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Information technology — Data centres key performance indicators —

Part 8:
Carbon usage effectiveness (CUE)

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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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. In the IEC, see www.iec.ch/understanding-standards.

This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 39, *Sustainability, IT and data centres*.

A list of all parts in the ISO/IEC 30134 series can be found on the ISO and IEC websites.

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 and www.iec.ch/national-committees.

Introduction

The global economy is today reliant on information and communication technologies and the associated generation, transmission, dissemination, computation and storage of digital data. All markets have experienced exponential growth in that data, for social, educational and business sectors and, while the internet backbone carries the traffic, there are a wide variety of data centres at nodes and hubs within both private enterprise and shared/collocation facilities.

The historical data generation growth rate exceeds the capacity growth rate of information and communications technology hardware. In addition, with many governments having "digital agendas" to provide both citizens and businesses with ever-faster broadband access, the very increase in network speed and capacity will, by itself, generate ever more usage (Jevons Paradox). Data generation and the consequential increase in data processing and storage are directly linked to increasing power consumption.

With this background, data centre growth, and power consumption in particular, is an inevitable consequence; this growth will demand increasing power consumption despite the most stringent energy efficiency strategies. This makes the need for key performance indicators (KPIs) that cover the effective use of resources (including but not limited to energy and water) and the reduction of CO_2 emissions essential.

Within the ISO/IEC 30134 series, the term "resource usage effectiveness" is generally used for KPIs in preference to "resource usage efficiency", which is restricted to situations where the input and output parameters used to define the KPI have the same units.

Carbon usage effectiveness (CUE) is intended to enable data centre practitioners to quickly calculate the sustainability of their data centres, compare the results and determine if any energy efficiency and/or sustainability improvements need to be made. The impact of operational carbon usage is emerging as being extremely important in the design, location and operation of current and future data centres.

In order to determine the overall resource efficiency of a data centre, a holistic suite of metrics is required. This document is one of a series of International Standards for such KPIs and has been produced in accordance with ISO/IEC 30134-1, which defines common requirements for a holistic suite of KPIs for data centre resource efficiency. This document does not specify limits or targets for the KPI and does not describe or imply, unless specifically stated, any form of aggregation of this KPI into a combination with other KPIs for data centre resource efficiency. This document presents specific rules on CUE's use, along with its theoretical and mathematical development. This document concludes with several examples of site concepts that could employ the CUE metric.

Information technology — Data centres key performance indicators —

Part 8: Carbon usage effectiveness (CUE)

1 Scope

This document specifies carbon usage effectiveness (CUE) as a KPI for quantifying the CO_2 emissions of a data centre during the use phase of the data centre life cycle.

CUE is a simple method for reporting the CO_2 intensity of the data centre operating. By reporting CO_2 emissions, it is possible to present the data centre's contribution to climate change (enhanced greenhouse effect).

This document:

a) defines the CUE of a data centre,

b) introduces CUE measurement categories,

c) describes the relationship of this KPI to a data centre's infrastructure, information technology equipment and information technology operations,

d) defines the measurement, the calculation and the reporting of the parameter, and

e) provides information on the correct interpretation of the CUE.

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/IEC 30134-1, *Information technology — Data centres — Key performance indicators — Part 1: Overview and general requirements*

ISO 8601-1, *Date and time — Representations for information interchange — Part 1: Basic rules*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1.1
carbon usage effectiveness
CUE
ratio of the data centre annual CO_2 emissions and IT equipment energy demand

3.1.2
total data centre energy consumption
total annual energy consumption for all energy types serving the data centre at its boundary

Note 1 to entry: The total data centre energy is measured in kWh; the energy is measured with energy metering devices at the boundary of the data centre or at points of generation within the boundary.

Note 2 to entry: This includes energy derived from sources such as natural gas, hydrogen, bioethanol and district utilities (e.g. chilled water, condenser water).

Note 3 to entry: Total annual energy includes supporting infrastructure.

[SOURCE: ISO/IEC 30134-2:2016, 3.1.7, modified.]

3.1.3
IT equipment energy consumption
energy consumed by equipment that is used to manage, process, store or route data within the compute space

Note 1 to entry: The IT equipment energy consumption is measured in kWh; examples for IT equipment are servers, storage equipment, and telecommunications equipment.

[SOURCE: ISO/IEC 30134-2:2016, 3.1.1, modified.]

3.1.4
global warming potential
radiative impact of a given greenhouse gas relative to that of carbon dioxide

3.1.5
greenhouse gases
GHG
gaseous constituent of the atmosphere 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: Within the context of this document, seven GHGs are considered: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Note 2 to entry: A list of greenhouse gases with their recognized global warming potentials is provided in ISO 14067.

3.1.6
carbon dioxide equivalent
global warming potential of a greenhouse gas expressed in terms of the global warming potential of one unit of carbon dioxide

3.1.7
emission factor for carbon dioxide
specific carbon dioxide emission stemming from the data centre's energy use and facility operations

Note 1 to entry: The term "facility operations" covers CO_2 emissions caused, for example, by refrigerants or diesel generators.

3.2 Abbreviated terms

For the purposes of this document, the abbreviated terms in ISO/IEC 30134-1 and the following apply.

CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CUE	carbon usage effectiveness
DC	data centre
DC CO_2	Data-centre-related carbon dioxide emissions
dCUE	design carbon usage effectiveness
EFC	emission factor for carbon dioxide
ex	external
GHG	greenhouse gases
GWP	global warming potential
iCUE	interim carbon usage effectiveness
iPUE	interim power usage effectiveness
int	internal
pCUE	partial carbon usage effectiveness
PUE	power usage effectiveness

3.3 Symbols

For the purposes of this document, the following symbols apply.

C_{DC}	CO_2 emissions of the data centre in kg
$C_{DC,ee}$	CO_2 emissions of the data centre for testing emergency power supply engines
$C_{DC,ex,el}$	data centre CO_2 emissions for electricity from the grid
$C_{DC,int,el}$	data centre CO_2 emissions for on-site generation (e.g. testing diesel engines)
$C_{DC,rf}$	data centre CO_2 emissions for refrigerant (leakage)
C_S	CO_2 emissions of a subsystem in kg
c_{rf}	filling capacity of refrigerant
E_{DC}	total data centre energy consumption (annual) in kWh
E_{IT}	IT equipment energy consumption (annual) in kWh
$E_{ex,el}$	acquired electrical energy from outside the data centre boundaries
$E_{ex,el,ad}$	acquired electrical energy and all additional energy supply from outside the data centre boundaries
$E_{int,el}$	electrical energy produced inside the data centre boundaries
$E_{int,el,ad}$	electrical energy and all additional energy supply produced inside the data centre boundaries

f_e	EFC in kg CO_2e/kWh
$f_{e,ex}$	EFC of external energy demand in kg CO_2e/kWh
$f_{e,ex,el}$	EFC of external electrical energy demand
$f_{e,int}$	EFC of internal energy demand in kg CO_2e/kWh
$f_{e,int,el}$	EFC of internal electrical energy demand
$f_{e,int,rf}$	EFC of refrigerant
P_{DC}	annual average data centre power in kW
$r_{L,a}$	annual leakage rate
$r_{L,m}$	monthly leakage rate
t_D	runtime for diesel engines
t_G	runtime for gas engines
$\eta_{U,C}$	carbon usage effectiveness
$\eta_{U,C,p}$	partial carbon usage effectiveness
$\eta_{U,P}$	power usage effectiveness
$\eta_{U,P,i}$	interim power usage effectiveness

4 Applicable area of the data centre

CUE as specified in this document:

— is associated with the data centre infrastructure and IT equipment within its boundaries only;

— describes the CUE relative to facilities with given environmental conditions, IT load characteristics, availability requirements, maintenance and security requirements;

— measures the relationship between the total data centre CO_2 emissions and the IT equipment energy consumed.

CUE does not:

— account for the efficiency of other resources such as human resources, space or water;

— provide a data centre productivity metric;

— provide a standalone, comprehensive efficiency metric.

5 Determination of CUE

CUE provides a way to determine the carbon emissions associated with data centres. CUE has an ideal value of 0,0, indicating that no carbon use is associated with the data centre's operations. CUE has no theoretical upper boundary.

CUE is defined using Formula (1):

$$\eta_{U,C} = \frac{C_{DC}}{E_{IT}} \quad (1)$$

NOTE 1 The values for C_{DC} differ regarding to the CUE category (see 6.2.2).

NOTE 2 The accuracy of measuring IT energy for CUE is not necessarily the same as the accuracy of measuring IT energy for PUE (e.g. CUE category 1 can be reported with an accuracy of measuring IT energy referring to PUE category 2).

CUE may be applied in mixed-use buildings when measurement of the CO_2 emisions caused by the data centre and that for other functions is possible.

6 Measurement of CUE

6.1 General

All KPIs of the ISO/IEC 30134 series are defined within the same boundaries.

6.2 Calculation and measurement method of CO_2

6.2.1 Calculation, measurement period and frequency

The minimum calculation and measurement period requires twelve months of cumulative DC CO_2 values. Annualized data used to calculate CUE shall be documented. The annual DC CO_2 values collected or calculated shall cover the same time period. It is not necessary to define the frequency of measurement and calculation or assessments for the annual CUE determination, as the annual DC CO_2 value is a continuous integration of DC CO_2 emitted in that timeframe. The required EFC values shall be determined in accordance with Annex C.

NOTE 1 The measurement or assessment frequency can be necessary for subsystem improvements (refer to partial PUE), but is not required for CUE disclosures.

NOTE 2 Direct measurements for CO_2 can sometimes be taken (e.g. for diesel engines). However, calculations are also sometimes made by measurements of energy, refrigerant losses, etc. and their EFC.

6.2.2 Categories of CUE

6.2.2.1 Introduction

CUE categories 1 to 3 are defined, as shown in Table 1, to provide a defined route that refines the extent of the carbon emission sources considered.

Table 1 — CUE categories

Source	Category 1 (CUE_1) basic	Category 2 (CUE_2) intermediate	Category 3 (CUE_3) advanced
Considered emission source	External and internal DC electricity.	External and internal DC electricity, all additional DC energy supply and all additional DC emission sources.	Reserved for future use.
Considered GHG	CO_2	CO_2 equivalents.	Reserved for future use.

Annex A provides examples for the calculation of the CUE categories.

6.2.2.2 CUE category 1: CO_2 emissions from electricity only

For category 1, the CO_2 emissions of all internal and external power supplies are considered, taking into account electricity only. In the event that different energy sources are used, Annex B provides examples