

ISO/TC 301

Secretariat: ANSI

Voting begins on:
2020-06-16

Voting terminates on:
2020-08-11

Calculation methods for energy efficiency and energy consumption variations at country, region and city levels

Méthode de calcul pour l'efficacité énergétique et les variations de consommation d'énergie aux niveaux national, régional et urbain

ITeH STANDARD PREVIEW
(standards.iteh.ai)
Full standard:
<https://standards.iteh.ai/catalog/standards/sist/582867f-ab11-4d9b-bf48-d3f63cba7ebd/iso-fdis-50049>

RECIPIENTS OF THIS DRAFT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

IN ADDITION TO THEIR EVALUATION AS BEING ACCEPTABLE FOR INDUSTRIAL, TECHNOLOGICAL, COMMERCIAL AND USER PURPOSES, DRAFT INTERNATIONAL STANDARDS MAY ON OCCASION HAVE TO BE CONSIDERED IN THE LIGHT OF THEIR POTENTIAL TO BECOME STANDARDS TO WHICH REFERENCE MAY BE MADE IN NATIONAL REGULATIONS.



Reference number
ISO/FDIS 50049:2020(E)

iTeh STANDARD PREVIEW
(standards.iteh.ai)
Full standard:
<https://standards.iteh.ai/catalog/standards/sist/5682467f-ab11-4d9b-bf48-d3f63cba7ebd/iso-fdis-50049>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2020

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	v
Introduction	vi
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Factors to be calculated	4
4.1 General.....	4
4.1.1 Overview of methods included in the document.....	4
4.1.2 Objectives of calculations.....	4
4.1.3 Types of explanatory factors to be calculated.....	5
4.2 Indicators, methods and applications.....	7
4.2.1 Indicators.....	7
4.2.2 Types of data used.....	7
4.2.3 Structure effects.....	8
4.2.4 Indicator choice for energy efficiency and energy savings calculation.....	8
4.2.5 Climatic corrections of energy consumption.....	9
5 Evaluation of structure effects in the variation of energy intensity	9
5.1 General.....	9
5.2 Calculation methods.....	10
5.2.1 Introduction to the calculation of structure effect.....	10
5.2.2 Decomposition of the energy intensity variation with the Divisia method.....	11
5.3 Calculation issues related to structure effects.....	12
5.3.1 General.....	12
5.3.2 Options of calculation of the Divisia decomposition.....	13
5.3.3 Disaggregation level.....	14
5.3.4 Chained or unchained calculation.....	14
6 Calculation of energy efficiency indices	14
6.1 Objective and overview of calculation.....	14
6.2 General calculation.....	15
6.2.1 General.....	15
6.2.2 Step 1: Selection of subsectors or energy uses.....	15
6.2.3 Step 2: Choice of indicators.....	15
6.2.4 Step 3: Calculation of indicator values.....	16
6.2.5 Step 4: Calculation of indicator trends as index.....	16
6.2.6 Step 5: Calculation of weighting factors.....	16
6.2.7 Step 6: Calculation of energy efficiency indices by sector.....	17
6.2.8 Step 7: Calculation of an overall energy efficiency index.....	18
6.3 Computational issues in the calculation of the energy efficiency indices.....	18
6.3.1 General.....	18
6.3.2 Options for calculation.....	18
6.3.3 Indicators resulting in negative energy efficiency improvement.....	19
6.4 Reliability of energy efficiency indices.....	19
6.4.1 General.....	19
6.4.2 Status of data sources.....	20
6.4.3 Appropriateness of the indicator.....	20
6.4.4 Length of period.....	20
7 Decomposition analysis of energy consumption variation	20
7.1 Objective and overview of calculation.....	20
7.2 General calculation.....	21
7.2.1 General.....	21
7.2.2 Definition of explanatory factors.....	21
7.2.3 Calculation of the activity factor.....	22

7.2.4	Calculation of the energy savings factor.....	23
7.2.5	Calculation of structure effects.....	24
7.2.6	Calculation of other factors.....	24
7.3	Other issues related to the decomposition of the energy consumption variation.....	24
7.3.1	General.....	24
7.3.2	Calculation over a period.....	25
7.3.3	Indicators resulting in negative energy efficiency improvement.....	25
Annex A (informative) Calculation of structure effects.....		26
Annex B (informative) Examples of energy efficiency indicators.....		34
Annex C (informative) Examples of explanatory factors.....		45
Annex D (informative) Climatic corrections of energy consumption.....		56
Bibliography.....		57

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Full standard:
<https://standards.iteh.ai/catalog/standards/sist/5682467f-ab11-4d9b-bf48-d3f63cba7ebd/iso-fdis-50049>

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 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.

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.

Introduction

Due to the increasing role of energy efficiency improvements and of controlling the energy consumption growth in international climate and energy policies, there is a need for harmonization of methods to evaluate the impact of these policies at the international level.

This document is concerned with the evaluation of energy consumption and energy intensity changes through explanatory factors, as well as the calculation of an energy efficiency index, at national and regional levels. The practical application can be different due to specific restrictions, such as methodologies, availability of data at lower levels of disaggregation, or difficulty in understanding and communicating.

The methods presented here can provide valuable insights into trends in energy use and factors linked to those trends. Still, not all aspects of the phenomena that affect energy use are accounted for by the methods in this document, as these methods are primarily descriptive. While the analysis presented here can reveal patterns or shifts in patterns of energy use, they do not necessarily reveal causality, an aspect that can also require additional analysis.

The user should be aware of some issues associated with the methods presented in this document. Some of these arise from analytic issues. For example, whether to combine all fuels in a sector into a single energy variable or to treat them separately is a question best addressed by clear reference to the purpose of the analysis using the methods presented here. Other aspects are phenomena not explicitly included in the methods presented here. An example is the role of the prices of energy or other goods, which can require additional methods.

This document is composed of three different calculation methods:

- evaluation of structure effects in the variation of energy intensity;
- calculation of energy efficiency indices;
- decomposition analysis of energy consumption variation.

Energy intensity is often considered as an indicator of energy efficiency at aggregate level when limited data are available. Their use as a proxy for energy efficiency can be improved by removing from their variations changes in economic structures: this is the objective of the first part of this document.

With more detailed data on energy consumption available by subsectors or energy uses (e.g. space heating) or by modes of transport (e.g. cars), it is possible to assess energy efficiency trends through a more accurate indicator than energy intensity, called “energy efficiency indices”: this is the objective of the second method of calculation presented in this document.

The variation of energy consumption can be related to change in economic activity, to energy savings as well as to other explanatory factors: the purpose of the third method of calculation described in this document is to present the method of decomposition of changes in energy consumption. It makes use of indicator-based savings, i.e. energy savings calculated according to the indicator-based method, as described in ISO 17742.

This document considers all end-use sectors, such as industry, transport, households, services (also known as the “tertiary sector”) and agriculture. It does not generally incorporate the energy supply sectors, such as power plants, refineries or coal mines. However, the integration of the power sector can be considered in the decomposition of the primary energy consumption to account for the effect of variations in energy efficiency and energy mix in the power sector.

Energy consumption considered in this document excludes feedstock energy, such as oil feedstock used to produce plastics or natural gas used as a feedstock for the production of fertilisers, as they are not affected by energy efficiency policies.

This document can be used by any interested parties (decision-makers, companies, researchers, NGOs, etc.) that want to understand changes in the energy intensity or the energy consumption, as well as to assess energy efficiency by sector over a specific period.

This document is part of a set of documents developed by TC 301 (see [Figure 1](#)) and builds on the general principles outlined in ISO 17743, including reporting and system boundaries, and on the energy savings calculations presented in ISO 17742.

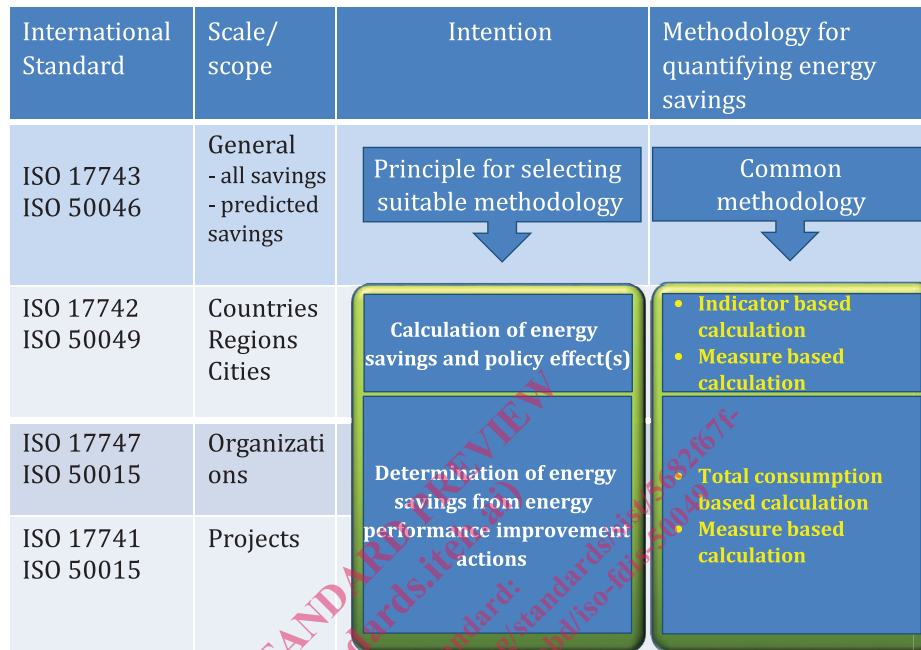


Figure 1 — Relationship between documents

The document covers more precisely three types of calculation methods based on energy efficiency indicators. Compared to ISO 17742, it details more advanced methodologies that facilitate a more comprehensive understanding of changes in: a) energy intensity, b) energy efficiency and, finally, c) energy consumption. The evaluation of energy efficiency trends relies on the calculation of energy efficiency indices. Variations in energy consumption are explained from a decomposition into different explanatory factors, one of which being energy savings. Therefore, this document complements ISO 17742 on energy savings calculation methods. More specifically, it complements how ISO 17742 deals with indicator-based methods. For each calculation method, examples of specific calculations are presented separately in [Annexes A to C](#).

When applying this document, the user can choose between different options of the methods proposed. In order to be transparent in the way results have been obtained, the user of this document should specify the methodology used when presenting the results.

The general methodologies to evaluate trends in energy intensity, energy efficiency and energy consumption and its link to energy savings are presented in [Clause 4](#). The calculation of the influence of structural changes in the energy intensity variation is described in [Clause 5](#). The calculation method for the energy efficiency index is described in [Clause 6](#). Finally, the method of decomposition of the energy consumption is given in [Clause 7](#). [Annexes A to C](#) provide examples to illustrate various types of calculations. [Annex D](#) presents the methodology of climatic corrections, as most of these calculations should be done with energy efficiency indicators adjusted to a normal climate.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

Full standard:
<https://standards.iteh.ai/catalog/standards/sist/5682467f-ab11-4d9b-bf48-d3f63cba7ebd/iso-fdis-50049>

Calculation methods for energy efficiency and energy consumption variations at country, region and city levels

1 Scope

This document gives guidelines for methods for analysing changes in energy efficiency and energy consumption, and for measuring energy efficiency progress, for countries, regions and cities. It is composed of three different calculation methods:

- evaluation of structure effects in the variation of energy intensity;
- calculation of energy efficiency indices;
- decomposition analysis of energy consumption variation.

This document is applicable to providing an aggregated statistical evaluation for a country, region or city. It does not apply to calculating changes in the energy consumption or in energy efficiency at the individual consumer's level (e.g. households, organizations, companies).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

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

3.1

activity factor

variation in the energy consumption levels of a sector or subsector due to the variation of the activity of the sector for a given period

Note 1 to entry: The quantification of this factor depends on the driver used to measure the activity.

3.2

apparent energy efficiency improvement

increase in *energy efficiency* (3.5) without correction or adjustment (i.e. gross value resulting from a calculation)

3.3

base year

reference year in the calculation

Note 1 to entry: It is usually the first year of calculation.

Note 2 to entry: The year can be calendar or fiscal. All data should have the same definition of year, whether calendar or fiscal.

3.4
behavioural factor

factor that shows the impact on the variation of energy consumption or on an energy indicator of changes in the behaviour of consumers

EXAMPLE Change in the level of thermal comfort with a higher or lower use of heating or air cooling equipment.

3.5
energy efficiency

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

[SOURCE: ISO/IEC 13273-1:2015, 3.4.1, modified — The symbol has been deleted and “commodities” has been added.]

3.6
energy efficiency improvement

increase in *energy efficiency* (3.5) as a result of technological, behavioural and/or economic changes

[SOURCE: ISO/IEC 13273-1:2015, 3.4.3, modified — “technological, behavioural and/or economic changes” has replaced “technological, design, behavioural or economic changes”]

3.7
energy efficiency index

index (such as 100 for base year) measuring the increase in *energy efficiency* (3.5) compared to a *base year* (3.3)

3.8
energy intensity

quotient describing the total energy consumption per unit of economic output

Note 1 to entry: The economic output should be measured at a constant price.

Note 2 to entry: The intensity can be interpreted as the amount of energy required to produce one unit of activity expressed in monetary terms (GDP or value added).

Note 3 to entry: The intensity can also be used at sector level (e.g. industry, residential, services). In that case, it is often referred to as “sectoral energy intensity”.

Note 4 to entry: The term “energy intensity” is sometimes used with the same meaning as *specific energy consumption* (3.17), but this is not the case in this document.

[SOURCE: ISO/IEC 13273-1:2015, 3.1.14, modified — The example has been deleted and Notes 1, 2, 3 and 4 to entry have been added.]

3.9
energy savings

reduction of energy consumption compared to an energy baseline at same level of service

Note 1 to entry: Energy savings are positive when they reduce consumption. Due to some external factors that cannot be accounted for, consumption can increase instead of decrease: this phenomenon is referred to as “negative energy savings”.

3.10
energy use

application of energy

EXAMPLE Ventilation; lighting; heating; cooling; transportation; data storage; production process.

Note 1 to entry: Energy use is sometimes referred to as “energy end-use”.

[SOURCE: ISO 50001:2018, 3.5.4]

3.11**energy using system**

physical items with defined system boundaries, using energy

EXAMPLE Plant, process, building, machines, equipment, product.

[SOURCE: ISO 50047:2016, 3.1, modified — The example has been replaced.]

3.12**explanatory factor**

factor explaining the variation in an indicator or in the energy consumption

Note 1 to entry: It is different from the concept of “relevant variable” as defined in other standards as a “quantifiable factor that impacts energy performance and routinely changes” (e.g. ISO 50006:2014, 3.14). “Relevant variable” is more related to the performance of an *energy using system* (3.11), whereas “explanatory factor” relates to a sector and to both its consumption and performance. “Relevant variable” is more a micro concept, whereas “explanatory factor” is a macro concept.

3.13**final energy**

energy as delivered to an *energy using system* (3.11)

Note 1 to entry: This concept is sometimes referred to as “delivered energy”

[SOURCE: ISO/IEC 13273-1:2015, 3.1.11, modified — Note 2 to entry has been deleted.]

3.14**fuel substitution factor**

factor that shows the impact of fuel substitutions between types of energy with very different end-use efficiency on the variation of an energy indicator

3.15**indicator-based savings**

energy savings (3.9) calculated by *indicator-based methods* (3.16)

[SOURCE: ISO 17742:2015, 2.28]

3.16**indicator-based method**

determination of *energy savings* (3.9) from the variation of energy consumption indicators over a period

[SOURCE: ISO 17742:2015, 2.27, modified — The example has been deleted.]

3.17**specific energy consumption**

quotient describing the total energy consumption per unit of output or service

EXAMPLE Gigajoule (GJ) per ton of steel, annual kilowatt-hour (kWh) per square meter (m²), litres of fuel per 100 kilometre (km).

[SOURCE: ISO/IEC 13273-1:2015, 3.1.15]

3.18**structure effect****structural effect**

measure of the variation in energy consumption or in *energy intensity* (3.8) due to a variation in economic structures

Note 1 to entry: Structure effects may refer more generally to any changes in the share of different activities (e.g. industrial branches in total value added of industry, transport modes in total traffic).

Note 2 to entry: “Hidden structure effect” refers to structure effects that exist but cannot be quantified due to a lack of data.

4 Factors to be calculated

4.1 General

4.1.1 Overview of methods included in the document

This clause is an introduction to [Clauses 5, 6](#) and [7](#) on methods to assess energy intensity and energy efficiency trends and to analyse the energy consumption variation. It describes common issues, such as the different explanatory factors that need to be considered in these assessments (case of energy intensity and energy consumption) or excluded to measure energy efficiency improvements and the various ways to calculate them. This clause clarifies what kind of explanatory factors are covered in this document.

Explanatory factors of changes in energy intensity or in energy consumption and energy efficiency trends are calculated for a given period of time, normally one or more calendar years. The methods make use of statistical data and are normally applied to calculate explanatory factors, such as energy savings or energy efficiency improvements made during the past years. However, if a comparable set of data is available as projections, e.g. from an energy scenario outlook, the methods can be applied for future years.

This document relates to the so-called “top-down” methods of energy saving calculations as reported in ISO 17742 and ISO 17743, based on statistical energy efficiency indicators. The first and third methods analyse observed trends in energy intensity indicators (see [Clause 5](#)) and in energy consumption (see [Clause 7](#)) through the identification of some of the explanatory factors behind these trends. The second method (see [Clause 6](#)) proposes an energy efficiency index that is as far as possible corrected for factors that are not linked to energy efficiency.

4.1.2 Objectives of calculations

The main objective of this document is to help monitoring energy efficiency targets, on energy intensity, on energy consumption or on energy efficiency improvements. More generally, this document can help to understand variations observed in energy intensity and energy consumption. It is critical for the analysis presented in this document to be useful that these objects of the analysis be carefully specified to align with the policy questions the analysis will inform. Mis-specifying the analytic objects can undermine the usefulness of the analytic framework presented in this document. For examples, see [4.2.4](#).

The target on energy intensity reduction used to be the most popular target linked to energy efficiency policy^[9], as it is simple to define and to monitor. Separating structure effects can help in understanding the distance to the target and why targets are not reached. However, the scope of energy efficiency target is now broader and includes targets on energy savings, energy consumption and energy efficiency progress.

If targets on total primary or final energy consumption have been formulated, understanding the factors behind the observed variation in the energy consumption is useful each time there is a deviation as compared to the target.

EXAMPLE Annex XIV of Article 24 of the EU Energy Efficiency Directive requires that “in sectors where energy consumption remains stable or is growing, Member States shall analyse the reasons for it and attach their appraisal”.

The methodology proposed in this document can be used to fulfil such a reporting requirement. More generally, it allows evaluating the contribution of energy savings in the variation of energy consumption.

Policymakers often formulate targets for energy efficiency improvements but lack instruments to measure them. Energy efficiency indices help with formulating and monitoring such targets. More generally, they provide a quantitative assessment of the magnitude of energy efficiency improvements.

4.1.3 Types of explanatory factors to be calculated

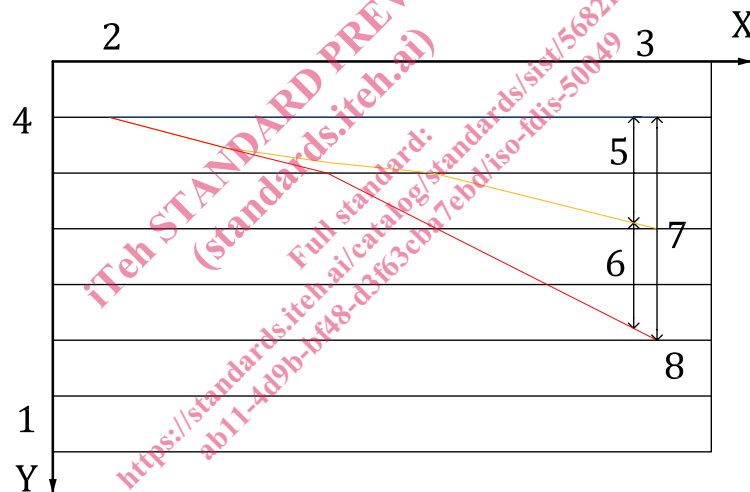
4.1.3.1 General

The three methods have in common to either quantify the effect of structure effects or to remove them as far as possible to assess energy efficiency trends.

4.1.3.2 Energy intensity

Energy intensity trends are influenced by changes in the structure of economic activities (e.g. increase in the share of the service sector in the GDP or of energy intensive branches in industry), as well as by other factors. These other factors include many influences, such as energy efficiency improvements, but also other effects (e.g. modal shift in transport, change in the mix of product/process in industry, changes in ownership of household equipment, climatic changes).

The relationship between energy intensity trends and structure effects is shown in [Figure 2](#). Key 2 represents energy intensity in the base year. If everything is kept constant, the energy intensity will be constant up to the calculation year (Key 3). In reality, the energy intensity has decreased up to the calculation year (Key 8) because of two effects: changes in the structure of economic activities, called the “structure effect” (Key 5), and changes in the energy intensity of subsectors, mainly linked to energy efficiency improvements, called the “energy intensity effect” (Key 6).



Key

- X year
- Y energy intensity
- 1 unit of the energy intensity (e.g. MJ/\$ at constant price)
- 2 base year
- 3 calculation year
- 4 energy intensity at base year
- 5 structure effect of the observed energy intensity
- 6 energy intensity effect
- 7 observed change in energy intensity
- 8 observed value of energy intensity at calculation year

Figure 2 — Trends in energy intensity and structure effect