BS ISO 50015:2014

BSI Standards Publication

Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of ISO 50015:2014.

The UK participation in its preparation was entrusted to Technical Committee SEM/1/1, Energy Management Systems and Energy Audits.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

ISBN 978 0 580 76914 6

ICS 27.010

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2015.

Amendments issued since publication

Date	Text affected

INTERNATIONAL STANDARD

ISO 50015

First edition
2014-12-15

Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance

Systèmes de management de l'énergie — Mesure et Vérification de la performance énergétique des organismes — Principes généraux et recommandations

Reference number
ISO 50015:2014(E)

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 establish a common set of principles and guidelines to be used for measurement and verification (M&V) of energy performance and energy performance improvement of the organization. M&V adds value by increasing the credibility of energy performance and energy performance improvement results. Credible results can contribute to the pursuit of energy performance improvement.

This International Standard can be used irrespective of the type of energy used.

This International Standard can be used in several organizational contexts:

— by organizations with or without existing energy management systems, such as ISO 50001;

— for the M&V of energy performance or energy performance improvement;

— for all or part of an organization.

This International Standard can be used by organizations of any size, M&V practitioners, or any interested parties, in order to apply M&V to the reporting of energy performance results. The principles and guidance in this International Standard can be used independently or in conjunction with other standards and protocols. The principles and guidance in this International Standard are not required by ISO 50001, but can be applied by organizations using ISO 50001.

This International Standard does not specify calculation methods; rather, it establishes a common understanding of M&V and how M&V could be applied to different calculation methods. These principles and guidelines are applicable irrespective of the M&V method used.

Annex A provides an overview of the M&V flow that is used throughout this International Standard.

This International Standard is one of a family of International Standards developed by ISO/TC 242 and ISO/TC 257, on energy management and on the evaluation of energy savings related to regions and projects. Both ISO/TC 242 and ISO/TC 257 address organizational energy management and energy savings.

Energy management systems — Measurement and verification of energy performance of organizations — General principles and guidance

1 Scope

This International Standard establishes general principles and guidelines for the process of measurement and verification (M&V) of energy performance of an organization or its components. This International Standard can be used independently, or in conjunction with other standards or protocols, and can be applied to all types of energy.

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
baseline period
specific period of time used as the reference for comparing with the *reporting period* (3.19)

Note 1 to entry: Use for comparing energy performance and the calculation of the *energy performance* (3.9) and of the *energy performance improvement action* (3.5).

3.2
consequential effect
indirect energy effect (3.3) or *non-energy effect* (3.4)

3.3
indirect energy effect
effect on organizational *energy performance* (3.9) beyond the direct effect of the *energy performance improvement action* (3.5)

EXAMPLE The reduced load on the cooling system due to the improved efficiency of the lighting system resulting in an indirect energy effect.

3.4
non-energy effect
effect of implementing *energy performance improvement actions* (3.5) that is additional to the energy impact

EXAMPLE As a result of the installation of a more efficient washer, less water is needed resulting in a water non-energy effect.

Note 1 to entry: The M&V objective defines to what extent non-energy items that result from energy performance improvement actions are considered.

3.5
energy performance improvement action
EPIA
action or measure or group of action or measures implemented or planned within an *organization* (3.17) intended to achieve *energy performance improvement* (3.10) through technological, managerial or operational, behavioural, economical, or other changes

3.6
energy
electricity, fuels, steam, heat, compressed air, and other like media

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

Note 2 to entry: Energy can be defined as the capacity of a system to produce external activity or perform work.

[SOURCE: ISO 50001:2011, 3.5]

3.7
energy baseline
quantitative reference(s) providing a basis for comparison of *energy performance* (3.9)

Note 1 to entry: An energy baseline reflects a specified period of time.

Note 2 to entry: An energy baseline can be normalized for *relevant variables* (3.18) which affect *energy use* (3.12) and/or *energy consumption* (3.8), e.g. production level, degree days (outdoor temperature), etc.

Note 3 to entry: The energy baseline is also used for calculation of energy savings, as a reference before and after implementation of *energy performance improvement actions* (3.5).

[SOURCE: ISO 50001:2011, 3.6]

3.8
energy consumption
quantity of *energy* (3.6) applied

[SOURCE: ISO 50001:2011, 3.7]

3.9
energy performance
measureable results related to energy efficiency, *energy use* (3.12) and *energy consumption* (3.8)

Note 1 to entry: In the context of energy management systems, results can be measured against the *organization's* (3.17) energy policy, objectives, targets and other energy performance requirements.

Note 2 to entry: Energy performance is one component of the performance of the energy management system.

[SOURCE: ISO 50001:2011, 3.12]

3.10
energy performance improvement
improvement in measurable results related to energy efficiency, *energy use* (3.12) or *energy consumption* (3.8) compared to the *energy baseline* (3.7)

3.11
energy performance indicator
EnPI
quantitative value or measure of *energy performance* (3.9), as defined by the *organization* (3.17)

Note 1 to entry: *EnPIs* (3.11) could be expressed as a simple metric, ratio or a more complex model.

Note 2 to entry: For the purposes of this International Standard, a quantitative value or measure of energy performance developed by the *M&V practitioner* (3.15) is referred to as an energy performance metric.

[SOURCE: ISO 50001:2011, 3.13, modified – Added Note 2 to entry.]

3.12
energy use
manner or kind of application of *energy* (3.6)

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

[SOURCE: ISO 50001:2011, 3.18]

3.13
measurement and verification
M&V
process of planning, measuring, collecting data, analysing, verifying, and reporting *energy performance* (3.9) or *energy performance improvement* (3.10) for defined *M&V boundaries* (3.14)

3.14
M&V boundary
organizational, physical, site, facility, equipment, systems, process or activity limits within which *energy performance* (3.9) or *energy performance improvement* (3.10) is measured and verified

3.15
M&V practitioner
individual or team that performs *measurement and verification* (3.13)

Note 1 to entry: The Spanish equivalent is “profesional en M&V” or “experto en M&V”.

3.16
non-routine adjustment
adjustment made to the *energy baseline* (3.7) to account for unusual changes in *relevant variables* (3.18) or *static factors* (3.22), outside the changes accounted for by *routine adjustment* (3.20)

Note 1 to entry: Non-routine adjustments may apply where the energy baseline no longer reflects current *energy use* (3.12) or *energy consumption* (3.8) patterns, or there have been major changes to the process, operational patterns, or energy systems.

3.17
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 *energy consumption* (3.8)

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

[SOURCE: ISO 50001:2011, 3.22]

3.18
relevant variable
quantifiable factor that impacts *energy performance* (3.8) and routinely changes

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

3.19
reporting period
report period
defined period of time selected for calculation and reporting of *energy performance* (3.9)

3.20
routine adjustment
adjustment made to the *energy baseline* (3.7) to account for changes in *relevant variables* (3.18) according to a predetermined method

Note 1 to entry: ISO 50001 uses the term “predetermined method” to refer to this concept.

3.21
significant energy use
energy use (3.12) accounting for substantial *energy consumption* (3.8) and/or offering considerable potential for *energy performance improvement* (3.10)

Note 1 to entry: Significance criteria are determined by the *organization* (3.17) or the *M&V practitioner* (3.15).

[SOURCE: ISO 50001:2011, 3.27, modified — Added “or the M&V practitioner” to Note 1 to entry.]

3.22
static factor
identified factor that impacts *energy performance* (3.9) and does not routinely change

EXAMPLE 1 Facility size; design of installed equipment; the number of weekly production shifts; the number or type of occupants, range of products.

EXAMPLE 2 A change in a static factor could be a change in a manufacturing process raw material, from aluminium to plastic, and can lead to a *non-routine adjustment* (3.16).

4 Measurement and verification principles

4.1 General principles

These principles are the basis for the subsequent guidance on the M&V of organizational energy performance and energy performance improvement. Principles are not requirements rather, these principles should guide decisions made in both planned and unanticipated situations.

The purpose of M&V is to provide confidence to interested parties that reported results are credible.

The following principles (described in detail in 4.2 to 4.8) should be addressed:

— appropriate accuracy and management of uncertainty;

— transparency and reproducibility of M&V process(es);

— data management and measurement planning;

— competence of the M&V practitioner;

— impartiality;

— confidentiality; and

— use of appropriate methods.

4.2 Appropriate accuracy and management of uncertainty

Uncertainty of results, including measurement accuracy, needs to be managed to an appropriate level for the purpose of the M&V. A clear statement regarding the accuracy of results and steps taken to mitigate uncertainty should be included in the reported results.

4.3 Transparency and reproducibility of M&V process(es)

An M&V process should be documented to ensure transparency and traceability of the process. The entire M&V should be documented in a manner that ensures reproducibility, which contributes to confidence in the M&V result.

NOTE When the data are confidential, transparency can be limited for some interested parties.

4.4 Data management and measurement planning

The M&V process should include information on how the data will be managed during the M&V activities. Data management includes (but is not limited to) the means to store, backup, maintain and secure the data. The M&V process should also include information on measurement planning such as location, frequency, and installation of meters or sensors. These issues need to be included in the documentation.

4.5 Competence of the M&V practitioner

Competence of the M&V practitioner contributes to confidence in the results reported. The M&V practitioner will meet relevant legal, regulatory, certification or other requirements for the M&V process. The organization requesting the M&V may define competency requirements. In all cases, the M&V practitioner should declare their competence with regards to the provided M&V services. M&V practitioners should work within their field of expertise and comply with appropriate codes of ethics.

4.6 Impartiality

Impartiality contributes to confidence in the reported results. Impartiality does not require third party independence. The M&V plan as well as the M&V reports should contain a statement outlining the impartiality of the M&V practitioner. The interested parties should formally disclose any conflict of interest before starting activities or as they arise during the M&V process.

4.7 Confidentiality

Any confidential information necessary to perform the M&V should be made accessible to the M&V practitioner. If information necessary to perform the M&V cannot be made available to the M&V practitioner due to confidentiality requirements, the M&V practitioner should highlight this in the M&V plan and details of any restrictions that may affect the M&V result. The M&V practitioner should ensure that confidentiality is maintained.

4.8 Use of appropriate methods

The M&V method as well as the calculation methods selected should follow established good practices. The reasons for selecting the M&V method and calculation methods should be clearly described in the M&V plan.

5 Measurement and verification plan

5.1 General

There are six fundamental steps in the M&V process which are specified in the M&V plan:

— 1. Establish and document an M&V plan (see 5.2 to 5.13): the M&V plan is the document that describes how each phase of the M&V should be performed.

— 2. Data-gathering (see 6.1).

— 3. Verify the implementation of EPIA(s) if any (see 6.2).

— 4. Conduct M&V analysis (see 6.4).

— 5. Report M&V results and issue documentation (see 6.5).

— 6. Review the need to repeat the process, as necessary (see 6.6).

Repeat the steps 1 to 5 of the M&V process, as determined in step 6. The sequence of these six basic steps is illustrated in Figure 1. The M&V plan is outlined in 5.2 to 5.13.

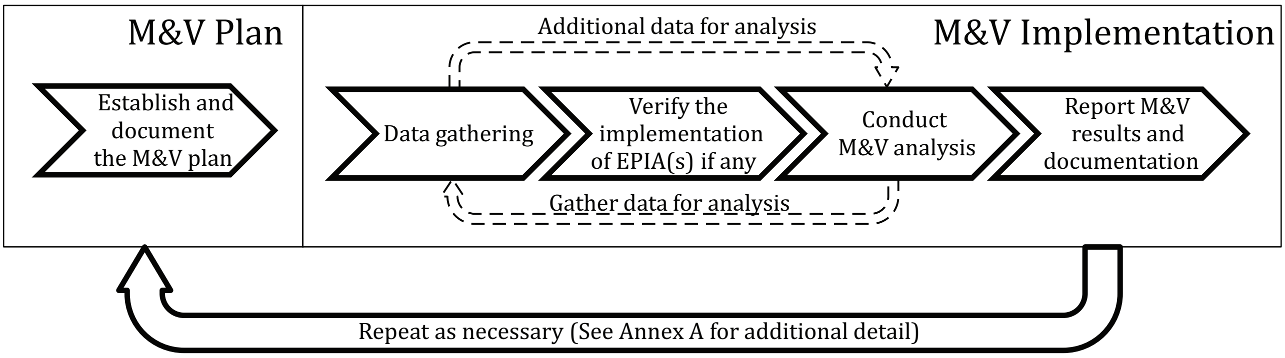

Figure 1 — Fundamental steps in the M&V process

5.2 Scope and purpose

The scope and purpose of the M&V plan should describe:

a) the organization for whom the M&V is undertaken;

b) reason(s) for carrying out the M&V;

NOTE 1 Understanding the reason(s) for performing the M&V is important in selecting the methods used as well as the levels of accuracy required.

EXAMPLE 1 The reason(s) for carrying out the M&V could be for quantifying improvements in energy performance, for financial repayments, to comply with requirements for subsides or grants, for taxation purposes, for corporate social responsibility, etc.

c) parties responsible for the M&V, their roles and relationship to the organization, consistent with the principle of impartiality (see 4.6);

d) confidentiality requirements (see 4.7);

e) parties who will receive the results;

f) any identified legislative or other requirements, including additional standards with which the M&V process should comply;

g) summary of the physical scope of M&V (see 5.4), including if the M&V in question is applicable to the whole or part of the organization: if it applies to a part of the organization, the scope should specify which part of the organization;

h) what is being measured and verified, including energy performance metrics, EnPI(s) or EPIA(s);

i) potential consequential effects;

NOTE 2 The list of such effects can be provided in the scope with reference to uncertainty (see Clause 7).

j) M&V method used;

k) summary of the data to be collected and analysed, including the type and frequency;

EXAMPLE 2 Type of data can include estimated data, measured data, utility data, etc.

l) applicable accuracy or uncertainty requirements to be met;

m) frequency (e.g. monthly, quarterly, annually) and format of M&V reports;

n) process, if any, for updating the M&V plan;

o) confirmation that the M&V scope is within the capability of the M&V practitioner, conforming with the principle of competence of the M&V practitioner (see 4.5).

5.3 Energy performance improvement actions

This section of the M&V plan should describe the various EPIAs, if any, that have an impact in the defined M&V scope and timeframe, and should therefore be measured and verified. This section should be described in sufficient detail, as listed below, to ensure that any other competent M&V practitioner would be able to assess that the M&V process used was appropriate:

— description of each of the EPIA(s), including the baseline(s) for M&V;

— how or why implementing the EPIA(s) is expected to contribute to maintaining or improving energy performance;

— expected improvement or maintenance in energy performance resulting from the implementation of the EPIA(s);

— designation of responsibility for implementing the EPIA(s);

— how the EPIA(s) will be implemented;

— timeframe and sequence for implementation of each EPIA;

— location where the EPIA(s) will be implemented;

— EPIA(s) costs, if relevant to the M&V objectives;

— how implementation of the EPIA(s) will be physically verified;

EXAMPLE 1 Boilers 1 and 2 will be replaced with more efficient boilers; physical inspection with photographs will confirm installation.

— description of consequential effects;

— identification of which consequential effects will or will not be quantified in the M&V;

EXAMPLE 2 The consequential effect might not be quantified is it cannot be determined or has little effect on the M&V results.

— description of the potential implication of consequential effects not qualified.

5.4 M&V boundaries

The choice of M&V boundaries is often determined by a number of considerations, including (but not limited to) the scope and purpose of the M&V, the nature of the EPIA (s) to be measured, choice of calculation and M&V method (see 5.8).

M&V can be applicable to the organization as a whole or to a part of the organization. Accordingly, M&V boundaries should be drawn around the organization as a whole or part of the organization.

In situations where an energy baseline needs to be established, systems, processes or equipment with a significant energy use within the scope of the M&V should be determined and should be included as part of the energy baseline and any subsequent quantification of energy performance. In cases where any significant energy use has not been included, the M&V practitioner should note the reason for this omission.

NOTE 1 Systems, processes or equipment whose energy performance is found neither to affect nor be affected by the EPIA a can be removed from the M&V boundaries in order to simplify the M&V process. However, consequential effects need to be considered when determining which elements are not affected by the EPIA or energy performance.

NOTE 2 M&V boundaries need not be physical boundaries, provided that it is possible to clearly describe the boundary and that it is possible to measure relevant variables and static factors, as well as significant energy use affecting energy consumption inside the boundary. For example, M&V boundaries might be drawn around a vehicle fleet.

The M&V plan should clearly describe and document the M&V boundaries, including the relevant systems, processes or equipment. A statement should be made by the M&V practitioner outlining the reasons for choosing the M&V boundaries and the impact of these choices on uncertainty (see Clause 7).

5.5 Preliminary M&V plan assessment

The preliminary M&V plan assessment is a high-level identification of the systems, data and materials to be used in the M&V process. The preliminary M&V plan assessment includes the following:

a) develop and document the current energy uses, facilities and equipment characteristics, as well as energy consumption patterns within the M&V boundaries: this understanding should be sufficient to enable the M&V practitioner to select an appropriate M&V method and calculation method (see 5.8);

b) identify and document an appropriate and representative period of time for conducting M&V that captures the range of operating conditions;

c) identify the data needed for the data-gathering plan (see 5.9);

d) identify the data needed for the energy baselines and their maintenance (see 5.10);

e) identify the availability and quantity of the energy data and, if necessary, the need for additional data;

f) identify the equipment and other resources necessary to perform the M&V.

5.6 Characterization and selection of energy performance metrics including EnPIs

5.6.1 General

Energy performance of the organization is measured by energy performance metrics. Quantifying these metrics is sometimes the purpose of the M&V. Energy performance metrics may be used to support other M&V objectives. Energy performance metrics defined by the organization are termed EnPIs (see 3.8).

5.6.2 Characterization of energy performance metrics

Characterization of each energy performance metric or EnPI should include a definition, description, and unit of measure. Characterization of energy performance metrics based on ratios or more complex models should include the mathematical equation(s) or specific steps to determine the energy performance metric. When M&V is conducted for an EnPI, the characterization should be obtained from the organization.

EXAMPLE 1 Value-based energy performance metrics include total energy consumption per month (in kWh), total monthly production volume (in tonnes).

EXAMPLE 2 Ratio-based energy performance metrics include specific monthly energy consumption calculated as total monthly energy consumption (in kWh) divided by total monthly production (in tonnes).

EXAMPLE 3 Model-based energy performance metrics can be derived from linear or nonlinear regression models, etc. For additional information on EnPIs and energy baselines, see ISO 50006.

Based on the results of preliminary M&V plan assessment (see 5.5), the M&V practitioner should report and document relevant variables and static factors, as well as conditions that influence the value of EnPI(s) and energy performance metrics.

EXAMPLE 4 An EnPI, defined as kWh/product, can be strongly influenced by production volume, i.e. kWh/product at 100 % production capacity can be very different from kWh/product at 50 % production volume.

5.6.3 Selection of energy performance metrics

The M&V practitioner should identify energy performance metrics needed for the M&V. Since the EnPIs may not be sufficient for the purposes of the M&V, additional energy performance metrics may need to be defined by the M&V practitioner. The M&V practitioner will document the reason for the additional energy performance metrics. The additional energy performance metrics may or may not be adopted as EnPI(s).

EXAMPLE A lighting retrofit can lead to a substantial decrease in lighting energy consumption without having a notable impact on an EnPI such as kWh/unit produced, in cases where lighting is a small fraction of overall energy consumption. In such a case, the M&V practitioner will identify an alternative energy performance metric such as lighting kWh/m^2.

5.7 Characterization and selection of relevant variables and static factors

The following steps are needed for the characterization and selection of relevant variables and static factors:

— establish the criteria for selecting relevant variables or static factors that affect energy performance within the M&V boundaries;

— identify relevant variables as well as static factors;

— determine the typical operating range of the identified relevant variables and level of the static factor;

— determine a representative period of time;

— identify and specify the data characteristics and data source(s) for each relevant variable or static factor according to the guidelines in the data-gathering plan (see 5.9);

— identify and describe consequential effects that may occur;

— determine which consequential effects will or will not be quantified in the M&V;

EXAMPLE The consequential effect might not be quantified if it cannot be determined or has little effect on the M&V results.

— describe the potential application of consequential effects not quantified; and

— list the variables or static factors considered and determined not to be relevant along with the reasons for their omission.

5.8 Selection of the M&V method and calculation method

There are numerous methods, standards, protocols and calculation methods available worldwide to quantify energy performance and energy performance improvement. The M&V practitioner should select an appropriate M&V method. The selection is typically based on a number of factors, including (but not limited to):

— purpose of the M&V;

— accuracy requirements;

— relevant experience of the M&V practitioner;

— nature of the EPIA(s) or energy performance metrics to be measured and verified;

— nature and size of the organization as well as the choice of M&V boundaries;

— information gathered during the preliminary M&V planning assessment (see 5.5);

— legal, regulatory or other requirements, including other standards or protocols;

— costs of methods under consideration.

Irrespective of the choices made by the M&V practitioner, this section of M&V plan should contain:

a) a step-by-step description of the M&V method and the calculation method as well as a reference to any selected protocols;

b) description that is sufficiently detailed to ensure that other competent M&V practitioners would be able to implement the M&V process; and

c) the rationale for selecting the M&V method and calculation method, including the advantages and disadvantages.

5.9 Data–gathering plan

The data that will need to be collected is based on the energy performance metrics, including EnPIs (see 5.6) or EPIAs and the M&V method selected M&V method and calculation method (see 5.8). For each data element needed, the following should be described:

— name of variable;

— data source, existing or new;

NOTE 1 The description will typically include the type of data source (i.e. operating manual, instrument, etc.), instrument serial numbers (where available), list of measurement points, physical measurement location(s), and measurement process or measurement method.

— data quality;

NOTE 2 Data quality can include the appropriateness, accuracy, validation, reliability, completeness, etc. of data from the data source.

NOTE 3 Data quality includes information on source calibration (where available). In cases where calibration information is not available, the potential impact will be described in the context of uncertainty (see Clause 7).

— identification and disposition of outlier(s) or gaps in data with justification;

— frequency at which data will be collected (i.e. hourly, daily, monthly, etc.);

NOTE 4 The frequency of data collection needs to be sufficient to capture the range of operating conditions.

— measurement type;

EXAMPLE 1 Integrated measurement (e.g. average over a period of time) or spot measurement (instantaneous).

— method of collection;

EXAMPLE 2 Weather conditions can be obtained from a number of means, including:

a) directly from degree (day database or the nearest reliable weather measurement point),

b) computed from the temperature database of the nearest weather measurement point, or

c) computed from a local temperature meter (existing or not).

— individual(s) responsible for conducting the measurements, e.g. the organization the M&V practitioner or contractors;

— preparation of, and access to, measurement points;

— operating constraints are implementation constraints;

EXAMPLE 3 Plant shut down might be needed for installation of some instruments.

— type of meter or sensor to be used.

The choice of meter or sensor should consider the range, accuracy, precision, capability, conditions of use and the M&V objectives.

This section of the M&V plan should provide the reasoning behind the choices made to obtain the data, and how these choices affect the accuracy and uncertainty of the results (see Clause 7) as appropriate to the M&V objectives. This section should also specify how data should be recorded and maintained. The plan should provide contingency for data loss or data backup.

In cases where energy performance improvement is reported, an energy baseline needs to be established. In such cases, there may be differences between the data–gathering plan during the baseline period and the data–gathering plan during the reporting period, in which case, two separate data–gathering plans (one for each period) should be documented. The description of the data-gathering plan should be comprehensive enough to ensure the process of obtaining the data can be both repeatable and reproducible.

5.10 Energy baseline establishment and adjustments

5.10.1 Establishment of energy baseline

In cases where the energy performance improvement is to be determined, an energy baseline should be established according to the requirements and guidelines of the M&V method and calculation method selected (see 5.8).

Data used to establish the energy baseline should be gathered according to the guidance in data-gathering plan (see 5.9) and analysed according to the M&V plan. The energy baseline should be established prior to the implementation of any EPIA(s) if practicable. However, the M&V practitioner can establish the energy baseline after the implementation of EPIA(s) on condition that the data required to establish the energy baseline are available. If the energy baseline is established after the EPIA(s), the reason(s) for this should be documented in the M&V plan.

NOTE 1 When ISO 50015 is being used with ISO 50001, the energy baseline is determined using the information in the energy review.

This section of the M&V plan should document how the energy baseline is established and should include:

a) the raw data used to develop the energy baseline determined during the data-gathering process (see 5.9);

   NOTE 2 Raw data are unprocessed data.

   NOTE 3 The entire raw data set need not form a part of the M&V plan, provided that the M&V plan clearly describes where and how the raw data are stored and how it can be accessed.

b) the specific time period for the energy baseline and related conditions;

c) the process followed to establish the energy baseline;

   NOTE 4 This process will be described in sufficient detail to promote confidence, traceability, repeatability, reproducibility and consistency.

d) the processed data where applicable, the energy consumption model representing the energy baseline.

5.10.2 Adjustments of the energy baseline

The M&V method and calculation method chosen can require the energy baseline to be adjusted to the conditions of the reporting period.

This section of the M&V plan will provide the conditions and reasons under which routine baseline adjustments are required and will outline the method(s) used to perform such adjustments.

The M&V plan will also specify the non-routine adjustments of the energy baseline, including:

— means for monitoring the need for non-routine adjustments of the energy baseline;

EXAMPLE 1 M&V practitioner will check periodically for major changes in the range of variation of data, including both relevant variables and static factors related to processing equipment, energy consumption, relevant variables, or energy performance metrics.

— the procedure to be followed when non-routine adjustments to the baseline are required; and

— the specific method of, and reasons for, any expected or known non-routine adjustments to the energy baseline.

EXAMPLE 2 If a simulation is used as a part of the M&V method, the M&V practitioner will document the conditions, if any, under which recalibration of the simulation is required along with the recalibration method.

5.11 Resources required

M&V resources should be appropriate to the M&V objective. The resources section of the M&V plan should document:

a) the resources required for conducting the M&V;

NOTE Resources include budget, measurement and other equipment, access to measurement points, human resources, including qualifications and competency requirements, access to data and evidence records, etc.

b) a statement by the M&V practitioner confirming the resources available are appropriate to the scope and purpose of the M&V objective.

5.12 Roles and responsibilities

The roles and responsibilities of the parties involved in the M&V should be documented along with the following:

— methods for communication between the different parties;

— changes to key personnel their contact details and how this information will be updated in the the plan;

— competencies determined according to the principle of competency of the M&V practitioner (see 4.5).

5.13 Documentation of the M&V plan

Elements of the M&V plan, as described in 5.1 to 5.12, should be documented in a manner to promote confidence, traceability, repeatability, reproducibility and consistency. The M&V plan should be recorded and maintained to ensure the information is readily available and easy to locate.

There should be appropriate records supporting the reasons for decisions made in order to establish an audit trail. This may include recording electronic correspondence between relevant parties.

The remainder of this International Standard briefly outlines the steps recommended after the M&V plan has been establish in order to apply the M&V process to the reporting of energy performance results.

6 Implementation of M&V plan

6.1 Data–gathering

The M&V practitioner should collect and record the data according to the requirements of the data-gathering plan (see 5.9).

6.2 Verification of the implementation of the EPIA(s)

The M&V practitioner should verify the EPIA(s) as described in the M&V plan (see 5.3) have been appropriately implemented. The following, relative to the current M&V plan, should be recorded:

a) actions implemented;

b) actions not implemented and the reason(s);

c) actions differing from the current M&V plan and the reason(s).

If an implemented EPIA(s) differs from its description in the M&V plan (see 5.3) in a way that requires an adjustment M&V plan, that adjustment should be made, documented and included in the periodic M&V reporting (see 6.5). Elements of the M&V plan that may require adjustment include (but are not limited to) method, M&V boundary selection, relevant variables and static factors.

6.3 Observation anticipated or unforeseen changes

The M&V practitioner is responsible for ensuring the M&V results reported conform to the requirements and objectives of the M&V plan. Situations requiring non-routine adjustments should be noted and recorded by the M&V practitioner or the organization. Such situations may include changes in scope, changes to the implementation, execution or constitutional parts of EPIA(s), as well as changes internal or external to the M&V boundaries.

The M&V practitioner should:

— record this situation as part of the periodic M&V reporting (see 6.5);

— consultant and update the M&V plan to incorporate the non-routine change into the M&V plan.

6.4 M&V analysis

During this step of M&V, the energy performance or energy performance improvement is determined based on the analysis and results of the data-gathering (see 5.9). M&V analysis should follow the scope, time periods, data frequency and method specified in the M&V plan.

If the M&V objective includes determining energy performance improvements, the M&V practitioner should calculate the baseline according to the M&V plan. Any non-routine adjustments or changes to methods used should be recorded. The outcome of this step is measured and verified energy performance results. These results should be reported according to the requirements of the M&V plan.

If two or more EPIA(s) are implemented during the same or overlapping time periods, the M&V result from their combined effect could be different from the sum that would occur from each EPIA(s) individually. The M&V analysis should ensure that the M&V result determined for the combination of the EPIA(s) appropriately addresses any such difference.

EXAMPLE Two EPIA(s) are implemented:

a) improving combustion efficiency of a heating system, and

b) improving building insulation.

Savings from the combustion efficiency improvement alone could be determined based on the efficiency changes at the initial insulation level. Savings from the insulation improvement alone could be determined based on the insulation difference at the initial efficiency level. The combined effect is determined based on the difference between the initial state and the consumption at both the improved efficiency and improved insulation level.

6.5 M&V reporting

M&V should be documented and reports at intervals as established in the M&V plan. Reports may be a single annual report, ongoing quarterly reports, monthly reports, etc.

Reports should summarize the scope and purpose (see 5.2) of the M&V.

Report should specify the responsible person that performs the M&V and their relationship to the organization. In order to provide confidence in the results, reports should include a clear statement regarding the accuracy or uncertainty of measurement.

Typically M&V reports should:

a) list implemented EPIA(s);

b) list EPIA(s) planned for implementation that were not implemented, specifying why they were not implemented;

c) provide details of any EPIA's implementation differed from the original plans;

d) identify changes that have occurred and if the change requires a non-routine adjustment(s);

NOTE 1 This includes changes to relevant variables as well as changes to static factors.

e) provide energy performance or energy performance improvement results according to the requirements of the M&V plan, as well as legal, regulatory, or other requirements that may be applicable.

The M&V practitioner should report any challenges experienced and how these were addressed as a part of the M&V process. These challenges may include:

— data quality or data availability not meeting the M&V plan requirements;

— operational changes.

NOTE 2 Operational changes might have occurred making it difficult to compare the energy baseline and reporting periods under constant conditions (significant changes might include changes in operating shifts, significant changes in production volume or mix, introduction of feedstock, etc.).

NOTE 3 The information provided in the reports can be adjusted to avoid duplication in periodic reports. For example, if the scope is outlined in the first monthly report, repetition the following month might not be required.

6.6 Review the need to repeat the process

The M&V practitioner should review the need to repeat all or part of the M&V process based on any of several factors, such as:

— frequency is determined in the M&V plan;

— results achieved;

— opportunities or EPIA(s) to be implemented;

— other requirements identified in M&V plan; or

— effects of issues or challenges encountered.

7 Uncertainty

Understanding of uncertainty is necessary in order to interpret and communicate M&V results effectively and to ensure credibility of reported M&V results. Sources of uncertainty should be identified where possible and should be quantified to the extent practicable and useful to the M&V objectives.

There is a trade-off between uncertainty levels and M&V cost. Full quantification of uncertainty may not be required if this is prohibitively expensive in relation to the M&V objectives. Where a rigorous, meteorological and statistically valid evaluation of uncertainty is not feasible, potential contributors to uncertainty should be identified with reasonable estimates of the magnitude of each component's uncertainty.

Sources of uncertainty to be considered may include (but are not limited to) the following:

a) M&V method chosen;

b) calculation method chosen;

c) M&V boundaries chosen;

d) selection/choice of significant energy use within the boundary;

e) excluded energy types;

f) frequency of data collection;

g) data intervals;

h) measurement method used;

i) energy consumption model diagnostics and bias;

NOTE Uncertainty from some of these sources can be quantified through common diagnostics such as t-statistics, R^2 values, p-values, confidence levels, model prediction bounds, or other goodness of fit measures. Where engineering calculations or simulations are used, uncertainty can be described based on the methods employed, using common rules from handbooks or through sensitivity analysis.

j) competency of the M&V practitioner;

k) sample size and whether the sample size is considered representative;

l) measurement equipment uncertainty;

m) possible consequential effects not included in the M&V result.

Examples of measurement uncertainty are given in Annex B.

8 Measurement and verification documentation

All M&V activity should be documented, including:

a) the M&V plan (see 5.13),

b) M&V report (see 6.5), and

c) materials necessary to reproduce the M&V results a specified in the M&V plan.

Documentation should be subject to change control processes to ensure that issued versions of a document and the related changes remain available for access according to the M&V plan for such period as the interested parties may specify.

Annex A
(informative)

Overview of the measurement and verification flow

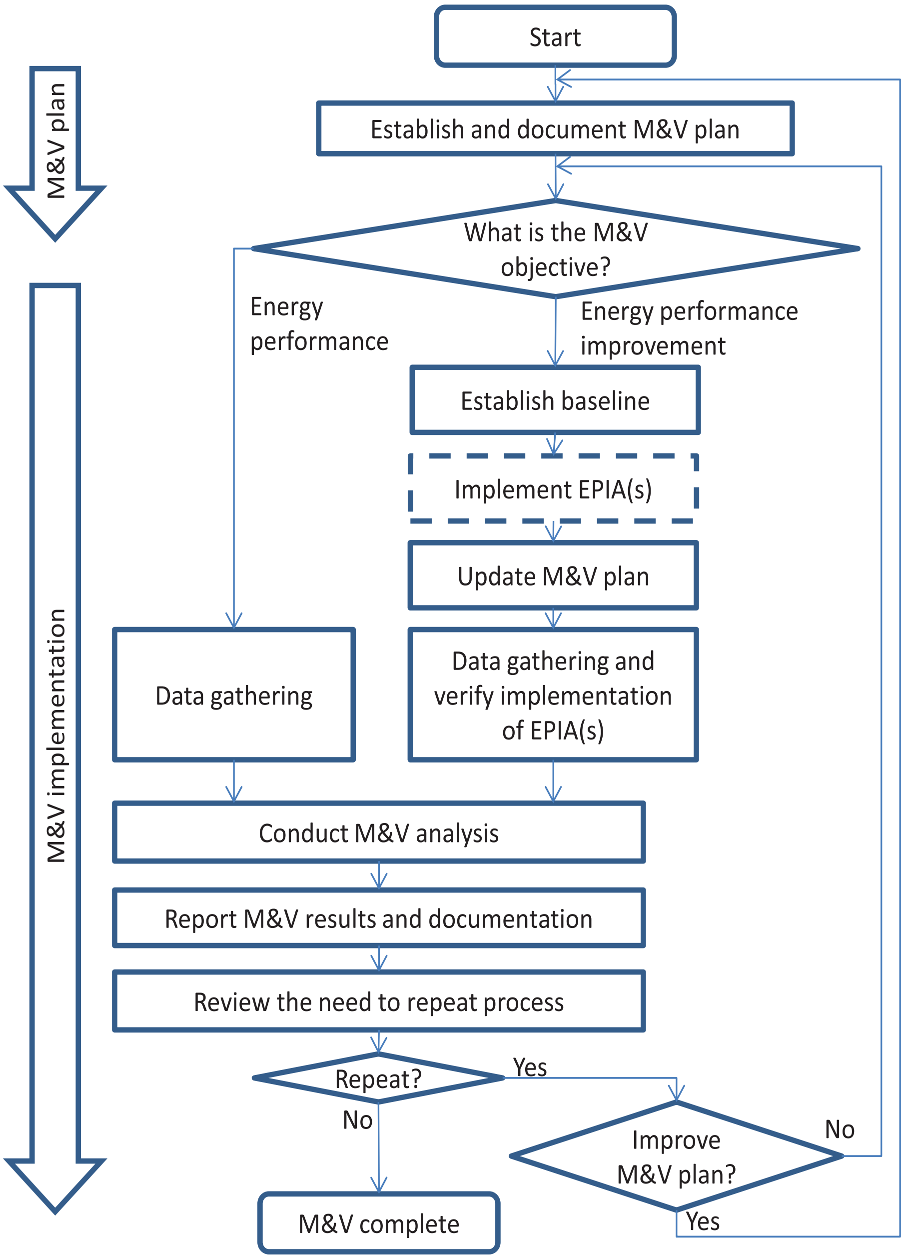

Figure A.1 — Overview of the measurement and verification flow

Annex B
(informative)

Measurement uncertainty examples

The analysis of uncertainties associated with data, methods and models used to identify and analyse energy performance improvement results plays an important part in their application. Uncertainty analysis involves the determination of the variation or imprecision in the results, resulting from the collective variation in the parameters and assumptions used to define the results.

An area closely related to uncertainty analysis is sensitivity analysis. Sensitivity analysis involves the determination of the size and significance of the magnitude of results to changes in individual input parameters. It is used to identify those data which need to be accurate, and those which are less sensitive and hence have less effect upon overall accuracy.

EXAMPLE 1 This example shows how you could make use of "un-calibrated" measurement instruments, but still states the result with confidence. Assume you need to measure the amount of water leaking from a tap during a 24h period. You do not have a calibrated volumetric container at hand. As an alternative, you decide to use a 1l, glass soft drink bottle. You know the bottle might not be calibrated to the nearest 15ml. You also know that the glass bottle cannot expand or contract significantly enough to influence the volume of the bottle by more than 5ml, otherwise it would break. You decide that you will fill the bottle to the point where it overflows before you consider it to contain 1l. You know this gives you a "safety-margin" close to 20 ml since the normal practice by the soft drink company is to leave some space (roughly 20ml) between the liquid and the bottle cap. In this case, the result could be stated as an accurate lower bound (e.g. "minimum of").

EXAMPLE 2 There are three timepieces as follows:

— A: a mechanical watch with hour, minute and second hands and second graduations printed on the face;

— B: a mechanical stop watch with graduations in 1/2 s graduations;

— C: an electronic stop watch that digitally displays graduations in 1/10 increments.

Three individuals will watch a short video clip; they must determine the start and stop times on their own. After the video has finished, the result of timepiece A is 33 s, of timepiece B is 28,5 s and of timepiece C is 30,03 s. There is a total range of 4,5 s error. The video played for 30 000 s, so there is variation inherent in the timepieces and the personnel using them. The error of 4,5 s might contribute little to the reporting results, given that the video clip is used as a safety video for the organization, and timing is not so important; however, if the video clip were an actual television commercial, this could be considered excessive variation and might be costly. The intent is to show that the same variation might be acceptable for the application and needs of the user, while others might not. It is important to determine, understand and calculate the amount of variation in order to determine its contribution to the results reported.

EXAMPLE 3 When measuring the height of your desk, you might obtain a value of 1,0 m. Due to uncertainty of measurement, you cannot report with confidence that the height of the desk is 1,0 m. It is easy to imagine that you have some experience using a measuring tape. You might feel completely confident that the tape measure you are using would not be stretched or shrunk by more than 3 cm. You might also feel confident that your method of measurement will not be inaccurate by more than 2 cm. The combined effect of the tape measure's uncertainty, and the uncertainty associated with your measurement technique, would therefore not be inaccurate by more than 5 cm. You can now report with complete confidence that the desk is not higher than 1,05 m and not shorter than 95 cm (1m ± 5 cm). You could also state with complete confidence that the desk is at least 95 cm high. Alternatively, you could state with complete confidence, that the desk is shorter than 1,05 m.

NOTE No measurement is exact and the imperfections give rise to error in the result. Consequently, the energy performance result is an approximation and is only complete when accompanied by a statement of uncertainty of that approximation. ISO/IEC Guide 98-3 establishes general rules for evaluating and expressing uncertainty in measurement that are intended to be applicable to a broad spectrum of measurements.

Bibliography

[1] ISO/TR 16344, *Energy performance of buildings — Common terms, definitions and symbols for the overall energy performance rating and certification*

[2] ISO 16818, *Building environment design — Energy efficiency — Terminology*

[3] ISO 17747[1)], *Determination of energy savings in organizations*

[4] ISO 50001:2011, *Energy management systems — Requirements with guidance for use*

[5] ISO 50002, *Energy audits — Requirements with guidance for use*

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

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

[8] ISO 50006, *Energy management systems — Measuring energy performance using energy baselines (EnB) and energy performance indicators (EnPI) — General principles and guidance*

[9] ISO/IEC Guide 98-3, *Uncertainty of measurement — Guide to the expression of uncertainty in measurement (GUM:1995)*

[10] Energy Savings Management Guide: How to Estimate, Measure, Evaluate and Track Energy Efficiency Opportunities version 2.0, Commonwealth of Australia, 2013, ISBN 978-1-922106-60-5

[11] Measurement and Verification Operational Guide: Best Practice M&V processes, State of NSW and Office of Environment and Heritage, December 2012, ISBN 978 1 74293 956 8

[12] A Best Practice Guide to Measurement and Verification of Energy Savings Australasian Energy Performance Contracting Association for the Innovation Access Program of Ausindustry in the Australian Department of Industry and Tourism and Resources, 2004

[13] International Performance Measurement and Verification Protocol Concepts and Options for Determining Energy and Water Savings, Volume 1, January 2012

[14] International Energy Efficiency Financing Protocol Standardized Concepts, April 2009

[15] International Performance Measurement and Verification Protocol Concepts and Options for Determining Energy and Water Savings, Volume 2 Concepts and Practices for Improved Indoor Environmental Quality Volume II, 2002

[16] International Performance Measurement and Verification Protocol Concepts and Options for Determining Energy and Water Savings, Volume 3 Concepts and Options for Determining Energy Savings in New Construction Volume III, 2003

[17] National Energy Efficiency Evaluation, Measurement and Verification (EM&V) Standard: Scoping Study of Issues and Implementation Requirements, April 2011, LBNL – 4265E

[18] Energy Efficiency Program Impact Evaluation Guide: Evaluation, Measurement, and Verification Working Group, December 2012, DE AC02-05CH11231

[19] M&V Guidelines: Measurement and Verification for Federal Energy Project Version 3.0 FEMP, April 2008

[20] ASHRAE Guideline 14-2002, *Measurement of Energy and Demand Savings*, ISSN 1046-894X

1) Under preparation.

[21] SANS 50010:2011, *Measurement and verification of energy savings*, ISBN 978-0-626-26352-2

ICS 27.010

Price based on 19 pages

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

bsi.

...making excellence a habit.™