systems, instrumentation types.

   NOTE Part of the available data can be collected and collated by an external party, e.g. a utility company.

f) future plans that can affect energy performance;

   EXAMPLE 4 Planned expansions, contractions or changes in production volume.

   EXAMPLE 5 Planned changes in, or replacement of, equipment or systems that have significant energy implications.

   EXAMPLE 6 Removal of facilities, equipment or systems.

g) design, operation and maintenance documents;

   EXAMPLE 7 As-built drawings, equipment specification sheet; plot plan; control system data, energy supply connections and system schematics, asset register.

h) previous energy audits related to energy performance;

i) current energy rate schedule(s) (or tariffs) or a reference rate (or tariff) to be used for financial analysis;

j) other relevant economic data;

k) knowledge on how the organization manages its energy use and consumption;

l) the energy distribution system and its management.

If there are missing data and information, depending on the energy audit scope and level of thoroughness required, the energy auditor shall:

— request the information from the organization;

— plan and conduct additional measurements;

— where quantifying the requested data is not possible, make an assumption about the data and document the assumption made.

5.5 Measurement plan

In cases where the data collected (see 5.4) are not sufficient, the energy auditor may consider the need to carry out additional data measurement and collection. The energy auditor and the organization shall come to an agreement on a measurement plan. In the measurement plan, the minimum content to be considered by the organization shall include:

a) a list of relevant measurement points and their associated processes and measuring equipment;

b) identification of any additional measurement points, suitable measurement equipment, their associated processes and feasibility of installation;

c) accuracy and repeatability required for the measurements and their associated measurement uncertainty;

d) measurement duration and frequency for each measurement (i.e. individual data points or continuous monitoring);

e) acquisition frequency for each measurement;

f) a suitable time period for the activities to be conducted;

g) relevant variables provided by the organization (e.g. operating parameters, production data);

h) responsibilities for carrying out the measurements, including personnel working for, or on behalf of, the organization;

NOTE 1 The people responsible can be from the organization, the energy auditor or an external body such as a subcontractor.

i) (if feasible or practicable) calibration and traceability of measurement equipment;

j) (if feasible or practicable) verification and validation needs.

It is important that some required data, such as historical monthly production and utility and other bills, is provided by the organization. The organization should clarify the accuracy of its own energy, production and other data. The energy auditor confirms whether the analysis is based on accurately metered data and describes how the data has been obtained (i.e. read from a meter, estimated or otherwise calculated) and the analysis verifies that the data sets are comparable.

NOTE 2 Data verification refers to a documented method that is used to verify whether or not the data set is precise, consistent, typical, representative when sampled and unique. The data verification method is able to correct a raw data set so that the verified data set is accurate, consistent and unique. More information about measurement and verification is available in ISO 50015.

Sampling procedures shall be required when it is not practical or cost-effective to examine all available information during an energy audit. Sampling is described in Annex C. Procedures and methods should be selected based on their suitability for the scope of the energy audit.

NOTE 3 Annex A provides additional guidance on the data measurement plan.

If the additional measurements require resources not available during the energy audit, the organization and the energy auditor shall agree on the path forward (e.g. modify the scope of the audit, carry on with the audit and complete it when the resources become available).

5.6 Site visit

The energy auditor shall agree with the organization to:

a) identify one or more individuals to provide access and act as guide and escort for the energy auditor during site visits, as required: these individuals shall have the necessary competences and authority to request or carry out direct operations on processes and equipment, if required;

b) where agreed during the energy audit planning and measurement plan (see 5.5), identify one or more individuals to install data loggers and energy monitoring equipment during site visits: these individuals should have the necessary authority to ask the authorized operation or maintenance personnel to carry out direct operations on processes and equipment, if required;

c) permit the installation of energy monitoring equipment and data loggers as agreed during the energy audit planning;

d) give the energy auditor access to relevant documents (see 5.4);

EXAMPLE Drawings, manuals, other technical documentation.

e) give the energy auditor the authority to interview relevant personnel.

If the organization is unable to meet these requests, the energy auditor should consider whether to revise the energy audit scope.

The energy auditor shall:

— observe the energy uses within the organization and compare with the information provided in 5.4;

— evaluate the energy use and consumption according to the energy audit scope, boundary, audit objective(s) and agreed methods;

— understand the impact of operating routines, user behaviour, relevant variables and static factors (if applicable) on energy performance;

— determine the indicators to be used to monitor energy performance, including their normalization, if needed;

— generate ideas, opportunities, operational and maintenance changes or technologies that can lead to energy performance improvement;

— list areas and processes for which additional data are needed for later analysis;

— ensure that measurements, observations and past data are representative of operational practices;

NOTE 1 Facilities can have two or more modes of operation (e.g. day, night, evening, weekend). There can also be seasonal operational differences (e.g. for a food processing facility).

NOTE 2 It can be beneficial to make observations and measurements outside normal working hours, during shut-down periods or when no weather-related load is expected.

— ensure that historical data provided is representative of normal operation.

If the energy auditor encounters any unexpected difficulties during the energy audit, including access to data and documentation, the energy auditor shall promptly inform the organization of this difficulty and any implications on completing the energy audit.

5.7 Analysis

5.7.1 General

In order to facilitate an effective energy audit, the energy auditor shall evaluate the validity and availability of data provided by the organization and highlight any issues that would prevent the audit from achieving its objectives. If necessary, the energy auditor may propose a different method to collect or supplement the data (see 5.5 and 5.6).

The energy auditor shall:

a) use technically appropriate and verifiable calculation methods;

b) document the methods used and any assumptions or estimates made;

c) ensure that the variables that affect measurement uncertainty and their contribution to the results have been taken into account;

d) consider any regulatory or other agreed schemes or constraints that would impact opportunities for improving energy performance.

5.7.2 Analysis of current energy performance

During this phase, the energy auditor shall establish and evaluate the current energy performance of the energy uses within the defined energy audit scope.

The analysis of the current energy performance provides the basis for evaluating improvements. The analysis shall include:

a) analysis of utility billing and tariff structure;

b) breakdown of the energy consumption by use and type;

c) significant energy use(s) [SEU(s)];

d) where appropriate, the method of normalization and its purpose, namely energy performance or comparison of energy efficiency or energy consumption;

e) where available and comparable, comparison with benchmarks of similar processes;

f) a historical pattern of energy performance;

g) expected energy performance improvement;

h) where appropriate, relationships between energy performance and relevant variables and static factors (if applicable), potentially using a model;

i) an evaluation of the existing EnPIs and, if necessary, proposals for (a) new EnPI(s).

NOTE The procedure of identifying EnPIs described in ISO 50006 can be used.

5.7.3 Identification of energy performance improvement opportunities

The energy auditor shall determine energy performance improvement opportunities based on the results of the data analysis (see 5.7.1 and 5.7.2) and the following:

a) opportunities for improvement proposed by the organization;

b) their own competency and expertise;

c) evaluation of the design and configuration options to address the system needs;

NOTE 1 The minimum energy consumption for a system to deliver an output or service.

d) the operating lifetime, condition, operation and level of maintenance of the audited objects;

e) need for energy resilience and decarbonization;

f) the technology of existing energy uses in comparison with more efficient ones available in the market;

g) management practices and user behaviours;

h) best practices in the operation and maintenance of equipment;

i) future changes in operation.

NOTE 2 Opportunities for improving energy performance can also be complemented by suggestions for alternative energy types, fuel switching, cogeneration, renewable energy sources, etc.

5.7.4 Evaluation of energy performance improvement opportunities

The energy auditor shall evaluate the impact of each opportunity on the current energy performance based on the following:

a) predicted energy performance improvement over an agreed time period or expected operating lifetime;

b) predicted energy-related GHG emissions reduction over an agreed time period or expected operating lifetime;

c) financial evaluation for each improvement opportunity;

d) necessary investments;

e) agreed economics and other criteria identified in the energy audit planning;

f) availability of local, regional and national incentives for implementation;

g) other quantifiable non-energy benefits (such as productivity, maintenance or air quality);

h) potential interactions between various opportunities.

NOTE 1 Depending on the audit objectives and level of detail of the energy audit, additional work to fully identify and quantify impact of opportunities can be required.

NOTE 2 As far as possible, opportunities are assessed over the planned or expected operating lifetime.

Where appropriate to the energy audit scope, boundary and audit objective, the energy auditor may complement these results with additional data and further analysis.

5.7.5 Prioritization of energy performance improvement actions

The energy auditor shall consider whether to prioritize EPIAs based on the following:

a) eliminating the energy use;

b) changing management practices;

c) implementing operational enhancements;

d) implementing best maintenance practices;

e) retrofitting with energy efficient equipment;

f) recovering and reusing energy and other resources *in situ* or in adjacent energy use;

g) implementing alternative processes to manufacture products or provide the same services that are less energy intensive;

h) using renewable energy;

NOTE Renewable energy can refer to renewable energy produced on-site, provided with a guarantee of origin based on local/regional disclosure requirements.

i) options to decarbonize and/or achieve net zero.

5.8 Reporting

5.8.1 General

In accordance with 5.2, the auditor shall agree on a reporting schedule. When reporting the energy audit results, the energy auditor shall:

a) ensure that the organization's requirements have been met, including methods and reporting formats;

b) identify the relevant measurements made during the energy audit, including the following details:

   1) frequency, consistency, accuracy, repeatability and representativeness of the data;

   2) rationale for the measurements and how they contribute to analysis;

   3) difficulties encountered in data collection, site visit and analysis;

   4) measurement and sampling uncertainty and the effects on the reported data;

c) state whether the basis for the analysis is engineering calculations, energy consumption simulations, statistical modelling or estimates;

d) summarize the analyses, detailing any estimates, assumptions and uncertainty;

e) as applicable, state the limits of accuracy for energy performance improvements and costs;

f) provide a prioritized list of EPIAs;

g) suggest recommendations for the implementation of the opportunities.

NOTE Depending on the agreed energy audit scope and level of detail for the energy audit, this can include feasibility for implementation, action steps, known financial incentives, any non-energy benefits, corresponding decarbonization benefits, etc.

5.8.2 Report content

The content of the report shall be appropriate to the defined energy audit scope, boundaries and objective(s) of the energy audit.

The energy audit report shall include the following topics, where applicable:

a) executive summary:

   1) objective of the energy audit;

   2) summary of energy use and consumption;

   3) output of financial analysis;

   4) ranking of opportunities for improving energy performance;

   5) suggested implementation programme;

   6) background;

b) general information on the organization, energy auditor and energy audit methods:

   1) relevant legal requirements and other requirements applicable to the energy audit;

2) statement of confidentiality;

3) context of the energy audit;

4) energy audit description, defined scope and boundaries, audited objective(s) and time frame;

c) energy audit details:

1) information on data collection:

i) measurement plan (see 5.5);

ii) type of data used (acquisition frequency, measurement period, which is measured and which is estimated);

iii) copy or reference to key data used, including test reports, calibration certificates and equipment records in accordance with 5.2 (energy audit planning);

2) information on the SEU(s);

3) analysis of energy performance and any EnPI(s) and the associated EnBs, including the results of benchmarking with equivalent conditions;

4) basis for calculations, estimates and assumptions, and an indication on the resulting accuracy:

i) assumptions and methods used in calculating the reductions in energy consumption and improvements in energy performance, and the resulting accuracy;

ii) assumptions used in calculating the costs of implementation, and the resulting accuracy;

iii) appropriate economic analysis, including known financial incentives, any non-energy benefits and corresponding decarbonization benefits;

5) criteria for ranking opportunities for improving energy performance;

d) opportunities for improving energy performance:

1) a description of recommended EPIAs;

2) predicted energy performance improvements and energy-related GHG emissions reductions of the recommended EPIAs;

3) a suggested implementation programme;

4) potential interactions with other proposed recommendations;

e) measurement and verification methods recommended for use in a post-implementation assessment of the recommended opportunities;

f) conclusions and recommendations.

5.9 Closing meeting

Before the closing meeting, the report on the energy audit shall be provided to the organization.

At the closing meeting the energy auditor shall:

a) present the results of the energy audit in a way that facilitates decision-making by the organization;

b) explain the results and address questions;

c) if applicable, identify items requiring further analysis or follow-up by the energy auditor.

6 Competence of the energy auditor

6.1 General

The energy auditor shall have the knowledge and skills necessary to complete the defined energy audit scope.

The person leading the energy audit team shall have the knowledge and skills necessary to manage and provide leadership to other members of the energy audit team.

NOTE Where there is a single auditor, they are considered to be the energy auditor as well as the lead energy auditor.

6.2 Generic competence of energy auditors

6.2.1 General

The energy auditor shall have competence in the areas described in 6.2.2 to 6.2.5.

6.2.2 Energy audit principles, processes and methods

Competence in this area enables the energy auditor to ensure that energy audits are performed in a consistent and systematic manner. This should include the following:

a) understand the types of risks and opportunities associated with auditing and the principles of the risk-based approach to auditing;

b) define the energy audit objectives, scope and boundary;

c) plan and organize the energy audit activities effectively;

d) perform the energy audit within the agreed time schedule as assigned by the lead energy auditor;

e) communicate effectively, both orally and in writing;

f) collect information through effective interviewing, listening, observing, measuring and reviewing documented information;

g) understand the appropriateness and consequences of using sampling techniques during the energy audit;

h) conduct the energy audit from start to finish, including interrelations with the organization's processes and different functions, where appropriate;

i) assess those factors that can affect the reliability of the energy audit recommendations;

j) document energy audit activities and energy audit findings, and prepare reports;

k) maintain the confidentiality and security of information.

6.2.3 Energy audit standards and other references

Competence in this area enables the energy auditor to understand the energy audit process. This should include the following:

a) energy audit standards or other normative or guidance/supporting documents used to establish energy audit objectives, scope and boundary;

b) the application of the energy audit standards by the energy auditor to the organization;

c) relationships and interactions between the energy audit processes.

6.2.4 Organization and its context

Competence in this area enables the energy auditor to understand the organization's structure, processes and activities. This should include the following:

a) type of organization, governance, size, structure, functions and relationships;

b) needs and expectations of relevant interested parties that impact the energy performance of the organization;

c) general business and management concepts, processes and related terminology, including planning, budgeting and day-to-day operations;

d) cultural and social aspects of the organization.

6.2.5 Applicable legal requirements and other requirements

Competence in this area enables the energy auditor to be aware of, and work within, the organization's requirements related to the organization's activities, processes, products, services and jurisdiction. This should include the following:

a) statutory and regulatory requirements and their governing agencies applicable to the organization's activities, processes, products and services;

b) statutory and regulatory requirements and their governing agencies applicable to energy performance, energy management and associated activities.

Awareness of statutory and regulatory requirements does not imply legal expertise. An energy audit should not be treated as an energy-related legal compliance audit.

6.3 Energy specific competence of energy auditors

The energy auditor shall have the collective discipline and sector-specific competence appropriate for auditing the particular types of energy use, scope, boundaries, audit objectives and sectors. Energy-specific competence should include the following:

a) identify energy use and energy losses within the energy audit scope, and the energy related GHG emissions;

NOTE 1 The term "energy losses" refers to the dissipation or reduction of usable energy in a system, often resulting in a decrease in the overall efficiency of a process. Energy can be lost in various ways, and these losses are prevalent in different systems and devices.

b) techniques of measuring, sampling, sub-metering and establishing an energy balance, and quantification of energy performance;

c) verify the relevance and accuracy of collected information;

d) define any additional energy and other data measurements needs;

e) confirm the accuracy, repeatability and representativeness of energy audit information to support EPIAs;

f) analyse and scrutinize the energy performance information to identify energy performance improvement opportunities;

g) conduct diagnostic analysis and troubleshoot the causes of poor energy performance of energy use within the energy audit scope;

h) describe the EPIAs and their implementation plan;

i) relationship between energy consumption and GHG emissions;

j) evaluate any non-energy benefits (e.g. air quality, water reduction) related to the EPIAs;

k) evaluate the financial and non-financial benefits for the recommended EPIAs;

l) identify the risks and opportunities for the recommended actions to achieve the organization's intended outcome;

m) prepare, present and communicate the findings of an energy audit to a variety of audiences with different levels of energy competence.

NOTE 2 Where a national or local energy auditor certification scheme, or equivalent, is available, a certified energy auditor can be considered. Some schemes can be technology specific.

6.4 Generic competence of a lead energy auditor

In order to facilitate the efficient and effective conduct of the energy audit, a lead energy auditor shall have additional competencies to plan, lead and manage the energy audit process. In order to facilitate the efficient and effective conduct of the energy audit, a lead energy auditor should have the competence to:

a) discuss and agree with the organization on the energy audit objective, scope and boundary, and the intended outcomes of an energy audit;

b) identify and take actions to address any energy audit team competency gaps;

NOTE 1 Applicable actions can include, for example, the provision of training to, the mentoring of or the reassignment of currently employed persons, or the hiring or contracting of competent persons.

c) plan the energy audit and assign audit tasks according to the competence of individual energy auditors;

d) develop and maintain a collaborative working relationship among the energy auditors as well as with the organization;

e) manage the audit process, including:

1) making effective use of resources during the energy audit;

2) managing the uncertainty of achieving audit objectives;

3) protecting the health and safety of the energy auditors during the energy audit, including ensuring compliance of the energy auditors with the relevant health, safety and security arrangements;

4) directing the energy audit team members;

5) providing direction and guidance to energy auditors-in-training;

6) preventing and resolving conflicts and problems that can occur during the energy audit, including those within the energy audit team, as necessary;

f) represent the energy auditor in communications with the organization;

g) lead the audit team to reach the audit conclusions;

h) prepare and complete the energy audit report.

NOTE 2 The energy auditor is encouraged to demonstrate continual professional development to maintain and improve auditing knowledge, technical skills and personal attributes. Continual professional development can be achieved through means such as attendance at meetings, seminars, conferences, technical training, work experience, self- study, coaching or other relevant activities.

Annex A
(informative)

Guidance on the use of this document

A.1 Applicability of this document

This document is based on good practice from energy management and energy auditing. It includes a minimum set of requirements and guidance to improve the specification, execution, acceptance and closure of an energy audit. Since innovation and differentiation are important contributors to the value added by energy auditing, this document focuses only on the generic processes and outcomes to be expected from an energy audit.

The energy audit identifies EPIAs but does not mandate organizations to implement them. The level of detail and the energy audit cost should be appropriate to the aim of the energy audit and audit scope.

The organization can benefit from an increased organizational knowledge as a result of the energy audit and also from taking action to implement the recommended EPIAs.

A.2 Assessment of audit levels

A.2.1 General

Depending on the needs of the organization, one or more of the following levels of audit, as summarized in Table A.1, may be selected as a guide to the determination of the scope and level of detail of the audit:

— Level 1: This is a walk-through survey that identifies the rough potential for energy performance improvement in a facility and includes benchmarking the facility's energy use against comparable buildings. The level 1 audit provides a general overview of the energy performance of the facility, and identifies low-cost and no-cost measures, as well as potential capital improvements that require further analysis.

— Level 2: This is an energy survey and analysis that provides a more detailed assessment of the facility's energy systems and quantifies the energy and cost savings of the identified measures. The level 2 audit includes a breakdown of the energy use by end use, a more comprehensive data collection and analysis, and a financial evaluation of the proposed measures.

— Level 3: This is a detailed analysis of capital-intensive modifications that involves a more rigorous engineering evaluation of the facility's energy systems and provides a higher level of accuracy and confidence in the estimated savings. The level 3 audit can include simulations, a measurement and verification plan, and detailed design specifications for the selected measures.

The levels of audit and their description as outlined in Table A.1 are not absolute requirements. The level of detail for the energy audit should be discussed and agreed between the organization and the energy auditor. Level 1 represents the minimum level of detail that can be appropriately referred to as an energy audit.

The appropriate level of detail required for an audit depends on the object of the audit, the energy uses and energy consumption, and the resources available for the audit. As a preliminary audit activity, the organization and the energy auditor should establish the availability of data for the energy audit and determine whether the data are sufficient to enable a more detailed level of audit. If an additional measurement is required, the organization and the auditor should typically agree on the extent of the required measurements before undertaking the audit. For audits at or above Level 2, it is advisable for the organization and the auditor to agree on a current or a reference tariff to be used for financial analysis.

There can be some parts of this document that are not applicable for internal auditors, based on the level of detail required for the audit and the familiarity of the auditor with the area (e.g. a start-up meeting). Based on the level of detail, an organization may choose an external audit to meet the requirements of this document.

There can be some cases where the organization chooses to undertake an audit using a combination of internal and external auditors.

High-level energy surveys, such as a brief site walk-through or a simple analysis of monthly energy bills, are preliminary activities that can be undertaken in advance of an audit but should not be referred to as energy audits. In such cases, organizations may refer to the standard requirements as best practice, but not necessarily conform to the standard requirements.

The benefits of having different levels of energy audit is that this allows organizations to compare the proposals provided, as well as providing other options when the organization's needs change.

Table A.1 — Indicative details of energy audit level

Level	1	2	3
Typical application	Facilities/processes or fleets. Suitable as energy audit of smaller organizations or facilities, or preliminary audit for larger organizations or facilities.	Single site/process or fleet. Detailed energy audit. Generally, not cost-effective for organizations with smaller energy budgets.	Whole site, process, system or fleet. Comprehensive energy audit with significant input from the organization. Generally, only cost-effective for organizations with high energy spends or institutions with targeted capital investment grants. Also applicable at the system level (e.g. compressed air).
Business need addressed	Indication of potential savings and benefits that can result from undertaking more detailed investigations, such as a Level 2 or Level 3 energy audits. Identification of focus areas for energy management resources. Improved awareness of energy costs and the potential benefits of energy management.	Identification and evaluation of a range of coherent and specific opportunities with quantified costs and benefits. Identification of opportunities for further or more detailed investigation. Auditors should have appropriate technical, managerial and professional experience and skills, and familiarity with the energy uses being audited. Auditors with the appropriate professional skills and expertise analyse energy and process data to identify and evaluate opportunities.	Identification and evaluation of a range of coherent and specific energy performance improvement opportunities with identified costs and benefits, including quantification of "non-energy" gains. Auditors should have appropriate technical, managerial and professional experience and skills, and familiarity with the specific energy uses being audited, to analyse detailed energy and process data to identify and evaluate opportunities. More detailed investigation of opportunities. Consideration of business strategies in the audit.

Table A.1 *(continued)*

Level	1	2	3
Data collection	Basic engineering or technical training with a general understanding of energy sources and systems. Facility energy data, including sub-meters and daily load profiles (where available). Appropriate data on relevant variables (e.g. production data, occupancy data) and static factors (if applicable) to establish overall EnPIs. Site equipment lists to include nameplate energy data, equipment description, operating schedules, duty factors and estimates of load factors.	Overall available energy data, including daily load profiles. Appropriate relevant variable data (e.g. production data, occupancy data) and static factors (if applicable) to establish EnPIs for SEUs. Sub-meter data. Full use to be made of available site data. It is not necessary for the auditor to take additional measurements as part of the audit unless the need for additional data is required to fulfil the requirements of the audit scope. Energy data and information to be collected in the audit can include: — detailed data on energy consuming systems, processes and equipment, including known relevant variables; — monitoring equipment configuration, and analysis information; — design, operation and maintenance documents; — energy audits or previous studies related to energy and energy performance; — future plans that affect energy use; — production and process data for evaluating performance.	Operating/load profile of the site or fleet. Appropriate relevant variable data (e.g. production data, occupancy data) and static factors (if applicable) to establish EnPIs for SEUs. Sub-meter data, evaluated down to load profile level for significant meters. Energy consumption data for the key site processes, systems and equipment. Full use to be made of available site data, including metered interval data. Installation of additional sub-meters for monitoring or conducting specific logging exercises should be considered. Data should be collected for a sufficient period to account for the expected range of values for the relevant variables and system demands. Energy data and information to be analysed in the audit can include: — detailed data on energy consuming systems, processes and equipment, including known relevant variables; — monitoring equipment configuration and analysis information; — design, operation and maintenance documents; — energy audits or previous studies related to energy and energy performance; — future plans affecting energy use; — information on how the organization manages its energy performance; — supplier quotes for improvement opportunities.

Table A.1 *(continued)*

Level	1	2	3
Analysis	Energy consumption data and equipment data to organize by equipment, systems and/or processes. Energy use, equipment data to prepare preliminary energy balance and identify SEUs. High-level review of consumption profiles to identify anomalies in daily, weekly, monthly or seasonal patterns. Comparison with available benchmarks to identify high energy consumers or inefficiencies.	Analysis of current and historical energy data. EnPIs at plant, fleet, system, process or equipment level for analysis of specific opportunities, where applicable. Detailed energy balance reconciled with sub-metering data at annual and profile level, including seasonal or production variations, as applicable. Mass balance for equipment, systems and/or processes that include significant product flows influencing energy consumption, or equivalent analysis of energy and material flows. Balances used to establish current performance and improvement potential. Evaluation of the design and configuration options to address the system needs. Evaluation of the energy performance improvement associated with equipment, system or process changes.	Analysis of current and historical energy data. EnPIs at plant area or fleet level and for SEUs. Detailed energy balance reconciled with sub-metering data, using data of a sufficient frequency to capture variation in performance. Mass balance for processes that include significant product flows influencing energy consumption (or equivalent analysis of energy and mass flows). Evaluation of the design and configuration of options to address the system needs. Application of a range of analysis methods to explore relationships between energy consumption, relevant variables and static factors (if applicable). Recommendations for additional data/investigation to improve data accuracy.

Table A.1 *(continued)*

Level	1	2	3
Opportunities identification	Walk through to visually inspect energy uses. Identify and quantify low-cost and easily quantifiable energy performance improvement opportunities. Identification of more capital-intensive energy performance improvement opportunities at a generic level but not taken through to technical resolution.	One or more site energy survey(s) can satisfy audit requirements. Identification of a suite of specific and implementable energy performance improvement opportunities, including short-, medium- and long-term actions with energy performance improvements reconciled against the detailed energy balance. All, or the majority of, energy performance improvement opportunities provided with costs and benefits, including indications of "non-energy" gains (e.g. maintenance savings improved safety or reduced environmental impact). NOTE Non-energy gains are not always quantifiable within the scope of the audit. Identification of energy performance improvement opportunities where additional data/investigation would be required to improve or clarify measures. The organization may be provided with a draft list of opportunities to review, in order to confirm the feasibility or suitability of proposed opportunities prior to detailed analysis/investigation. Comparison against benchmarks.	One or more site energy survey(s) can satisfy audit requirements. Quantification of a range of specific and implementable energy performance improvement opportunities, including short-, medium- and long-term actions (if requested) with energy performance improvements reconciled against the detailed energy balance. Identification of any energy performance improvement opportunities where additional data/investigation is required to improve data or evaluation accuracy. Presentation of a draft list of opportunities to the organization for discussion, to confirm the feasibility of opportunities prior to a detailed analysis/investigation. Other analysis, techniques or experimental approaches (e.g. engineering, vehicle trials, pilot studies, logistical approaches, computer simulations, ultrasonic surveys or thermographic imaging) may be used to fully understand energy consumption. Discussion with vendors to identify or verify latest technologies for energy performance improvement.

Table A.1 *(continued)*

Level	1	2	3
Opportunities evaluation	Indicative or typical savings calculated using common rules reconciled to the EnB. Nomination of typical payback periods. Outline of steps required to generate specific EPIAs that can be implemented.	Savings calculated using technology specific energy performance improvement opportunities reconciled to detailed energy balance. Costs based on a composite of capital and labour items using rules of thumb, standardized costs or readily available supplier information. Quotes from suppliers are not required. Presentation of agreed economic analysis, typically including simple payback but which may include methods such as internal rate of return (IRR) or net present value (NPV).	Savings calculated using technology specific energy performance improvement opportunities reconciled to detailed energy balance and considering system interactions. Costs calculated based on a composite of capital and labour items, to the level of accuracy required by the company's existing capital expenditure process. NOTE The organization can assist the auditor with cost data. All energy performance improvement opportunities provided with costs and benefits, including "non-energy" gains. Presentation of agreed economic analysis, typically including IRR or NPV with simple paybacks as a minimum, to provide input to the organization's capital expenditure process.
Outputs	Identification and basic evaluation of low-cost opportunities that can be easily implemented. Understanding of energy consumption at site, system, process or fleet level. Improved awareness of the relative contribution from each site energy source, average unit costs for each source and the potential benefits of managing energy. Determination of the extent of more capital-intensive opportunities.	Detailed understanding of energy consumption and use. Understanding of the relative contribution from each site's energy source, average and marginal unit costs for each source. Identification and basic evaluation of low-cost opportunities that can be easily implemented. Determination and analysis, including comprehensive savings calculation and preliminary investment cost, for capital measures. Compilation of data for energy review/monitoring purposes. Operational profile and detailed energy balance.	Detailed understanding of energy consumption and use. Identification and analysis of energy performance improvement opportunities, including no cost, low-cost and capital investment measures to include energy and non-energy benefits, preliminary equipment design or process improvement and detailed cost requirements. Data for energy review purposes. Examination of metering systems and recommendations to address data gaps.

A.2.2 Energy audit considerations

Organizations need to be aware that the scope of the energy audit and the requirements for analysis can have a marked effect on the cost of the audit. Factors that can affect audit costs include:

a) the level of uncertainty/accuracy;

b) the extent to which longer payback opportunities are investigated;

c) the scope/boundaries of the audit;

d) the availability of data, both energy performance data and equipment-related data;

e) the availability of previous energy audit reports/studies;

f) the complexity of the site and whether processes and equipment are unusual or custom designed;

g) the number of sites to audit;

h) the competency of the energy auditor.

Organizations should discuss the energy audit scope with the energy auditor to ensure that the energy audit balances analytical rigour and the costs of the audit.

A.2.3 Role of the energy auditor for different levels of energy audit

Table A.2 indicates the job roles of an energy auditor depending on the selected energy audit level.

Table A.2 — Indicative duties of an energy auditor based on selected audit level

Level	1	2	3
Job role	Define energy audit scope. Review historical energy consumption data and rate structure. Obtain and review background information provided by customer. Perform a site assessment/visit the site to obtain additional information about systems, equipment, processes, etc. Collect and analyse field data related to energy usage. Inspect or evaluate building envelopes, mechanical systems, electrical systems or process systems. Identify and prioritize EPIAs. Identify opportunities to improve the operation, maintenance, or energy efficiency of building or process systems. Recommend energy efficient technologies or alternate energy types. Educate customers on EPIAs measures. Prepare audit reports containing energy analysis results or recommendations for EPIAs. Calculate potential for energy savings. Provide information on incentives applicable to the EPIAs or clarify if this is not included. [Optional] Perform technical test for measurement purposes to determine energy efficiency of the building, site, process or system.	All in Level 1 plus: Calculate potential for energy savings. Establish EnBs for the site, and if possible, the EPIAs. Where additional information is needed beyond what the client is able to provide, measure energy consumption with devices such as data loggers, universal data recorders, light meters, sling psychrometers, psychrometric charts, flue gas analysers, amp-probes, watt meters, volt meters, thermometers or utility meters. Inspect or evaluate building envelopes, mechanical systems, electrical systems or process systems to determine the energy consumption of each system. Analyse technical feasibility of EPIAs using knowledge of engineering, energy production, energy use, construction, maintenance, system operation or process systems. Determine operating patterns of the building and/or process to show annual, monthly, weekly or daily energy consumption trends. Examine the site to determine the feasibility of installing equipment that allows automatic energy reduction during peak demands. [Optional] Provide information of any related non-energy benefits.	All in Level 1 and 2 plus: Perform measurement and verification of EPIAs. Use life cycle cost analysis (LCCA) to evaluate the capital costs required to implement the EPIAs. Perform an assessment to identify and plan actions to mitigate EPIA implementation risks.

A.2.4 Content of the energy audit report for different levels of energy audit

Table A.3 indicates the additional content of an energy audit report depending on the selected energy audit level.

Table A.3 — Indicative energy audit report content based on selected audit level

Level	1	2	3
Executive summary	Overall assessment of benchmarking and energy performance Potential savings and return on investment (ROI) Table of recommended EPIAs with estimated level of savings and ROI	All in Level 1 plus: Aggregated savings and costs of recommended measures Table of recommended EPIAs with detailed savings and costs Information on any non-energy benefits	All in Level 1 and 2 plus: LCCA Risk assessment
Introduction	Energy audit objective and scope Key dates Contact information		
Facility description	Site information Notable conditions	Site/building Building envelope/process information Process and plug loads Process/building heating, cooling, ventilating Hot, cold, chilled water Lighting On-site energy generations etc.	
Historical utility data	Data summary and rate schedules Existing sub-metering data EnPIs related to the site/building operations	Data summary Utility rate structures Additional sub-metering data Benchmarking Target and savings estimate End-use breakdown EnPIs related to the site/building operation and the energy use within the energy audit scope	
EPIAs	Benchmarking Establish target and estimate savings Low cost/no-cost savings measures Capital projects	Low-cost/no-cost savings measures Capital projects Distributed/renewable energy opportunity EPIAs that were considered but were not recommended	Proposed monitoring and verification plan to verify achieved benefits of EPIAs Interactions between different EPIAs and between EPIA and planned changes Measurement and analysis LCCA Risk assessment Schematic diagrams EPIAs considered but not recommended

Table A.3 *(continued)*

Level	1	2	3
Calculation tables	Tabulated utility data Utility rate schedules Basis for savings and cost estimates (Optional) Equipment and lighting inventory tables	Tabulated utility data Utility rate schedules Calculation methodology Savings calculations Cost estimates Equipment and lighting inventory tables Operations and maintenance (O&M) logs Equipment specifications EPIA cost estimates EPIA economic analysis Quality assurance	Tabulated utility data Utility rate schedules Calculation methodology Savings calculations including energy model input/output Vendor quotes and cost estimates Equipment and lighting inventory tables O&M logs Equipment specifications Measurement and monitoring data LCCA calculations Risk assessment data

A.3 Communication

To facilitate a timely completion of the energy audit, the energy auditor and organization should agree on the lines of communication, including:

a) clearly identifying the responsibilities of the energy auditor and organizational personnel;

b) assigning responsibilities for collating and analysing data, and the information required;

c) communication channels and methods between the energy auditor and other organizational and external personnel involved in the energy audit;

d) allocating responsibilities for supervision, reporting and site support;

e) outlining which personnel are authorized to negotiate any changes in the audit objective(s), energy audit scope or boundaries of the audit.

A.4 Organizational roles and responsibilities and authority for audit planning tasks

Roles, responsibilities and authority for the organization in planning the energy audit should include:

a) in consultation with the audited organization:

   1) determining the need for the energy audit and defining the audit objectives;

   2) determining the energy audit scope and criteria of the energy audit;

   3) defining which energy audit tasks will be conducted by the energy auditor and which will be the responsibility of the organization;

b) selecting the energy auditor;

c) obtaining organizational support for the audit and endorsement of the audit objectives:

   1) commit the necessary funding, personnel and resources for planning and conducting the energy audit, including site personnel, as required;

   2) communicate to site personnel the audit's importance to the organization;

d) establishing lines of communication required for the audit (see Clause A.5);

e) providing appropriate access to:

1) audit areas, energy uses and other facilities or services required to conduct the audit;

2) relevant personnel, systems and equipment (engineering, operations, maintenance, etc.) for energy audit purposes;

3) other information sources, such as drawings, manuals, process and/or activity description, test reports and historical utility bill information;

4) monitoring and control data, electrical equipment panels and calibration records necessary to conduct the audit.

Roles, responsibilities and authorities for the energy auditor in planning activities of the energy audit should include:

— in consultation with the audited organization:

  — defining the audit objectives;

  — defining which energy audit tasks will be conducted by the energy auditor and confirming which will be the responsibility of the organization;

  — determining the scope and criteria of the energy audit, if appropriate, in consultation with the organization (organization's policy, legal requirements and other requirements, equipment set-up and configurations, etc.);

— when more than one energy auditor is required, selecting the team based on the overall competencies required to conduct the audit based on the defined energy audit scope and audit objectives;

— securing management support and resources for the energy audit;

— establishing lines of communication required for the energy audit (see Clause A.5):

  — within the energy audit team when more than one auditor is required;

  — between the energy auditor and the organization;

— defining requirements and securing appropriate access to:

  — audit areas, energy uses and other facilities or services required to conduct the audit;

  — relevant personnel, systems and equipment (engineering, operations, maintenance, etc.) for energy audit purposes;

  — other information sources, such as drawings, manuals, test reports and historical utility bill information;

  — computer monitoring and control data, electrical equipment panels and calibration records necessary to conduct the audit;

— defining the measurement requirements and measurement plan.

A.5 Data measurement plan

A.5.1 General

There are three important stages during the implementation of the measurement plan, as described in A.5.2 to A.5.4.

A.5.2 Step 1: Use of measurement instruments

The energy auditor should:

a) define the methodology of the measurements and their level of accuracy;

b) be responsible for the measurements taken on-site;

NOTE In this context, "responsible" does not necessarily imply actual installation of meters as this can require specialized skills and certifications.

c) check the calibration of the measurement equipment;

d) check the operations and functioning of the measurement equipment;

e) check that the measurement taken is accurate and repeatable.

The type of measuring device to be used is specified in line with the nature of the variable being measured, its magnitude, the operating range, the accuracy required and the conditions of use.

A.5.3 Stage 2: Data measurement

The data should be measured over a period and at measurement intervals that are representative, accounting for the typical range of variation for the relevant variables. The required time period for data acquisition will vary according to the energy uses and the nature of the processes involved. During the data measurement stage, the organization provides the corresponding, relevant variables (e.g. operating parameters, production data).

A.5.4 Stage 3: Preliminary data treatment

This stage is to organize the large amount of collected measurements into usable data for analysis. This includes:

a) ensure that the data are clean and devoid of any issues such as missing or erroneous values;

b) the principle of each measurement, the level of uncertainty and the elements to be assessed;

EXAMPLE Keeping a record of how the measurement was made, manufacturer's stated precision, calibration certificate.

c) the methods used and any assumptions made;

d) the calculations and their range of applicability.

Results of the measurement can be presented in charts and graphs or summarized in a table.

Annex B
(informative)

Applicability of this document to other International Standards

B.1 ISO 50001: Energy management system

ISO 50001 requires that an energy review be conducted and energy performance be improved over time. An energy review carried out in accordance with ISO 50001 shall consist of analysis of past and present energy use and consumption based on measurements and other data, identifying areas of SEU, identifying, prioritizing and recording opportunities for improving energy performance, and estimating future energy use and consumption.

The use of an energy audit is not a requirement for ISO 50001 and other procedures may be utilized to complete the energy review or demonstrate energy performance improvement (e.g. internal energy review procedures by energy managers of the organization utilizing methods in ISO 50004, energy flow analysis for the organization followed by improvement potential analysis or other tools).

An organization can conduct an energy audit to provide information for an ISO 50001 energy review or demonstrate energy performance improvement at particular points in time for the audited objects. If an organization does so, this can help it to undertake comparable audits between different sites, fleets or activities and therefore to prioritize EPIAs.

If an organization decides to complete an energy audit to facilitate an ISO 50001 energy review or demonstrate energy performance improvement, the requirements in this document applies. Additionally, an energy audit can be conducted without the intention of providing information for an ISO 50001 energy review.

When carrying out an energy audit with the intent of fulfilling the requirements of an energy review, there are several considerations that need to be taken into account. This is due to the ability to define a different scope and boundaries of an energy audit compared to that of an EnMS. Table B.1 identifies the main considerations when conducting an energy audit as part of an ISO 50001 energy review.

Table B.1 — Considerations when using ISO 50002 series energy audit to achieve ISO 50001 energy review requirements

ISO 50001:2018, 6.3, energy review	Energy audit scope and boundary is the same as EnMS	Energy audit scope and boundary is the subset of EnMS	Multiple energy audits make up the EnMS scope and boundary
a) analyse energy use and consumption based on measurement and other data to: 1) identify current types of energy; 2) evaluate past and current energy use(s) and consumption.	There is no explicit requirement to identify the current types of energy. This will need to be added to the scope of works. Evaluation of energy performance is only valid up to the end of the reference data or measurement used during the energy audit.	As previous. Identification of energy types; past and current energy performance is limited to the scope and boundary of the energy audit. The remaining energy use in the EnMS scope and boundaries will need to be carried out separately.	As previous. The identification of current energy types and evaluation of past energy use and consumption will be located in different reports. Some form of data collation will need to be carried out separately.

Table B.1 *(continued)*

ISO 50001:2018, 6.3, energy review	Energy audit scope and boundary is the same as EnMS	Energy audit scope and boundary is the subset of EnMS	Multiple energy audits make up the EnMS scope and boundary
b) based on the analysis, identify SEUs	What energy use is deemed as significant is dependent on two things: 1) large proportion of energy consumption; 2) energy use with significant opportunity for improvement. This involves a choice to be made by the organization, not the energy auditor. In addition, there is no explicit requirement to specify the SEUs. This will need to be added to the scope of works and the criteria for SEUs communicated to the energy auditor.	As previous. The energy use within the energy audit scope and boundary is not necessarily the SEU within the EnMS. The organization will need to identify and specify the SEU(s) separately.	As previous. The identification of SEU(s) will be based on energy audit data located in different reports. Some form of data collation will need to be carried out separately.
c) for each SEU: 1) determine relevant variables; 2) determine current energy performance; 3) identify the person(s) doing work under its control that influences or affects the SEUs.	There is no explicit requirement to establish of an EnB during an energy audit. However, establishing an energy performance of energy use, verifying the suitability of relevant variables and static factors (if applicable) and energy performance is included. This will need to be added to the scope of works. Relevant variables and static factors will need to be identified by the organization and provided to the energy auditor for analysis. The energy auditor may also measure the relevant variables and static factors during the energy audit. It is not always possible for energy auditors to identify all applicable relevant variables for the organization. There is no explicit requirement to identify the person(s) doing work under its control that influences or affects the SEUs. This will need to be added to the scope of works.	As previous. The energy use within the energy audit scope and boundary is not necessarily the SEU within the EnMS.	As previous. The determination of relevant variables, static factors (if applicable), current energy performance, and person(s) working under its control that influences or affects the SEUs will be based on energy audit data located in different reports. Some form of data collation will need to be carried out separately.

Table B.1 *(continued)*

ISO 50001:2018, 6.3, energy review	Energy audit scope and boundary is the same as EnMS	Energy audit scope and boundary is the subset of EnMS	Multiple energy audits make up the EnMS scope and boundary
d) determine and prioritize opportunities for improving energy performance	This is included in the energy audit.	Identification of energy performance improvement opportunities are limited to the scope and boundary of the energy audit. Improvement opportunities from other areas outside the scope and boundary of the energy audit will need to be carried out separately. The improvement opportunities identified in the energy audit and other means will need to be prioritized separately.	The determination and improvement opportunities will be based on energy audit data located in different reports. Some form of data collation will need to be carried out separately. The collated opportunities will need to be prioritized separately.
e) estimate future energy use(s) and energy consumption	There is no explicit requirement to estimate future energy use(s) and energy consumption. External energy auditor is not always best placed to estimate the future energy use(s) and consumption. This will need to be carried out separately.	As previous. There is insufficient information to estimate the future energy use(s) and energy consumption based on the energy audit data.	As previous. There is insufficient information to estimate the future energy use(s) and energy consumption based on the energy audit data.
The energy review shall be updated at defined intervals, as well as in response to major changes in facilities, equipment, systems or energy-using equipment.	The energy audit data and report is only valid for the reference data it is based on. An energy review is a live document with the energy data refreshed as appropriate. The organization needs to initiate an energy audit covering the same scope and boundary at defined intervals as well as in response to major changes in facilities, equipment, systems or energy-using equipment.	As previous.	As previous.
The organization shall maintain as documented information the methods and criteria used to develop the energy review.	The organization will need to specify and maintain documented information that the energy review is developed based on the ISO 50002 series with the above taken into consideration.	As previous.	As previous.

B.2 Standards on energy efficiency

There are numerous International Standards and other standards on assessing the energy efficiency of specific equipment.

The ISO 50002 series covers analysis and improvement opportunities within a defined scope and boundary of an audit. Depending on the energy audit scope and boundary, it can cover a large number of energy uses, a sub-set of energy use or specific equipment.

International Standards and other standards only cover the measurement and analysis of energy efficiency of specific equipment.

In addition, energy performance improvement can be affected via management of energy use and energy consumption without changing the efficiency of the equipment. These opportunities are not captured by other International Standards and other standards on energy efficiency.

Annex C
(informative)

Sampling

NOTE 1 Based on ISO 19011:2018.

Audit sampling takes place when it is not practical or cost-effective to examine all available information during an audit, e.g. audited objects are too numerous or too dispersed geographically to justify the examination of objects (building, process, vehicle).

The principle of sampling for a lot (a lot of vehicles or sites) is to analyse the individuals in the sample to issue recommendations that will be valid for each individual in the lot.

The objective of audit sampling is to provide information for the auditor to have confidence that the audit objectives can or will be achieved.

The risk associated with sampling is that the samples are not necessarily representative of the audited object from which they are selected. Thus, the auditor's conclusion can be biased and different from that which would be reached if the whole audited object was examined.

Therefore, the selected sample shall be representative of the whole audited objects.

EXAMPLE Same SEUs, same size, process or vehicle.

The energy auditor shall agree with the organization on the samples selected.

Audit sampling typically involves the following steps:

a) establishing the objectives of sampling;

b) selecting the extent and composition of the scope to be sampled;

c) selecting a sampling method;

d) determining the sample size to be taken;

e) conducting the sampling activity;

f) compiling, evaluating, reporting and documenting results.

When sampling, consideration should be given to the quality of the available data as sampling insufficient and inaccurate data will not provide a useful result. The selection of an appropriate sample should be based on both the sampling method and the type of data required.

Reporting on the sample selected can take into account the sample size, selection method and estimates made based on the sample and the confidence level.

NOTE 2 Various sampling methods for multisite companies exist in different countries.

Bibliography

[1] ISO 19011:2018, *Guidelines for auditing management systems*

[2] ISO 50001:2018, *Energy management systems — Requirements with guidance for use*

[3] ISO 50002-2, *Energy audits — Part 2: Guidance for conducting an energy audit using ISO 50002-1 in buildings*

[4] ISO 50002-3, *Energy audits — Part 3: Guidance for conducting an energy audit using ISO 50002-1 in processes*

[5] ISO 50003, *Energy management systems — Requirements for bodies providing audit and certification of energy management systems*

[6] ISO 50004, *Energy management systems — Guidance for the implementation, maintenance and improvement of an ISO 50001 energy management system*

[7] ISO 50006:2023, *Energy management systems — Evaluating energy performance using energy performance indicators and energy baselines*

[8] ISO 50015:2014, *Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance*

[9] EN 16247-1:2022, *Energy audits — Part 1: General requirements*

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