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Energy audits — Requirements with guidance for use

Audits énergétiques — Exigences et recommandations de mise en oeuvre

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 documents 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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 242, *Energy management*.

Introduction

The purpose of this International Standard is to define the minimum set of requirements leading to the identification of opportunities for the improvement of energy performance.

An energy audit comprises a detailed analysis of the energy performance of an organization, equipment, system(s) or process(es). It is based on appropriate measurement and observation of energy use, energy efficiency and consumption. Energy audits are planned and conducted as part of the identification and prioritization of opportunities to improve energy performance, reduce energy waste and obtain related environmental benefits. Audit outputs include information on current use and performance and they provide ranked recommendations for improvement in terms of energy performance and financial benefits.

An energy audit can support an energy review and can facilitate monitoring, measurement and analysis as described in ISO 50001, or it can be used independently.

This International Standard 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 energy audit process is presented as a simple chronological sequence, but this does not preclude repeated iterations of certain steps.

The main body of this International Standard covers the general requirements and framework common to all energy audits that can be supplemented by equivalent national audit standards. For auditing of specific types of facilities, processes or equipment, refer to the relevant international, national and local standards and guidelines, some of which are referenced in the Bibliography.

In this International Standard, the following verbal forms are used:

— “shall” indicates a requirement;

— “should” indicates a recommendation;

— “may” indicates a permission;

— “can” indicates a possibility or a capacity.

Energy audits — Requirements with guidance for use

1 Scope

This International Standard specifies the process requirements for carrying out an energy audit in relation to energy performance. It is applicable to all types of establishments and organizations, and all forms of energy and energy use.

This International Standard specifies the principles of carrying out energy audits, requirements for the common processes during energy audits, and deliverables for energy audits.

This International Standard does not address the requirements for selection and evaluation of the competence of bodies providing energy audit services, and it does not cover the auditing of an organization's energy management system, as these are described in ISO 50003.

This International Standard also provides informative guidance on its use (see Annex A).

2 Normative references

There are no normative references.

3 Terms and definitions

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

3.1
audit objective
purpose of an *energy audit* (3.3) agreed between the *organization* (3.13) and the *energy auditor* (3.5)

3.2
boundary
physical or site limits and/or organizational limits as defined by the *organization* (3.13)

Note 1 to entry: The boundary of an energy management system can be different from the boundary of an *energy audit* (3.3).

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

EXAMPLE The whole site and all energy using systems; the boiler plant; the vehicle fleet.

3.3
energy audit
systematic analysis of *energy use* (3.12) and *energy consumption* (3.7) within a defined *energy audit scope* (3.4), in order to identify, quantify and report on the opportunities for improved *energy performance* (3.10)

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 "diagnostic" in French.

3.4
energy audit scope
extent of *energy uses* (3.12) and related activities to be included in the *energy audit* (3.3), as defined by the *organization* (3.13) in consultation with the *energy auditor* (3.5), which can include several boundaries

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

Note 1 to entry: The energy audit scope can include energy related to transport.

3.5
energy auditor
individual, or team of people, conducting an *energy audit* (3.3)

Note 1 to entry: Energy audits can be conducted by the *organization* (3.13) 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* (3.4).

[SOURCE: EN 16247-1:2012, 3.2, modified — The expression "group of people or body" has been deleted and substituted by "or team of people".]

3.6
energy balance
accounting of inputs and/or generation of energy supply versus energy outputs based on *energy consumption* (3.7) by *energy use* (3.12)

Note 1 to entry: Energy storage is considered within energy supply or energy use. If included in the *energy audit scope* (3.4), 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, goods and products that enter the system *boundary* (3.2) against the energy, goods and products leaving the system boundary.

3.7
energy consumption
quantity of energy applied

[SOURCE: ISO 50001:2011, 3.7]

3.8
energy efficiency
ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy

EXAMPLE Conversion efficiency; energy required/energy used; output/input; theoretical energy used to operate/energy used to operate.

Note 1 to entry: Both input and output need to be clearly specified in quantity and quality, and be measurable.

[SOURCE: ISO 50001:2011, 3.8]

3.9
energy flow
description or mapping of processes for transfer of energy or conversion of energy within the defined *energy audit scope* (3.4)

3.10
energy performance
measurable results related to *energy efficiency* (3.8), *energy use* (3.12) and *energy consumption* (3.7)

[SOURCE: ISO 50001:2011, 3.12, modified — Notes 1 and 2 have been deleted as they are specific to energy management.]

3.11
energy performance indicator
EnPI
quantitative value or measure of *energy performance* (3.10), as defined by the *organization* (3.13)

Note 1 to entry: EnPIs could be expressed as a simple metric, ratio or a more complex model.

[SOURCE: ISO 50001:2011, 3.13]

3.12
energy use
manner or kind of application of energy

EXAMPLE Ventilation; lighting; heating; cooling; transportation; processes; production lines.

[SOURCE: ISO 50001:2011, 3.18]

3.13
organization
company, corporation, firm, enterprise, authority or institution, or part or combination thereof, whether incorporated or not, public or private, that has its own functions and administration and that has the authority to control its *energy use* (3.12) and consumption

Note 1 to entry: An organization can be a person or a group of people.

[SOURCE: ISO 50001:2011, 3.22]

3.14
relevant variable
quantifiable parameter impacting *energy consumption* (3.7)

EXAMPLE Ambient weather indicators; operating parameters (indoor temperature, light level); working hours; production throughput.

4 Principles

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 would enable energy auditors, working independently from one another, to reach similar conclusions in similar circumstances.

It is essential that energy auditor(s) are familiar with applicable health and safety requirements throughout the audit process.

The organization selects the energy auditor(s) based on the expected energy audit scope, boundaries, audit objectives and their competencies.

4.2 Energy auditor

4.2.1 Competency

Application of the following principles by the energy auditor is fundamental to the success of the energy audit.

The energy auditor shall have the knowledge and skills necessary to complete the defined energy audit scope. Competence can be shown by:

a) appropriate education, skills, experience and/or training considering local or national guidelines and recommendations;

b) relevant technical skills specific to the energy uses, scope, boundaries and audit objective;

c) knowledge of appropriate legal and other requirements;

d) familiarity with the energy uses being audited;

e) knowledge of the requirements of this International Standard, national and local energy auditing standards;

f) (for a team member designated as lead energy auditor) having the skills to manage and provide leadership to the energy audit team: a lead auditor should have managerial, professional and leadership skills in order to manage a team.

NOTE 1 Where there is a single auditor, he/she is considered to be the lead auditor.

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

NOTE 3 The energy auditor is encouraged to demonstrate continual professional development to maintain and improve auditing knowledge, technical skills and personal attributes. Continual professional development could be achieved through means such as attendance at meetings, seminars, conferences, technical training, work experience, self- study, coaching, or other relevant activities.

4.2.2 Confidentiality

The confidentiality of the audit deliverables shall 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.

4.2.3 Objectivity

The energy auditor shall act independently and in an impartial manner. Conflicts of interest (personal, financial or other) shall 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.

4.2.4 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, facility/facilities, equipment, system(s) and 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.

4.3 Energy audit

The energy audit shall be conducted according to the following principles:

a) the audit is consistent with the agreed energy audit scope, boundary and audit objective(s);

b) the measurements and observations are appropriate to the energy uses and consumption;

c) the collected energy performance data are representative of the activities, processes, equipment and systems;

d) the used data for quantifying energy performance and identifying improvement opportunities are consistent and unique;

e) the process of collecting, validating and analysing data is traceable;

f) the energy audit report provides energy performance improvement opportunities based on appropriate technical and economic analysis.

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

4.4 Communication

The energy auditor and organization shall establish communication channels and methods necessary to facilitate the audit in a timely manner. Clear lines of communication are essential for the energy audit team, among the team and with the organization, in a timely manner.

4.5 Roles, responsibilities and authority

The energy auditor(s) and the organization shall determine their respective roles, responsibilities and authority prior to the start of the energy audit.

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

5 Performing an energy audit

5.1 General

The energy audit process consists of the following stages, as illustrated in Figure 1:

a) energy audit planning (5.2);

b) opening meeting (5.3) and data collection (5.4);

c) measurement plan (5.5);

d) conducting the site visit (5.6);

e) analysis (5.7);

f) energy audit reporting (5.8);

g) closing meeting (5.9).

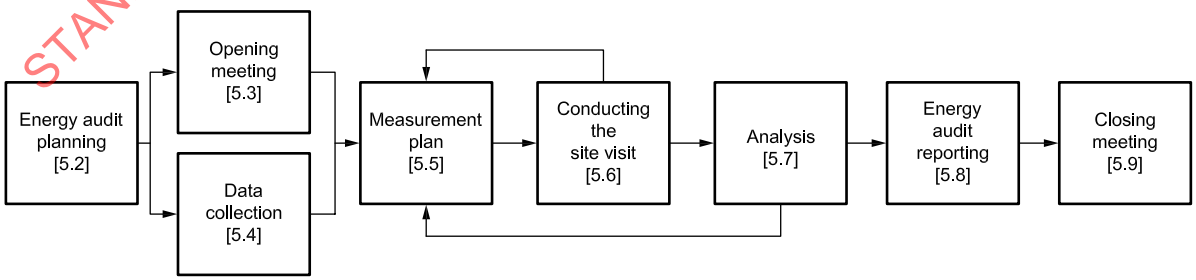

Figure 1 — Energy audit process flow diagram

5.2 Energy audit planning

Energy audit planning activities are essential to define the energy audit scope and the objective(s), and to gather preliminary information from the organization.

In order to develop the energy audit scope and ensure that an effective energy audit is conducted, the following shall apply.

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

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

   2) needs and expectations to achieve the audit objectives;

   3) the level of detail required;

   NOTE 1 Annex A provides guidance that might be useful at the planning stage, including indicative types of audit.

   4) the time period to complete the energy audit;

   5) criteria for evaluating and ranking opportunities for improving energy performance;

   EXAMPLE 1 Return on investment; potential energy saving over time; life cycle costing; incremental cost analysis for replacement with more energy efficient equipment.

   NOTE 2 Opportunities for improving energy performance can include non-energy benefits.

   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 2 Drawings; plant layout; historical energy consumption; utility 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 should be presented to the organization for comment;

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

   11) the process for agreeing on any change in the energy audit scope.

b) The energy auditor shall request information to establish the energy audit context, including, as applicable:

   1) regulatory requirements or other variables affecting the energy audit;

   2) regulatory or other constraints affecting the scope or other aspects of the proposed energy audit;

   3) strategic plans that may affect the organization's energy performance;

   EXAMPLE 3 Asset management plans; changing product mix; expansion plans; planned projects; outsourcing facilities management or equipment maintenance.

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

   5) factors or special considerations that may 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) facilities, equipment and services required to enable the energy audit to be carried out;

2) commercial or other interest which could influence his or her conclusions or recommendations;

3) any other conflict of interest issues.

5.3 Opening meeting

The purpose of the opening meeting is for the energy auditor to brief interested parties regarding the energy audit objectives, defined energy audit scope, boundaries and methods, and to review the arrangements for the energy audit (e.g. site safety inductions, access, security, etc.).

NOTE 1 A meeting can include telephone calls, teleconferencing and other electronic methods.

a) The energy auditor shall request the organization to:

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

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

3) ensure the cooperation of the affected parties;

4) confirm any unusual conditions that may 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.

NOTE 2 Some of these requirements might already have been addressed at an earlier stage.

b) The energy auditor shall agree with the organization on:

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

2) requirements for health, safety, security and emergency rules and procedures;

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

4) applicable non-disclosure agreements (e.g. tenants in a building);

5) requirements for any special measurements, if needed;

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

The energy auditor shall review the details of the energy audit planning with the organization, including schedules, processes, the possible need for additional metering equipment, interviewing the organization's personnel, meetings, site visits, etc.

5.4 Data collection

Where available, the energy auditor shall collect, collate and record the appropriate energy data that support the audit objectives. This includes the following information:

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 influence energy performance;

c) historical and current energy performance data, including:

   1) energy consumption;

   2) relevant variables;

   3) relevant related measurements;

   EXAMPLE 1 Power factor measurements; results from a thermographic or compressed air survey.

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

d) monitoring equipment, configuration and analysis information;

   EXAMPLE 2 Local gauges, distributed control systems, instrumentation types.

   NOTE The availability of measured data can be collected and collated by an external party, e.g. a utility company.

e) future plans that may affect energy performance;

   EXAMPLE 3 Planned expansions, contractions or changes in production volume.

   EXAMPLE 4 Planned changes in, or replacement of, equipment or systems that have significant energy implications.

   EXAMPLE 5 Removal or the outsourcing of facilities, equipment or systems.

f) design, operation and maintenance documents;

   EXAMPLE 6 As-built drawings; equipment specification sheet; plot plan; control system data.

g) energy audits or previous studies related to energy performance;

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

i) other relevant economic data;

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

k) the energy distribution system and its management.

5.5 Measurement plan

For any on-site data measurement and collection, the energy auditor and the organization shall come to an agreement on a measurement plan. The data measurement plan may be revised based upon the energy auditor's findings during the energy audit. The main items that shall be included in the measurement plan are:

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 where the activities are representative;

g) relevant variables provided by the organization, e.g. operating parameters and 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.

NOTE 2 It is important that some required data, such as historical monthly production and utility bills, is provided by the organization: the organization clarifies the accuracy of its own energy, production and other data; the auditor confirms whether the analysis is based on accurately metered data and specify how the data has been obtained, i.e. read from a meter, estimated or otherwise calculated; the analysis also verifies that the data sets are comparable.

Sampling procedures may be required when it is not practical or cost effective to examine all available information during an energy audit. Sampling is described in ISO 19011:2011, Clause B.3. 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.

5.6 Conducting the site visit

5.6.1 Management of field work

The energy auditor(s) shall:

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

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

c) understand the impact of operating routines and user behaviour on energy performance;

d) generate preliminary ideas, opportunities, operational changes or technologies that can lead to energy performance improvement;

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

f) 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” or “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 climatic load is expected.

g) ensure that historical data provided is representative of normal operation;

h) promptly inform the organization of any unexpected difficulties encountered during the energy audit, including access to data and documentation.

5.6.2 Site visits

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 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, identify one or more individuals to install data loggers and energy monitoring equipment during site visits: these individuals should have necessary authority to ask the authorized operation or maintenance personnel to carry out direct operations on processes and equipment, if required;

c) give the energy auditor access to relevant documents (see data collection in 5.4);

EXAMPLE Drawings, manuals and other technical documentation.

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

If the organization is unable to meet these requests, the energy audit scope may need to be revised.

5.7 Analysis

5.7.1 General

In order to facilitate an effective energy audit, the energy auditor(s) shall evaluate the validity and availability of data provided and highlight any issues that would prevent the audit from continuing. If necessary, the energy auditor may propose a different method to collect or supplement the data.

The energy auditor shall:

a) use transparent and technically appropriate 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 current energy performance provides the basis for evaluating improvements and shall include:

a) a breakdown of the energy consumption by use and source;

b) energy uses accounting for substantial energy consumption;

c) where available and comparable, comparison with reference values of similar processes;

d) a historical pattern of energy performance;

e) expected improvements for energy performance;

f) where appropriate, relationships between energy performance and relevant variables;

g) an evaluation of the existing energy performance indicator(s) and, if necessary, proposals for (a) new energy performance indicator(s).

NOTE Data verification refers to a documented method that is used to verify whether or not the data set is precise, consistent and unique. The data verification method is able to correct raw data set so that the verified data set is accurate, consistent and unique.

5.7.3 Identification of improvement opportunities

The energy auditor shall identify energy performance improvement opportunities based on analysis and the following:

a) their own competency and expertise;

b) 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.

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

d) the technology of existing energy uses in comparison to the most efficient on the market;

e) best practices, including operational controls and behaviours;

f) future energy use and changes in operation.

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

5.7.4 Evaluation of improvement opportunities

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

a) energy savings over an agreed time period or expected operating lifetime;

EXAMPLE Energy savings, improvements in specific energy consumption, etc.

b) financial savings anticipated from each improvement opportunity;

c) necessary investments;

d) agreed economic and other criteria identified in the energy audit planning;

e) other non-energy gains (such as productivity or maintenance);

f) the ranking of energy performance opportunities;

g) potential interactions between various opportunities.

NOTE 1 The organization might need to undertake additional work to fully identify and quantify impacts of opportunities.

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

Where appropriate to the agreed energy audit scope, boundary and audit objective of the energy audit, the energy auditor should complement these results with requirements for additional data and define further analysis needed.

5.8 Energy audit reporting

5.8.1 General

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

a) ensure that the energy audit requirements agreed with the organization have been met, including agreed 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 calculations, simulations or estimates;

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

e) as applicable, state the limits of accuracy for savings and costs;

f) provide a prioritized list of energy performance improvement opportunities;

g) suggest recommendations for the implementation of the opportunities.

NOTE Depending on the agreed level of detail for the energy audit, this can include feasibility for implementation, action steps, etc.

5.8.2 Energy audit 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:

a) executive summary:

   1) summary of energy use and consumption;

   2) ranking of opportunities for improving energy performance;

   3) suggested implementation programme;

b) background:

   1) general information on the organization, energy auditor and energy audit methods;

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

   3) statement of confidentiality;

   4) context of the energy audit;

5) energy audit description, defined scope and boundaries, audited objective(s) and timeframe;

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, equipment records in accordance with 5.2 (energy audit planning);

2) analysis of energy performance and any energy performance indicator(s);

3) basis for calculations, estimates and assumptions and the resulting accuracy;

4) criteria for ranking opportunities for improving energy performance;

d) opportunities for improving energy performance:

1) recommendations and the suggested implementation programme;

2) assumptions and methods used in calculating energy savings, and the resulting accuracy of calculated energy savings and benefits;

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

4) appropriate economic analysis, including known financial incentives and any non-energy gains;

5) potential interactions with other proposed recommendations;

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

e) 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) be able to explain the results and address questions;

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

Annex A
(informative)

Guidance on the use of this International Standard

A.1 Applicability of this International Standard

This International Standard is based on good practice from energy management and energy auditing. It includes a minimum set of requirements to improve the specification, execution, acceptance and closure of an energy audit. Since innovation and differentiation are important contributors to energy auditing value added, this International Standard focuses only on the generic processes and outcomes to be expected from an energy audit. Organizations and external energy auditors are encouraged to use additional methods, approaches, technologies or software.

The applicability and use of this International Standard and specific requirements will be dependent upon a number of factors, such as the energy consumption of the organization and the audited object, the type of auditor, and the purpose of the audit. In some circumstances, not all of the standard requirements will necessarily be applicable. Some of the requirements may be too costly and not relevant for the purpose of the audit. When the energy cost and reduction opportunities for the audited object are proportionally small, the energy audit cost should be appropriate for the application.

In order to obtain benefits from an energy audit, organizations should provide resources for post-audit evaluation of audit recommendations to enable decisions to be made on whether to implement the recommended energy performance improvement opportunities and any energy management actions.

A.2 Applicability of this International Standard to an ISO 50001 energy review

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 measurement and other data, identify areas of significant energy use, identify, prioritize and record opportunities for improving energy performance, and estimate 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. However, an organization may wish to 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 decides to complete an energy audit to facilitate an ISO 50001 energy review or demonstrate energy performance improvement, the energy audit is not required to be in accordance with this International Standard, unless specifically designated by the organization. While ISO 50001 does not require energy audits to be carried out in accordance with this International Standard, if an organization does so, this can help it to undertake comparable audits between different sites, fleets or activities and therefore to prioritize energy performance improvement actions. Additionally, an energy audit may be conducted without the intention of providing information for an ISO 50001 energy review.

A.3 Assessment of audit types

A.3.1 General

Depending on the needs of the organization, one or more of the following types of assessment (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.

The types of audit outlined in Table A.1 are not absolute requirements. Organizations may adjust the level of detail of the energy audit between type 1 and type 3 to suit the needs of the organization. Type 1 represents the minimum level of detail that might 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 or not the data are sufficient to enable a more detailed type of audit. If additional measurement is required, the organization and the auditor should typically agree on the extent of required measurements before undertaking the audit. For audits at or above type 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 may be some parts of this International Standard 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 International Standard.

There may 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 might 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 comply with the standard requirements.

A.3.2 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 might 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.

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.

Table A.1 — Indicative details of energy audit types

Type	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 could result from undertaking more detailed investigations, such as a Type 2 or Type 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 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.
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) to establish overall EnPIs. Site equipment lists to include name-plate 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) to establish EnPIs for significant energy uses. 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 could 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) to establish EnPIs for significant energy uses. 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 of 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 could 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)*

Type	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 significant energy uses (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 significant energy uses. 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 and relevant variables. Recommendations for additional data/investigation to improve data accuracy.
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-term, medium-term and long-term actions with energy savings 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 might not always be 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 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-term, medium-term and long-term actions (if requested) with energy savings 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 draft list of opportunities to the organization for discussion, to confirm the feasibility of opportunities prior to 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)*

Type	1	2	3
Opportunities evaluation	Indicative or typical savings calculated using common rules reconciled to the energy baseline. 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 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 may include methods such as IRR or NPV.	Savings calculated using technology specific energy performance improvement opportunities reconciled to detailed energy balance and considering system interactions. Costs calculated based on composite of capital and labour items, to the level of accuracy required by the company's existing capital expenditure process. NOTE: The organization might need to 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 a site, system, process or fleet level. Improved awareness of 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 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 saving 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.

NOTE Table A.1 presents a detailed summary of requirements at three defined types of audit. Each of the nominated requirements is a minimum for each type. In some cases, it might be appropriate to go beyond the level of detail outlined in the table, as agreed between the organization and the energy auditor.

A.4 Energy auditor principles

A.4.1 Competency

The energy auditor should have suitable knowledge for the type of work being undertaken and the agreed energy audit scope, boundary and audit objective(s). Appropriate education and training may involve professional qualifications in relevant technical or quantitative fields.

The degree of technical and managerial experience and skills required will increase for type 2 and type 3 audits due to the need for process-specific knowledge and the need to identify energy performance improvement opportunities that can be implemented within the organization being audited.

EXAMPLE A mechanical engineer with experience in auditing and optimization of boilers in commercial buildings might not have the knowledge necessary to audit the boiler in a large thermal power station.

A.4.2 Data measurement plan

Energy performance data may be considered representative where it accounts 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.