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Energy management systems — Guidance for the implementation, maintenance and improvement of an energy management system

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National foreword

This British Standard is the UK implementation of ISO 50004:2014.

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**Energy management systems —
Guidance for the implementation,
maintenance and improvement of an
energy management system**

*Systèmes de management de l'énergie — Lignes directrices pour la
mise en oeuvre, la maintenance et l'amélioration d'un système de
management de l'énergie*



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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

This International Standard provides guidance when implementing the requirements of an energy management system (EnMS) based on ISO 50001 and guides the organization to take a systematic approach in order to achieve continual improvement in energy management and energy performance. This International Standard is not prescriptive and each organization determines how to best approach meeting the requirements of ISO 50001.

This International Standard provides guidance to users with varying levels of energy management and EnMS experience, including those:

- with little or no experience of energy management or management system standards;
- undertaking energy efficiency projects but with little or no EnMS experience;
- having an EnMS in place, not necessarily based on ISO 50001;
- having experience with ISO 50001 and looking for additional ideas or suggestions for improvement.

Energy management will be sustainable and most effective when it is integrated with an organization's overall business processes (e.g. operations, finance, quality, maintenance, human resources, procurement, health and safety and environmental).

ISO 50001 can be integrated with other management system standards, such as ISO 9001, ISO 14001, and OHSAS 18001. Integration can have a positive effect on business culture, business practice, embedding energy management into daily practice, operational efficiency and the operating cost of the management system.

The examples and approaches presented in this International Standard are for illustrative purposes. They are neither intended to represent the only possibilities, nor are they necessarily suitable for every organization. In implementing, maintaining or improving an EnMS, it is important that organizations select approaches appropriate to their own circumstances.

This International Standard includes practical help boxes designed to provide the user with ideas, examples and strategies for implementing an EnMS.

Ongoing commitment and engagement by top management is essential to the effective implementation, maintenance and improvement of the EnMS, in order to achieve the benefits in energy performance improvement. Top management demonstrates its commitment through leadership actions and active involvement in the EnMS, ensuring ongoing allocation of resources, including people to implement and sustain the EnMS over time.

Energy management systems — Guidance for the implementation, maintenance and improvement of an energy management system

1 Scope

This International Standard provides practical guidance and examples for establishing, implementing, maintaining and improving an energy management system (EnMS) in accordance with the systematic approach of ISO 50001. The guidance in this International Standard is applicable to any organization, regardless of its size, type, location or level of maturity.

This International Standard does not provide guidance on how to develop an integrated management system.

While the guidance in this International Standard is consistent with the ISO 50001 energy management system model, it is not intended to provide interpretations of the requirements of ISO 50001.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 50001 and the following apply.

3.1.1

commissioning

process by which equipment, a system, a facility or a plant that is installed, is completed or near completion is tested to verify if it functions according to its design specification and intended application

3.1.2

energy balance

accounting of inputs and/or generation of energy supply versus energy outputs based on energy consumption by energy use

Note 1 to entry: Where present, energy storage can be considered within energy supply or energy use.

[SOURCE: ISO 50002:2014, 3.6, modified — Deleted original Notes 1 and 2 to entry; added new Note 1 to entry]

3.2 Abbreviated terms

| | |
|------|------------------------------|
| EnMS | energy management system |
| EnPI | energy performance indicator |
| PDCA | Plan–Do–Check–Act |
| SEU | significant energy use |
| HDD | heating degree days |

4 Energy management system requirements

4.1 General requirements

It is good practice to keep the EnMS as simple and easy to understand as possible while still meeting the ISO 50001 requirements. For example, organizational objectives for energy management and energy performance should be reasonable and achievable and aligned with current organizational or business priorities. Documentation should be straight forward and responsive to organizational needs, as well as easy to update and maintain. As the system develops based on continual improvement, simplicity should be maintained.

Defining the scope and boundaries of the EnMS allows the organization to focus their efforts and resources in energy management and energy performance improvement. When defining the scope and boundaries, an organization should not divide or exclude energy using equipment or systems unless it is separately metered or a dependable calculation can be made. Over time, the scope and boundaries may change due to energy performance improvement, organizational change or other circumstances, and the EnMS is reviewed and updated as needed to reflect the change.

Documenting the scope and boundaries of the EnMS can be in any format. For example, it may be a simple list, or a map or line drawing indicating what is included within the EnMS.

| Practical Help Box 1 – Items to consider in defining scope and boundaries |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Scope: <ul style="list-style-type: none">— What facilities are included?— What operations and activities are included?— Is energy for transport included?— Are other media, for example, water and gas flows such as nitrogen included?— Who is top management within the defined scope and boundaries? |
| Boundaries: <ul style="list-style-type: none">— What parts of the site are included?— Are all buildings and processes included?— Are other sites included?— What parts of the site or locations are not included? |

4.2 Management responsibility

4.2.1 Top management

Ongoing top management commitment is a critical factor in the continued success of the EnMS and the improvement of energy performance. Top management demonstrates its commitment through its leadership actions and active involvement in the EnMS. Top management needs to retain its EnMS responsibilities and should make its actions visible to employees across the organization.

Top management should understand that a fundamental requirement for demonstration of its commitment is ongoing allocation of resources – which includes people to implement, sustain and improve the EnMS and energy performance over time. One resource area that is often overlooked and needs to be specifically addressed is the means of gathering and reporting data to support the ongoing maintenance and improvement of the EnMS.

Early in the EnMS implementation process, top management should initiate ongoing communications across the organization about the importance of energy performance and energy management. A communication approach that has proven itself within the organization and the organizational culture is more likely to be effective. Initial communication can be accomplished by top management's announcement of the appointment of the management representative, the establishment of the energy team and by presenting the energy policy and the decision to implement an EnMS directly to the employees.

Energy management and energy performance improvement should align with the organization's business strategy and long-term planning and resource allocation processes.

4.2.2 Management representative

Regardless of whether the management representative has a technical background, certain capabilities are key to the success of the role. The following capabilities should be considered in the choice of management representative:

- leading and motivating personnel;
- managing or effecting change;
- communicating effectively across all levels of the organization;
- problem solving and conflict resolution skills;
- understanding energy use and consumption concepts;
- basic analytical skills to understand energy performance.

Often the management representative is the individual responsible for the operation of a process or facility.

Whether the management representative is internal or external to the organization, top management needs to ensure that the representative has the appropriate authority to fulfil their duties. Additional communications by top management with employees may be needed in order to clearly establish the authority of an external management representative.

| Practical Help Box 2 – Communication of energy management responsibilities and authorities |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Energy management responsibilities and authorities can be defined and communicated in a variety of ways. For example, they can be: <ul style="list-style-type: none">— included in EnMS procedures or instructions;— incorporated into job descriptions;— identified in a responsibility matrix;— set forth in an energy or EnMS manual;— included in operational and technical training, including workbooks;— part of employee performance reviews;— reinforced during awareness training or shift meeting presentations. |

Ways that the management representative can ensure that both the operation and control of the EnMS are effective could include:

- a) scheduling regular team meetings;
- b) reviewing internal audit and corrective action results;

- c) the use of management tools such as business scorecards and trends in energy data;
- d) reviewing of energy performance indicator (EnPI) control limit anomalies.

Integration of energy management responsibilities with the organization's performance evaluation (appraisal) system may improve EnMS outcomes by institutionalizing responsibilities.

Good practice is to have a cross functional energy management team of more than one person that includes representatives from areas that can affect energy performance. This approach provides an effective mechanism to engage different parts of the organization in the planning, implementation and maintenance of the EnMS. Membership of the team may change over time and should be based on defined roles rather than named individuals.

| Practical Help Box 3 – Considerations in selecting members of the energy management team |
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| Selection of members of the energy management team (as appropriate to the organization's size and complexity) should consider the following: <ul style="list-style-type: none">— personnel representing a mix of skills and functions to address both the technical and organizational components of the EnMS;— financial decision makers or access to them;— procurement personnel;— operational personnel, particularly those performing tasks associated with SEUs;— representatives of tenants in commercial buildings, where appropriate;— individuals who can take responsibility for operational controls or other elements of the EnMS;— maintenance and facility personnel;— production or other personnel who may be already involved in improvement mechanisms such as continuous improvement teams;— individuals that will further the integration of EnMS into the organization;— people who are committed to energy performance improvement and able to promote the EnMS throughout the organization;— representatives from different shifts, where applicable;— supply chain managers as appropriate;— personnel who may not be directly working with energy uses but may be important, for example accessing critical data (utility energy bills, building management data, financial data, etc.), making changes to work practices, raising awareness. |

The team approach takes advantage of the diversity of skills and knowledge of individuals. The organization should consider building energy management and improvement capability and capacity throughout the organization. This could include additional training and rotation of the management representative position and membership of the energy management team.

4.3 Energy policy

The energy policy sets the direction for implementing and improving the organization's EnMS and energy performance. The policy demonstrates the commitment of top management so that the organization is able to continually maintain and enhance its efforts to achieve improved energy performance.

The energy policy can be developed either before or after the initial energy review. In either case the energy policy should be reviewed to ensure its appropriateness to the nature and scale of the organization's energy use and consumption. Developing the energy policy before the initial energy review can provide a strong platform of management commitment on which to build the initial energy review. Developing it after the energy review can provide solid data and information on which to build a strong policy. Developing the energy policy before the energy review and then revisiting it to ensure its appropriateness to energy use and consumption afterwards is a good practice.

Whether the energy policy is made available to the public is a decision by the organization, consistent with its own priorities and needs. Once the EnMS is fully implemented and begins to mature, the policy could be made publicly available as part of an improvement to the system (e.g. the energy policy could be included in sustainability, corporate social responsibility and other annual reports, the organization's website, etc.).

Top management's commitment is required to fully integrate the energy policy into the underlying culture of the organization to ensure its continuity. As a part of an integrated management system, it may be possible to integrate an energy policy with an existing organizational policy (e.g. environmental, sustainability, health and safety, quality). Care should be taken to ensure that the energy policy is not weakened or compromised and conforms with ISO 50001 requirements.

During the initial EnMS implementation, defining the energy policy should focus on the commitments explicitly required. The commitments can be stated using terminology consistent with the culture of the organization. It is recommended to avoid lengthy policy statements that may be difficult for personnel to understand and apply. Implementation of lengthy policies can consume significant training and communication resources. The organization should avoid duplicating within the policy other components of the EnMS i.e. scope and boundaries. The policy statement itself need not include the fact that it is documented, communicated, regularly reviewed and updated as necessary, however, it includes the required commitments of ISO 50001.

The energy policy's support for the procurement of energy efficient products and services and design would not require the organization to always purchase the most energy efficient items. Support for the purchase of energy efficient products and services and design for energy performance improvement should support business productivity and longer term profitability.

In general, the energy policy does not change often. Decisions on changes to the policy are made as part of the management review process. Possible reasons to change the policy include changes in organizational ownership, structure, legal and other energy requirements, and major changes in energy uses, sources, operations or business conditions or as part of continual improvement.

NOTE Examples of energy policies are given in [Annex A](#).

4.4 Energy planning

4.4.1 General

Energy planning is the "Plan" part of the PDCA cycle of the EnMS.

Energy planning provides the foundation for developing an EnMS that is based on an understanding of an organization's energy performance. This is the step where the organization's analysis of its energy data, along with other energy information is used to make informed decisions on actions to continually improve energy performance.

Examples of the relationship between objectives, associated energy targets, action plans, EnPIs, operational control, monitoring and measurement are given in [Table E.1](#). Examples of the relationship between significant energy uses (SEUs), operational controls, competency and training, procurement, associated EnPIs, monitoring and measurement and calibration are given in [Table E.2](#).

4.4.2 Legal requirements and other requirements

Legal requirements refer to applicable mandatory requirements related to an organization's energy use, consumption, or energy efficiency.

Other requirements could refer to voluntary agreements, contractual arrangements or corporate requirements subscribed to by the organization related to energy use, energy consumption and energy efficiency.

Information on legal requirements and other requirements can be obtained from a variety of sources, such as in-house legal departments, government or other official websites, consultants, professional bodies and various regulatory bodies. If the organization already has a process to determine legal requirements, that process may be used to identify and access energy related legal requirements. The process used to identify and evaluate legal compliance should be clear and include a description of how compliance is assessed. In addition, it should establish the responsibilities for monitoring, reviewing and ensuring compliance.

In addition to reviewing legal requirements and other requirements at defined intervals, examples of occasions when additional review may be required include:

- a) changes in applicable legal requirements and other requirements;
- b) changes in the operations of the organization that might affect applicable requirements.

Early consideration of legal requirements and other requirements can assist the organization in identifying related data requirements to address in the energy review. It may be useful to establish a list of legal requirements and other requirements so their implications can be considered for other parts of the EnMS including SEUs, operational controls, records, and communication.

| Practical Help Box 4 – Examples of legal requirements and other requirements |
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| Legal requirements: <ul style="list-style-type: none">— Local, state, provincial, national and international legal requirements;— Energy performance standards required by law for equipment;— Regulated energy assessment or audit requirements;— Building energy codes;— Energy source installation codes. Other requirements to which the organization may subscribe, if applicable: <ul style="list-style-type: none">— Organizational guidelines or requirements;— Agreements with customers or suppliers;— Non-regulatory guidelines;— Voluntary principles or codes of practice;— Voluntary energy agreements;— Requirements of trade associations;— Agreements with community groups or non-governmental organizations;— Public commitment of the organization or its parent organization;— Voluntary minimum specifications for energy performance issued by government or private agencies;— Network limits on electricity or gas supply, or limitations on electricity exports to the network. |

4.4.3 Energy review

The energy review is the analytical part of the energy planning process. The quality of the energy review is influenced by the availability, quality and analysis of the data collected.

When implementing an energy review for the first time, the starting point is the available data. The energy review can be improved as the organization gains more experience with energy data management and decision making based on energy data analysis.

A good practice is to utilize the output of any available energy audits or engineering studies as part of the energy review.

NOTE ISO 50002 provides information on energy audits.

a) Analysis of energy use and consumption

Developing an understanding of the organization's energy use and consumption is the first step in an energy review. This is accomplished through:

- identifying current energy sources;
- identifying current energy uses;
- evaluating energy use and consumption, including past and present trends.

The resulting information is used to identify SEUs and energy performance improvement opportunities.

Energy sources can include, but are not limited to: electricity, natural gas, fuel oil, propane, solar, wind, biomass, cogeneration and recovered waste energy. In some organizations, it can include externally supplied energy sources such as compressed air, chilled or hot water and steam. Typically, energy sources should exclude feedstock except where the feedstock also contributes energy within the scope and boundaries of the EnMS.

Identification of energy sources can be accomplished through the review of existing records (e.g. utility bills, fuel delivery receipts, procurement records, etc.). It is good practice to examine energy flows and end uses to ensure all energy sources are identified. These results form the basis for the remainder of the energy review.

The next step in the energy review is linking the energy sources to energy uses. A single energy source can be associated with multiple energy uses. Interviews with organizational personnel responsible for the operation of equipment, systems and processes can be helpful in identifying energy uses. Other possible sources for energy use information and energy consumption data can be found in Practical Help Box 5.

Once the energy uses are identified, evaluate past and present energy use and consumption. A suitable period (e.g. one, three, six or twelve months) is established to evaluate historic energy consumption and identify trends. The period(s) selected should be representative of the variation in organizational operations (e.g. seasonal production, occupancy levels). It is good practice to analyse data for a period of at least one year to account for seasonal effects and other variables.

Additionally, the data should be of a suitable frequency to understand the variability in energy performance and any anomalies in energy consumption. The frequency of data collection should be at least monthly to allow for identification of trends in energy use and consumption. For some operations, more frequent data collection may be appropriate.

Energy use and consumption information should be presented by graphs, charts, tables, spreadsheets, process maps and simulation models.

| Practical Help Box 5 - Possible sources of energy use and consumption data |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Possible sources of energy use and consumption data include:</p> <ul style="list-style-type: none"> — compiled utility bills for the period of examination for each energy source, including individual line items for energy charges: <ul style="list-style-type: none"> — whenever possible bills should be checked for accuracy against utility meter readings and not based on utility estimates; — attention is needed to check that the period of energy consumption and the period represented by the compiled bills correspond to each other; — meter readings from utility meters and applicable submeters (recorded manually or electronically), for energy consumption of facilities, equipment, systems and processes; — estimations of energy consumption; — model simulations of energy use and consumption; — equipment data (e.g. name plate energy rating, stated efficiencies from manufacturer's equipment manuals, asset inventory lists and data sheets); — weekly or daily maintenance logs (e.g. boiler house logs, compressor run hours); — service logs (e.g. vendor or distributor service visit records); — control system data; — bills or other records of purchase of other energy sources, such as fuel oil, coal, biofuels, that may be delivered periodically and stored onsite; — bills or other records of purchase of compressed air, steam, hot and chilled water; — energy audit reports or engineering studies; — records of previous energy reviews. |

The outputs from the analysis of energy use and consumption include:

- identified current energy sources;
- identified energy uses;

- measured or estimated energy consumption associated with each identified energy use for the period established as suitable.

This information provides a basis for the identification and analysis of SEUs.

b) Based on the analysis of energy use and consumption, identify the areas of SEUs

SEUs are determined for the purpose of establishing priorities for energy management, energy performance improvement and resource allocation. In identifying areas of SEU, it may be helpful for the organization to take a holistic view of its uses and consumption of energy within the scope and boundaries.

The selection of the number of SEUs should consider available resources since for SEUs there are requirements for competency and training, procurement, operational controls, and monitoring and measurement. Organizations starting to implement an EnMS may find it helpful to limit the number of SEUs with a plan to develop additional SEUs as resources are available.

Based on the definition of SEU, the organization has the flexibility to determine SEUs based on energy consumption, energy improvement opportunity, or a combination of both. Establishing a process for determining SEUs involves deciding the criteria for:

- “substantial energy consumption”, which could include the use of an energy balance to determine energy uses that account for at least a certain percentage of the organization’s total energy consumption (alternatively, Pareto analysis could be used for this purpose);
- “considerable opportunity for energy performance improvement”, which could include the outputs of energy audits, engineering studies, interviews with personnel with responsibilities related to the energy use, comparison with internal and external benchmarks and other information to evaluate and prioritize energy improvement opportunities.

The determination of SEUs may be an iterative rather than a sequential process. Opportunities for improvement can be an input into the determination of SEUs at this point in the energy review process. This includes consideration of how the behaviour of personnel working for or on behalf of the organization, and the organization’s work practices can influence energy performance.

| Practical Help Box 6 – Possible methods to assist in the identification of an organization’s SEUs |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Possible methods to assist in the identification of an organization’s SEUs include: <ul style="list-style-type: none">— energy audits (e.g. ISO 50002 and other energy assessment standards);— process maps;— graphs and charts;— spreadsheets or tables;— Sankey diagrams;— mass and energy balance;— mapping of energy use;— energy use and consumption simulation models;— surveys of end-use equipment, systems, or processes;— inventory of energy-using equipment, including energy rating and typical hours of operation;— regression analysis of energy consumption of equipment, systems, or processes against relevant variables that affect their energy consumption. |

Analysis of energy uses will result in a list for consideration as SEUs. In the absence of measured data, energy consumption should be estimated. Final determination of SEUs will consider whether the energy consumption of these energy uses is substantial or whether they represent considerable opportunity for improvement or both. Any use with substantial energy consumption should receive consideration as an SEU.

Energy consumption is affected by many variables. Data should be collected and analysed to determine the effects of the relevant variables on the SEU. If estimates of SEU energy consumption are made, then additional analysis will be needed to determine the effects of relevant variables.

Submetering of SEUs represents a good practice to establish the current energy performance of SEUs and to track future improvements in their energy performance. Careful consideration should be given to the submetering and its potential use in the EnMS. The energy management team should engage with appropriate operations personnel when identifying and defining the relevant variables.

ISO 50001 requires energy data to be monitored in order to fulfil the requirements of several of its clauses, including energy baselines, EnPI, monitoring and measurement and analysis. When appropriate, normalize the energy data to levels of production, weather or other relevant variables that affect energy consumption.

NOTE ISO 50006 provides additional information on normalization of energy data.

| Practical Help Box 7 - Examples of relevant variables that can affect SEUs |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Examples of relevant variables that can affect SEUs (preferably over the same time period as the energy consumption data) include the following:</p> <ul style="list-style-type: none"> — weather, including heating and cooling degree days; — production related, such as rate, product mix, quality, rework or output; — process parameters such as ambient temperature, cooling water temperature setpoint, steam temperature; — material flows, properties and characteristics (including raw materials); — building occupancy levels; — daylight availability and ambient light levels; — operating hours; — levels of activity (e.g. work load, occupancy); — distances travelled for transportation energy; — vehicle loading and utilization; — variation in availability or energy content of the energy sources (e.g. moisture content, calorific value). |

The current energy performance of the SEUs should be established using available energy consumption data and information concerning the identified relevant variables.

| Practical Help Box 8 - Example of methods for determining current energy performance of the SEUs |
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| <p>Examples for determining current energy performance of the SEUs include comparisons such as:</p> <ul style="list-style-type: none"> — normalization of: <ul style="list-style-type: none"> — air compressor electricity consumption against production volumes and ambient air temperature; — refrigeration plant electricity consumption against cooling load, supply temperature and ambient temperature; — building electricity consumption against occupancy and cooling degree days; — building natural gas consumption against occupancy and heating degree days; — aircraft fuel consumption against flying hours and the number of take offs; — energy consumption per unit of output and other simple ratio such as energy efficiency and coefficient of performance; — coefficient of performance of refrigeration systems at their operating loads and environmental conditions compared to energy efficient systems; — comparison of current energy consumption with historical consumption if consumption is not affected by a relevant variable. |

After collecting and analysing energy use and consumption data and relevant variables for the suitable period, estimate future energy use and consumption for an equivalent time period. The estimation should consider each SEU, relevant variable, and anticipated changes to facilities, equipment, systems and processes during this future period. Some organizations choose to complete the future estimates after decisions regarding action plans have been finalized for the coming period.

Outputs from this part of the energy review include a list of potential SEUs based on substantial energy consumption; the relevant variables affecting the identified SEUs, an analysis of the current performance of the SEUs and an estimation of future energy use and consumption.

c) Identify, prioritize and evaluate opportunities for improving energy performance

The identification of opportunities for improving energy performance and the development of a prioritized list of these improvement opportunities is an output from the energy review. The collection and analysis of data forms the foundation for prioritizing opportunities for improvement.

— Identifying opportunities

Opportunities for improvement begin with ideas that can be generated from the analysis of energy use and consumption, the determination of SEUs or from a variety of other sources. Involving a range of people in this process such as operational and maintenance staff can help to reveal a full range of ideas. These ideas become opportunities through examination and refinement, using data analysis to determine potential for energy performance improvement and feasibility.

The identification of opportunities for the improvement of energy performance should be part of a continuous process, but may also involve periodic analysis using proven techniques.

Practical Help Box 9 – Example of tools and techniques for identifying opportunities

Tools and techniques for identifying opportunities can include the following:

- employee suggestions;
- other business improvement methodologies (e.g. Lean Manufacturing, Six Sigma, Kaizen);
- energy audits, ranging in cost and complexity from walkthroughs to detailed audits;
- needs analysis to avoid inappropriate design decisions;
- internal or external benchmarking;
- equipment specification and data sheets;
- metering reviews;
- maintenance techniques (e.g. maintenance assessments, predictive maintenance);
- examination of the age, condition, operation and level of maintenance of the energy uses;
- review of new and emerging technologies;
- review of case studies;
- team meetings, brainstorming, opportunity identification workshops;
- opportunity lists and energy saving tips available on various government and efficiency organization websites;
- continuous monitoring systems that report any deviations from pre-established energy performance parameters (fully or partially automated);
- energy efficiency networks, seminars, forums, conferences to exchange ideas and experiences;
- engineering analysis techniques and modelling (e.g. review of pump and systems curves, pinch analysis).

— Prioritizing opportunities

Prioritizing energy performance improvement opportunities starts with evaluation. Evaluation involves data analysis to quantify the expected energy performance improvement, benefits and costs of opportunities. Evaluation of opportunities can include technical feasibility and business consideration such as asset management strategies and maintenance impacts. The evaluation should include additional benefits of energy performance and be derived from examination of system interactions wherever possible.

Having evaluated the identified opportunities, the organization prioritizes its energy performance improvement opportunities based on its own criteria and maintains and updates the information in a format selected by it.

Methods to prioritize opportunities are described in Practical Help Box 10.

Practical Help Box 10 – Examples of criteria for prioritizing opportunities

Criteria for prioritizing opportunities can include:

- estimated energy savings;
- return on investment or other organizational investment criteria (capital or operational);
- other business impacts or priorities;
- estimated cost of implementation;
- ease of implementation;
- improved environmental impacts;
- actual or potential legal requirements;
- perceived level of risk including technological risk;
- availability of funding (internal or external);
- impact and value of additional benefits (e.g. reduced maintenance, increased comfort, improved safety, increased throughput).

Organizations should examine the prioritized list of opportunities to determine which opportunities can proceed to a detailed investigation.

NOTE An abridged example of an energy review output is given in [Annex B](#).

— Recommendations to management

Once the organization's criteria have been applied to establish prioritized opportunities, the management representative typically compiles recommendations for improvement and whether opportunities should undergo further investigations, be implemented or not be implemented. The management representative should communicate to top management the results from the energy review together with the recommendations for improvement.

The evaluation of opportunities may result in the determination of new or revised SEUs. As the EnMS matures over time the determination of SEUs can be expanded to include additional energy uses, and may vary for different parts of the organization.

The defined intervals for updating the energy review may be different for each element of the energy review. Effective change management and robust communication processes support timely updating of the energy review in response to major changes in facilities, equipment, systems and processes.

The output from this part of the energy review includes prioritized opportunities and recommendations to management.

Management with authority to allocate the required resources decides whether opportunities are considered priorities for implementation, subject to further investigation, or not to be implemented. Reasons for not implementing opportunities should be recorded. In establishing these priorities, management ensures that the necessary resources are made available.

4.4.4 Energy baseline

The energy review provides the information and data needed to establish the energy baseline.

The energy baseline is the reference for measuring energy performance over time. The type of energy baseline depends on specific purpose of the EnPI and can be established at the facility, system, process or equipment level. The energy baseline may be:

- expressed as a mathematical relationship of energy consumption as a function of relevant variables;
- an engineering model;
- a simple ratio; or

- simple consumption data (if there are no relevant variables).

NOTE 1 Simple ratios are used to calculate energy performance where there is no base load and a single relevant variable. In some cases, it can be acceptable to use a ratio when there is a small base load and a single relevant variable.

Since it is established for comparison purposes, the time period of the baseline should be representative of the variation in organizational operations (e.g. seasonal production, occupancy, etc.). When determining energy performance improvement, the data needs to represent the same period as the baseline.

In almost all cases energy consumption is affected by relevant variables. Energy baseline data should be normalized for relevant variables affecting energy consumption. For normalization, one may use regression analysis of energy consumption against relevant variables or other applicable methods.

Examples of changing the baseline “according to a predetermined method” as stated in ISO 50001 can include:

- normalize energy baseline by relevant variables;
- reset energy baseline using a moving energy baseline or at a defined interval;
- energy baseline requires compliance with legal requirements.

NOTE 2 ISO 50006 provides information on energy baselines.

In some cases the baseline may need to be modified, where the current EnPIs, the corresponding boundaries, and the energy baselines are no longer appropriate and effective in measuring energy performance. ISO 50001 provides the criteria for this modification.

4.4.5 Energy performance indicators (EnPI)

The energy review should provide the information and data needed to establish the EnPIs.

EnPIs and their corresponding energy baselines are metrics that are defined by the organization to measure energy performance. An EnPI can be at a facility, system, process or equipment level and should have an appropriate baseline at the same level for comparative purposes. Types and examples of EnPIs include the following:

- energy consumption (in total or broken down by energy use) (e.g. kWh, GJ);
- simple ratio such as energy consumption per unit of output (e.g. kWh per tonne, kWh per man hour worked);
- statistical model (e.g. linear and nonlinear regression);
- engineering based model (e.g. simulation).

NOTE 1 Energy consumption can also be referred to as energy value, if metered with or without a conversion factor. ISO 50006 provides further information.

NOTE 2 It is important that simple metrics or ratios are used with caution. Simple metrics or ratios can be indicative of areas needing more analysis.

EnPIs should enable various groups within an organization to understand the energy performance for which they are responsible, inform continual improvement efforts and take necessary actions.

EnPI(s) are typically set at management and operational levels. Management level EnPI will generally relate to the facility level such as the overall control of SEUs and patterns in organizational energy performance. Operational level EnPI may relate to specific processes, systems or equipment.

NOTE 3 ISO 50006 provides information on EnPIs.

4.4.6 Energy objectives, energy targets and energy management action plans

4.4.6.1 Energy objectives and energy targets

Setting objectives and targets provides the means for transforming the energy policy into action. This ensures that the organization has defined criteria for improving energy performance. Objectives and targets provide the direction for energy performance improvement initiatives, including the allocation of resources. Energy objectives and targets can be used to improve any facet of the organization's energy performance, consistent with the commitments of the energy policy.

The data analysis and other information outputs from the energy review are used in developing the energy objectives and targets. Energy objectives and targets are typically used for, but not limited to, improving the performance of SEUs and pursuing the prioritized opportunities that were developed as part of the energy review.

Just as SEUs and opportunities are taken into account in setting and reviewing objectives and targets, there are other items that need consideration. These items aim to reflect the realities of the situations, conditions and environment under which an organization operates (e.g. management plans, maintenance plans, shutdown and refurbishment schedules). Targets are specific, measurable, achievable, relevant, and time based. Since targets have measurable results, there should be a sufficient number of specific action plans associated with them to achieve the planned results. Targets are often expressed in terms of a) the percentage improvement in energy performance, b) improvement in the energy consumption, or c) other EnPI. Energy targets are often associated with specific equipment, systems or processes.

4.4.6.2 Energy management action plans

4.4.6.2.1 Energy performance improvement objectives and targets can only be achieved if people and resources are provided which enables action plans to be effective. Objectives, targets and action plans should be presented for approval to top management by the management representative, with support from the energy management team or others, as appropriate.

An effective energy management action plan should include, but may not be limited to, the following:

- a) allocation of responsibility for energy management action plan tasks;
- b) statement of objectives and targets addressed by the action plan;
- c) summary of actions to meet the objectives and targets;
 - 1) measures that will be taken to monitor energy performance;
 - 2) necessary changes to competence, training and awareness;
 - 3) necessary changes to operational controls and communication;
- d) allocation of resources (human, technical and financial) for implementation of the action plan,
- e) methods to verify energy performance improvement achieved by execution of the action plan for an energy improvement opportunity;
- f) methods to verify the effectiveness of the action plan for all the activities in the action plan (i.e. were all the activities in the action plan taken and did they work);
- g) schedule for planned actions;
- h) schedule for reviewing and updating the plan.

Practical Help Box 11 – Actions and alternative strategies to implement action plans

Examples of actions by which targets could be achieved:

- implementation of simple best practices such as turning equipment off when not needed;
- establishing a compressed air leak reduction programme;
- adoption of energy efficient procurement practices;
- capital project involving the installation of new, more efficient equipment.

Examples of alternative strategies for implementing action plans:

- alternative funding mechanisms;
- alternative contractual mechanisms;
- alternative energy service providers;
- energy performance contracts;
- energy supplier obligation schemes.

4.4.6.2.2 When setting the objectives and targets, the means to verify the results and the energy performance improvement achieved are included in the action plan.

The method of verifying the energy performance improvement should be determined prior to implementation and may use a combination of EnPI data and other forms of pre and post implementation measurement data where available. The verification of the results should ensure that actions outlined in the plan were properly executed and result in the intended outcomes. These two types of verification help address the ISO 50001 requirements (see ISO 50001:2011, 4.6.1) for monitoring and measurement of energy performance, the effectiveness of the action plans, and the evaluation of actual versus expected energy consumption.

The review of the objectives and targets and progress made toward achieving them is not limited to management review and internal audits.

NOTE 1 Examples of the relationship between energy objectives, energy targets, energy management action plans and other processes of the EnMS are provided in [Table E.1](#).

Additional training and revised documentation may result from the implementation of action plans. An action plan may lead to revised operating criteria and maintenance practices which could require changes to process controls and maintenance procedures, as well as, retraining of operators. Other relevant documentation that could change includes engineering drawings and product specifications.

NOTE 2 An example of an energy management action plan is given in [Annex C](#).

4.5 Implementation and operation

4.5.1 General

Implementation and operation is the “Do” part of the PDCA cycle of the EnMS.

This is the part of the management system where the organization is managing the SEUs and implementing the action plans. Implementation and operation involves establishing connections that allow energy management (i.e. SEU) and energy performance improvement (i.e. action plans) to be linked to the business processes of the organization (i.e. competency, training, communication, operational controls, etc.).

4.5.2 Competence, training and awareness

Ensuring competency begins with clearly defining the education, training, skills or experience required for staff and contractors whose activities relate to the organization’s SEUs. Managing competency should be supported by records demonstrating that the personnel performing that work have met the

applicable competency requirements. Many organizations start with the qualification requirements contained in job descriptions, position statements and contractor agreements. Qualifications focus on requirements related to education, experience, skills and training and are not the same as the list of responsibilities that generally are included in job descriptions. Depending on the SEU involved, there may be a variety of personnel whose competency needs to be addressed in the EnMS, in addition to operation and maintenance functions. Competence within the organization can be maintained or improved through training, mentoring, coaching and career planning for those involved with SEUs.

An organization should review its existing training approach to ensure that it is appropriate to meet the needs of personnel working on its behalf as related to the identified SEUs. Appropriateness of training is dependent on the organization's size and complexity, the nature and scale of its activities and SEUs.

EXAMPLE The chilled water system is identified as an SEU. It is important that the operator understands and is sufficiently trained in the efficient operation of the chilled water system in relation to its energy performance.

Personnel need to be aware of how their activities relate to energy use and consumption, also understand the consequences when their activities deviate from defined processes, operational or maintenance controls, objectives and targets. Awareness of personnel assists organizations in fostering and maintaining an energy conscious culture. The effectiveness of the processes that support ongoing energy awareness can be continually improved by a variety of means. Use of updated communication techniques and new awareness materials can help sustain the awareness programme.

| Practical Help Box 12 - Examples of approaches to promote employee awareness |
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| <p>Examples of approaches to promote employee awareness include the following:</p> <ul style="list-style-type: none"> — bulletins or newsletters; — shift meetings; — briefings of personnel; — vendor or supplier provided training; — general awareness training; — through kick-off meeting/workshops; — presentation by top management via multi-media formats; — intranet postings/display boards; — corporate branding around energy use; — posters; — labelling campaigns detailing energy consumption of equipment, processes and systems; — incentive programmes and reward schemes; — social media platforms and applications; — signage on equipment (e.g. reminding operators to switch off when not in use). |

| Practical Help Box 13 - Examples of approaches to achieving awareness among on-site contractors |
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| <p>Examples of approaches to achieving awareness among on-site contractors includes the following:</p> <ul style="list-style-type: none"> — incorporating energy objectives and targets into contracts; — contractor Environmental, Health and Safety communications; — site orientation and induction; — procurement policies; — visitor brochures. |

EnMS training and awareness need to be updated as the SEUs and energy objectives change over time.

4.5.3 Communication

4.5.3.1 Internal communication

Effective communication within the organization strengthens the commitment of employees to the organization's energy policy and helps to motivate them to contribute to achieving the energy objectives and targets.

Practical Help Box 14 – Examples of internal communication methods

Internal communication methods include the following:

- organization intranet sites;
- emails and bulletins;
- personnel notice boards, company magazines, energy displays including EnPIs;
- periodic communication meetings, seminars and toolbox talks;
- awareness days and campaigns;
- reward and recognition programmes;
- posters;
- labelling campaigns detailing energy consumption of equipment, processes and systems.

Internal communication provides information on the performance of the EnMS, energy performance and can provide information on the following:

- a) the financial benefits achieved;
- b) progress on achieving the objectives, targets, and energy management action plans;
- c) other benefits of energy performance improvements, such as improved quality or environmental performance;
- d) initiatives to further energy performance;
- e) contact points for information;
- f) feedback from management review.

Communication should be a multi-directional activity. Employees, contractors, or those working on behalf of the organization should be encouraged to contribute comments and suggest improvements in energy performance and the EnMS. Incentives and other rewards for suggestions that are implemented can help stimulate interest and participation in the suggestion process.

4.5.3.2 External communication

4.5.3.2.1 There are many reasons why an organization may decide to communicate externally about its energy performance or its EnMS. For example, it can be to:

- meet legal or other requirements;
- communicate with customers and suppliers;
- satisfy investors and financiers;
- demonstrate leadership in energy performance and energy management.

4.5.3.2.2 The organization decides if it will communicate externally about its energy policy, EnMS and energy performance based on its priorities and needs. If the organization decides to communicate externally, the communication strategy should address the following:

- whether the external communication will be reactive or proactive or both;

- the method(s) of communication to be used;
- who, for each type of external interested party, is authorized to receive and respond to energy related communication requests;
- if applicable, who is responsible for proactive communication of the policy and information about the organization's EnMS and energy performance;
- what information is to be included in the records of the external communications.

| Practical Help Box 15 - Examples of external communication |
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| <p>External communication could include the following:</p> <ul style="list-style-type: none"> — statements of certification to ISO 50001; — EnMS policy or portions of it; — commitments to the policy or to energy savings, improvements or conservation; — energy stewardship statements or commitments; — awards received from various bodies, customers or agencies; — cost improvements/profitability; — objectives and targets and progress made towards them; — energy performance accomplishments; — emissions data from energy performance improvement; — sustainability reports. |

4.5.4 Documentation

4.5.4.1 General

EnMS documentation includes documents and records that the organization has determined are needed for its EnMS. In making these decisions the organization should consider modifying the existing documentation to address energy management.

The core elements of the EnMS and their interaction can be described in a number of ways. Common approaches include the preparation and use of an energy manual, a graphical representation of the PDCA model that maps the organization's EnMS processes or a matrix or hierarchy that identifies specific documentation relevant to each of the core elements of the EnMS.

It is strongly recommended to keep the documents and records simple, so that they are easy to understand and maintain.

4.5.4.2 Control of documents

Where appropriate, the organization may use an existing process for document control.

Correct identification of the EnMS documents is crucial to ensure that the most up to date documents are in use, that they can be easily located and that obsolete documents are removed from the points of use.

Documents of external origin are those generated outside of the organization. They cannot be changed or updated by the organization but may be needed for effective planning and control of the EnMS. For example, the ISO 50001 standard is an external document. Other examples include:

- laws, ordinances, regulations;
- building codes;
- voluntary codes of practice;

- industry or other standards;
- utility rate and tariff schedules;
- protocols such as measurement and verification, greenhouse gas or sustainability.

4.5.5 Operational control

Operational and maintenance controls should bring the SEUs and the energy uses related to the energy objectives, targets and action plans into efficient and sustainable operation.

As part of continual improvement, operational and maintenance controls can be extended to other energy uses. As the management system matures, equipment, processes and systems will be governed by appropriate operational and maintenance controls.

Effective operational control and associated training of relevant personnel often provide considerable energy performance improvement opportunities and typically at low cost. In some cases it may be possible to reduce variability in energy performance caused by human factors through technical improvements such as automated switching, control system automation, or engine speed limiters for vehicles. Also, it is important to update or modify operator training in response to changes in operational and maintenance controls.

| Practical Help Box 16 – Operational control |
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| Operational control can take a number of forms, such as: <ul style="list-style-type: none">— documented procedures;— operating instructions;— critical operating parameters;— physical devices (e.g. flow control valves, automation systems, or programmable logic controllers);— set points;— maintenance;— licensed personnel;— design or other specifications;— monitoring techniques such as control charts;— any combination of the above. |

Maintenance is an important and often cost effective element of operational control.

| Practical Help Box 17 – Examples of maintenance techniques |
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| Examples of maintenance techniques include the following: <ul style="list-style-type: none">— preventive maintenance;— predictive maintenance ;-such as thermal monitoring, vibration analysis;— reliability centred maintenance (will require equipment specific maintenance routines);— overall equipment effectiveness;— total productive maintenance;— other principles may be applied, such as “right first time” (i.e. aiming to ensure that the desired outcome is achieved at the first attempt);— breakdown contingency plan. |

NOTE Practical Help Box 20 provides examples of ways to identify significant deviations.

4.5.6 Design

Identifying opportunities for the improvement of energy performance at the earliest stages of design and throughout the entire design process typically yields the best results. This approach can avoid frequent barriers to appropriate energy performance, such as oversized equipment, over specified systems and

the use of inefficient technology. The opportunity to overcome these barriers narrows as the design progresses. The design process should seek to optimize energy performance by evaluating a range of options that minimizes energy consumption and meets system needs. Metering energy consumption and process variables should be considered during the design process to provide optimal monitoring of energy performance during operations. Typically the cost of installing appropriate metering after construction is significantly more than the cost of incorporating it at the design stage.

Adoption of a “systems” approach that considers interactions arising from the flows of energy and materials between processes can enable the most energy efficient solutions to be identified across the entire site and prevent common failures.

| Practical Help Box 18 – Examples of energy efficiency failures in the design process |
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| <p>Examples of energy efficiency failures in the design process include the following:</p> <ul style="list-style-type: none"> — decisions are made prior to consideration of energy performance; — failure to consider the life cycle cost of equipment, including small or auxiliary equipment, — specifying new equipment rather than optimizing the performance of existing equipment of equivalent energy efficiency in order to meet additional organizational requirements; — incorporating existing equipment, systems and processes into new designs when more energy efficient alternatives are available; — over sizing of systems, e.g. pumping systems, compressed air systems, motors; — lack of coordination across the design team professions e.g. architectural design resulting in inefficient mechanical systems; — lack of consideration of innovative approaches e.g. natural ventilation, daylight harvesting and heat recovery; — lack of consideration of energy costs in contracts for services in design or construction; — not spending sufficient time considering energy efficiency in the detailed design; — design that does not account for energy performance with fluctuating or varying loads; — lack of consideration of alternative approaches and more energy efficient options, e.g. lower pressure blowers instead of air compressors; — use of standardized solutions rather than solutions designed to meet system needs; — lack of integration of automated control systems to maximize energy performance; — lack of attention to small or auxiliary systems, such as pumps and piping, as compared to larger systems e.g. boilers, process chillers. |

When designing new, modified or renovated facilities, equipment, systems and processes, the organization should consider best available energy efficient techniques, practice and emerging technology trends. This promotes greater awareness of design options and can move the organization towards more innovative and energy efficient designs and use of energy sources. Projects with the potential to significantly impact energy performance need to be managed from an energy perspective. Design should consider the management of the risks and opportunities associated with using emerging technologies. The design process should provide a framework for projects to deliver the most energy efficient design and operational outcomes.

This typically includes the following phases:

- a) design (from conceptual to detailed design);
- b) tendering and procurement;
- c) construction;
- d) commissioning;
- e) hand over to operations.

Commissioning can be used to help ensure the new design has been effectively implemented. Commissioning is carried out by suitably qualified persons for new facilities, equipment, fixtures and fittings, and records are maintained. The commissioning and hand over phases are important as there is an opportunity for operators and management to develop best operational practices.

It is possible that equipment and systems may operate at partial or variable loads for significant periods of time. This should be taken into account during the design, procurement and commission phases of

the project. This is because partial and variable loads are often less energy efficient depending on the system, than full or optimum loads. Equipment and systems should be as efficient as possible at expected operating loads. It is important for commissioning to be carried out over the load variations that occur to ensure that energy efficiency is also achieved across the load points instead of only at full load.

The hand over process by project personnel to operating personnel involves validation of design objectives or specifications related to energy. Organizations should establish standards or specifications related to energy performance before transfer to operations, and provide necessary training and information to operational, maintenance or management personnel.

After hand over it is important to optimize the operation beyond design specifications. The operating conditions may vary from the initial design and although design specifications are being met, operations may not be as energy efficient as possible. There may be minor adjustments to set points, maintenance schemes, control strategies which could provide better energy performance. Optimization is part of a good continual improvement strategy.

4.5.7 Procurement of energy services, products, equipment and energy

4.5.7.1 General

Procurement policy should include a requirement to take into account the energy implications of procurement decisions. Procurement decisions that affect SEUs should start with an evaluation of needs. Procurement specifications, tender and contract documentation should include energy performance criteria, where determined appropriate and a requirement to analyse the life-cycle costs of purchases.

Organizations should consider energy efficient services, products and equipment as a consideration in applicable procurement. Personnel who control or influence procurement decisions should be aware of the:

- products, equipment and services which can have a significant impact on the organization's energy performance;
- organization's identified SEUs;
- need to inform suppliers of energy performance criteria for purchases of products, equipment and energy services related to the SEUs;
- criteria established for assessing energy use, consumption and efficiency over the lifetime of purchases which can have a significant impact on the organization's energy performance;
- the frequency of equipment failures, and benefits of evaluating more energy efficient options in readiness for emergency replacement, as appropriate;
- the profile of energy tariffs, such as time of use pricing, peak charges and service delivery charges;
- provisions contained within energy procurement contracts.

4.5.7.2 Purchasing energy services

4.5.7.2.1 Energy services can be procured to support energy objectives and targets. Such service providers can include:

- energy consultancy;
- energy service companies;
- energy service providers;
- training;
- energy auditing.

4.5.7.2.2 There are many services procured by organizations that have the potential to impact energy performance, such as the following:

- maintenance services and contracts;
- equipment and technology advice;
- project design, construction and commissioning;
- vehicles and transport services;
- energy or utility suppliers.

It is important for the energy service providers to have adequate training, experience and competence in the area of energy performance as appropriate to their roles and services.

4.5.7.3 Purchasing products and equipment

It is important to consider the effect of purchases which may have an impact on energy performance.

Examples of criteria for evaluating energy use, consumption and efficiency in purchasing products and equipment can include:

- life cycle costs;
- expected impact on the overall system energy performance (e.g. the energy efficiency of a pumping system at the planned system operating conditions);
- performance at part load and under fluctuating loads;
- energy efficiency rating (including those based on labelling programmes);
- certification from agencies or other third parties.

When procuring raw materials, it is a good practice to consider their impact on energy performance (material composition, moisture content, material form, etc.).

The life cycle cost of any product or piece of equipment is the total lifetime cost to purchase, install, operate, maintain, and dispose of that product or equipment. The operating costs include energy costs.

EXAMPLE Energy efficient motors can have a higher initial purchase cost compared to less energy efficient motors but the savings in energy over time generally exceed the additional capital costs on a lifecycle cost basis.

4.5.7.4 Purchasing energy

In competitive markets, there may be opportunities for reducing costs in purchasing electricity and fuels. Care is needed in comparing quotations for the purchase of energy to ensure that lower cost does not result in higher energy consumption over time (e.g. increased consumption due to low quality fuel).

| Practical Help Box 19 – Factors for evaluation in the purchase of energy |
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| <p>Factors for evaluation in the purchase of energy could include the following:</p> <ul style="list-style-type: none"> — quantity, e.g. bulk discounts; — quality, e.g. voltage fluctuations and harmonic distortion in electricity supply ; — delivery, e.g. cost reduction through on-site energy storage; interruptible power supply rates; — price or rates, e.g. tariff structure or rebates, flexible contract terms; — contract period, e.g. reduced rates for a fixed contract term; — flexibility, e.g. fuel switching, demand response; — reliability, e.g. stability of supply via energy storage or backup generation. |

For deregulated markets, energy supply options may be quite complex and may require ongoing attention. These complexities can include hourly price, interruptible power supply, load factors, force majeure requirements, regional and local delivery options, and volatile energy marketplace dynamics, among others. A risk management analysis should be conducted, when appropriate, before energy supply bids and contracts are released. In this context, complex procurement strategies can be highly effective. It may be worth investigating the possibility of outsourcing this function to service providers that have significant expertise in this area.

It is important to compare like with like and to consider energy efficiency of vendors. If possible, the organization may also wish to consider using energy from renewable resources or cogeneration.

Where organizations have multiple utility supply options, attention to both the supply and the demand side of energy can facilitate optimization of energy management.

Internal communication between energy procurement personnel and those managing energy efficiency activities and projects (e.g. demand side activities) should take place to accomplish several goals:

- potential changes to load profile are tested against current rate structures;
- optional tariffs are tested against current load profile;
- energy supply criteria are updated when changes occur;
- the impact of energy rates and tariffs are understood by the whole energy management team;
- energy quality issues are discussed and alleviated;
- barriers are broken down between organizational functions.

As a result of internal communication, changes may be made to how energy is procured and this would be communicated externally to the energy supplier.

In most cases, price penalties related to tariffs can be avoided although this may have no impact on energy use, consumptions and efficiency.

4.6 Checking

Checking is the “Check” part of the PDCA cycle of the EnMS.

The organization may consider integration of these requirements with an existing management system. The effectiveness of the existing process should be verified as appropriate for the EnMS.

4.6.1 Monitoring, measurement and analysis

The purpose of monitoring, measurement and analysis is to obtain and analyse data in order to determine whether energy performance is improving, by how much and whether operational control is being maintained. This is applied to SEUs, relevant variables affecting the SEUs, EnPIs, and action plans. It may also be applied to any energy uses over which the organization chooses to exercise operational control. An organization can start with readily available data and expand the data collected and analysed over time. The analysis of measurement data can be enhanced through the use of different analytical methods or different instrumentation.

The energy measurement plan is often an output of the energy planning process. The measurement plan may be a single document or a series of documents that together, comprise the measurement plan. When establishing the measurement plan, consideration should be given to the complexity of the energy use. For example, a single utility on a single site may warrant a simple plan compared to a multi-site multi-utility configuration.

The energy measurement plan should describe the following:

- a) what is measured and monitored;

- b) why is it measured;
- c) how it is measured (e.g. device, method, frequency, accuracy and repeatability, calibration);
- d) the values to be expected;
- e) a significant deviation for that measurement;
- f) the action to be taken for a significant deviation;
- g) personnel responsible for data collection and measurement;
- h) what and where the record is;
- i) whether any measurements or parameters are especially process or safety critical;
- j) future measurement needs.

NOTE 1 An example of a measurement plan is given in [Annex D](#).

The frequencies defined for monitoring and measurement should take into account the analysis of appropriate trends (e.g. differences caused by the way different personnel operate the facility, fluctuations in energy consumption due to equipment or production variations, signs of equipment failure and occupancy levels). In justifying the relevance of the measurement frequency applied in relation to the identified energy use, simple risk analysis or benefit analysis may be used.

There are two types of measurements that are typically addressed by the measurement plan. One is those items needed for an EnPI and other energy performance measures (such as the effectiveness of the action plans). The other is critical parameters necessary for effective operation or maintenance.

NOTE 2 ISO 50015 provides guidance on measurement and verification, including measurement plans.

Visualization is an important and effective tool for monitoring energy performance. Trend charts, pie charts and other graphic representations of energy performance status and the results are often used to communicate key information to operators, top management and other stakeholders.

Where operating conditions have changed, the expected energy consumption and the measurement plan may need to be changed.

The organization determines when a deviation is significant. A deviation is a departure from a defined or acceptable level of energy performance. The deviations can be positive or negative.

A positive deviation occurs when energy performance is better than expected or planned. A negative deviation is one that is worse than expected or planned. In either case, a significant deviation requires an investigation that is recorded. Investigation of positive deviations can identify good practices, or result in findings to improve operational control. An organization investigating negative deviations should consider whether improved operational controls are appropriate and whether a corrective action is needed.

It is a good practice to use the corrective action process for investigating and responding to significant deviations.

| Practical Help Box 20 - Examples of ways to identify significant deviations |
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| <p>Ways to identify significant deviations can include:</p> <ul style="list-style-type: none"> — monitoring the progress towards energy objective and targets using process control charts or other tools; — examining changes in operational energy efficiency outside defined parameters; — monitoring deviations between EnPIs and associated targets. (e.g. Cumulative Sum Control Chart) |

An important principle of measurement and its outputs is that it should be increasingly integrated into the business management process to enable fact based decision making.

4.6.2 Evaluation of compliance with legal requirements and other requirements

The organization should determine if processes for evaluating compliance with legal and other requirements (e.g. environment, health, safety and corporate governance) are already in place and whether they can be adapted to address the needs of the EnMS.

4.6.3 Internal audits of the EnMS

4.6.3.1 An internal audit of an EnMS is an objective, systematic review of all or part of an organization's EnMS. The purpose of the audit is to:

- determine if the requirements are being met;
- identify and drive improvements in energy performance and the EnMS.

4.6.3.2 This is accomplished by an internal audit process, which is documented (see ISO 50001:2011, 3.20), and should include the following:

- a) competent auditors;
- b) verification of auditor competency;
- c) auditor independence from the area being audited;
- d) an audit schedule covering a defined period of time (usually at least one year);
- e) an audit schedule and individual audit plans not based on clauses alone, but on the processes of the EnMS, taking into account the organization's facilities, equipment, systems and processes;
- f) defined approaches for agreeing on EnMS audits scopes and objectives;
- g) processes for planning, and conducting audits, including the use of any audit forms, checklist or other audit tools, if applicable;
- h) compiling and communicating audit results to top management;
- i) clearly defined responsibilities and requirements for taking and completing corrective actions on audit nonconformities;
- j) appropriate records of the audit process and audit results.

4.6.3.3 EnMS internal audits should be prioritized and conducted more frequently for:

- areas that influence energy performance such as objectives, targets, SEUs, operational controls, significant deviations, measurement, monitoring and analysis, and energy review;
- other areas where important nonconformities have been identified in previous audits;
- areas that have experienced changes to equipment, systems, processes and personnel since the last EnMS audit;
- areas where changes are planned that could have a significant impact on energy performance.

4.6.3.4 EnMS internal audits may be conducted less frequently for:

- a) areas that do not significantly impact energy performance, such as document control; or
- b) processes that have fewer nonconformities from previous audits.

This ensures that the audit process is focused on the areas and processes that assist the organization in improving energy performance and the effectiveness of its EnMS.

4.6.3.5 The organization should maintain evidence that all the EnMS requirements were audited within a defined period of time specified on an audit schedule. This can be achieved in a number of ways:

- a matrix with processes/areas and the requirements applied to them during the audit(s);
- completed audit plans and audit schedules providing details of processes/ areas and requirements audited;
- recorded in audit notes, audit report or other format.

4.6.4 Nonconformities, correction, corrective action and preventive action

4.6.4.1 Correction and corrective action are the means by which deviations from the requirements of the EnMS can be corrected and their causes eliminated to prevent recurrence. The organization may find value in integrating the corrective action process with existing systems.

When a non-conformance is detected, the first step is to take appropriate action to resolve the immediate situation (correction), e.g. reduced compressed air pressure due to dirty filter – replace the filter. Using this example a corrective action could be to determine why the filter was dirty and to address the root causes to prevent recurrence.

A preventive action is the action to eliminate the cause of a potential nonconformity.

Issues that need to be raised in the correction, corrective and preventive action process can be identified from several sources in the EnMS, including the following:

- results of internal and external audits;
- results of evaluations of compliance reviews;
- failure to reach specified targets in monitoring and measurement processes;
- failure to comply with operational control procedures;
- repeated significant deviations.

4.6.4.2 External sources can be used in identifying potential preventive actions. These can include:

- a) supplier and customer information;
- b) benchmarking;
- c) competitive analyses;
- d) providers of outsourced services;
- e) published legal updates;
- f) regulatory changes;
- g) published best practices e.g. journals;
- h) trade associations.

4.6.4.3 It is important to manage the correction, corrective action and preventive actions to ensure easily accessible information. Managing the corrective and preventive action process typically involves identifying the following:

- sources of nonconformities e.g. audits, inspections, evaluations of compliance;
- the failure or potential failure;

- locations at which the actions arose;
- persons responsible for the area concerned;
- person responsible for completing the corrective and/or preventive action;
- agreed date to close the corrective and/or preventive action;
- actual date the corrective and /or preventive action was closed;
- results of the review of the effectiveness;
- date when the action was closed;
- trend analysis of causes and recurring problems.

The organization should perform root cause analysis to determine the causes of nonconformities or potential nonconformities. Without determining the actual root cause, the nonconformity may recur or potential nonconformities may occur.

4.6.5 Control of records

Records should be maintained that allow the organization to successfully demonstrate an effective EnMS and improved energy performance. The list given below is a minimum list of records based on the requirements of ISO 50001. An organization may maintain additional records according to its needs:

- energy review;
- energy opportunities;
- energy baseline;
- EnPIs;
- methodology for determining and updating the EnPIs;
- competency and training;
- design;
- measuring and monitoring of key characteristics;
- calibration;
- evaluation of compliance;
- internal audit;
- corrective and preventive action;
- management review.

4.7 Management review

4.7.1 General

Management review is the “Act” part of the PDCA cycle of the EnMS.

This is a key responsibility of top management. The key value that management review process provides is to answer the question “Is the EnMS delivering and sustaining the planned energy performance improvements?” Focused on ensuring the ongoing suitability, adequacy and effectiveness of the EnMS, the management review should be a dynamic process of reviews, evaluations, decisions and actions that ensure continual improvement in energy performance and the EnMS. The management review will

highlight to top management the positive outcomes as well as the weaknesses, in order to provide effective recommendations for improvements. It is through management review that the management system is adjusted, updated and kept relevant and capable of generating energy performance improvements.

Management review should be conducted at a frequency within which corrective actions can be taken and appropriate adjustments to the system can be made. It can also coincide with existing management meetings. Management review should not just be a look into the past to see where the organization has been but an active process that helps set the direction for a better course for the organization, its EnMS and energy performance.

4.7.2 Input to management review

Commonly, management review is conducted so that all the required inputs are addressed at least once per year although this may be accomplished through several meetings or over the course of multiple reviews. Not all of the inputs need to be covered at a single meeting or other management review activity. Instead, a management review may focus on specific topics or needs of the organization. The format for the management review meeting is also up to the organization and may be a face to face meeting, electronic meeting or other format that meets the organization's needs.

4.7.3 Output from management review

The decisions and actions from the management review need to be followed up so that any needed adjustments or changes are made to the EnMS so that it continues to provide value to the organization. Top management ensures responsibilities and resources are provided for the implementation of follow-up actions. This ensures that the PDCA cycle is complete and effective.

Annex A **(informative)**

Examples of energy policy

A.1 General

This annex provides examples of organizational energy policies. These examples are not intended to provide a template for implementation.

A.2 Example 1: Speciality glass manufacturer (single site)

As an energy intense manufacturer of speciality glass, the company strives to improve energy efficiency and reduce energy consumption costs and promote the long-term environmental and economic sustainability of its operations. We are committed to:

- reducing energy consumption in our manufacturing operations through the establishment of objectives and targets;
- ensuring continual improvement in our energy performance;
- deploying resources and leveraging information to achieve our objectives and targets;
- upholding legal and other requirements regarding energy use, efficiency and consumption;
- considering energy performance improvements in design and modification of our facilities, equipment, systems and processes;
- effectively procuring and using energy-efficient products, and services.

A.3 Example 2: Global manufacturer (multiple sites)

This policy applies to all ABC operations.

The objectives of this policy are to continually improve energy performance, reduce cost, optimize capital investments for energy efficiency, reduce environmental and greenhouse gas emissions, and conserve natural resources.

ABC will promote the efficient use of energy to produce and deliver products and services to its customers.

The following steps should be pursued to support this policy.

- Establish and implement an effective EnMS worldwide that supports manufacturing capabilities while providing a safe and comfortable work environment with the information and resources needed to set and achieve appropriate energy objectives and targets.
- Emphasize energy performance as a factor in procurement decisions, product development and in process and facility design.
- Secure adequate and reliable energy supplies at the most advantageous rates and implement contingency plans to protect operations from energy supply interruptions.
- Encourage continuous energy performance by employees in their work and personal activities.

- Drive further development of internal and external energy efficient and innovative technologies.
- Support governmental agencies, utility companies and other organisations on energy programmes and comply with all legal and regulatory requirements relating to energy use, consumption and efficiency.
- Report progress toward ABC's energy objectives and targets to executive management on a quarterly basis.

Annex B (informative)

Example of energy review

B.1 General

This annex contains an example of a partial energy review.

B.2 Organizational overview

XYZ Peroxide Ltd. has been operating at a single site in Mumbai, India, for the past 37 years. The facility employs 120 people and operates on three shifts, seven days a week. The facility produces hydrogen peroxide, which is used by the textile, paper and chemical industries.

The major processes consist of the following:

- a) hydrogenation;
- b) oxidation;
- c) extraction;
- d) distillation;
- e) utilities (e.g. cooling water, instrument air, etc.).

In the first step, the working solution is hydrogenated. It is then oxidized with air. Hydrogen peroxide produced in the oxidizer is then extracted with deionized water. It is then distilled to produce different concentrations of hydrogen peroxide.

B.3 Energy sources

The energy sources of XYZ Peroxide Ltd. are imported electricity from the grid and piped natural gas. Natural gas is used both as a fuel and a feedstock.

B.4 Identification of energy use

- a) Electrical: the preliminary analysis of the energy use and consumption is based on motor data, load factor and estimated operating hours (see [Table B.1](#)).

Table B.1 — Electrical energy use and consumption

| Energy use | No. of units | Name plate load Total MW | Operating hours | Estimated annual consumption ^a MWh | % estimated annual electrical consumption |
|----------------------------|---------------------|-----------------------------|-----------------|-----------------------------------------------------|-------------------------------------------------|
| Process air compressors | 4 | 1,64 | 8 400 | 12 915 | 56 |
| Cooling water pump | 2 | 0,52 | 8 400 | 3 084 | 13,38 |
| Instrument air compressors | 1 | 0,075 | 8 400 | 612 | 2,66 |
| | 2 | 0,090 | 8 400 | 420 | 1,82 |
| Other | Detail not provided | | | | |
| Total | | | | | 100 |

^a Motor efficiency and the percentage load factor are used to calculate the data in this column in accordance with IEC 60034-1.

- b) Thermal: the preliminary analysis of the energy use and consumption is based on heat balance, boiler efficiency and operating hours (see [Table B.2](#)).

Table B.2 — Steam use and consumption

| Energy use | No. of units | Name plate load hour | System efficiency (boiler) | Load MT/hour | Operating hours | Estimated annual consumption MT/year | % estimated annual steam consumption |
|-----------------|---------------------|-------------------------|----------------------------------|-----------------|--------------------|-----------------------------------------------|-----------------------------------------|
| Distillation | 1 | 4,21 | 0,92 | 4,58 | 8 400 | 38 525 | 73,72 |
| Steam preheater | 1 | 0,95 | 0,92 | 1,03 | 8 400 | 8 664 | 16,58 |
| SR unit | 6 | 0,45 | 0,92 | 0,50 | 8 400 | 4 190 | 8,02 |
| Other | Detail not provided | | | | | | |
| Total | | | | | | | 100 |

B.5 Past and present energy consumption

The typical tables showing the past and current energy consumption data are not shown in this annex for purposes of brevity. The analysis was carried out on the past and present energy consumption data. For purpose of this example, electrical energy was determined to be the focus and the process air compressors were identified as a potential SEU.

B.6 Identification of SEU

B.6.1 General

The relevant variable analysis was conducted at both the facility level and the level of the process air compressor. In each case, the relevant variable is production.

B.6.2 Facility analysis

The relation between electric energy consumption (kWh) and the relevant variable, production (MT), was carried out by using linear regression analysis using the monthly data for three years for the facility and for the potential SEU process air compressors.

[Figure B.1](#) shows the relationship between electric energy consumption and the relevant variable production for the facility. As demonstrated by the regression model the base load is rather small (i.e. 76 745 kWh).

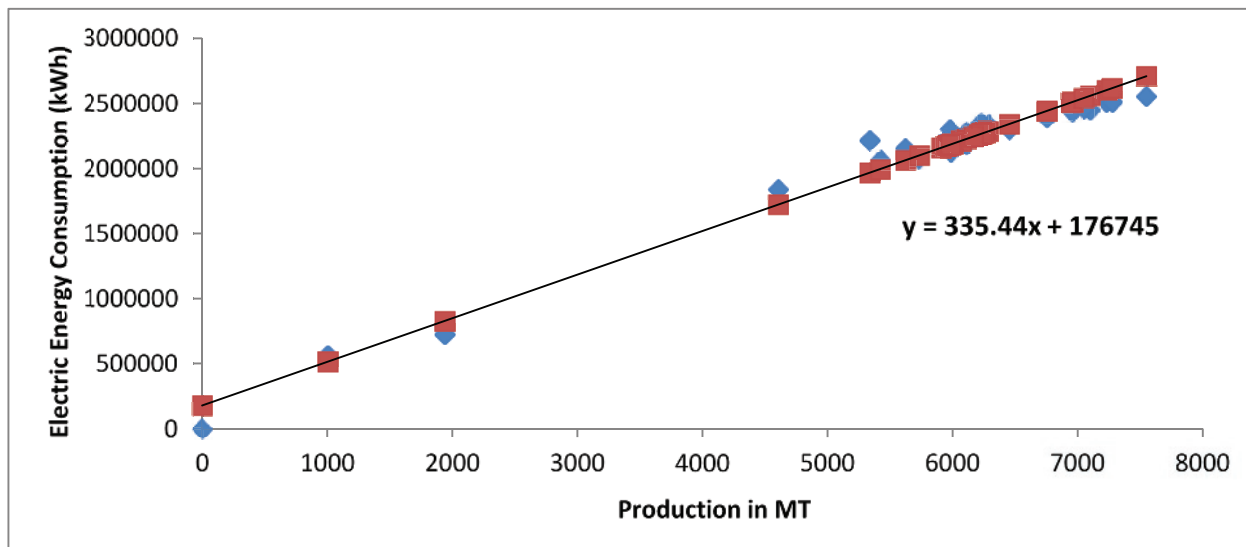


Figure B.1 — Facility electrical energy consumption vs. production

B.6.3 Potential SEU analysis

Figure B.2 shows relationship between electric energy consumption (kWh) and production (MT) for the potential SEU, process air compressor. The regression result is shown above for one compressor.

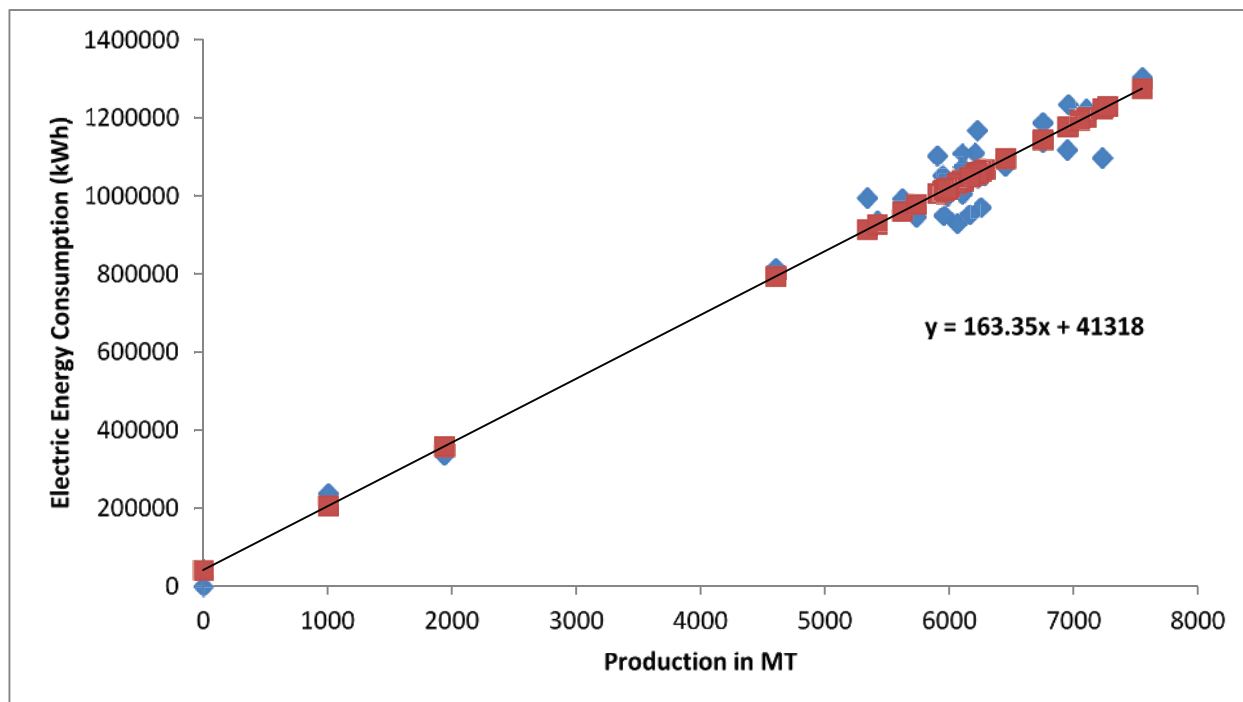


Figure B.2 — Process air compressor electricity vs. production

B.6.4 SEUs

SEUs are determined by using Pareto analysis of the past and present energy consumption for the period of 36 months, i.e. April 2010 to March 2013. The top two energy uses were selected as SEUs (accounting for over 50 % of total electrical energy consumption – meeting the criteria for significance). See Table B.3.

Table B.3 — SEUs

| SEU | Electrical energy consumption kWh | % total annual electrical energy consumption | Relevant variables considered for SEUs | Personnel |
|------------------------------|--------------------------------------|----------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Process air compressors | 35 678 946 | 46,60 % | Production(MT) | Shift operator; Shift supervisor; Plant manager; Senior maintenance engineer; Maintenance technicians; |
| Utility cooling water pumps | 10 254 454 | 13,40 % | | |
| Other energy uses | | 40 % | | |
| Total electrical consumption | 76 553 919 | 100 % | | Original equipment supplier for maintenance and services; Head of electrical engineering. |

B.6.5 Future energy use and consumption

Using linear regression of energy consumption as a function of production, which is the only relevant variable considered, for each of the energy sources, future consumption was projected. The relationship of electric energy consumption and production shown in [Table B.3](#) for the facility is reproduced as follows:

$$y = 335,44x + 176\,745$$

where

x is production (MT);

y is electric energy consumption of the facility (kWh).

Production based on monthly production plan was used to calculate the estimated energy consumption as shown in [Table B.4](#).

Table B.4 — Predicted facility electrical consumption for 2014-2015

| Month | Number of days | Production MT | Predicted electrical energy consumption kWh |
|------------|----------------|------------------|------------------------------------------------|
| April 2014 | 30 | 7 200 | 2 591 941 |
| May 2014 | 31 | 7 500 | 2 692 575 |
| June 2014 | 30 | 7 110 | 2 561 751 |
| (...) | | | |
| March 2015 | 17 | 3 920 | 1 491 685 |
| Total | | 84 000 | 30 298 230 |

The relationship of electric energy consumption and production shown in Clause [B.6](#) for the SEU process air compressor was reproduced as follows:

$$y = 163,35x + 41\,318$$

where

x is production (MT);

y is electric energy consumption for SEU process air compressor.

Production based on monthly production plan was used to calculate the estimated electric energy consumption for the SEU as shown in [Table B.5](#).

Table B.5 — Predicted process air compressor electricity consumption for 2014-2015

| Month | Number of days | Production MT | Predicted process air compressor elec- tricity consumption |
|------------|----------------|------------------|---------------------------------------------------------------|
| | | | kWh |
| April 2014 | 30 | 7 200 | 1 217 425 |
| May 2014 | 31 | 7 500 | 1 266 429 |
| June 2014 | 30 | 7 110 | 1 202 723 |
| (...) | | | |
| March 2015 | 17 | 3 920 | 681 643 |
| Total | | 84 000 | 14 217 061 |

B.7 Opportunities

In order to prioritize energy performance improvement opportunities the organization defined three criteria as shown in [Table B.6](#). For each opportunity, the implementation cost, anticipated energy cost savings and simple payback data were collected and are shown in [Table B.7](#), with the ranking results shown in [Table B.8](#).

Table B.6 — Opportunity rating criteria

| Opportunity criterion | Rating | | | |
|-------------------------------------------------|--------------------|--------------------|---------------------|--------------------|
| | 1 | 2 | 3 | 4 |
| Anticipated annual energy cost savings per year | less than \$1 000 | \$1 000 to \$1 999 | \$2 000 to \$10 000 | more than \$10 000 |
| Implementation cost per year | more than \$10 000 | \$2 000 to \$9 999 | \$1 000 to \$1 999 | less than \$1 000 |
| Simple payback (months) | more than 36 | 13 to 36 | 6 to 12 | less than 6 |

In general, organizations will use financial criteria for purposes of initial screening of opportunities during the energy review process. Once the opportunities have been prioritized, a more detailed analysis of benefits is typically conducted. This analysis would address other information such as energy savings, non-energy benefits, or other organizational criteria.

Table B.7 — Register of opportunities

| Sr. no. | Energy source | Annual energy savings | Annual savings | Implementation cost | Payback |
|---------|------------------------------------------------------------------------------------------------------|-----------------------|----------------|---------------------|---------|
| | | kWh | US\$ | US\$ | Months |
| 1 | Replacement of old cooling water pumps 401/A and 401/B with new energy efficient LLC pump | 56 280 | 9 000 | 34 300 | 45,73 |
| 2 | Impeller trimming of old CW pump 401/C to match the head of pump P401/A and P401/ | 168 840 | 27 020 | 200 | 0,09 |
| 3 | Replacement of old instrument air cooling water feed pump motor 404/B with new energy efficient pump | 8 148 | 1 200 | 1 600 | 16,00 |

NOTE For the purposes of brevity, additional detail is not provided.

Table B.8 — Opportunity rating

| Sr. no. | Description of opportunity | Anticipated annual energy cost savings | Implementation cost | Simple pay-back | Total rating score (x) |
|----------------|-------------------------------------------------------------------------------------------------------|-----------------------------------------------|----------------------------|------------------------|-------------------------------|
| 1 | Replacement of old CW pumps 401/a with new energy efficient LLC pump | 3 | 1 | 1 | 3 |
| 2 | Impeller trimming of old CW pumps 401/C to match the head of pumps P401/A and P401/B | 4 | 4 | 4 | 64 |
| 3 | Replacement of old instrument air cooling water feed pump motor 404/B with new energy efficient pumps | 2 | 3 | 2 | 12 |

Annex C (informative)

Example of an action plan

Table C.1 — Energy management action plan

| | | | | |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|----------------------|-------------------------------------|
| Project number/Reference | 2013-01 | | | |
| Related SEU (as applicable) | Compressed air | | | |
| Action plan | Compressed air pressure and leakage reduction | | | |
| Objective | Improve compressed air system energy performance | | | |
| Target | Reduce energy consumption by 200 000 kWh by end of fiscal year | | | |
| Action origin | <input type="checkbox"/> Energy review outputs, <input type="checkbox"/> Opportunities Register, <input type="checkbox"/> Staff Suggestion, <input type="checkbox"/> Other If Other; describe: | | | |
| Reason for action | The site energy audit revealed excessive leaks in compressor pipework. | | | |
| Estimated energy saving | €9 000 per year / 90 000 kWh per year | | | |
| Estimated cost | €2 000 | | | |
| Summary of tasks | Stage | Description of tasks | | |
| | Stage 1 | Carry out a leak test survey | | |
| | Stage 2 | Tag and repair leaks. | | |
| | Stage 3 | Adjust compressor controls as needed, check supply side operation. | | |
| | Stage 4 | Investigate feasibility of reducing pressure from 700 kPa to 600 kPa. Test and monitor pressure reduction | | |
| | Stage 5 | Implement pressure reduction by changing settings on the compressor, monitoring compressor controls for any further adjustments needed. | | |
| | Stage 6 | Monitor energy performance and verify energy savings. | | |
| EnPI | Energy consumption per output air volume kWh/m ³ month Note: measured by power meter (kWh), flow meter (m ³ h) normalized using standard temperature and pressure (25 °C and 101,3 kPa) and hour meter (h) | | | |
| Energy baseline | xxx kWh/m ³ /month | | | |
| Energy target | yyyy kWh/m ³ /month | | | |
| Measurement and verification plan | Analyse the monitoring and measurement data for the compressed air EnPI, using regression analysis of kWh of the air compressors, the independent variable being production. | | | |
| Comments | Actual leakage reduction has been greater than expected | | | |
| Task | Timescale | Responsibility | Date stage completed | Output (reference) |
| Stage 1 | January 2013 | D. Smith | January 2013 | AC Ltd Report |
| Stage 2 | January 2013 | P. Cheng | January 2013 | Leak Report AV 01 |
| Stage 3 | February 2013 | B. O'Sullivan | February 2013 | Operational control -02 Compressors |
| Stage 4 | March 2013 | L. Lee | March 2013 | Pressure Reduction Report LN 313 |
| Stage 5 | August 2013 | J. Jones | Ongoing | AC energy database |
| Stage 6 | December 2013 | L. Brown | Ongoing | Monitoring report |

Annex D (informative)

Developing measurement plans

[Table D.1](#) shows a typical format for a measurement plan, [Table D.2](#) addresses planning measurement resources and [Table D.3](#) shows critical operating parameters. [Tables D.2](#) and [D.3](#) are typically used to develop a measurement plan. These examples have been extracted for purposes of this annex and are not intended for use as a template.

Table D.1 — Measurement plan example 1

| What is measured | Why is it measured | How is it measured | How often is it measured | What values are expected | Who is responsible | What is the record | What is a significant deviation | What actions are taken for significant deviation |
|----------------------------------------------------------|--------------------|--------------------|--------------------------|--------------------------|--------------------|--------------------|---------------------------------|--------------------------------------------------|
| For the purposes of this example, no detail is provided. | | | | | | | | |

Table D.2 — Measurement resources

| SEU | EnPI | Relevant variables | Meters and data | Instrumentation currently in place | Instrument needed for measurement | Preferred meter options |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------------|------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Compressed air system | Energy consumption/output air volume (kWh/m ³ /day) | Compressed air flow | - Electricity meter - Compressed air flow meter | Electricity meter | Flow meter | - Spot check the flow - Continual measurement not cost effective for flow meter - Re-evaluate in three months or consider pressure as indicator |
| Steam | Comparison of actual vs expected using Fuel consumption of boiler regressed with production and heating degree days (HDD) | Production activity and HDD | - Fuel meter - Data sources: Production data and HDD data | Fuel meter | none | - Fuel meter - Consider upgrading to automated meter for next budget cycle |
| Building heating | Energy consumption normalized by heating degree day and occupancy (GJ/day) | HDD and occupancy | - Heat meter - Data sources: HDD and occupancy | Gas meter, HDD from web | Occupancy | Get security records for improved occupancy records |

Table D.3 — Critical operating parameters

| SEU | Parameter | Units | Normal set point or value | Upper limit | Lower limit | Measuring instrument designation | Calibration frequency | Who needs to be informed of these values? |
|---------------|---------------------------------|------------------|---------------------------|-------------|----------------|----------------------------------|-----------------------|-------------------------------------------|
| Steam system | Total dissolved solids | Ppm | 3 500 | 3 800 | 3 400 | TDS001 | 3 months | Operators |
| Steam system | Exhaust oxygen | % O ₂ | 3 | 3,5 | 2 | Portable 123 | 6 months | Operators |
| Steam system | Stack temperature | ° C | Non applicable | 300 | Non applicable | TT124 | 12 months | Operators |
| Refrigeration | Temperature lift | ° C | 25 ± 10 | 35 | 15 | T12 and T16 | 12 months | Operators |
| Refrigeration | Condenser approach temperature | ° C | 5 | 6 | Non applicable | T12 | 12 months | Operators |
| Refrigeration | Evaporator approach temperature | ° C | 5 | 6 | Non applicable | T12 | 12 months | Operators |

Annex E (informative)

Relationship between key concepts

E.1 Relationship between objectives, targets, action plans, operational control, monitoring and measurement

After an organization establishes an objective and related target there are associated requirements within ISO 50001. It is at the organization's discretion whether to establish objectives and targets for energy uses that are not deemed significant. These associated requirements are shown within [Table E.1](#) and include the related action plan, EnPI, operational control and monitoring and measurement. The examples provided are intended to help the user understand the relationships between these requirements.

Table E.1 — Relationship between energy, objectives, targets and associated requirements

| Objective | Target | Tasks within related action plan | EnPI(s) | Operational control | Monitoring and measurement |
|--------------------------------------------------------|------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reduce heating energy consumption in buildings. | Reduce building A heating energy consumption by at least 7 % on current year's level, by 2008. | Install optimum start controller for heating system. Upgrade heating distribution insulation. Install PVC strip curtains in loading bay. Draught-proof windows, roof lights and doors. Ensure thermostats are correctly set. Ensure heat emitters are unobstructed. Raise awareness. | Building heating energy consumption normalized for heating degree days (HDD) | Specification for installing optimum start controller. Specification for installing PVC strip curtains. Procedure for upgrading heating distribution insulation. Procedure for checking thermostat settings, state of heat emitters, windows and doors. | Monthly measurement of heating fuel energy consumption and monthly HDDs. Regular monitoring of space temperatures. Periodic monitoring of heating system time and control settings. |
| Reduce warm water usage. | Reduce warm water usage in kWh/m ³ by 5 % of current levels within 1 year. | Replace hose nozzles with more efficient models. Ensure solid waste residues on floor are swept up instead of flushed away. Ensure leaks are detected and fixed. Raise awareness. | Warm water usage kWh/m ³ processed | Specification for fitting new nozzles. Work instruction for floor cleaning. Procedure for detecting, reporting and fixing leaks. Basic instruction in basic correct floor cleaning. | Bi-weekly monitoring of warm water usage for cleaning. Regular monitoring of water temperature. Spot checks on operators. |
| Reduce diesel consumption associated with road haulage | Reduce the consumption of diesel by 20 % within the road haulage fleet | Installation of energy monitoring system Driver awareness programme Training deployed for economic driving including annual refresher Develop operational control measures for idle/waiting time Feasibility study for renewable fuel mix options | Driver litre/tonne*km average (normalized) Running idle time (hours) | Specification for fleet renewal requirements Policy for running idle time Annual refresher training requirements | Weekly driver l/100 km average Total fleet driver performance metric |

E.2 Relationship between SEUs, objectives, targets, training, operational control, procurement, EnPI, monitoring and measurement and calibration

When an energy use is determined to be an SEU, additional requirements in ISO 50001 apply. These requirements include consideration of SEUs in setting objectives and targets and ensuring competence and training, operational controls, procurement, EnPIs, monitoring and measurement and calibration. Addressing the relationships between these requirements helps to ensure effective management of the SEUs.

Table E.2 — Examples of relationship between SEUs and associated requirements

| SEU | Are there objectives and targets for this SEU? (yes/no) | Affected personnel (for competence and training) | Operational controls | Procurement | EnPI examples | Monitoring and measurement | Calibration |
|---------------------------------------------------|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Compressed air systems, including air compressors | Yes | Maintenance technicians and supervisors Production personnel using compressed air Procurement officers Service contractors responsible for servicing equipment | Compressed air system operating criteria specification Operating procedures manual – including compressor control strategy Maintenance procedures manual Preventive maintenance management system (PMMS) | Vendor notification that energy performance will be considered for all compressed air system purchases Develop purchasing specifications to optimize energy use Develop methodology for assessing energy performance or the expected lifetime of SEU | Absolute energy consumption (energy input) Compressed air system supply specific energy ratio (kWh/m ³) model-based (normalized for relevant variables, e.g. production, weather, etc.) | Electrical power demand (kW) and energy consumption(kWh) Pressure reading at distribution header Flow reading at distribution header (ideal) Production output level Pressure at critical points of end use Temperature upstream and downstream of air dryers, as applicable Pressure dew point | Compressor kW meter Flow meters Pressure gauges at distribution headers and critical points of use |

Table E.2 (continued)

| SEU | Are there objectives and targets for this SEU? (yes/no) | Affected personnel (for competence and training) | Operational controls | Procurement | EnPI examples | Monitoring and measurement | Calibration |
|----------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Steam systems, including boilers | Yes | Boiler operators Maintenance technicians and supervisors Contractor service technicians Procurement officers Service contractors responsible for servicing equipment Licensed boiler operators, as required | Steam system operating criteria specification Boiler operations manual, including burner operations (air/fuel control) Boiler maintenance manual Preventive maintenance management system (PMMS) | Vendor notification of that energy performance evaluation will be considered for all steam system purchases Develop purchasing specifications to optimize energy use Develop methodology for assessing energy performance or the expected lifetime of SEU | Absolute energy consumption (fuel input) Supply side efficiency (EnPI) Steam output/fuel input (EnPI) Fuel flow rate/optimum fuel flow rate Benchmark (ideal heat required / actual heat delivered) Model-based (energy consumption normalized for relevant variables, e.g. production, weather, etc.) | Fuel input Air/fuel ratio (relevant variable) Flue gas analysis (O ₂ trim system for high variability in fuel source) Blowdown flow Blowdown conductivity Condensate temp and quality Condensate return – volume, temperature, quality Feed water flow Steam distribution and boiler surface temperatures Steam conditions (steam enthalpy/desired enthalpy for process) | Fuel flow meter Flue gas analyser Feed water flow meter Flow meter Temperature sensors Conductivity meter |
| Oven | No | Oven operators Maintenance technicians and supervisors Procurement officers Service contractors responsible for servicing equipment | Process heating Criteria per product specification Oven operating criteria Maintenance procedures manual Preventive maintenance management system (PMMS) | Vendor notification of that energy performance evaluation will be considered for all oven purchases Develop purchasing specifications to optimize energy use Develop methodology for assessing energy performance or the expected lifetime of SEU | Fuel input flow rate/ optimum fuel flow rate Available heat/optimum available heat For drying applications: moisture content after heating/ moisture content before heating based on weight analysis | Fuel input flow Electric power consumption meter Air/fuel ratio (relevant variable) Flue gas analysis (O ₂ trim system for high variability in fuel source) Surface temperatures of process heating system | Fuel input meter Flue gas analyser Temperature sensors Electric power consumption meters |

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