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# Energy audits —

## Part 2:
## Guidance for conducting an energy audit using ISO 50002-1 in buildings

*Audits énergétiques —*

*Partie 2: Recommandations pour la conduite d'un audit énergétique selon l'ISO 50002-1 dans des bâtiments*

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

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

An energy audit can help an organization identify opportunities to improve energy efficiency. It can be part of a site-wide energy management system (EnMS). Energy audits in buildings can help to achieve improvements such as:

— energy conservation;

— energy efficiency;

— improved occupant comfort, health and well-being;

— sustainability goals and targets;

— climate resilience.

The benefits to the organization can include:

— reduced energy and operating costs;

— improved information for asset management;

— wiser investment strategy based on energy audit results;

— meeting organizational goals related to greenhouse gas (GHG), emissions reduction net zero, materials use, productivity and occupant satisfaction.

The use and operation of buildings requires the provision of services such as heating, cooling, ventilation, lighting, domestic hot water, transportation systems (e.g. elevators, escalators, moving walkways) in buildings, information systems and processes. In addition, the operation of buildings typically involves other energy end uses such as appliances or plug loads within the building.

A building's energy consumption depends on:

— local climate conditions;

— the characteristics of the building envelope;

— the age and typology of the building(s)

— the designed indoor environment conditions;

— the characteristics and settings of the technical building systems;

— activities and processes in the building;

— occupant behaviour and operational regime.

When dealing with buildings, the audited objects are sometimes similar, technically simple and numerous (e.g. in the residential sector), but can also be unique, complex and highly technical (such as hospitals, swimming pools and spas, etc.).

Energy audits in buildings may include the whole building, parts of the building or some particular technical system.

Energy performance indicators (benchmark values, if available) or average statistical specific energy consumption data are usually published nationally for different building types and ages. This information can be used in the analysis to provide comparative energy performance evaluation. Where this information is not available, comparable data can be found for similar climates through international sources (e.g. the International Energy Agency (IEA)).

NOTE The energy audits covered by this document can be independent from building energy performance certification.

Energy audits and energy saving opportunities identified in energy audits are best implemented in the context of an EnMS, such as one consistent with ISO 50001. Whether or not an organization has an EnMS in place, organizations are more likely to achieve the intended outcomes of an energy audit when their top management supports the audit objective(s) and agrees to provide sufficient resources for the audit process and post-audit activities.

# Energy audits —

# Part 2:
# Guidance for conducting an energy audit using ISO 50002-1 in buildings

## 1 Scope

This document gives guidance on how to apply ISO 50002-1 to carry out energy audits of a building or group of buildings (new or existing). It is intended to be used in conjunction with, and is supplementary to, ISO 50002-1.

This document does not apply to other areas such as process audits (see ISO 50002-3), specific energy systems (e.g. compressed air) or transport.

This document is applicable to buildings and can be used independently or in conjunction with ISO 50002-3.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 50002-1, *Energy audits — Part 1: General requirements with guidance for use*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 50002-1 and the following 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**
**building**
construction as a whole, including its envelope and all *technical building systems* (3.5), for which energy can be used to condition the indoor climate, and to provide domestic hot water, illumination and other services related to the use of the building and the activities performed within the building

Note 1 to entry: The term can refer to the building as a whole or to parts thereof that have been designed or altered to be used separately.

Note 2 to entry: The building can include its site location and related external environment.

Note 3 to entry: Processes within the building (e.g. chilling of food in supermarkets) are addressed in ISO 50002-3. To the extent that the energy use of such processes affects, or is affected by, the building, they can be included in the scope of the energy audit process described in this document.

**3.2**
**building envelope**
elements of a *building* (3.1) that enclose conditioned spaces through which thermal energy can be transferred to or from the exterior, or to or from unconditioned spaces

**3.3**
**building fabric**
all physical elements of a *building* (3.1), excluding *technical building systems* (3.5)

EXAMPLE Roofs, walls, floors, doors, gates and internal partitions.

Note 1 to entry: It includes elements both inside and outside of the thermal envelope, including the thermal envelope itself.

Note 2 to entry: The fabric determines the thermal transmission, the thermal envelope airtightness and (nearly all of) the thermal mass of the building (apart from the thermal mass of furniture and technical building systems). The fabric also makes the building wind and water tight. The building fabric is sometimes described as the building as such, i.e. the building without any technical building system.

[SOURCE: ISO 52000-1:2017, 3.1.5]

**3.4**
**building service**
service provided by the *technical building systems* (3.5) and by appliances to condition the indoor environment (thermal comfort, air quality, visual and acoustic quality) and other services related to the use of the *building* (3.1) (such as escalators/elevators)

**3.5**
**technical building system**
technical equipment for heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting, information systems including building automation and control, and on-site energy production

Note 1 to entry: A technical building system can refer to one or to several *building services* (3.4) (e.g. heating system including heating, domestic hot water system and controls).

Note 2 to entry: A technical building system is composed of different subsystems and includes controls.

Note 3 to entry: Electricity and thermal energy production can include cogeneration, wind power, photovoltaic systems, district energy, heat pumps and other renewable energy sources, within the agreed scope of the energy audit.

Note 4 to entry: ISO 52000-1 provides definitions of specific technical building systems.

[SOURCE: ISO 52000-1:2017, 3.3.13, modified — "information systems including" added and "on-site energy" replaced "electricity" in the definition. Example changed in Note 1 to entry. Notes 2 and 3 to entry expanded. Note 4 to entry added.]

## 4 Principles of energy auditing

The principles of ISO 50002-1 apply.

## 5 Performing an energy audit

### 5.1 General

The general requirements of ISO 50002-1 apply.

## 5.2 Planning

### 5.2.1 General

When planning an energy audit for a building, the relationships between the owner, operator and tenant should be clarified. Their roles and responsibilities in a building can be different. For example, a building can be owner-operated, occupied and maintained by a single organization. A building can also be owned, operated, maintained and occupied by different organizations and/or tenants.

The audit client should specify the objectives of the energy audit, and the level of detail and thoroughness required.

Considerations for the energy audit objective(s) include:

a) reducing energy consumption and costs;

b) reducing environmental impacts such as GHG emissions;

c) checking or ensuring the indoor environment for quality of health and well-being (comfort, indoor air quality and illuminance levels);

d) awareness of relevant legislation and voluntary obligations and commitments;

e) limitations on improving energy performance in controlled buildings (e.g. historical or culturally significant buildings);

f) evaluating potential options for use of renewable energy and/or storage.

ISO 50002-1:2025, Annex A, describes three different types of energy audit, each having a different level of detail and thoroughness. The level of detail agreed by the parties will have an impact on:

— application;

— business needs;

— data collection;

— analysis;

— opportunities identification;

— opportunities evaluation;

— outputs;

— the time on-site.

When planning for the energy audit, the audit client should identify all the interested parties, their roles in the building, their needs and expectations from the energy audit, and their respective influence on the energy audit. A breakdown of interested parties and their typical roles in an energy audit are shown in Table 1.

**Table 1 — Interested parties and their typical roles in a building energy audit**

| Interested party | Possible recipient of the energy audit | Data provider | Involved in the meetings | Involved in the field work |
|---|---|---|---|---|
| Building or apartment owner | X | X | X | |
| Property manager | X | X | X | |
| Facilities manager | X | X | X | X |
| Engineering services manager | | X | X | X |
| Operation and maintenance staff | | X | X | X |
| Security staff | | X | (x) | (x) |
| Occupant/tenant | y | y | y | y |
| Staff (who work in the building permanently) | | | (x) | Partly |
| Temporary occupants (patients, clients in a shop) | | | | |
| Contractors and safety personnel | | y | y | y |
| Commercial | X | Sometimes | No, unless the recipient | X |
| Residential | (x) | | No, unless the recipient | X |

**Key**

X: direct involvement

(x): indirect involvement

y: as appropriate

### 5.2.2 Energy audit scope and boundaries

The energy audit scope and boundaries should be defined and agreed between the energy auditor and the audit client. At a minimum:

a) the audit client should have operational control of, and have an ability to influence and seek the cooperation of, the tenants;

b) the energy audit scope should cover energy uses within the building and/or the interaction of energy uses with other energy use within the building (optimization of some energy use while excluding others can give misleading results);

c) where the scope of an audit includes only parts of a building, such as a tenancy, the audit scope may need to account for interactions with the base building (such as the building envelope) or technical systems (e.g. shared space heating or cooling systems).

Considerations for the energy audit scope and boundaries include:

— collection of buildings/campus, buildings from a list of buildings or parts of a building;

— interdependencies and interactions between the building fabric, energy use inside the building, and the building services and technical building systems;

— energy use outside the building affecting or impacting on those inside the building;

— where appropriate, energy performance indicators that can be used;

— criteria for evaluating and ranking opportunities for improving energy performance (e.g. simple payback, internal rate of return, decarbonization, non-energy benefits);

— constraints that can impact the energy performance of the buildings such as purpose or legal;

— on-site and renewable energy generation.

A joint site visit between the audit client and the energy auditor can facilitate the definition of energy audit scope and energy audit objective(s).

#### 5.2.3 Energy audit cost

The audit client should note that all of the above items affect the energy audit costs. Other factors that can affect energy audit costs include:

— the availability of both energy performance data and equipment-related data;

— the extent to which longer payback opportunities are investigated;

— the availability of previous energy audit reports/studies;

— the complexity of the building and whether processes and equipment are unusual or custom designed;

— excessive disruption and/or changes to the planned energy audit.

The organization should ensure that the scope of the energy audit and expected energy audit cost are reasonable (from the organization's perspective) in relation to the potential benefits of the energy audit.

#### 5.2.4 Initial agreement

Once the above has been established, the energy auditor and the audit client should agree on the energy audit time, audit client representative during the energy audit and resources for the energy audit. Involvement and cooperation from the audit client and various interested parties in the energy audit process is critical to the success of the energy audit and the achievement of energy audit objective(s).

### 5.3 Opening meeting

During the opening meeting the energy auditor should consider collecting preliminary information, if readily available, about the building from the organization. This helps to prepare for the later energy audit activities. Information to be collected can include:

a) set-points and operational limits of indoor environmental conditions (such as temperatures, air flows, air quality, illuminance and noise) and any seasonal variations;

b) occupancy patterns for the different range of activities within the building;

c) comments from any occupants or other parties on the operational performance of the building and the level of the building service (e.g. history and log of occupant complaints related to the building's operation and conditions);

d) the energy performance rating for the building (e.g. energy performance certificate, Leadership in Energy and Environmental Design (LEED) ratings);

e) whether any building occupant awareness or motivation programmes have been implemented;

f) any previous energy audit reports;

g) operating and maintenance practices, regimes and record-keeping.

During the opening meeting, the energy auditor should review the outputs of the energy audit planning with the organization and confirm that the energy audit can progress. This review can include:

— confirming the scope and boundaries of the energy audit;

— timing of site visits, e.g. whether within or outside normal working hours (or preferably both);

— level of occupant/tenant engagement;

— areas of restricted access;

— potential health hazards and risks;

— confirmation of any unusual conditions that can affect the energy audit.

During the opening meeting, it is also important to make arrangements and agreements with the organization on access to the building.

### 5.4 Data collection

The energy auditor should collect and collate the appropriate energy data to support the energy audit objective(s), required energy audit scope and level of thoroughness of the energy audit. This includes:

a) building:

   1) building plans;

   2) building zoning:

      i) asset register;

      ii) building energy consumption and performance records;

      iii) records, documents, permits on modelled or actual energy performance (e.g. LEED certificates, Building Research Establishment Environmental Assessment Methodology (BREEAM) ratings energy performance certificates);

b) building envelope:

   1) thermal transmittance (U-value) and possible improvements and restrictions (accessibility, height, possible resulting thermal bridges, conflicts with building use and appearance);

   2) shading and possible improvements and restrictions (for glazed elements and cooling);

   3) thermal inertia of the building;

   4) air tightness;

   5) joints and thermal bridges;

      NOTE 1 This is not the same as an indoor spaces visit. The focus here is on the building elements and their properties.

c) building systems (for each within the scope of the energy audit):

   1) functional diagram;

   2) control diagram;

   3) operating settings list:

      i) system inspection reports;

      ii) mechanical and electrical schematics;

   4) operating schedules;

d) existing design, operation and maintenance documents and information, such as:

   1) as-built building plans, together with details of any modifications if available;

2) any external factors that can influence the energy performance of the building (e.g. shading by adjacent trees or buildings);

3) indications of supplied building services (e.g. which rooms or zones are heated, cooled and ventilated) on the building lay-out plan;

4) technical building system schematics, indicating the system zones, if any;

5) control diagrams and settings;

6) appliance and component data and ratings;

7) operation and maintenance schedules, frequencies of inspections and records of repairs/replacements (e.g. air filters);

e) the building information model (BIM) and/or design models of the building, if available;

f) historical data:

1) delivered energy records and/or bills (for electricity, gas, liquid and solid fuels as appropriate);

2) heat metering records;

3) cooling metering records;

4) domestic hot water records;

5) other metering records (including sub-metering and other than delivered energy, such as readings from hour counters);

NOTE 2 Energy audits in the built environment can deal with hourly, daily, weekly or monthly energy consumption data. The relevant energy data can also be recorded by the building and control system. Some buildings have infrequent and estimated energy data. Depending on the level of thoroughness of the energy audit, monthly or weekly breakdowns can be estimated.

EXAMPLE 1 Heat meter, domestic hot water meter, fuel meter, burner hour counter.

g) relevant variable and static factors affecting energy consumption:

1) internal set points and operating pattern (e.g. start-up, shut-down, maintenance schedules);

2) climatic data obtained from calibrated sources;

EXAMPLE 2 Temperature, degree-days, hygrometry, lighting from the local building automation and control system (BACS).

3) occupancy patterns (which may include any relevant emergency patterns);

NOTE 3 It is possible that information for quantifying and normalizing the relevant variable is recorded on the building control system (e.g. occupancy times, degree-hours).

4) floor area and net usable floor area;

h) information on important changes in the past three years or the period covered by the available operational data, concerning:

1) the physical form of the building;

2) the spaces, either in dimension and/or in use;

3) the building envelope (renovation of windows, added insulation, etc.);

4) the technical building systems and the areas they serve;

5) fees, incentives and utility rate structure(s);

6) the tenant arrangements;

7) the occupancy of spaces (different occupancy times, extended hours behaviour and internal loads);

8) set points and occupant behaviour;

9) changes in the BAC system (e.g. system upgrades, provider changes);

i) any other data needed based on the energy audit objectives (e.g. data necessary to calculate benchmarks).

NOTE 4 See Annex A for examples of data that can be collected.

## 5.5 Measurement plan

### 5.5.1 General

The energy auditor should review the information collected and provided by the organization. This is carried out to ensure the information is complete, and to identify further information and measurement needs. It is also possible to identify preliminary opportunities for improvement or areas for investigation during the site visit.

### 5.5.2 Preliminary data analysis

The energy auditor should carry out an analysis of the data collected to:

a) undertake a preliminary analysis of the audited object's energy balance on the basis of energy data;

b) establish the relevant variables and static factors;

c) establish the relevant energy performance indicators;

d) evaluate the distribution of energy consumption (consumption breakdown) if possible, depending on the measured data available;

e) define the significant energy uses;

f) establish an initial energy reference (energy baseline), if there is sufficient information, to be used for quantifying the impacts of energy performance improvement opportunities;

g) plan further data collection and measurement to be carried out during field work.

The energy auditor should develop a preliminary list of energy performance improvement opportunities.

### 5.5.3 Data measurement plan

Where additional on-site measurement is determined to be feasible, ISO 50002-1 outlines a short list of data that can be measured while on-site. Specifically, in a building, the following details can also be collected during the site visit:

a) weather conditions (temperature and humidity) for the building location;

b) indoor temperatures and humidity, relative to legislative requirements and target comfort levels;

c) equipment specifications, as required to quantify opportunities identified in the preliminary data analysis;

d) indoor air quality.

The energy auditor should also review the collected data (and eventual data measurement) to see whether the energy audit objective(s), and energy audit scope are still appropriate and can be achieved. If the audit objective(s) and audit scope cannot be achieved, the energy auditor should discuss and agree with the organization on an alternative.

## 5.6 Site visit

### 5.6.1 Site visits

Site visit requirements are given in ISO 50002-1.

The energy auditor should ask the organization to:

a) arrange access (read only) to BACS and electronic data sources;

b) provide authorized assistance for any tests and operations required in the energy audit (e.g. switching on or off systems and equipment), and provide access to the main electrical incomer, on-site generation and micro-grids as appropriate;

c) arrange access to the parts of the building which are defined as relevant for conducting the energy audit.

### 5.6.2 Management of field work

The energy auditor should inspect the building(s)/campus within the audit scope in order to achieve the audit objective(s). This includes:

a) observing the activities inside the building to understand the data received;

b) for each significant building services, evaluating the actual and future level of service (e.g. temperature, humidity, illuminance level);

c) identifying opportunities and requirements for additional data collection or measurement;

d) assessing the technical systems to ensure that they are adequate for the intended purpose, i.e. can deliver the required level of service;

e) evaluating the energy performance of the technical systems, and where relevant to the scope of the energy audit, taking into account the generation, storage and distribution system, and its control;

f) using the insights to understand the relevant variables and their impact on the energy performance of the technical systems, such as seasonal demands;

g) identifying energy performance improvement opportunities and related constraints and restrictions.

## 5.7 Analysis

### 5.7.1 General

The general analysis requirements are given in ISO 50002-1.

### 5.7.2 Analysis of current energy performance

Analysis of current energy performance is given in ISO 50002-1.

Energy use in a building is linked to:

a) the supply of comfort services (e.g. heating, domestic hot water, ventilation);

b) the activities in the building and the use of appliances to support activities (e.g. household appliances, office machines, computer systems, medical systems, catering, laundry);

c) other energy uses.

The energy auditor develops:

— a breakdown of the delivered energy by type in terms of consumption, cost and emissions in consistent units (e.g. pie-charts);

— a breakdown of the energy end-use by service and other use in absolute or specific numbers and in consistent energy units (e.g. pie-charts);

— if applicable, an inventory of installed on-site energy production and export to third parties, in absolute numbers.

The energy audit in a building will necessarily include some modelling or calculations to determine the current energy use profile and the energy performance improvement opportunities. The energy modelling or calculation should be at a level appropriate to the scope and thoroughness of the energy audit.

The modelled energy use should ideally be checked for consistency with actual measured energy consumption. The calculation should ideally reflect actual values and conditions (use, occupancy, indoor temperatures, climate, etc.), and not standardized ones.

Where appropriate to the energy audit objective(s) and scope, the analysis should deliver at least the following:

— For each building service, a comparison of actual against appropriate level of service (such as indoor environmental criteria, etc.). The level of service (e.g. temperature, quality of air, illuminance) should not be compromised by any proposed energy saving measures. The level of service may, however, be changed if agreed with the client (e.g. change of indoor temperature to reduce heating or cooling demands).

— Evaluation of the actual performance of the technical systems against a suitable benchmark.

— Evaluation of the performance of the building envelope.

NOTE This includes levels of insulation, thermal bridges, air tightness, etc.

— Evaluation of the energy performance of the whole building, taking into account the potential interaction between technical systems and the building envelope.

The calculation of the energy performance indicators (such as specific energy consumption or use) or building specific baselines should be included in the analysis as appropriate. The energy auditor and organization should agree on the energy performance metric(s) to be used.

For comfort services, once the building energy model is established and validated against actual energy consumption, energy performance indicators such as specific energy consumption (kWh/($m^2$.a)), efficiencies of systems and sub-systems should be compared to appropriate benchmark values to generate preliminary ideas for energy saving opportunities.

Some common examples of building energy performance indicators are shown in Table 2.

**Table 2 — Example checklist for items to be visually inspected during a site visit**

| Global indicators | Detailed indicators |
|---|---|
| — kWh/($m^2$·a or kWh/($m^3$·a) for heating, cooling, domestic hot water, ventilation, electricity and combinations thereof<br>— kWh/($m^2$·K·day) for heating<br>— kWh/$m^3$ for domestic hot water<br>— kWh/ (person. a), kWh/patient-day, etc.<br>— Energy signature for heating | — U-value of structures (can include the effect of thermal bridges)<br>— kWh/$m^3$ auxiliary energy for ventilation<br>— Efficiencies of systems and subsystems<br>— Expenditure factors of systems and sub-systems |
| — kWh/($m^2$·a or kWh/($m^3$·a) for heating, cooling, domestic hot water, ventilation, electricity and combinations thereof<br>— kWh/($m^2$·K·day) for heating<br>— kWh/$m^3$ for domestic hot water<br>— kWh/(person.a), kWh/patient-day, etc.<br>— Energy signature for heating | — U-value of structures (can include the effect of thermal bridges)<br>— kWh/$m^3$ auxiliary energy for ventilation<br>— Efficiencies of systems and subsystems<br>— Expenditure factors of systems and sub-systems |

### 5.7.3 Identification of energy performance improvement opportunities

The guidance on the identification of improvement opportunities are given in ISO 50002-1

### 5.7.4 Evaluation of energy performance improvement opportunities

Evaluation of improvement opportunities is given in ISO 50002-1.

The identified energy performance improvement opportunities should be ranked on the basis of an agreed evaluation criterion to prioritize them. The sequence will depend on how each opportunity (or measure) can impact on the saving potential of each of the others.

Where relevant to the energy audit objective(s) and scope, the energy auditor should identify energy performance improvement opportunities on the basis of:

a) their own expertise;

b) comparison against benchmarks if applicable;

NOTE This can provide the first indication of improvement opportunities but will not provide details.

c) the building's and technical systems' age, their condition, and how they are operated and maintained;

d) the technology of existing systems and equipment in comparison to the best available technology;

e) the energy performance of the building envelope, its interaction with the technical building system and energy use within the building;

f) best practices;

g) analysis of energy performance indicators (EnPIs), and trends and anomalies in energy performance using the energy and process data provided.

Opportunities to improve energy performance can range from one or more of the following, which are illustrative but not exhaustive:

— measures in order to reduce or to recover the energy losses;

EXAMPLE 1 Improve insulation or heat recovery.

— replacement, modification or addition of equipment;

EXAMPLE 2 High efficiency boilers, variable speed motors, energy efficient lighting.

— more efficient operation and continual optimization;

EXAMPLE 3 Operating schedules, control parameter adjustment, maintaining the installed equipment to its best performance.

— improved maintenance;

EXAMPLE 4 Maintenance planning, instruction of the operation and maintenance staff.

— deployment of behavioural change programmes;

EXAMPLE 5 Training, energy awareness campaigns.

— improvement of energy management;

EXAMPLE 6 Improvement in metering and monitoring plan, implement an EnMS.

Opportunities for renewable energy, energy storage, or other options on energy types can be considered in agreement with the organization according to the agreed scope of the energy audit.

The energy auditor should categorize the energy improvement solutions into:

— no cost (set-point and time schedule adjustment, switching off lights, closing doors, etc.);

— low cost (adding or improving controls, etc.);

— high cost investments (thermal insulation of building envelope, major technical system modifications, renewable energy, combined heat and power, etc.).

The energy savings interventions should be ranked in order of an appropriate financial metric, the nature of which should be agreed with the client. In order of most informative (and complexity), these include:

— life cycle cost assessment;

— internal rate of return;

— net present value;

— levelized cost of saved energy (LCSE);

— simple payback.

Recommendations should consider the costs and benefits of the proposed energy performance improvements over the life of the equipment, including non-energy benefits (such as maintenance savings).

### 5.7.5 Prioritization of energy performance improvement actions

Considerations for the prioritization of energy performance improvement actions are given in ISO 50002-1.

## 5.8 Reporting

### 5.8.1 General

The contents of energy audit reports are given in ISO 50002-1.

The reporting format should be targeted such that it is relevant to both technical and executive personnel.

The energy savings interventions should be reported in the following categories:

a) high-cost measures (building envelope, technical building equipment, etc.);

b) low-cost measures (adaption of operation mode, reduction of supply losses, etc.);

c) training and awareness of end users (training, motivation and behaviour change);

d) reviewing the requirements of comfort, health and well-being (temperature- and humidity-level, room size, etc.).

### 5.8.2 Report content

The report should include recommendations for future measurement and verification methods for the energy saving interventions proposed.

Table 3 shows an example table of content for the energy audit of a whole building.

**Table 3 — Example table of content of an energy audit in a building**

| Content |
|---|
| 1. Introduction:<br>— description of a building energy audit;<br>— method of work;<br>— auditor's contact information;<br>— summary of the energy use of the building and suggested saving measures;<br>— introduction of the present consumption level and specific consumptions;<br>— main performance improvement measures in heating, electricity and water;<br>— summary table: present situation, performance improvement potential and investments;<br>— summary table: suggested performance improvement measures, their effect on energy and costs, and payback time for each measure. |
| 2. Basic data of the building:<br>— site information;<br>— connections to networks;<br>— consumption of energy and water;<br>— operation, maintenance and facility management. |
| 3. Audit on the mechanical and electrical systems (describing the existing situation):<br>— heating system;<br>— water and sewage system;<br>— ventilation and air conditioning systems;<br>— cooling systems;<br>— electrical systems;<br>— building envelope;<br>— other systems. |
| 4. Suggested energy performance improvement opportunities (describing the improvements): |

**Table 3** *(continued)*

| Content |
|---|
| — tariffs used in energy performance improvement calculations;<br>— heating systems;<br>— water and sewage system;<br>— ventilation and air conditioning systems;<br>— cooling systems;<br>— electrical systems;<br>— building envelope;<br>— other systems;<br>— change in user behaviour;<br>— changes to operation and maintenance practices;<br>— other suggestions.<br>5. Integrated impacts:<br>— decarbonization;<br>— energy resiliency planning;<br>— energy water nexus analysis.<br>Appendices |

### 5.9 Closing meeting

No additional guidance to ISO 50002-1.

## 6 Competence of the energy auditor

The energy auditor's competencies should include those that are required by the scope of the audit, including:

a) building envelope;

b) heating systems;

c) ventilation and air conditioning systems;

d) cooling systems;

e) lighting, including lighting control systems;

f) hot water systems;

g) electrical systems (including appliances);

h) building automation systems;

i) transportation systems in the building, in particular lifts, escalators and moving walkways;

j) processes within the building, such as occupant-operated equipment, kitchen, laundry, data centres and hot or cold storage.

Competencies should also cover knowledge of the following:

— comfort criteria, including thermal comfort, air quality and humidity;

— illuminance levels and lighting quality;

— operation and maintenance;

— health, safety and productivity.

# Annex A
(informative)

# Data which can be collected

This annex provides a list of data which can be collected. This is not an exhaustive list; depending on the level or scope of the energy audit, some of the information on this list is not necessarily applicable to a specific organization or site.

The following data can be collected:

a) general site and organization information:
   1) building name and name of organization;
   2) point of contact at the organization:
      i) name;
      ii) title;
      iii) email;
      iv) phone number;
   3) address/location;
   4) building area (i.e. square footage);
   5) age of the building and any major renovations including approximate date;
   6) hours and days of operation (i.e. 8 am to 5 pm, Monday to Friday);
   7) number of occupants;
   8) name of utility/energy providers;
   9) details of previous audits;
   10) whether the building owned or leased;
   11) whether there have been any recent energy efficiency projects and the status of these projects;

b) energy sources:
   1) inventory of energy sources used on-site;
   2) hourly/daily/monthly/annual consumption;
   3) hourly/daily/monthly/annual on-site production of energy (size and type of energy storage);

c) energy management:
   1) structure of energy consumption (energy consumption patterns);
   2) metering accuracy and location, and maintenance of meters;
   3) energy tariffs;
   4) invoice amounts/billing history (fuels, electricity, water);

5) peak demand management;

6) energy management monitoring process (which indicators, who monitors them);

7) training of staff in the rational use of energy;

d) building envelope:

1) wall construction type, orientation and condition;

2) window construction type, orientation and condition;

3) doors construction type, orientation and condition;

4) roof construction type, orientation and condition;

5) floor construction type, orientation and condition;

e) lighting;

1) description of the lighting system in distinct work spaces (office, storage, outdoors, etc.), area of work space, installed kW capacity, lighting system controls and daylighting if used;

2) installed system specifications (fixture type, number of fixtures, lamp type, ballast type, efficiency in lumens per watt);

3) age and condition of the lighting systems (per cent operational at appropriate age-adjusted lumen output);

4) lighting operation (system size and control optimization to match load) by work space (daily, weekly);

5) control method (on/off, occupancy control, timer, photo-sensitive, energy management system (EMS) schedule, dimming control, etc);

6) occupancy level for each work space when necessary;

f) heating, ventilation and air conditioning (HVAC):

1) description of the system (constant volume, variable volume, single zone, multi zone, etc.) by unit;

2) area served and installed capacity by system, and matching data to operational needs;

3) age and condition of the HVAC system;

4) cooling source (direct expansion, chilled water, etc.);

5) heat source (heating hot water, steam, heat pump, etc.);

6) heat recovery method (air-to-air, water-to-air, air-to-water, water-to-water);

7) heat recovery equipment age, effectiveness, operating condition (direct or indirect heat exchanger, tubes fouled or clean, etc.);

8) operational setpoint schedule (e.g. occupied and unoccupied temperature);

9) unit controls (direct digital control (DDC), manual, pneumatics, etc.);

10) general condition of the devices and the distribution pipe systems;

11) annual consumption levels by system, if submetered;

g) chillers:

1) description of the chiller(s), installed capacity (electric and/or cooling) and operating method (base load, peak load, sequencing, season), and matching data to operational needs;

2) number of machines and performance curves (compression- or absorption-based refrigerating unit, compressor, condenser, air cooler, heat pump, etc.);

3) type of the refrigerant;

4) temperatures of the input/output secondary refrigerant;

5) general condition of the material and the distribution network (system, pump, etc.);

6) operating schedule or annual operating hours;

7) annual consumption if submetered;

h) cooling towers:

1) description of the cooling tower system, installed capacity, type(s) and number of cooling towers (cross-flow, counter flow, etc.) and the corresponding operating parameters, and matching data to operational needs;

2) thermal capacity;

3) inlet and outlet temperatures, and flow rate;

4) fan and pump control method;

5) general condition of the cooling tower and the water distribution network (system, pump, etc.);

6) operating schedule or annual operating hours;

7) annual energy and water consumption if submetered;

i) boiler:

1) description of the facility, installed capacity and the boiler operating method (base load, peak load, sequencing) and matching data to operational needs;

2) number of and types of boilers, boiler fuel(s) used and boiler efficiency;

3) heat transmission method (air, water, steam) generator (commissioning date, power, brand, type, fluid (hot water, steam, super-heated water, thermal oil, air, etc.), pressure, outgoing temperatures, nominal flow rate, thermal insulation);

4) operating schedule (daily, weekly, monthly, seasonal);

5) control and measurement equipment (fuel, heat carrier, fumes), recovery of condensates and steam traps;

6) burner control method and burner specifications (nature of fuels, age, firing capacity, power, $O_2$ control);

7) presence and the operational and performance parameters of recuperators, superheaters, economizer and air heaters;

8) boiler feed water tank volume and inlet feed water temperature;

9) discharge of and treatment of combustion products;

10) power supply circuits and complementary accessories (circulation pumps, fans, etc.);

11) general condition of the equipment (last settings, recent combustion efficiency test results, routine maintenance records, recent repairs and modifications);

12) water treatment (inlet and outlet water chemistry before and after treatment, treatment method, frequency of treatment and tests);

13) atmospheric discharge flow, temperature and flue gas chemistry measurement and performance readings on the basis of the boiler house record book or the regular inspection report;

14) readings (including accuracy class);

15) annual fuel consumption, product mix and production output;

j) heat exchange:

1) description of the system, installed capacity, operating parameters and matching data to operational needs;

2) buildings and premises serviced, volume of exchange medium heated, and inlet/outlet temperatures and flow;

3) exchangers and blenders;

4) function (heating, domestic hot water (DHW), heating plus DHW);

5) primary fluid/secondary fluid;

6) operating schedule;

7) annual consumption;

k) pumps:

1) description of the pumping system and its use, capacity and performance curve for each installed and operating pump, and its operational method;

2) pump description(s);

3) pump type(s) and number;

4) pump application;

5) physical location of pump(s) and installed motor data (rated nameplate power, voltage, full load amperage, nominal efficiency, enclosure type, operating frequency);

6) operating schedule;

7) control method (e.g. control valve, variable speed drive (VSD), bypass);

8) flow rate;

9) pressure;

10) pumped media (liquid);

11) input/output temperature;

12) general condition of pumps;

l) fans:

1) description of the fan system and its use, capacity and its operational method;

2) fan(s) description;

3) fan type(s) and number;

4) fan application;

5) physical location of fan(s) and installed motor data (rated nameplate power, voltage, full load amperage, nominal efficiency, enclosure type, operating frequency);

6) operating schedule (HVAC dependent or specific schedule for non-HVAC application);

7) control method (VSD, on-off, continuous, etc.);

8) return/discharge temperatures;

9) general condition of fans;

m) DHW:

1) description of the system, installed capacity and its matching data to operational needs;

2) production principle (centralized, independent, mixed, etc.);

3) characteristics of the material (power, temperature, fluid pressure, etc.);

4) storage (temperature, insulating material, etc.);

5) description and characteristics of distribution (storage tanks (capacity, coupling), circulation pumps (flow rate, pressure), regulations, tank insulation, network (diameter, number of outgoing lines), pipe size, pipe material, pipe temperature, insulating material specifications if insulated);

6) DHW needs and number of points serviced;

7) condition of the equipment and distribution network;

8) submetered usage or operating parameters;

9) annual consumption.

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