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Part 8: Carbon Usage Effectiveness (CUE)

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143 **FOREWORD**

144 ISO (the International Organization for Standardization) is a worldwide federation of national standards
145 bodies (ISO member bodies). The work of preparing International Standards is normally carried out
146 through ISO technical committees. Each member body interested in a subject for which a technical
147 committee has been established has the right to be represented on that committee. International
148 organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO
149 collaborates closely with the International Electrotechnical Commission (IEC) on all matters of
150 electrotechnical standardization.

151 The procedures used to develop this document and those intended for its further maintenance are
152 described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the
153 different types of ISO documents should be noted. This document was drafted following the editorial
154 rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

155 Attention is drawn to the possibility that some of the elements of this document may be the subject of
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158 on the ISO list of patent declarations received (see www.iso.org/patents).

159 Any trade name used in this document is information given for the convenience of users and does not
160 constitute an endorsement.

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

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

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

- 168 — *Part 1: Overview and general requirements*
- 169 — *Part 2: Power usage effectiveness (PUE)¹*
- 170 — *Part 3: Renewable energy factor (REF)*
- 171 — *Part 4: IT equipment energy efficiency for servers (ITEE_SV)*
- 172 — *Part 5: IT equipment utilization for servers (ITEU_SV)*
- 173 The following parts are under preparation:
- 174 — *Part 6: Energy Reuse Factor (ERF)*
- 175 — *Part 7: Cooling Efficiency Ratio (CER)*
- 176 — *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.
179

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180 **INTRODUCTION**

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

186 The historical data generation growth rate exceeds the capacity growth rate of the information and
187 communications technology hardware and, with less than half (in 2014) of the world's population
188 having access to an internet connection, that growth in data can only accelerate. Besides, with many
189 governments having "digital agendas" to provide both citizens and businesses with ever-faster
190 broadband access, the very increase in network speed and capacity will, by itself, generate ever more
191 usage (Jevons Paradox). Data generation and the consequential increase in data manipulation and
192 storage are directly linked to increased power consumption.

193 With this background, data centres growth, and power consumption in particular, is an inevitable
194 consequence and that growth will demand increasing power consumption despite the most stringent
195 energy efficiency strategies. This makes the need for key performance indicators (KPIs) that cover the
196 effective use of resources (including but not limited to energy) and the reduction of CO2 emissions
197 essential.

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

201 Carbon Usage Effectiveness (CUE) will provide the data centre practitioner quickly the sustainability of
202 their data centers, compare the results, and determine if any energy efficiency and/or sustainability
203 improvements need to be made. The impact of operational carbon usage is emerging as extremely
204 important in the design, location, and operation of current and future data centers.

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

213

214 **Information Technology - Data Centres - Key Performance Indicators -**
 215 **Part 8: Carbon Usage Effectiveness (CUE)**

216 **1 Scope**

217 This document specifies the Carbon Usage Effectiveness as a KPI to qualify the CO₂ emissions of a
 218 data centre during the use phase of the data centre life cycle. CUE is defined as the ratio of the data
 219 centre CO₂ emissions divided by the sum of energy consumed by IT equipment.

220 Carbon Usage Effectiveness is a simple method for reporting the CO₂ intensity of the data centre
 221 operating. By reporting CO₂ emissions, it is possible to present the data centres contribution to climate
 222 change (enhanced greenhouse effect).

223 This International Standard

- 224 a) defines the Carbon Usage Effectiveness (CUE) of a data centre,
- 225 b) introduces CUE measurement categories,
- 226 c) describes the relationship of this KPI to a data centre's infrastructure, information technology
 227 equipment and information technology operations,
- 228 d) defines the measurement, the calculation and the reporting of the parameter,
- 229 e) provides information on the correct interpretation of the CUE.

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

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235 **2 Normative references**

236 The following referenced documents are indispensable for the application of this document. For dated
 237 references, only the edition cited applies. For undated references, the latest edition of the referenced
 238 document (including any amendments) applies.

239 ISO/IEC 30134-1, *Information Technology - Data Centres - Key Performance Indicators - Part 1:*
 240 *Overview and General Requirements*

241 ISO/IEC 30134-2, *Information Technology - Data Centres - Key Performance Indicators - Part 2:*
 242 *Power Usage Effectiveness (PUE)*

243 **3 Terms, definitions, abbreviations and symbols**

244 **3.1 Terms and definitions**

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

247 **3.1.1 Carbon Usage Effectiveness**

248 the ratio of the data centre annual CO₂ emissions and IT equipment energy demand

249 **3.1.2 total data centre energy**

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

252 Note 1 to entry: The total data centre energy is measured in kWh; the energy is measured with energy metering
 253 devices at the boundary of the data centre.

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

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

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

258 3.1.3 IT equipment energy consumption

259 energy consumed by equipment that is used to manage, process, store or route data within the
260 compute space

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

263 3.1.4 global warming potential

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

265 3.1.5 greenhouse gases

266 gaseous constituent of the atmosphere that absorbs and emits radiation at specific wavelengths within
267 the spectrum of infrared radiation emitted by the earth's surface, the atmosphere, and clouds

268 Note 1 to entry: For this standard seven GHG are considered: carbon dioxide (CO₂), methane (CH₄), nitrous oxide
269 (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆) and Nitrogen trifluoride
270 (NF₃).

271 Note 2 to entry: A list of greenhouse gases with their recognized global warming potentials is provided in ISO
272 14067:2018.

273 3.1.6 carbon dioxide equivalent

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

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

277 3.1.7 Emission Factor for Carbon Dioxide

278 specific carbon emission of the data centre energy

279 3.1.8 external Emission Factor for Carbon Dioxide

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

281 3.1.9 internal Emission Factor for Carbon Dioxide

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

283 Note 1 to entry: The specific carbon emission is measured in kg CO₂ per kWh.

284 3.2 Abbreviations

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

286	approx.	approximately
287	EFC	Emission Factor for Carbon Dioxide
288	CRAC	Computer Room Air Conditioning Units
289	CUE	Carbon Usage Effectiveness
290	CO ₂	carbon dioxide
291	CO ₂ e	carbon dioxide equivalent
292	DC	data centre
293	DC CO ₂	data centre related carbon dioxide emissions
294	E	energy
295	el	electrical
296	GHG	greenhouse gases
297	GWP	global warming potential
298	IT	Information Technologie
299	PUE	Power Usage Effectiveness
300	KPI	Key Performance Indicators

301 **3.3 Symbols**

302 For this document the following symbols apply.

303	E_{DC}	total data centre energy consumption (annual)
304	E_{IT}	energy consumption of IT equipment (annual)
305	$EFC_{external}$	external Emission Factor for Carbon Dioxide
306	$EFC_{internal}$	internal Emission Factor for Carbon Dioxide
307		

308 **4 Applicable area of the data centre**

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

- 310 a) is associated with the data centre infrastructure and IT equipment within its boundaries only;
- 311 b) describes the Carbon Usage Effectiveness relative to facilities with given environmental
312 conditions, IT load characteristics, availability requirements, maintenance, and security
313 requirement;
- 314 c) measures the relationship between the total data centre CO₂ emissions and the IT equipment
315 energy consumed.

316 CUE does not:

- 317 1) account for the efficiency of other resources such as human resource, space or water;
- 318 2) provide a data centre productivity metric;
- 319 3) provide a standalone, comprehensive efficiency metric.

320 **5 Determination of Carbon Usage Effectiveness**

321 CUE provides a way to determine the carbon emissions associated with data centres. CUE will range
322 from 0 to infinity. CUE has an ideal value of 0.0, indicating that no carbon use is associated with the
323 data centre's operations. CUE has no theoretical upper boundary.

324 Carbon Usage Effectiveness (CUE) is defined as:

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

326 Where

327 E_{IT} = IT equipment energy consumption (annual) [kWh]328 $DC\ CO_2$ = CO₂ emissions (annual) of the data centre [kg]329 NOTE: The values for DC CO₂ differ regarding to the CUE category (see 6.2.2).

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

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

334 CUE may be applied in mixed use buildings when measurement of the CO₂-emissions caused by the
335 data centre and that for other functions is possible.