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**Energy management and energy savings — Guidance for net zero energy in operations using an ISO 50001 energy management system**

*Management de l'énergie et économies d'énergie —  
Recommandations pour zéro énergie nette dans le cadre des  
opérations utilisant un système de management de l'énergie  
ISO 50001*

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# Contents

Page

<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
3.1 Terms related to net zero.....	1
3.2 Terms related to net zero energy operation.....	3
<b>4 EnMS implementation for NZE</b> .....	<b>5</b>
4.1 General.....	5
4.2 Scope and boundaries for NZE.....	5
4.3 NZE plans.....	7
4.3.1 General.....	7
4.3.2 NZE policy as part of an organization's energy plan.....	8
4.4 Defining the energy or carbon-emission goals.....	9
4.4.1 General.....	9
4.4.2 Energy management system.....	9
4.4.3 Renewable energy.....	10
4.5 Selecting zero energy performance indicators.....	11
4.6 Defining future-year goals.....	13
4.7 Data collection plan.....	14
4.8 Planning to account year to year variability.....	15
<b>5 Improving organization operation and maintenance for NZE or NZC</b> .....	<b>15</b>
5.1 General.....	15
5.2 Effective operation and maintenance.....	15
5.3 Control technology.....	16
<b>6 Integration of renewable energy</b> .....	<b>16</b>
6.1 Consideration of renewable off-site energy.....	16
6.1.1 General.....	16
6.1.2 Renewable resources acquired by the organization.....	17
6.1.3 Renewable energy resources on the grid.....	17
6.2 Utilizing energy provider inducements to change energy use — Demand response.....	17
6.3 Renewable grid connection.....	18
<b>Annex A (informative) Relationship between NZE design, construction and operation</b> .....	<b>19</b>
<b>Annex B (informative) NZE overview for implementation</b> .....	<b>20</b>
<b>Bibliography</b> .....	<b>26</b>

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

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

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

# Introduction

## 0.1 General

This document shows how an organization that manages its energy performance can use that process to achieve net zero energy (NZE). It explains what is meant by NZE and how an energy management system (EnMS) in accordance with ISO 50001:2018 can be implemented to achieve, maintain and improve NZE. It also considers the integration of renewable energy and issues around planning for NZE in new and retrofitted facilities which is beyond the scope of ISO 50001. In addition, it is designed to complement organizational action to achieve net zero carbon (NZC).

This document introduces several new concepts to the determination of whether a facility meets the criteria it recommends for showing that it meets NZE or NZC goals. Many jurisdictions use the two terms interchangeably, and others promote one goal over the other as discrete choices. This document attempts to reconcile these definitions. It distinguishes between several different scopes and boundaries for these different net zero goals and their targets, which are increasingly effective at reducing energy and greenhouse gas (GHG) emissions, and correspondingly more difficult to achieve. It suggests that an EnMS be structured to allow continual improvement from lower targets to higher ones.

A number of countries around the world have pledged to achieve a net zero goal, and many more have committed to significant energy savings and carbon reductions in their societies.<sup>[17]</sup> Meeting these commitments over the coming decades requires accelerated improvements in energy management.

Many organizations are undertaking specific actions to reduce their carbon emissions by better management of energy, including targeting NZE. These actions may include:

- measuring, managing and minimizing energy use to achieve NZE through operations;
- designing and constructing new buildings or other facilities to meet a target of NZE;
- retrofitting existing buildings to improve their performance toward or beyond NZE;
- integration of renewable energy, e.g. photovoltaics (PVs), solar water heating, geothermal energy, on-site wind turbines;
- coordinating robust energy management with other sustainability initiatives, to achieve or surpass NZC.

This document shows how an EnMS can include objectives such as specified levels of NZE and NZC. The EnMS conforms to ISO 50001:2018. This document recommends establishing specific, quantifiable targets for energy consumption that can serve as a pathway to NZE. Use of this document should enable closer harmonization of claims of NZE within and between organizations, and across regions and nations.

By following the standardized approach provided, the organization can take advantage of common resources (e.g. software) to produce reliable and documentable processes and results, and of the basic structure this document provides in developing its own management system.

This document provides flexibility for organizations to determine their own scope, boundaries and calculation methodology for calculating net energy consumption, and for setting a pathway towards NZE. It does not discuss how to measure non-energy-related GHG impacts; for these, see ISO 14064-2:2019 and ISO 14067:2018.

This document recognizes that energy targets and calculation methods are chosen by the organization to be specific to its situation and can be determined outside the organization (e.g. by governments or consequent upon a GHG-calculation methodology). For situations when the measurement and calculations are developed by the organization itself, this document includes a high-level set of recommendations based on global best practice.

**0.2 NZE goals are being increasingly adopted**

NZE is a key indicator for an organization wishing to demonstrate leadership in energy management and sustainable development. It is applicable for buildings, industries and other sectors. It may also be measured at the organizational, district or city level. The buildings sector has been the first to accept NZE concepts widely, but there are also NZE industrial facilities. To achieve NZE goals, buildings can use mandatory NZE codes. Meeting challenging targets requires industry to consider residual energy use.<sup>[14]</sup>

The global market for NZE buildings and industries is exhibiting rapid compound annual growth, spurred on in part by legislation or pledges at the local, national or supranational level (see, for example, EU Directive 2018/844<sup>[13]</sup>).

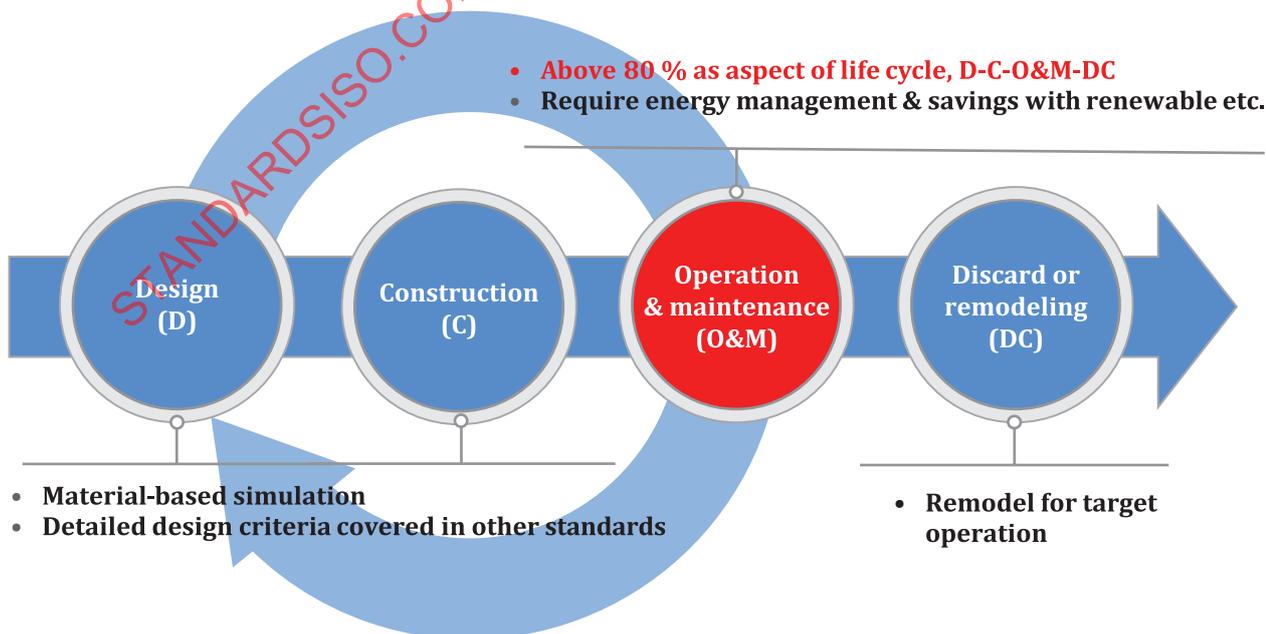
However, if these ambitious targets are to be met, a wide range of users including, but not limited to, energy service providers, building occupants, industrial managers, energy efficiency experts and government agencies require a common understanding of NZE and the use of standardized processes (such as those provided by this document) for targeting, measuring and maintaining it.

NOTE “Net zero building” is abbreviated as either “NZE building” or “NZC building”.

This document aims to meet these needs and uses the EnMS goal of continual improvement, as required by ISO 50001, to harmonize definitions and claims in the context of improving from one target to the next over time. It also allows facilities that find it impractical to reach NZE in the short term to show how close they come to achieving it, and to demonstrate how they choose to approach NZE over time.

**0.3 Importance of an energy management system to achieve NZE**

In a typical building’s life cycle, the operation and maintenance (O&M) phase (as shown in [Figure 1](#)) is more than 80 % of the total life-cycle energy consumption of that building and plant.<sup>[15]</sup> Thus, good energy management is critical to the life-cycle energy consumption of a building. As energy management improves as recommended by this document, it is likely that net energy consumption during operation declines dramatically, while energy consumption in other parts of the life cycle stays constant or declines by a smaller percentage. Thus, the non-operational energy impacts over the life cycle become relatively more important. That is one reason why that this document addresses these effects along with operational energy consumption, particularly when the energy targets are intended to be met in future years when energy performance is improved, and renewable energy production is increased.



**Figure 1 — Total life cycle energy use of an organization**

#### 0.4 Contents of this document

[Clause 4](#) provides a high-level introduction to the goals and processes of meeting different defined NZE targets, which are linked to each other by the process of continual improvement as part of an EnMS. It discusses how renewable energy should be treated in NZE demonstrations. It looks at how to select the most appropriate energy performance indicators (EnPIs) within an EnMS that can then be used to monitor progress towards achieving, maintaining and reaching higher levels of NZE (including NZC) over future years. The clause also considers how to develop a data collection plan, and ways of accounting for year-to-year variability, especially where renewable energy generation varies with weather conditions. The explanations of the rationales for the recommendation for NZE are provided in [Annex B](#).

The additional NZE targets, which go beyond many existing definitions of NZE, are variants on the principle of NZC. In this document, “carbon” is used in a variety of terms (e.g. carbon footprint, carbon neutral) as carbon dioxide (CO<sub>2</sub>) to represent GHG emissions and CO<sub>2</sub> equivalent, which is a unit of measurement for global warming effect. This document develops these recommendations on the effective O&M with renewable energy and how it is integrated into an EnMS. It highlights demand response as a way of matching energy consumption with available renewable energy in [Clauses 5](#) and [6](#).

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# Energy management and energy savings — Guidance for net zero energy in operations using an ISO 50001 energy management system

## 1 Scope

This document gives guidance on the use of an energy management system (EnMS) in accordance with ISO 50001:2018 to achieve net zero energy (NZE), and supports the achievement of net zero carbon (NZC) and other sustainability goals. It describes how to establish an enhanced EnMS designed to achieve:

- a) improvement of operational and maintenance practices based on NZE principles;
- b) integration of renewable energy into operations and maintenance;
- c) planning for facilities, systems, equipment or processes to implement NZE and NZC.

This document does not apply to technologies, design or construction. The technical specification of passive, active or renewable energy for NZE or NZC is also not included because of different regional conditions by countries.

## 2 Normative references

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

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

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 50001:2018 and the following apply.

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

### 3.1 Terms related to net zero

#### 3.1.1

##### **net zero**

state in which a quantity of a commodity with one attribute is balanced by the same quantity of the commodity with a different attribute

Note 1 to entry: The commodity can be physical (e.g. water), a waste, a by-product (e.g. greenhouse gas emissions) or a form of energy.

Note 2 to entry: Net zero can be applied within specified *net zero energy target boundaries* (3.1.7) over a defined period of time.

### 3.1.2

#### net zero energy

##### NZE

state in which a quantity of energy consumption is balanced by the same quantity of *clean renewable energy* (3.2.2) generated

Note 1 to entry: The energy consumed can be in the form of a fuel such as gas, oil or coal, or a medium such as electricity, steam or heat.

Note 2 to entry: NZE can be applied within specified *NZE target boundaries* (3.1.7) over a defined period of time.

### 3.1.3

#### net zero carbon

##### NZC

state in which a quantity of greenhouse gas (GHG) emissions is balanced by the same quantity of GHG removals

Note 1 to entry: Where *GHGs* (3.2.8) take the form of different gases (such as CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, F-gases or SF<sub>6</sub>) they can be converted to a common unit such as tonnes of CO<sub>2</sub>e using their global warming potential.

Note 2 to entry: NZC can be applied within boundaries specified by the organization over a defined period of time.

Note 3 to entry: The GHG removals can be achieved by *clean renewable energy* (3.2.2) generation.

Note 4 to entry: This document uses the term “net zero carbon” to mean net zero GHG emissions, following common practice among net zero energy practitioners. The difference between CO<sub>2</sub> and GHGs can be small or negligible for buildings but can be significant for industrial facilities.

### 3.1.4

#### energy independence rate

##### EIR

rate of energy generation compared with energy consumption within the same *net zero energy target boundaries* (3.1.7)

Note 1 to entry: It is expressed as a percentage.

### 3.1.5

#### zero energy performance indicator

##### zEnPI

indicator which trends to or is equal to zero for *net zero energy (NZE)* (3.1.2) or *net zero carbon* (3.1.3)

Note 1 to entry: zEnPI can be a ratio or rate between *renewable energy* (3.2.1) and *delivered energy* (3.2.4) within specified *NZE target boundaries* (3.1.7) over a defined period of time.

Note 2 to entry: zEnPI can be *normalized* (3.2.9) energy use (e.g. renewable energy consumption per unit of output).

Note 3 to entry: zEnPIs do not replace the energy performance indicators for the energy management system and can be used in defining the zEnPI, e.g. zEnPI is normalized energy consumption (kWh) minus renewable energy produced (kWh).

### 3.1.6

#### NZE target

##### net zero energy target

quantifiable objective of *net zero energy (NZE)* (3.1.2)

Note 1 to entry: The quantifiable objective of NZE is the zero energy performance indicator (zEnPI) value, which is = 0 based on the definition of zEnPI (3.1.5).

### 3.1.7

#### **NZE target boundaries** **net zero energy target boundaries**

physical or organizational limits within which an *NZE target* (3.1.6) is assessed

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

Note 1 to entry: The organization defines its NZE target boundaries.

## 3.2 Terms related to net zero energy operation

### 3.2.1

#### **renewable energy**

energy not depleted by extraction as it is replenished at a rate equal to or faster than it is extracted

Note 1 to entry: Renewable energy excludes recovered or wasted energy.

Note 2 to entry: Organic fraction of municipal waste can be considered as a renewable energy.

Note 3 to entry: Whether the energy stored in a technical system is renewable or not depends upon the nature of the original energy.

Note 4 to entry: Criteria to categorize an energy source as renewable can differ amongst jurisdictions, based on local environmental or other reasons.

[SOURCE: ISO 50007:2017, 3.38, modified — “naturally” deleted before “replenished” and “equal to or” added before “faster” in the definition.]

### 3.2.2

#### **clean renewable energy**

*renewable energy* (3.2.1) whose direct or indirect emissions of *greenhouse gas (GHG)* (3.2.8), other gases with adverse impacts on human health, water pollutants, or other toxic releases, and whose impacts on ecosystems are substantially lower than those of fossil fuels

Note 1 to entry: Geothermal energy that releases high levels of SO<sub>2</sub> gases to the atmosphere does not qualify under this definition.

Note 2 to entry: Wood pellet or solid wood combustion does not qualify if the GHG emissions associated with producing the wood-derived fuels are not substantially lower than those from gas-fired generation.

[SOURCE: ISO 50007:2017, 3.38, modified — “fossil fuels” replaced “conventional alternatives such as gas-fired generation” in the definition. “wood-derived fuels are not substantially lower than those from gas-fired generation” replaced “wood are similar to those of coal on the basis of a megajoule of fuel” in

Note 2 to entry.]

### 3.2.3

#### **off-site energy**

energy (such as electricity and heat) necessary for the organization and originating from outside the organization’s boundary

Note 1 to entry: Off-site energy is one of the energy production and supply methods to achieve *net zero energy* (3.1.2).

Note 2 to entry: On-site energy generation is a method of supplying and producing energy within the boundary of the site.

Note 3 to entry: The electricity generated is delivered to the grid first.

### 3.2.4

#### **delivered energy**

energy arriving at the boundaries of an organization

[SOURCE: ISO 50047:2016, 3.3, modified — Note 1 to entry deleted.]

### 3.2.5

#### **primary energy**

energy that has not been subjected to any conversion or transformation process

Note 1 to entry: Primary energy can be either a non-renewable or a *renewable energy* (3.2.1), or a combination of both.

[SOURCE: ISO 50047:2016, 3.17]

### 3.2.6

#### **embodied energy**

energy consumed in the processes associated with the production, transportation, installation and assembly of materials, products and services through their lifecycle

[SOURCE: ISO 6707-3:2017, 3.7.6, modified — “total of all the” deleted before “energy” and “transportation, installation and assembly of materials, products and services through their lifecycle” replaced “of materials and products” in the definition.]

### 3.2.7

#### **demand response**

ability of an organization consuming energy to respond to a trigger by lowering or raising their power consumption temporarily

Note 1 to entry: The trigger may be from a utility system operator, load-serving entity, regional transmission organization/independent system operator or other entity.

Note 2 to entry: The trigger may be a reliability trigger or a price trigger.

Note 3 to entry: Demand response is a temporary change in energy consumption, sometimes with a decrease in service level (e.g. less comfortable climate, non-optimal lighting).

### 3.2.8

#### **greenhouse gas**

#### **GHG**

gaseous constituent of the atmosphere, both natural and anthropogenic, that absorbs and emits radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere and clouds

Note 1 to entry: For a list of GHGs, see the latest Intergovernmental Panel on Climate Change Assessment Report.

Note 2 to entry: Water vapour and ozone are anthropogenic as well as natural GHGs, but are not included as recognized GHGs due to difficulties, in most cases, in isolating the human-induced component of global warming attributable to their presence in the atmosphere.

[SOURCE: ISO 14064-1:2018, 3.1.1]

### 3.2.9

#### **normalize**

modify data to account for changes to enable comparison of energy performance under equivalent conditions

## 4 EnMS implementation for NZE

### 4.1 General

This document should be used by the management of a facility or an organization with multiple facilities in the context of the implementation of an EnMS based on ISO 50001:2018. It is also recommended that the EnMS follow the guidance in ISO 50004:2020. This document describes how to extend the organization's EnMS to achieve net zero outcomes for energy or carbon emissions.

It recommends the organization develop and implement an energy plan to achieve one or more specific quantitative targets for net energy consumption. These can take into account the organization's situation such as size, region and goals to reduce emissions and possible use of renewable energy. The energy targets can be expressed in absolute terms, relative terms or other metrics such as an energy independence rate (EIR).

The organization should develop a multi-year strategy using its energy plan to meet progressively more demanding targets (see 4.4). For the more ambitious goals, a Management System Standard that parallels that of an EnMS should be established to continually improve performance in reducing emissions of other GHGs than energy-related carbon dioxide whenever they are found to be significant.

### 4.2 Scope and boundaries for NZE

Before developing a plan to reach NZE, the organization should determine:

- the boundaries of the organization's NZE target(s);
- the scope for NZE (see 4.6).

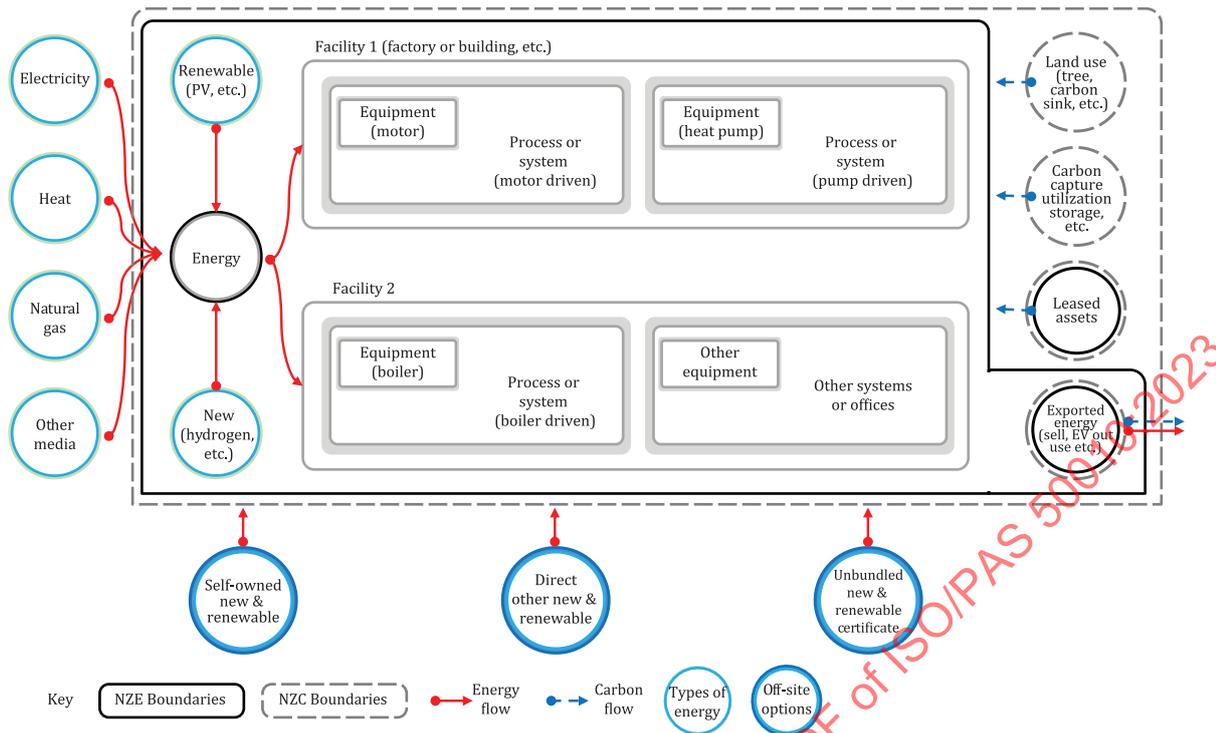
Where there is an EnMS based on ISO 50001:2018, or other EnMS, the NZE target boundaries may be aligned with those of the EnMS. However, it is possible that the NZE target boundaries are different than those of the EnMS. If they are different, this should be indicated in the documented information. An organization's EnMS boundaries can differ from its NZE target boundaries due to on-site energy consumption or off-site renewable energy use.

**EXAMPLE 1** An organization's EnMS includes all its production facilities. However, as some sites have more energy intensive processes, top management decides to implement NZE in one facility at a time.

**EXAMPLE 2** An organization operates a factory or a building, for which the organization has implemented an EnMS based on ISO 50001. The organization has leased assets such as an administration building and offices that it has not included in the EnMS. In this case, top management decides that it can achieve NZE across the entire organization.

**NOTE 1** An organization can operate a single building and the processes therein, a group of facilities or an entire company, or any part(s) thereof.

**Figure 2** provides a diagram for the scope and boundaries of NZE and NZC. The energy and carbon flows are described in an organization (facilities, equipment, systems or energy-using processes) using new and renewable energy generation. The use of off-site renewable energy should be considered if the energy produced from within the boundary is less than the facility uses. The options for renewable energy are described in [Clause 6](#).



NOTE The land use (tree, etc), carbon capture utilization and storage, and leased assets are activities in the boundary of NZC.

Figure 2 — Example boundaries for NZE and NZC

The organization may choose to include parts of its supply chain within the NZE target boundaries, e.g. where they provide an integral part of its final products. The scope for NZE should comprise all the energy used by the organization. This should be measured on a delivered energy basis or on a primary energy basis. Using primary energy is best practice. Energy should include solid, liquid and gaseous fuels as well as electricity, heat, steam and other energy types.

NOTE 2 In carbon accounting terms, these are regarded as energy contributing to direct, energy indirect and other indirect emissions. These are sometimes referred to as “scope 1”, “scope 2” and “scope 3”.

The scope of the NZE/NZC EnMS should include, at a minimum, all operational energy consumption. It may optionally include:

- embodied energy in goods and services purchased by the organization;
- energy used in the production of capital items, such as the construction of a new building;
- energy released through exothermic reactions and used by the organization (e.g. an organic Rankine cycle turbine generating electricity using captured waste heat).

Where energy is consumed both as a source of process energy and as a feedstock, the organization should ensure that it accounts for the energy use. The scope should include all renewable energy generated within the NZE target boundaries, whether it is used on site or exported across the boundaries. The scope should also include energy flows into or out from energy storage, such as utility-scale batteries or inter-seasonal thermal stores.

The NZE objectives set by the organization should be aligned with the NZE target boundaries and NZE scope (see 4.4).

The NZE scope can frequently be narrower than the scope for NZC or carbon neutrality. NZC/neutrality may extend to all GHGs and include fugitive or other emissions not associated with the energy

consumption. It may also include a wider scope of other indirect emissions, e.g. by including emissions associated with employee travel to work or the use phase of products.

The organization should document the NZE target boundaries and NZE scope that it has selected for each chosen NZE target. If these are different compared with NZC or carbon neutrality, it should document the reasons for the differences. The organization should periodically review the NZE target boundaries and NZE scope to ensure that they are still appropriate and, where relevant, aligned with the EnMS.

## 4.3 NZE plans

### 4.3.1 General

Energy plans should focus first on reducing energy consumption through energy performance improvement actions (EPIAs), which has several benefits:

- implementation of these actions can open the possibility of new EPIAs as part of continual improvement;
- these actions are usually less expensive to implement than other approaches to net zero;
- improvements in product or service quality or other hard-to-measure features;
- integration of renewable energy sources that vary with the weather into regional electric grids.

Thus, the implementation of NZE should:

- a) reduce energy consumption by improvement of energy performance during operation;
- b) minimize energy consumption (improve energy performance) through good design and construction;
- c) transfer the remaining energy consumption to less carbon-intensive or renewable energy;
- d) change the timing of energy consumption to reduce the amount of energy consumption or emissions from power plants supplying the facility or organization (see [4.4](#), [4.5](#) and [4.6](#)).

This list reflects a prioritized sequence of actions, which has been the observed outcome in the data from NZE buildings, where the typical energy intensity is about half of typical new construction with equipment, systems or energy using processes (see [Figure 3](#)).

Examples of actions for NZE implementation include:

- enhancing an EnMS by installing smart meters;
- controlling the air handling unit to improve energy efficiency on building, factory, home, etc;
- installing PV on the roof of the facility.

**NOTE** For the implementation of NZE, the organization can plan to minimize energy demand, maximize energy efficiency, optimize EIR and to implement EnMS. For organizations that consider implementing an EnMS for NZE or NZC with the relationship between NZE design, construction and operation, see [Annex A](#).

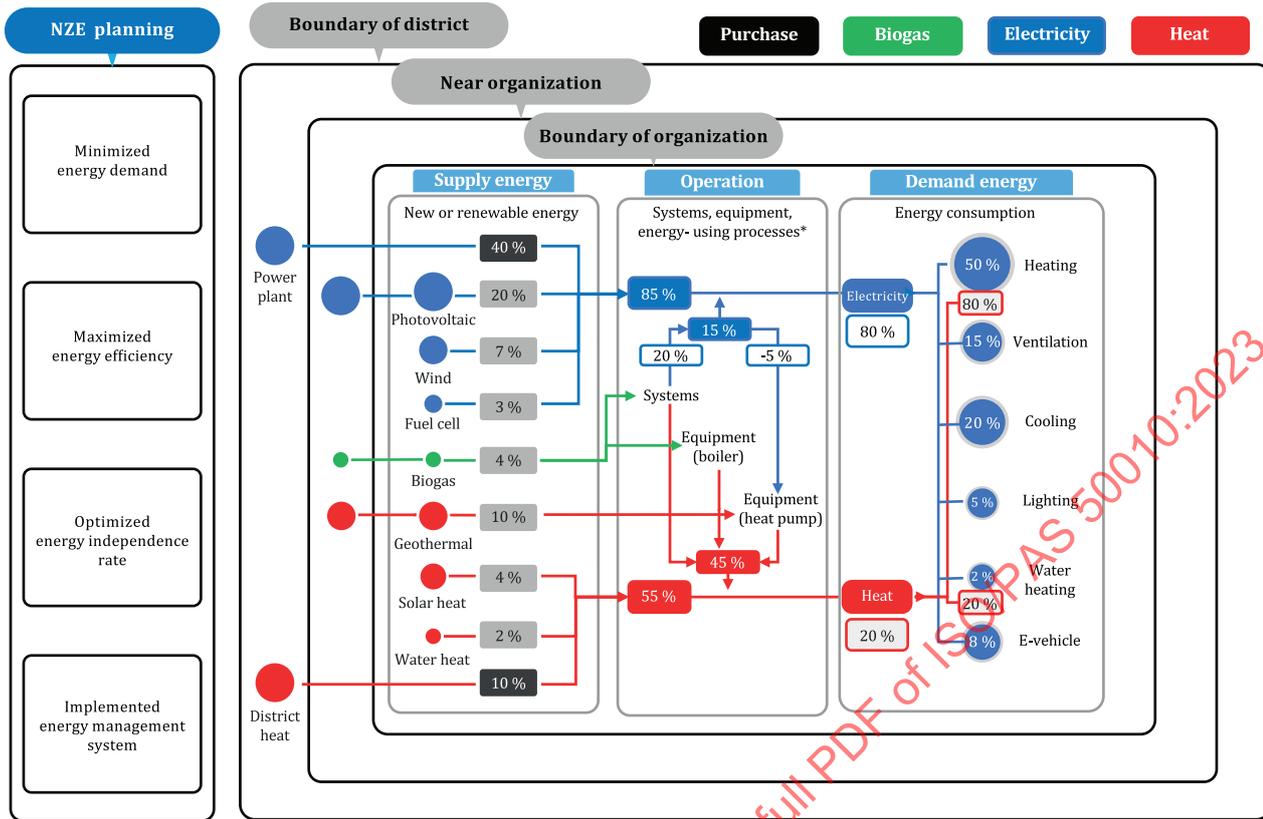


Figure 3 — Schematic diagram for the NZE building

#### 4.3.2 NZE policy as part of an organization’s energy plan

An appropriate NZE or NZC policy should be established for each organization, taking into account the size, use, region and significant energy uses (SEUs) of the organization and by evaluating the amount of renewable generation and energy efficiency improvement potentially available.

An energy plan outline incorporating NZE or NZC should include these components:

- developing the actions to improve energy performance;
- time frame, milestones and timing of actions to achieve NZE or NZC;
- energy performance and emissions metrics and metric values used to track progress (e.g. values for milestones or independence rate);
- implementation of operational performance quantification capabilities, which can include real-time or regular-time interval monitoring and optimizing energy through data-based analysis;
- utilizing renewable energy sources (amount and acquisition date).

The technologies and design methods for improving energy performance, generating renewable energy and storing energy to change the time of energy consumption continue to improve. Accordingly, the energy plan should be based on the assumption that new opportunities emerge both from the organization’s EnMS, and also from newly externally available options, for incorporation into the organization’s energy plan.

## 4.4 Defining the energy or carbon-emission goals

### 4.4.1 General

The organization should specify the initial and future NZE targets for the facility seeking NZE recognition or for the organization as a whole. This specification should include the following components in its management system:

- a) commitment by top management to an energy policy that includes a multi-year energy plan with quantitative energy targets;
- b) a management process that continually identifies and implements energy or carbon performance improvement;
- c) a measurement system capable of tracking whether or not the organization is meeting those targets;
- d) a mechanism that can correct departures from achieving the targets;
- e) a defined scope and boundary for the EnMS and the zero energy performance indicators (zEnPIs), making it clear what energy uses are counted toward energy consumption and what renewable energy can be counted toward an NZE target;
- f) for any non-energy-related GHG the organization chooses to manage, the performance indicators should include one or more indicators relating to non-energy-related GHG emissions or total emissions.

NOTE GHG emissions are generally categorized as follows:

- scope 1: direct GHG emission: GHG emission from GHG sources owned or controlled by the organization;
- scope 2: energy indirect GHG emission: GHG emission that is a consequence of an organization's energy use inside the organizational boundaries, but that arises from GHG sources that are not owned or controlled by the organization;
- scope 3: other indirect GHG emission: GHG emission that is a consequence of an organization's operations and activities, but that arises outside the organizational boundary.

The measurement system required to track progress toward goal achievement sometimes needs to include methods to calculate carbon reductions. The organization should rely on publicly available sources or methods to do this and should be able to support the calculations it undertakes. If there is no approved local source, the organization may choose to use approaches such as the Greenhouse Gas Protocol<sup>[18]</sup>, ANSI/RESNET/ICC 301-2019 Addendum D-2022<sup>[9]</sup> or the carbon calculator built into the 50001 Ready Navigator<sup>[16]</sup>.

The organization should select a definition for renewable energy that is the most restrictive of the following:

- the organization's own definition of renewable energy;
- the jurisdiction's definition of renewable energy, which can refer to both the jurisdiction in which the facility(ies) is located and the jurisdiction(s) in which the renewable energy sources are located;
- clean renewable energy.

If the organization uses a definition that differs from clean renewable energy, or from national or other requirements, then it should explain and justify its choice of definition.

### 4.4.2 Energy management system

This document provides guidance on how to track both energy consumption and renewable energy production. It also recommends using current and future-year targets for one or several zEnPIs (see

4.5). NZE should be based on measured, normalized energy data, as the goal involves both process and equipment design and operational effectiveness.

The organization should have established an EnMS so that issues related to energy use and consumption are being fully and satisfactorily covered. The organization should integrate its EnMS with its renewable energy generation projections to achieve its objectives. In this way, the organization should participate in the construction of the EnMS, determining boundaries, scope and all its management elements: planning, support and operation, performance evaluation and improvements.

The organization implementing NZE should consider the most efficient manner of integrating into the EnMS and should be capable of:

- determining if the chosen target of NZE was met in a given year;
- taking corrective action when a target of NZE was not met;
- establishing more ambitious NZE targets.

NOTE 1 The concept of more ambitious NZE targets is explained in 4.6.

The EnMS should define carefully what energy uses are within its scope and boundaries. Energy uses can include:

- which fuels are consumed at the facility;
- whether electricity is used to charge motor vehicles at a building or premise, where the chargers are located, and how this electricity is counted toward the selected NZE goals.

The energy used to charge electric motor vehicles is often not included in the calculation of building NZE unless the vehicles being charged are included in the NZE or NZC boundary. The ability to use the vehicles' batteries for storage should be within the defined time interval of energy calculation (e.g. hourly calculations) or part of an NZC calculation that includes both the building and vehicles.

NOTE 2 Carbon emissions from all fuels used for transport are part of suggested Goal 5 (see 4.6).

For the NZC goals, the organization should consider whether a joint EnMS that includes organizations in its supply chain is appropriate, allowing the scope and boundaries to include supplier organizations. For guidance on how to establish an EnMS for multiple organizations, see ISO 50009.

#### 4.4.3 Renewable energy

The organization should establish rules for the conditions under which renewable energy should be counted to offset its energy consumption. These rules should inform its operations and investment decisions in its energy plans. The rules should give a preference for on-site clean renewable energy that is under the direct control of the management of the facility.

The organization should consider including the following in these rules:

- excluding credit toward meeting an NZE goal from offsets or renewable energy credits that are unrelated to the operation of the facility or of the organization;
- excluding credit for renewable resources located on the facility site but owned and operated by others for the sale of energy off-site.

The organization may consider including the following in its rules allowing off-site renewable energy:

- discount factors dependent on a specified combination of factors relating to the distance of the generation from the facility site;
- the ability of the facility or organization to control the output and the generation;
- the degree of directness of the transmission facilities connecting renewables to the facility(ies);

- the ownership of the generation;
- the exclusivity that the facility has with respect to the facility's use of the output of the renewable energy;
- the extent of connection of the generation to the grid on which the facility relies, or to any grid at all;
- the quality and duration of contracts for the energy between the owner or operator of the generation and the management of the facility;
- the ability to physically inspect the renewable generation facility to allow for an audit or review.

The rules should include retiring any renewable energy credits that are counted toward meeting the NZE goal. The renewable energy can be generated on-site or off-site depending on the availability on-site (sun, wind) or on the cost effectiveness of renewable generation. The organization should consider renewable generation and energy performance improvement on-site before considering off-site renewable generation. The organization should consider using a discount (or weighting) factor in its rule for off-site generation, considering the types and installation cost of renewable generation.

**EXAMPLE 1** An organization sets the NZE target at 20 % EIR (see 4.5) and decides to prioritize efforts to generate renewable energy on-site. In case on-site renewable energy is not possible for achieving the target, a discount factor for renewable off-site energy generation is applied. The discount factor for renewable off-site energy generation can be, if the target of 20 % EIR on-site renewable energy is not achieved, 0,7 on less than 10 % of on-site renewable production, 0,8 on 10 % or more to less than 15 %, 0,9 on 15 % or more to less than 20 %, and 1,0 on 20 % or more.

The addition of renewable energy sources can include a number of considerations. Depending on the specific circumstances, the following may be issues to consider:

- whether the renewable energy source is to be owned by the facility owner or a third party;
- whether the renewable energy source is derived from an on-site process (e.g. methane produced at a waste-water treatment plant, or heat for drying as part of a painting operation);
- whether the renewable energy source is on-site or not;
- whether the output from renewable energy source is used on-site or exported, or both;
- whether the NZE or NZC goal applies to more than one facility and, if so, how each be treated (i.e. separately, in sub-groups or through the use of trade-offs) in achieving an overall target;
- to what extent supply-chain emissions are included;
- the need to separate carbon-containing materials used as feedstocks (e.g. petroleum products used to manufacture plastic pipe) from carbon-containing materials used in a way that results in carbon emissions.

**EXAMPLE 2** An industrial facility purchases oil that is converted to plastic for use as a building material. The material remains in place for a projected 50 to 100 years and can be recycled thereafter. Thus, the energy and emissions content of the amount of oil needed to produce the plastic are not counted in the EnPIs because they do not lead to emissions for the foreseeable future.

#### 4.5 Selecting zero energy performance indicators

As part of the organization's NZE energy plan, specific performance indicators (zEnPIs) can be adopted. The considerations in adopting these indicators include the following:

- Do the proposed zEnPIs show the effects on energy use or carbon emissions resulting from the implementation of actions in the energy plan?
- Are the resources required to calculate the zEnPI's values within the organization's abilities?
- Are the inputs needed to calculate the zEnPIs (numeric) value available?

- Is the calculation of the proposed zEnPI verifiable?
- Are energy values determined as the energy used on-site (e.g. at the facility) or at the source of generation?

Types of zEnPIs include the following:

- facility normalized annual energy use;
- facility normalized annual carbon emissions;
- normalized energy use per unit output;
- normalized carbon emissions per unit of output;
- facility score or rating on a system for energy use or carbon emissions consistent with targets or goals in the organization’s energy plan (e.g. EIR).

Key issues that can need to be addressed in defining zEnPIs include:

- whether the energy values are the ones measured at the facility (“site” values) or at the point of generation (“source” values; source is preferred);
- whether the energy values are the “marginal” ones;
- whether the input values are consistent in that they are comparable, and the same or similar sources are used to obtain them;
- for carbon emissions, which of scope 1, 2 or 3 emissions are included and the reasons for inclusion or exclusion.

Marginal source energy means the energy used to produce the next incremental unit of delivered energy. Data concerning marginal source energy and emissions are not always available, especially if the user chooses to look at hourly calculations. See 4.7 for recommended actions in such cases. Identifying marginal source energy can require examination of the supply chain of the facility.

EXAMPLE 1 It is discovered that a facility can produce a component using less energy than is currently used in its supply chain. When the facility moves the manufacture of the component in-house, the energy usage of the facility (both scope 1 and 2) increases. This also decreases both the supply-chain source energy consumption and carbon emissions. Overall, there is a decrease of energy use and carbon emissions by displacing more energy-intensive production.

The zEnPI should be defined in such a way that allows for clear determination of when the NZE target has been met. For example, an overall facility-wide zEnPI should have a value of zero when NZE is achieved. A good choice of zEnPI highlights actions that can appear to change an organization’s performance but, in aggregate, do not. An example is outsourcing production activities that previously occurred in the facility. This can appear to improve the values of the facilities’ EnPIs without changing overall energy performance. Another example is that the facility can decide to undertake these activities in-house, resulting in apparent degradation of the EnPIs value that does not reflect overall energy performance changes.

EXAMPLE 2

zEnPI of an office is expressed as the following:

$$I = 1 - (r/d)$$

where

- $I$  is the energy independence indicator;
- $r$  is the total annual renewable energy per unit area;
- $d$  is the total annual energy delivered per unit area.

## EXAMPLE 3

$$I = [1 - (r/d)] * 100$$

where

- $I$  is the energy independence indicator;
- $r$  is the total annual renewable energy per unit area;
- $d$  is the total annual energy delivered per unit area.

## EXAMPLE 4

$$I_{zEP} = O_s/E_c$$

where

- $I_{zEP}$  is the zero energy performance indicator;
- $O_s$  is the total on-site energy generated;
- $E_c$  is the total energy consumed.

NOTE This ratio can be by unit area and/or time period.

When the organization develops future-year targets based on the planned success of its EnMS, it may consider transitioning the basis of its zEnPIs from annual average energy to energy use calculated on either:

- a) a time-dependent basis, or
- b) energy calculated from a site use basis to a source basis (see [4.4](#) and [4.6](#)).

This can lead it to analyse and implement EPIAs that alter the time of energy consumption to reduce its source energy or emissions more than would be achieved by merely consuming less energy. Such actions include controls that change the times of maximum energy consumption through the use of storage or through scheduling of production or operation.

zEnPIs are also useful for situations where a facility cannot feasibly meet any NZE goal due to its limited potential for renewable energy generation on-site combined with its energy intensity.

EXAMPLE 5 Multi-story urban hospitals, chemical plants with limited site area, airlines.

In such cases, the zEnPI can be established such that its value in the energy baseline is 100 and its value for an imagined NZE case is 0.

EXAMPLE 6 A facility can only achieve a 60 % improvement over the next five years. In this case, the achievement of a zEnPI value of 40 shows that the facility has 60 % of the way to zero, even if it cannot develop an energy plan that ever gets fully to 0.

This topic and the reasoning underlying it are further explored in [Clause B.3](#).

#### 4.6 Defining future-year goals

The organization should set a sequence of progressively higher goals. With such a sequence, it can better plan its longer-term activities and ensure these are aligned with any applicable governmental requirements. It is important that the goals are not limited to realizing NZE or NZC; some organizations can find it possible to improve performance even further. For example, the organization should consider setting a sequence of goals around improving NZE performance as follows:

- Goal 1: NZE based on annual energy;
- Goal 2: NZE over a calendar year based on hourly energy consumption;
- Goal 3: NZC based on hourly carbon emissions;

- Goal 4: Meeting Goal 3 and also achieving NZC for new facilities or planned additions, including emissions associated with constructing the facilities (life cycle analysis);
- Goal 5: Meeting Goal 4 and also achieving reductions in scope 3 emissions associated with transporting people (e.g. staff, customers or business partners; residents in a housing development) as well as supplies to the facility;
- Goal 6: Meeting Goal 5 and an additional consequential reduction in emissions (e.g. product disposal).

For each goal, the energy plan should include a target date and one or more sets of activities which result in achieving that goal. Each goal should also specify the NZE target boundaries within which the calculation is to be made: whether it is for a specific facility, for a group of the organization's facilities, or whether others' energy use or carbon emissions (e.g. supply chain) are included. For Goal 4 and higher, it can be helpful to develop a single EnMS for the supply chain of a facility. Guidance on how to do this is provided in ISO 50009.

In many cases, the majority of GHG emissions are carbon dioxide associated with fuel or electricity consumption. In the remaining cases, additional analysis of the GHG emissions is needed.

**EXAMPLE 1** For a facility producing refrigerators, an NZE goal includes the energy consumed in producing the steel and plastic used in the product as well as the energy consumed in producing components such as compressors that are not produced in the facility. In addition, it includes a life cycle analysis of the renewable energy generation facilities that provide the clean renewable electricity used to achieve NZE.

**EXAMPLE 2** An air conditioner factory's life cycle analysis includes the energy/emissions to transport staff to the plant and the energy/emissions to ship the aluminium, steel and refrigerants to the plant, but does not include the energy consumed by the air conditioners after they were sold in any goal except Goal 6.

**NOTE 1** For the transport of people, there are statistical means of estimating the number of vehicle kilometres travelled. These are based on the characteristics of the neighbourhood in which the facility is located, such as compactness of development and availability of public transport.

**NOTE 2** For production facilities, the energy or emissions from the supply chain are likely to be large enough to be worth the effort of analysing them.

The organization's energy plan should include a schedule for achieving each of these more ambitious targets at a definite time in the future (see [Clause B.3](#)).

Goals 1 through 5 above can be most easily met using data on upstream carbon calculated on a cradle-to-gate basis. This method allows the data from several sequential suppliers in the supply chain to be added. Thus, emissions from the highest-upstream producer can be added to those of the next producer in the chain without having already being counted by the previous producer.

### 4.7 Data collection plan

The organization should develop a plan for the collection of data that are required for achievement and demonstration of NZE. These go beyond those needed for an EnMS because they include data on the metered output of the renewable energy system and data needed to normalize energy production for weather and other relevant variables.

When the organization is planning on achieving higher levels of NZE performance, it should collect data on hourly or shorter patterns of energy consumption for the facility. Smart meters already collect such hourly data. It can also be necessary to collect data on relevant variables on an hourly basis to best normalize the hourly patterns of energy use.

The organization should also collect data on the marginal source energy and emissions factors for all the hours of the year for the grids from which it is buying energy.

**NOTE** Such factors, while they vary most from hour to hour for electricity, also vary for pipeline gas and can vary for other fuels as well.

The hourly source energy or emissions factors should be based on government or energy provider analysis, where possible. If such data does not exist, the organization should request that its government, energy provider or a research institute develop such data. A final option is for it to attempt to do so on its own. Common data ensures there is the best possible comparability between NZE or NZC claims from different organizations.

#### 4.8 Planning to account year to year variability

The organization's energy plan should develop and implement methods to normalize both energy consumption data and clean renewable energy production data for relevant variables such as weather and the output level of the facility, and for any changes in static factors. Achievement of NZE or NZC should be based on comparing normalized energy consumption data to normalized clean renewable energy production data. Similarly, measured energy performance should be compared to normalized baseline energy performance data (see [Clause B.4](#)).

## 5 Improving organization operation and maintenance for NZE or NZC

### 5.1 General

The organization should establish a team for managing NZE and NZC, including all management objectives and O&M plans. This team should understand how the organization uses energy and should be capable of managing effectively toward achieving NZE or NZC with improved energy efficiency and the use of renewable energy. The team should be responsible for implementing the energy plan.

For all levels of goals for NZE beyond Goal 1 and for reducing carbon emissions, the importance of the time of energy use becomes significant. This is because of the potential for additional energy or carbon savings from changing the timing of energy use and consumption. These energy performance benefits as measured by zEnPIs calculated from seasonal, monthly, daily or hourly data ("time dependent") open up new avenues in which the energy management team can reduce source energy or carbon emissions through manual and automated O&M improvements. Tools such as artificial intelligence (AI) and analysis of short-interval data can reveal unforeseen opportunities for energy performance improvement. The organization should analyse these opportunities both at the level of the energy management team and at more operational levels of the staff.

The development and maintenance of the zEnPIs should be focused on using them to isolate opportunities for O&M improvements more clearly: changes that look like they affect energy consumption by only a few per cent when overall energy use is considered become much more visible when the values of the EnPIs are centred on or near zero.

**EXAMPLE** If the initial value for the zEnPI is 100 and O&M variations allow it to fluctuate by 5, plus or minus, then it can change the EnPI by only 5 %. But if the goal is zero and the fluctuation is from -5 to +5, then this is a big effect.

### 5.2 Effective operation and maintenance

Good O&M practices can generate substantial energy savings and should be considered a resource. Moreover, improvements to facility O&M programmes can often be accomplished quickly and at a relatively low cost, and can be improved continually for long periods of time.

The well-defined elements of an effective O&M for NZE include, but are not limited to, the following:

- collection data on energy resource, SEUs, etc.;
- monitoring energy, cost and equipment status;
- data review by hourly or more frequent periods;
- analysis of energy consumption for the organization's zEnPIs and comparing with similar organizations where possible;

- analysis of SEU performance and efficiency;
- provision of indoor and outdoor relevant variables;
- prediction of energy consumption including renewable energy for comparison with measurements;
- identifying energy performance improvement opportunities;
- planning new EPIAs;
- obtaining, monitoring and analysing for regular time intervals;
- incorporating analytic results into control system operation;
- management of meter, data, indicators, performance, and renewable energy use and production.

### 5.3 Control technology

The organization should analyse what types of control technology should be added to achieve its NZE targets. These technologies should take advantage of variations in the energy and emissions intensity of energy supplied at different hours by rescheduling energy use and consumption from periods when consumption carbon emissions are high to hours when energy is mostly or entirely supplied by clean renewable energy. This analysis, and the implementation of the results, should be part of the organization's energy plan.

The organization should plan for developing new operating protocols for staff to take maximum advantage of the new scheduling controls, both in terms of their own procedures and in terms of evaluating new upgrades to controls.

NOTE 1 This can require staff training.

The target of NZC and net zero source energy creates many new opportunities for the use of control technology as part of an organization's energy plan. This use of controls can allow the shifting of energy consumption from hours of high emissions impact to hours of low or zero impact. Controls can yield improvements in the zEnPIs even if the total annual energy consumption does not decrease.

NOTE 2 Controls can be less cost-effective to the organization if the electricity providers' prices are independent of the time of consumption or do not include a charge for kW of power demand as well as for kWh of energy.

This topic is explored further in [Clause B.5](#).

## 6 Integration of renewable energy

### 6.1 Consideration of renewable off-site energy

#### 6.1.1 General

The renewable off-site energy with the highest priority should be energy provided by means of a private wire or a limited grid which can connect more than one user or more than one source of energy. Renewable off-site energy sources can include:

- self-owned new and renewable off-site energy generation;
- direct access other-owned new and renewable generation;
- unbundled renewable energy certificates (power purchase agreement).

The organization should develop a quantitative methodology to calculate how new and existing renewable off-site energy generation affects its zEnPIs for NZE or carbon emissions. This methodology should include renewable resources the organization builds or otherwise controls (e.g. by contract) as

well as existing renewable resources delivered through a grid. The organization should be able to share its methodology.

Further, it should work with interested parties to achieve agreement among them about the amount of renewable energy each organization receiving energy from the grid is using. The renewable energy being used should balance the renewable energy provided to the grid. In particular, this methodology should address whether the organization has one or multiple facilities and one or multiple grids.

### 6.1.2 Renewable resources acquired by the organization

When the organization acquires its own clean renewable energy resources, it should consider how they are:

- integrated into the operation of the facility(ies) on whose site(s) the resources are located (energy use should be controlled to better align the timing of energy use with the timing of production of clean renewable energy resources that it has installed or contracted for);
- optimized to produce energy at those hours of the day or days of the year in which the emissions from grid-provided electricity are the highest.

NOTE 1 For solar PV systems, the angle of the array(s) normally would be chosen to maximize annual energy production but can instead be chosen to maximize useful energy that can be consumed on-site.

NOTE 2 Electricity generated by solar PV on-site can be left as DC power and used to serve energy uses for which DC power is more efficient. This avoids transmission and distribution system losses which can be as much as 20 % of the energy used.

The organization may also consider movable PV collectors that track the sun to optimize the generation of electricity relative to on-site demands.

### 6.1.3 Renewable energy resources on the grid

When considering zEnPIs for an eventual target of zero emissions, the value of resources on the grid is best modelled using time-varying source energy (or relative emissions of pollutant(s) of interest). This design of metrics or zEnPIs encourages greater improvements in energy performance at times when the effect in terms of emissions from energy use is at its highest. It also encourages the organization to look for ways that energy can be used at hours when it is emissions-free and can displace energy that would have been used at times of high emissions. The use of improved controls is one way this can be accomplished.

If a detailed calculation in which each hour of the year has a separate source energy or emissions factor is not possible to obtain, an approximation that groups similar hours of the year, or of a typical day, is a better approximation than ignoring time dependence. This can be done by season or simplified time of day, e.g. peak, shoulder, off-peak hours.

NOTE This leads the EnMS to value EPIAs that shift the time of use to lower impact hours.

## 6.2 Utilizing energy provider inducements to change energy use — Demand response

To facilitate achieving NZE, the organization should consider any offerings from its energy providers that incentivize the organization to change its pattern of energy consumption consistent with the organization achieving NZE. These can include tariff structures with specific charges for high demand by the organization or payment to the organization for reducing energy demand in specific time periods (demand response programmes). These can require the organization to change O&M practices, or make equipment investments, but these can be part of its least cost path to NZE.

These actions should be incorporated into and coordinated with other actions in its energy plan. This topic, including more on demand response, is further explored in [Clause B.5](#).

### 6.3 Renewable grid connection

If the organization is considering adding renewable generation at its facilities, it can consider not just its own energy requirements, but also providing renewable energy to its electricity provider or nearby facilities owned by others. This can improve the cost of achieving NZE. It should do this by:

- expanding new renewal energy generation on otherwise unused land, roofs or parking areas;
- improving regeneration or surplus energy supply using heat-pump technology;
- providing, trading or sharing energy with nearby energy users.

The choice of new, renewable generation may reflect weather conditions such as the amount of sunshine and temperature.

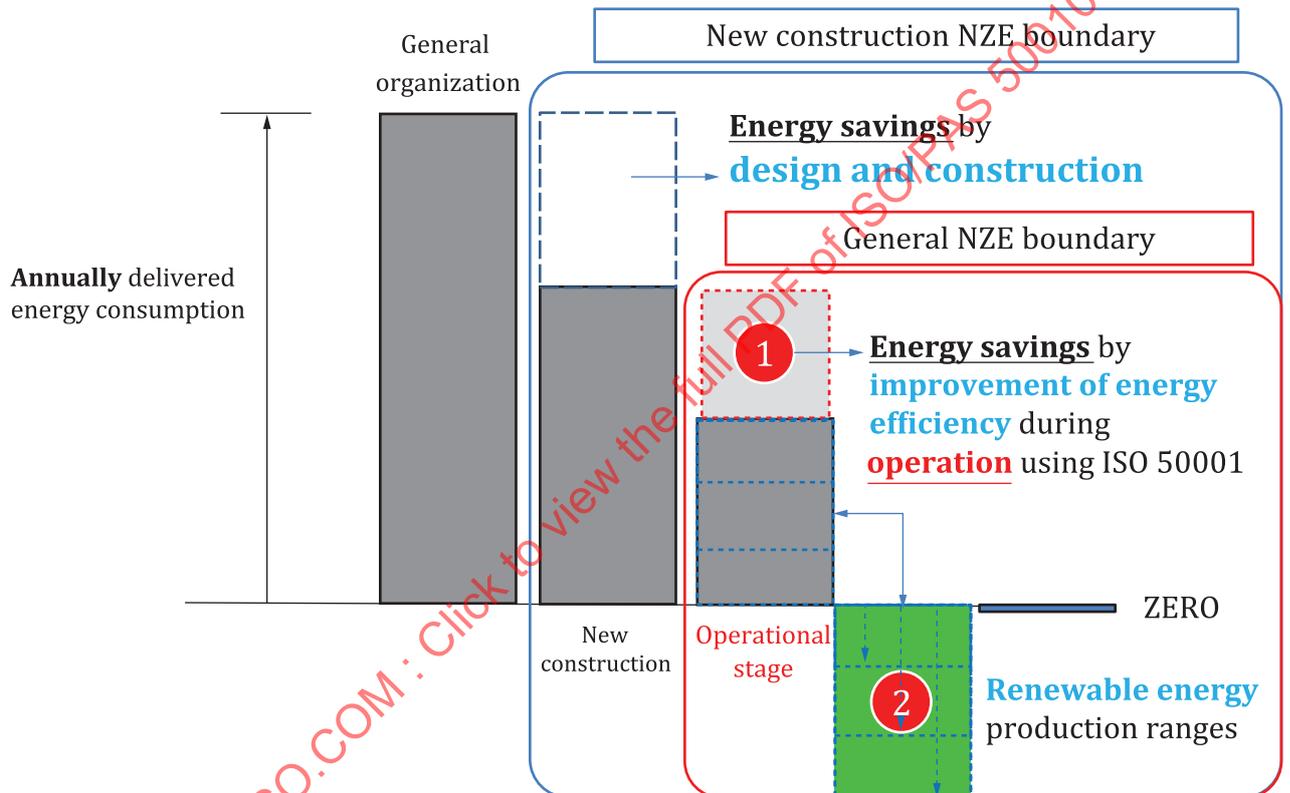
NOTE Organizations can make efforts to share energy to minimize energy use. They can consider shared use of energy storage systems, especially during peak hours, sharing unused renewable energy.

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## Annex A (informative)

### Relationship between NZE design, construction and operation

The organization's energy consumption should provide a step-by-step plan for design, construction and operation after setting NZE goals. This document focuses on the activities of the NZE operation stage through the energy efficiency improvement based on ISO 50001 operation and renewable energy (see [Figure A.1](#)).



#### Key

- 1 energy savings through the use of ISO 50001
- 2 renewable energy production and production ranges which can be replaced with the energy consumption left for zero energy

Figure A.1 — Relationship between NZE design, construction and operation

## Annex B (informative)

### NZE overview for implementation

#### B.1 General

The material in this document is perhaps unfamiliar to many users, especially as a number of the concepts and issues around renewable energy and the perspective of net zero are not necessarily in common use in practising energy management. This annex provides additional information and discussion to clarify these concepts. It also provides the rationale for the guidance provided in this document.

#### B.2 Concepts of NZE and the relationship to energy management — Background to [4.4.3](#)

NZE can be defined as occurring when the renewable energy production equals or exceeds the energy consumption. Thus, the organization must have a consistent and defensible way of measuring both energy consumption and renewable energy production. Energy consumption may be best measured as part of an EnMS for most facilities, where direct measurements of energy consumption must be normalized and expressed in terms of appropriate EnPIs. It is also necessary to ensure that a facility is on track to, at worst, maintain NZE performance over the years but preferably to advance to more ambitious NZE goals.

NZE is dependent on how “renewable energy” is defined. Defining renewable energy that can be counted toward offsetting energy consumption is not always a straightforward issue. Just the question of what “renewable energy” means is nuanced, as many jurisdictions have long and detailed definitions of renewable energy that are far more restrictive than the word “renewable energy” implies. In addition, there is a set of issues about what restrictions must be placed on renewable energy that should count for achieving NZE.

It is important before deciding on an NZE goal in which “renewable energy” compensates fully for energy consumption to establish what qualifies as a renewable energy resource according to the laws and regulations of the jurisdiction(s) where facilities are located. These laws or regulations can also depend on where the renewable resources are located. Absent such a definition, only resources that meet the definition of clean renewable energy should be counted because this mitigates the risk of the organization’s accounting scheme being considered unacceptable by interested parties.

It is also advisable to state explicitly how renewable off-site energy is counted for NZE goals. Again, jurisdictions sometimes have procedures for how to do this. If there are no such rules, or the organization wants to establish more demanding goals than those required by law or regulation, the organization should establish procedures that give precedence to on-site clean renewable energy, and also to resources that are directly connected to the energy uses of the facility, and under the control of the management of the facility. The organization may choose to count clean renewable off-site energy only when there is a direct electrical connection and/or a long-term contract between the renewable provider and the organization.

For clean renewable off-site energy that is not directly connected by wires or contractual agreements, the organization can apply a discount factor, such that, for example, only 30 % of the clean renewable energy generation counts towards the NZE goal. The goal of establishing a firm policy on off-site renewable energy is to strike an appropriate balance between two extremes. On one extreme is the case in which an organization claims they have an NZE facility because they have purchased renewable energy credits for power production that is in a different country and on a different grid. This outcome