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Information technology — Data centres — Key performance indicators —

Part 8:
Carbon Usage Effectiveness (CUE)

ICS: 35.020

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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 ISO documents should be noted. This document was drafted following the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information.

The committee responsible for this document is ISO/IEC JTC 1, Information technology, SC 39, Sustainability for and by Information Technology.

ISO/IEC 30134 consists of the following parts, under general title *Information technology — Data centres — Key performance indicators:*

— *Part 1: Overview and general requirements*

— *Part 2: Power usage effectiveness (PUE)*[1)]

— Part 3: *Renewable energy factor (REF)*

— Part 4: *IT equipment energy efficiency for servers (ITEE_SV)*

— Part 5: *IT equipment utilization for servers (ITEU_SV)*

The following parts are under preparation:

— Part 6: *Energy Reuse Factor (ERF)*

— Part 7: *Cooling Efficiency Ratio (CER)*

— Part 9: *Water Usage Effectiveness (WUE)*

[1] It is recognized that the term "efficiency" should be employed but "effectiveness" provides continuity with an earlier market recognition of the term.

177 Additional parts will be developed, each describing a specific KPI for resource usage effectiveness or
178 efficiency.

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INTRODUCTION

The global economy is now 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 the information and communications technology hardware and, with less than half (in 2014) of the world’s population having access to an internet connection, that growth in data can only accelerate. Besides, 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 manipulation and storage are directly linked to increased power consumption.

With this background, data centres growth, and power consumption in particular, is an inevitable consequence and that 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 the reduction of CO2 emissions essential.

Within the ISO/IEC 30134 series, the term “resource usage effectiveness” is more 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) will provide the data centre practitioner quickly the sustainability of their data centers, 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 extremely important in the design, location, and operation of current and future data centers.

To determine the overall resource efficiency of a data centre, a holistic suite of metrics is required. This International Standard is one of a series of 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 International Standard 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. The paper presents specific rules on CUE’s use, along with its theoretical and mathematical development. The paper 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 the Carbon Usage Effectiveness as a KPI to qualify the CO_2 emissions of a data centre during the use phase of the data centre life cycle. CUE is defined as the ratio of the data centre CO_2 emissions divided by the sum of energy consumed by IT equipment.

Carbon Usage Effectiveness 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 centres contribution to climate change (enhanced greenhouse effect).

This International Standard

a) defines the Carbon Usage Effectiveness (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,

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

NOTE: The greenhouse effect is a natural process that warms the earth's surface. When the sun's energy reaches the earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the earth. The enhanced greenhouse effect designates human activities like burning fossil fuels (coal, oil and natural gas), agriculture and land clearing which are increasing the concentrations of greenhouse gases. This is the enhanced man-made greenhouse effect, which is contributing to the warming of the earth.

2 Normative references

The following referenced documents are indispensable for the application 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/IEC 30134-2, *Information Technology - Data Centres - Key Performance Indicators - Part 2: Power Usage Effectiveness (PUE)*

3 Terms, definitions, abbreviations and symbols

3.1 Terms and definitions

For the purposes of this document the definitions of ISO/IEC 30134-1 and -2 and the following terms shall apply.

3.1.1 Carbon Usage Effectiveness

the ratio of the data centre annual CO_2 emissions and IT equipment energy demand

3.1.2 total data centre energy

total annual energy consumption for all energy types serving the data centre at the point of utility handoff

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.

Note 2 to entry: This includes electricity, natural gas and district utilities such as supplied chilled water or 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.

3.1.4 global warming potential

the radiative forcing impact of a given greenhouse gas relative to that of carbon dioxide

3.1.5 greenhouse gases

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: For this standard seven GHG 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 14067:2018.

3.1.6 carbon dioxide equivalent

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

Note 1 to entry: The definition follows ISO 14067:2018.

3.1.7 Emission Factor for Carbon Dioxide

specific carbon emission of the data centre energy

3.1.8 external Emission Factor for Carbon Dioxide

specific carbon emission of the data centre energy from outside the data centre boundaries

3.1.9 internal Emission Factor for Carbon Dioxide

specific carbon emission of the data centre energy produced inside the data centre boundaries

Note 1 to entry: The specific carbon emission is measured in kg CO_2 per kWh.

3.2 Abbreviations

For this document, the abbreviations of ISO/IEC 30134-1 and the following apply.

approx.	approximately
EFC	Emission Factor for Carbon Dioxide
CRAC	Computer Room Air Conditioning Units
CUE	Carbon Usage Effectiveness
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DC	data centre
DC CO_2	data centre related carbon dioxide emissions
E	energy
el	electrical
GHG	greenhouse gases
GWP	global warming potential
IT	Information Technologie
PUE	Power Usage Effectiveness
KPI	Key Performance Indicators

3.3 Symbols

For this document the following symbols apply.

E_{DC}	total data centre energy consumption (annual)
E_{IT}	energy consumption of IT equipment (annual)
$EFC_{external}$	external Emission Factor for Carbon Dioxide
$EFC_{internal}$	internal Emission Factor for Carbon Dioxide

4 Applicable area of the data centre

Carbon Usage Effectiveness (CUE) as specified in this standard:

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

b) describes the Carbon Usage Effectiveness relative to facilities with given environmental conditions, IT load characteristics, availability requirements, maintenance, and security requirement;

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

CUE does not:

1) account for the efficiency of other resources such as human resource, space or water;

2) provide a data centre productivity metric;

3) provide a standalone, comprehensive efficiency metric.

5 Determination of Carbon Usage Effectiveness

CUE provides a way to determine the carbon emissions associated with data centres. CUE will range from 0 to infinity. 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.

Carbon Usage Effectiveness (CUE) is defined as:

$$CUE = \frac{DC\ CO_2}{E_{IT}} \quad (1)$$

Where

E_{IT} = IT equipment energy consumption (annual) [kWh]

$DC\ CO_2$ = CO_2 emissions (annual) of the data centre [kg]

NOTE: The values for DC CO_2 differ regarding to the CUE category (see 6.2.2).

The accuracy of measuring IT energy shall refer to PUE categories. The accuracy of measuring shall be reported in section 8.1 required supporting evidence (8.1.2.1).

NOTE: 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.