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Information technology — Data centres — Key performance indicators —

Part 2:
Power usage effectiveness (PUE)

Technologies de l'information — Centres de données — Indicateurs de performance clés —

Partie 2: Efficacité dans l'utilisation de la puissance (PUE)

Reference number
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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).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC 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 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*, Subcommittee SC 39, *Sustainability for and by Information Technology*.

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

— *Part 1: Overview and general requirements*

— *Part 2: Power usage effectiveness (PUE)*

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

The following parts are under preparation:

— *Part 4: IT Equipment Energy Efficiency for Servers (ITEEsv)*

— *Part 5: IT Equipment Utilization for Servers (ITEUsv)*

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. 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 manipulation and storage are directly linked to increasing power consumption.

With this background, it is clear that data centre 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 CO_2 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.

In order to determine the overall resource effectiveness or efficiency of a data centre, a holistic suite of metrics is required. This part of ISO/IEC 30134 specifies power usage effectiveness (PUE), which has become a popular metric to determine the efficient utilization and distribution of energy resources within a data centre.

NOTE It is recognized that the term "efficiency" is to be employed for PUE but "effectiveness" provides continuity with earlier market recognition of the term.

This part of ISO/IEC 30134 belongs to 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 usage effectiveness or efficiency.

The ISO/IEC 30134 series does not specify limits or targets for any KPI and does not describe or imply, unless specifically stated, any form of aggregation of individual KPIs into a combined nor an overall KPI for data centre resource usage effectiveness or efficiency.

Information technology — Data centres — Key performance indicators —

Part 2: Power usage effectiveness (PUE)

1 Scope

This part of ISO/IEC 30134 specifies the power usage effectiveness (PUE) as a key performance indicator (KPI) to quantify the efficient use of energy in the form of electricity.

This part of ISO/IEC 30134

a) defines the power usage effectiveness (PUE) of a data centre,

b) introduces PUE 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 PUE.

PUE derivatives are described in Annex D.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 30134-1:2016, *Information technology — Data centres — Key performance indicators — Part 1: Overview and general requirements*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

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

3.1.1
information technology (IT) equipment energy consumption
energy consumed, measured in kilowatt-hour (kWh), by equipment that is used to store, process, and transport data within the computer room, telecommunication room and control room spaces

Note 1 to entry: Examples are servers, storage equipment, and telecommunications equipment.

3.1.2
power distribution unit
PDU
equipment that allocates or partitions power for other energy consuming equipment

3.1.3
power usage effectiveness
PUE
ratio of the data centre total energy consumption to information technology equipment energy consumption, calculated, measured or assessed across the same period

Note 1 to entry: Sometimes the inverse value of PUE, referred to as Data Centre Infrastructure Efficiency (DCiE), is used.

3.1.4
partial power usage effectiveness
pPUE
derivative of PUE, which is the ratio of the total energy consumption within a defined boundary to the information technology equipment energy consumption

3.1.5
designed power usage effectiveness
dPUE
derivative of PUE, which is a projected PUE determined by the design targets of the data centre

3.1.6
interim power usage effectiveness
iPUE
derivative of PUE, which is measured over a specified time other than a year

3.1.7
total data centre energy consumption
total energy consumption for all energy types serving the data centre, measured in kWh at its boundary

Note 1 to entry: Energy measured with energy metering devices at the boundary of the data centre or points of generation within the boundary.

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

3.2 Abbreviated terms

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

CRAC	computer room air conditioner units
CRAH	computer room air handler units
dPUE	designed power usage effectiveness
DX	direct expansion
iPUE	interim power usage effectiveness
PDU	power distribution unit
pPUE	partial power usage effectiveness
r.m.s.	root mean square
ROI	return on investment
UPS	uninterruptible power supply

3.3 Symbols

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

E_{DC}	total data centre energy consumption (annual) in kWh
E_{IT}	IT equipment energy consumption (annual) in kWh

4 Applicable areas of the data centre

Power usage effectiveness (PUE) as specified in this part of ISO/IEC 30134

— is associated with the data centre infrastructure within its boundaries only,

— describes the infrastructure's energy efficiency relative to facilities with given environmental conditions, IT load characteristics, availability requirements, maintenance, and security requirement, and

— illustrates the energy allocation of a data centre.

When viewed in the proper context, PUE provides effective guidance and useful insight into the design of efficient power and cooling architectures, the deployment of equipment within those architectures, and the operation of that equipment.

PUE provides a means to determine

— opportunities for the improvement of the operational efficiency of a data centre,

— the improvement of the designs and processes of a data centre over time, and

— a design target or goal for new data centres across the anticipated IT load range.

PUE does not take into account the

— energy efficiency of the IT load, its utilization or productivity,

— efficiency of on-site electricity generation,

— efficiency of other resources such as human resource, space or water, and

— use of renewable energy resources or accounts for re-use of waste by-products (such as heat).

PUE is not a

— data centre productivity metric, and

— standalone, comprehensive resource efficiency metric.

Derivatives of PUE which are useful in certain circumstances as described in Annex C. PUE should not be used to compare different data centres.

5 Determination of power usage effectiveness (PUE)

PUE is defined using Formula (1):

$$PUE = \frac{E_{DC}}{E_{IT}} \tag{1}$$

where

E_{DC} is the total data centre energy consumption (annual), in kWh;

E_{IT} is the IT equipment energy consumption (annual), in kWh.

By definition, the calculated PUE is always greater than 1.

Where the only energy source is from the electrical utility, then E_{DC} is determined by the location of the utility meter. PUE may be applied in mixed use buildings that allow of the differentiation between the energy used for the data centre and that for other functions. Alternatively, the derivative partial PUE (pPUE) may be applied (see Annex C).

E_{IT} includes, but is not limited to,

— IT equipment (e.g. storage, processing and transport equipment), and

— supplemental equipment (e.g. keyboard/video/mouse (KVM) switches, monitors, and workstations/laptops used to monitor, manage, and/or control the data centre).

E_{DC} includes E_{IT} plus all the energy that is consumed to support the following infrastructures:

— power delivery [e.g. UPS systems, switchgear, generators, power distribution units (PDUs), batteries, distribution losses external to the IT equipment, etc.];

— cooling system [e.g. chillers, cooling towers, pumps, computer room air handling units (CRAHs), computer room air conditioning units (CRACs), direct expansion air handler (DX) units, etc.];

— others (e.g. data centre lighting, elevator, security system and fire detection/suppression system).

6 Measurement of power usage effectiveness

6.1 Measuring energy consumption

6.1.1 General

In order to calculate PUE, it is necessary to measure E_{DC} and E_{IT}. This is not a trivial task, especially within existing data centres which may require the installation of instrumentation to collect the data.

NOTE Although measurement of E_{DC} and E_{IT} are adequate to calculate PUE for the defined equipment and supporting infrastructure, more monitoring data of logical subsets is necessary to assess areas for potential improvements and to evaluate the resulting improvements to PUE across the data centre.

6.1.2 Measurement period and frequency

The calculation of PUE requires the recording and documenting of E_{DC} and E_{IT} over a coincident period of 12 months. This part of ISO/IEC 30134 does not specify the frequency of measurements of E_{DC} and E_{IT}, since PUE is calculated on an annual timeframe. However, the frequency of measurement employed will define the timing of subsequent PUE calculations on a rolling annual basis.

6.1.3 Meter and measurement requirements

Measurement of E_{DC} and E_{IT} shall be undertaken using either

— watt meters with the capability to report energy usage, or

— kilowatt-hour (kWh) meters that report the actual energy usage (true r.m.s), through the simultaneous measurement of the voltage, current, and power factor over time.

NOTE Kilovolt-ampere (kVA), the product of voltage and current, is not an acceptable measurement. Though the product of volts and amperes mathematically results in watts, the actual energy consumption is determined by integrating a power factor-corrected value of volts and amperes. The frequency, phase variance, and load reaction causes energy calculation difference between apparent energy and actual energy consumption. The error is inherently significant when power delivery includes alternating current (AC). Kilovolt-ampere (kVA) measurements may be used for other functions in the data centre; however, kVA is insufficient for efficiency measurements.

6.2 Categories of power usage effectiveness

6.2.1 General

Three categories of PUE are defined as:

— Category 1 (PUE_1) — provides a basic level of resolution of energy performance data;

— Category 2 (PUE_2) — provides an intermediate level of resolution of energy performance data;

— Category 3 (PUE_3) — provides an advanced level of resolution of energy performance data.

The higher categories provide progressively

— more accurate measurements of energy usage (as the measurements are made closer to the devices that consume the energy), and

— greater scope for energy efficiency improvements.

Table 1 provides a summary of the locations for the measurement of IT equipment energy consumption associated with each category. In all cases, the total data centre energy consumption is measured from the utility service entrance that feeds all of the electrical and mechanical equipment used to power cool and condition the data centre.

To properly assess PUE, it is critical to account for all systems that support the data centre, in addition to the environmental conditions, reliability, security and availability requirements independent of which PUE measurement category is chosen (see ISO/IEC 30134-1:2016, Annex A).

Table 1 — PUE categories

	PUE_1	PUE_2	PUE_3
Location of IT equipment energy consumption measurement	UPS output[a]	PDU output[b]	IT equipment input[c]

[a] Includes impact of fluctuating IT and cooling loads.

[b] Excludes impact of losses associated with PDU transformers and static switches.

[c] Excludes impact of losses associated with electrical distribution components and non-IT related devices.

6.2.2 Category 1 (PUE_1) — Basic resolution

The IT load is measured at the output of the UPS (or equivalent) equipment and may be read

— from the UPS front panel,

— through a meter on the UPS output, and

— in cases of multiple UPS modules through a single meter on the common UPS output bus.

The incoming energy is measured from the utility service entrance that feeds all of the electrical and mechanical equipment used to power, cool, and condition the data centre.

If UPS or an equivalent power failure ride through or conditioning unit is not available, other categories may apply.

6.2.3 Category 2 (PUE_2) — Intermediate resolution

The IT load is measured at the output of the PDUs within the data centre and is typically read from the PDU front panel or through a meter on the PDU output (with or without transformer, the measurement point is then after the transformer). Individual branch circuit measurement is also acceptable for Category 2.

6.2.4 Category 3 (PUE_3) — Advanced resolution

The IT load is measured at the IT equipment within the data centre. This can be achieved either by metered rack (e.g. plug strips) that monitors aggregate set of IT systems or at the receptacle level or by the IT device itself. Note that non-IT loads shall be excluded from these measurements.

6.2.5 Measurement placement

Each category enables progressively improved accuracy of measurement of IT equipment energy consumption, as the measurements are taken closer to the IT devices that consume energy.

7 Reporting of power usage effectiveness

7.1 Requirements

7.1.1 Standard construct for communicating PUE data

In order for a reported PUE to be meaningful, the reporting organization shall provide the following information:

— data centre (including the boundaries of the structure) under inspection;

— PUE value;

— category.

The PUE category shall be provided as a subscript to the name of the metric, e.g. PUE_2 for a Category 2 value.

7.1.2 Example of reporting PUE values

Using the construct of 7.1.1, Table 2 provides examples of specific PUE designations and their interpretation.

Table 2 — Examples of PUE reporting

Example PUE designations	Interpretation
Data centre X, PUE_1 (2012–12–31) = 2,25	In the year 2012, the PUE value of data centre X was 2,25. It was a Category 1 PUE.
Data centre Y, PUE_1 (2013–06–30) = 1,75	In the period 2012–07–01 to 2013–06–30, the PUE value of data centre Y was 1,75. It was a Category 1 PUE.
Data centre Z, PUE_2 (2013–12–31) = 1,50	In the year 2013, the PUE value of data centre Z was 1,50. It was a Category 2 PUE.

7.1.3 Data for public reporting of PUE

7.1.3.1 Required information

The following data shall be provided, when publicly reporting PUE data:

— contact information;

Only the organization’s name or contact should be displayed in public inquiries.

— data centre location information (address, county or region);

Only state or local region information are required to be displayed in public inquiries.

— measurement results: PUE with appropriate nomenclature including category designation.

7.1.3.2 Supporting evidence (where required by authorities having jurisdiction)

Information on the data centre which shall be available upon request as a minimum includes

— organization's name, contact information and regional environmental description,

— measurement results: PUE with appropriate nomenclature,

— E_{DC} and E_{IT},

— start and measurement(s) dates the assessments were completed,

— the accuracy level (IEC 62052 series and IEC 62053 series provide a reference for measurement of electrical energy),

— report on the size of computer room, telecom room and control room spaces, and

— external environmental conditions consisting of minimum, maximum and average temperature, humidity and altitude.

7.2 Recommendations

7.2.1 Use of PUE category

The PUE category should be appropriate to the expected value of PUE.

— PUE > 1,50: Category 1 to Category 3

— 1,50 ≥ PUE > 1,20: Category 2 or Category 3

— PUE ≤ 1,20: Category 3

7.2.2 Trend tracking data

The following information may be useful in tracking the PUE trends within a data centre:

— data centre size (facility square metres);

— total data centre design load for the facility (e.g. 10,2 MW);

— name of the possible auditor and method used for auditing;

— data centre contact information;

— data centre environmental conditions;

— data centre's mission;

— data centre archetype percentages (e.g. 20 % web hosting, 80 % email);

— data centre commissioned date;

— numbers of servers, routers, and storage devices;

— average and peak server CPU utilization;

— percentage of servers using virtualization;

— average age of IT equipment by type;

— average age of facility equipment by type (cooling and power distribution equipment);

— data centre availability objectives (see ISO/IEC 30134-1:2016, Annex A);

— cooling and air-handling details.

NOTE Other KPIs within the ISO/IEC 30134 series can assist in the recording of the above information.

Annex A
(normative)

Energy measurements

A.1 Measuring energy and calculating power usage effectiveness

In Figure A.1, total data centre energy consumption is measured at or near the data centre's utility meter(s) to accurately reflect the energy entering the data centre (see Annex B for other energy sources) in order that the measurement represents the total energy consumed in the data centre.

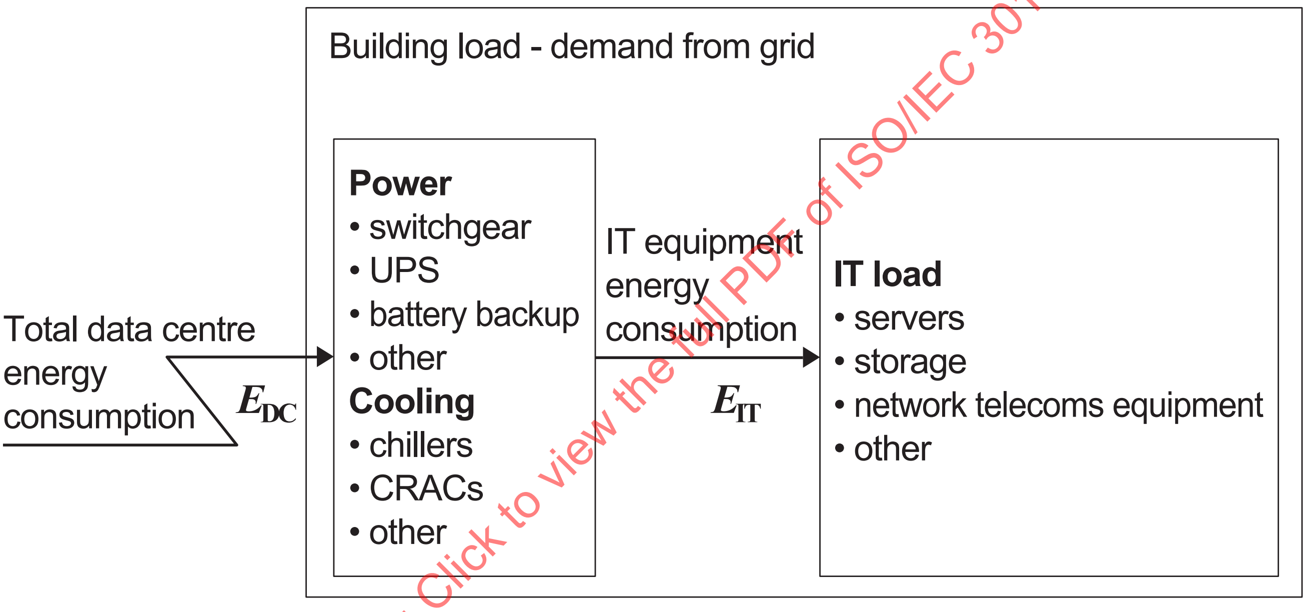


Figure A.1 — Schematic of PUE calculation from measurements

Only the data centre portion of a facility's utility consumption meter relevant to the data centre shall be measured, since including in the calculation any energy that is not intended to be consumed in the data centre would result in a non-compliant PUE calculation. For example, if a data centre resides in an office building, the total energy drawn from the utility will be the sum of the total facility energy consumption for the data centre and the total energy consumed by the non-data centre offices in the building. In this case, the data centre administrator shall measure and subtract the amount of energy being consumed by the non-data centre offices in order to calculate an accurate PUE.

A.2 Measurement locations

Figure A.2 shows measurement points to support the determination of E_{DC}. E_{DC} is measured after the utility feed at the utility metering point (i.e. point A). This measurement is consistent across all categories. The additional measurement points shown in Figure A.2 relate to the three PUE categories. The measurement points to allow determination of Category 1 PUE (PUE_1), Category 2 PUE (PUE_2) and Category 3 PUE (PUE_3), are indicated by B, C and D, respectively.

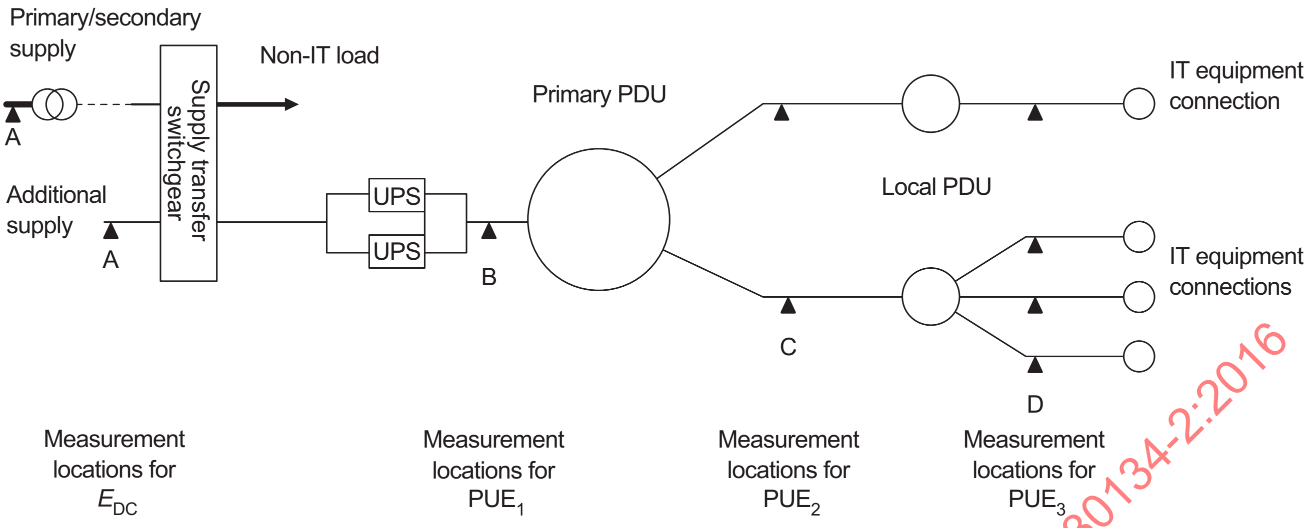


Figure A.2 — Monitoring and measurement points

Monitoring energy consumption involves many aspects that can prevent it from being easy and straightforward for the data centre operator. Costs can be quite high to install measuring instruments at every point in the critical power path. Collecting, processing, and interpreting all the data also can be complex.

There is also some degree of error inherent in each of the meters measuring energy consumption, which can affect results.

For a practical and achievable approach to monitoring, data centre operators should identify where it is most beneficial to measure, taking into account associated improvements in PUE accuracy.

A.3 Assessment frequencies

Increasing the minimum frequency of the assessment cycle provides a larger and more accurate data set to analyse.

To fully understand and successfully manage the energy performance of a data centre, continuous real-time monitoring should be used so that historical trending and statistical analysis can be done to determine where efficiencies can be gained. This approach also enables early detection of unexpected variations that could indicate system issues.

In cases where continuous real-time monitoring is not practical or economically justifiable, some form of repeatable, defined process should be in place to capture measurements enabling the calculation of PUE as often as possible for internal comparison purposes. If automated systems are employed the minimum assessment frequency should be daily.

In all cases, the measurement methodology shall be consistent with the categories and locations defined in 6.2.

Annex B
(normative)

Calculation of PUE using various energy supplies

B.1 Usage of different energy sources

E_{DC} includes all energy consumed for data centre operation. The energy includes not only grid electricity but also on-site generated electricity and non-electricity forms of energy such as purchased district chilled water. Energy measurements for PUE shall be captured in the form of kWh. To enable PUE calculations for a data centre utilizing on-site electric generation, the generated electricity which is measured by kWh meter should be accounted for.

For a data centre utilizing non-electric energy, such as district chilled water, an energy conversion factor enables the data centre owner/operator to include the energy of the chilled water.

Energy conversion factors are region-dependent because the amount of fuel needed to produce one unit of chilled water will depend on the predominant method of chilled water generation in a given region. Some countries have published values for these conversion factors. If regional energy conversion factors are unavailable, the standard energy conversion factors of Table B.1 shall be used. These represent average values of factors from different regions of the world. Naturally occurring cold water from the ground and air of direct free cooling is not accounted for.

Table B.1 — Standard energy conversion factors

Energy type	Standard energy conversion factor
District chilled water	0,4
District hot water	0,4
District steam	0,4
Fuel (for absorption type chiller)	0,35

Formula (B.1) shows an example of how the PUE of a data centre that purchases electricity and district chilled water can be expressed:

$$PUE = \frac{E_{DC}}{E_{IT}} = \frac{E_{\text{electrical}} \times 1,0 + E_{\text{chilled water}} \times 0,4}{E_{IT}} \quad \text{(B.1)}$$

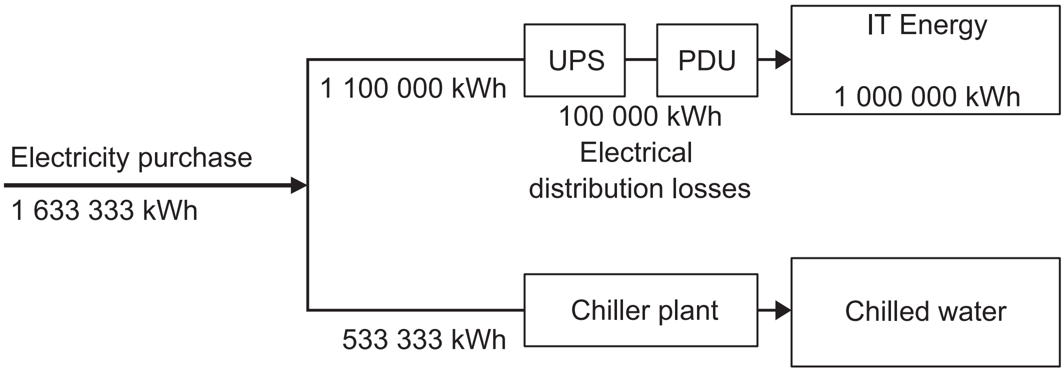
where

$E_{\text{electrical}}$ is the electrical energy consumed;

$E_{\text{chilled water}}$ is the district chilled water energy consumed.

B.2 Examples of PUE calculation with various energy supplies

Figures B.1 to B.4 show examples of PUE calculation with various energy supplies.

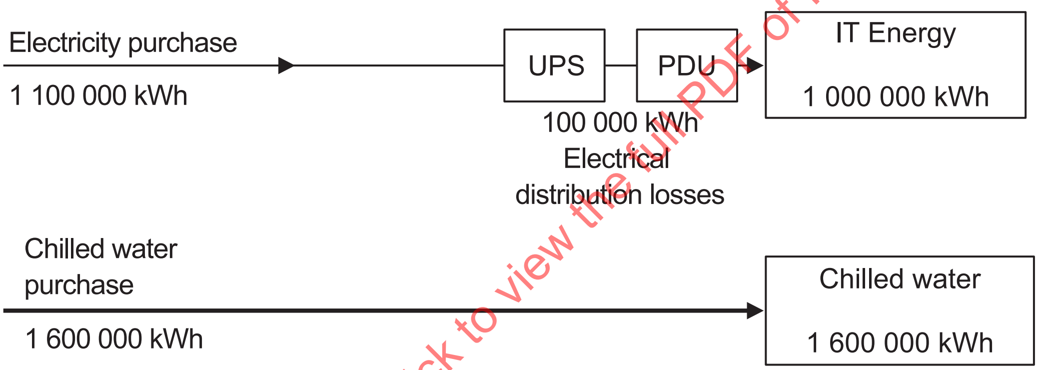


$PUE = E_{DC} / E_{IT}$

$= (1\ 633\ 333) / (1\ 000\ 000)$

$= 1{,}63$

Figure B.1 — Example for a data centre purchasing all electricity

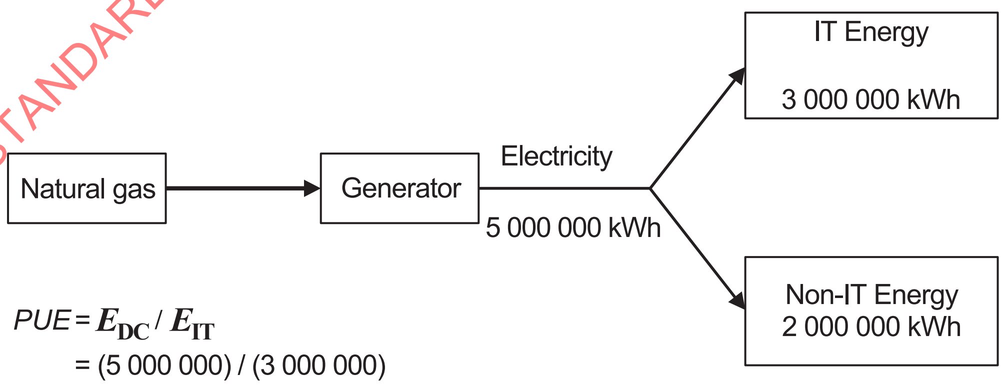


$PUE = E_{DC} / E_{IT}$

$= (1\ 100\ 000 \times 1 + 1\ 600\ 000 \times 0{,}4) / (1\ 000\ 000)$

$= 1{,}74$

Figure B.2 — Example for a data centre purchasing electricity and chilled water

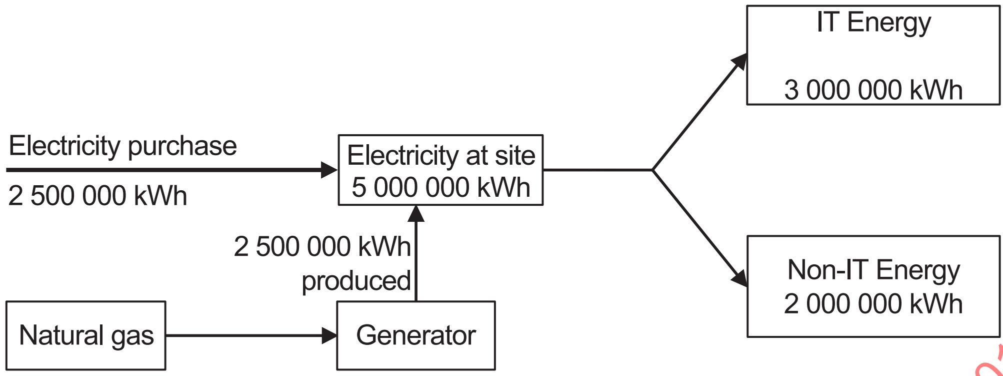


$PUE = E_{DC} / E_{IT}$

$= (5\ 000\ 000) / (3\ 000\ 000)$

$= 1{,}67$

Figure B.3 — Example for a data centre purchasing natural gas

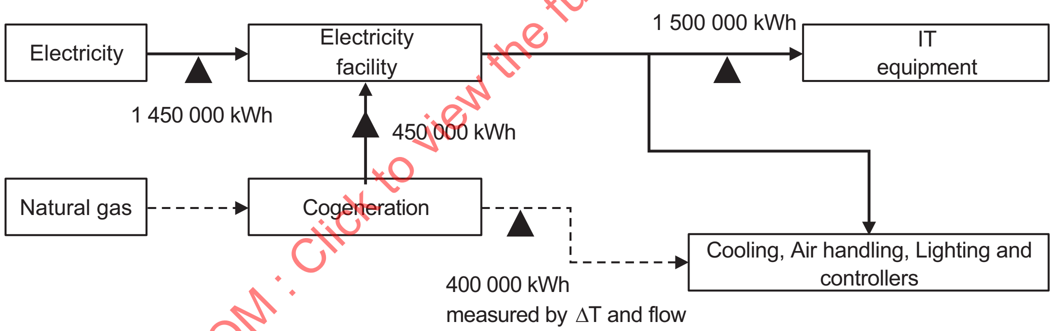


$$PUE = E_{DC} / E_{IT}$$
$$= (2\,500\,000 + 2\,500\,000) / (3\,000\,000)$$
$$= 1{,}67$$

Figure B.4 — Example for a data centre purchasing electricity and natural gas

B.3 Examples of PUE calculation with cogeneration using electricity and natural gas

Figures B.5 and B.6 show examples of PUE calculation with cogeneration using electricity and natural gas.



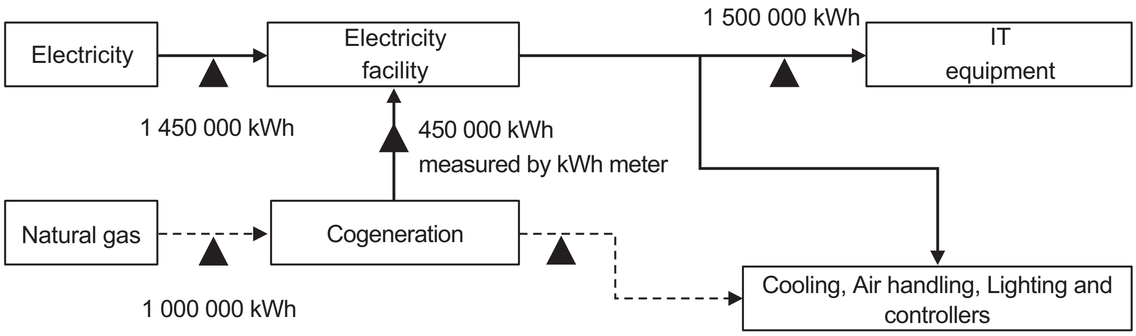
$$PUE = E_{DC} / E_{IT}$$
$$= (1\,450\,000 + 450\,000 + 400\,000 \times 0{,}4) / (1\,500\,000)$$
$$= 1{,}37$$

Key

→ electricity
- - → heat or chilled water
▲ measurement point

Figure B.5 — Method 1: Measured by chilled water flow

If the energy consumption of the chiller cannot be measured, the heat energy of chilled water may be multiplied by 0,4. Note that in this case, the efficiency of the chiller is not taken into account for PUE calculation. Since the performance of the chiller is regarded to be the same as district chilled water, the actual PUE value can increase or decrease.



$PUE = E_{DC} / E_{IT}$

$= (1\,450\,000 + 450\,000 + 0{,}35 \times 1\,000\,000 \times 0{,}47) / (1\,500\,000)$

$= 1{,}38$

Key

→ electricity

- - -▶ heat or chilled water

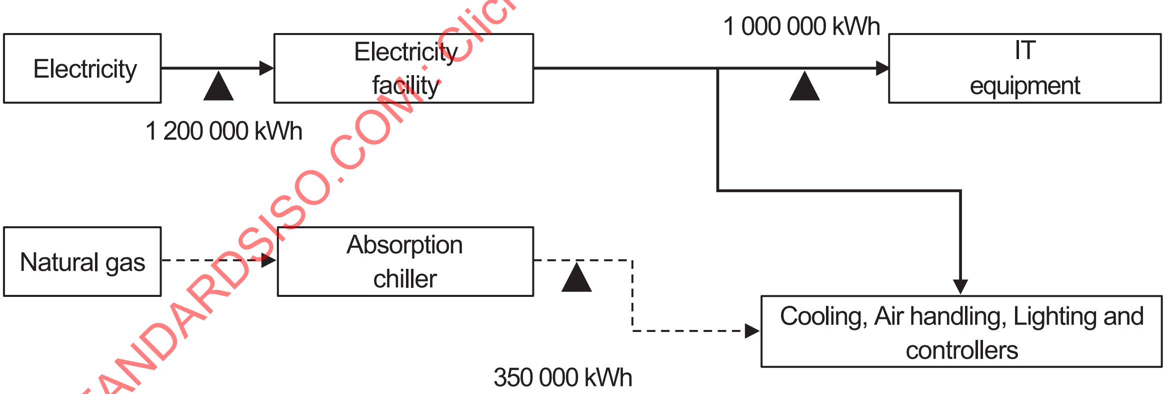
▲ measurement point

Figure B.6 — Method 2: Calculated from energy required to produce chilled water

In the example of method 2, the input energy ratio for chilled water and electricity should be measured for this co-generation system, based on the benchmark method defined in ISO 26382. The input energy ratio is assumed to be 47 % for chilled water and 53 % for electricity.

B.4 Examples of PUE calculation with absorption type chiller

Figures B.7 and B.8 show examples of PUE calculation with absorption type refrigerator.



$PUE = E_{DC} / E_{IT}$

$= (1\,200\,000 + 350\,000 \times 0{,}4) / (1\,000\,000)$

$= 1{,}34$

Key

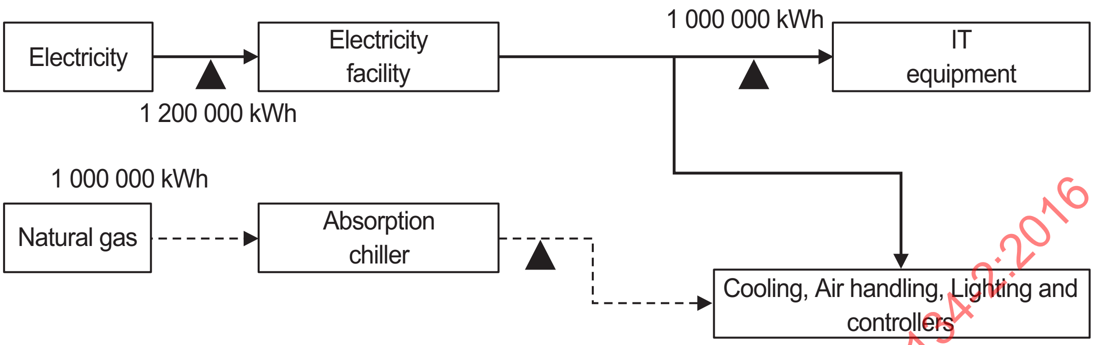
→ electricity

- - -▶ heat or chilled water

▲ measurement point

Figure B.7 — Method 1: Measured by chilled water flow

If the energy consumption of the chiller or the refrigerator cannot be measured, the heat energy of chilled water may be multiplied by 0,4. Note that in this case, the efficiency of the chiller is not taken into account for PUE calculation. Since the performance of the chiller is regarded to be the same as district chilled water, the actual PUE value can increase or decrease.



$$PUE = E_{DC} / E_{IT}$$

$$= (1\ 200\ 000 + 0{,}35 \times 1\ 000\ 000) / (1\ 000\ 000)$$

$$= 1{,}55$$

Key

- ——▶ electricity
- - - -▶ heat or chilled water
- ▲ measurement point

Figure B.8 — Method 2: Measured by input gas

Annex C
(normative)

PUE derivatives

C.1 General

C.1.1 Purpose of PUE derivatives

PUE derivatives are useful to support an effective energy management process. Each derivative shall be accompanied with specific information that describes the specific situation.

C.1.2 Using PUE derivatives

The PUE derivatives shall be designated and shall be documented as one of the following: pPUE, iPUE and dPUE.

a) Partial PUE (pPUE) describes the power usage effectiveness of a data centre infrastructure subset. pPUE shall include, but should not be limited to, the following supporting data:

   — the boundaries of the data centre including resiliency level;

   — an explicit list of shared resources;

   — assessment method used to determine amount of shared resources included;

   — all other PUE supporting evidence.

b) Interim PUE (iPUE) describes a PUE measured for a period less than a year (see C.2). iPUE shall include, but should not be limited to, the following supporting data:

   — the boundaries of the data centre including resiliency level;

   — time interval(s) under assessment;

   — all other PUE supporting evidence which exists during the defined intervals.

   iPUE may be used to validate dPUE parameters.

c) Designed PUE (dPUE) describes a predicted PUE for a data centre prior to its operation or to a specified change in operation (see C.4). dPUE shall include, but should not be limited to, the following supporting data:

   — the boundaries of the data centre including resiliency level;

   — a schedule of interim PUE and PUE based on target IT loads and environmental conditions;

   — all other PUE supporting evidence available prior to operation including target commissioning date.

Combined use of the terms is permitted to describe specific situations and values. An example use of these derivatives are:

— i/d/pPUE (20XX-08-01:20XX-08-31) = 3,1 [ref. jjj];

— [jjj]: [boundaries of the data centre, shared cooling, space, physical security];

— 40 % IT load; environmental conditions; etc.

C.2 Interim PUE (iPUE)

The definition of PUE clearly indicates that it is an annual figure and requires continuous measurement of IT energy and total data centre energy for at least one year. Reporting requires accompanying every PUE value with its category and the period of measurement.

For energy management purposes, periods smaller than a full year can be measured and reported. These values shall be designated as "interim PUE" (iPUE). They shall also be accompanied by its category, the period of measurement, and the other context and reporting information required for annualized PUE.

By decreasing the measurement interval to a minimum, a real-time iPUE can be established.

C.3 Partial PUE (pPUE)

C.3.1 General

While PUE is defined using total data centre energy, pPUE is determined on the energy use of particular and specified sub-systems of the data centre's infrastructure. The boundaries of these sub-systems are within the data centre and pPUE may be applied for all kinds of data centres.

Partial PUE (pPUE) is calculated using Formula (C.1):

$$pPUE_{\text{sub}} = \frac{E_{\text{sub}} + E_{\text{IT}}}{E_{\text{IT}}} \quad \text{(C.1)}$$

where

E_{sub} is the energy consumption (annual) of the sub-system, in kWh;

E_{IT} is the IT equipment energy consumption (annual) in kWh.

As with the PUE, pPUE is related to IT energy use and is an annual figure that requires a full year of measurement. Reporting pPUE requires the same disclosures as PUE, in addition to a clear delineation of the sub-system or zone under investigation. A zone comprises a meaningful set of infrastructure components that are using energy and the energy efficiency of which needs to be examined.

To be useful in an energy management process, the zones for the sub-systems should be defined in every individual data centre. Electrical distribution (including UPS), air handling and cooling are typical sub-systems that apply to most of the data centres nowadays. They are defined by Formulae (C.2) to (C.4):

$$pPUE_{\text{power}} = \frac{E_{\text{electrical}} + E_{\text{IT}}}{E_{\text{IT}}} \quad \text{(C.2)}$$

where

$E_{\text{electrical}}$ is the energy consumption (annual) of the electrical systems, in kWh.

$$pPUE_{\text{HVAC}} = \frac{E_{\text{HVAC}} + E_{\text{IT}}}{E_{\text{IT}}} \quad \text{(C.3)}$$

where

E_{HVAC} energy consumption (annual) of the heating, ventilation and air conditioning systems, in kWh.

$$pPUE_{\text{cooling}} = \frac{E_{\text{cooling}} + E_{\text{IT}}}{E_{\text{IT}}} \quad \text{(C.4)}$$

where

E_{cooling} is the energy consumption (annual) of the cooling systems, in kWh.

This part of ISO/IEC 30134 allows other zones to be defined as required, with the purpose of gaining useful pPUE to analyse and understand the contribution of a data centre sub-system to the total energy use and to improve the energy efficiency of the sub-system under inspection.

The pPUE concept (and any reported value) is only applicable to the zones of a data centre under study.

It is meaningless to apply a pPUE to a part of the building that is not a zone of the data centre.

Specifically, there is no meaning in pPUE for zones that do not contain IT load (other KPIs may be applicable).

pPUE may also be employed to evaluate specific regions in the data centre or facilities where the IT equipment resides but share resources with other regions. The other regions not under investigation may or may not contain IT equipment, but, those regions are not considered part of the evaluation. The boundaries of the region under evaluation are described in ISO/IEC 30134-1.

C.3.2 Zoning

The normal use of pPUEs is within the boundaries of a data centre. As a step of the energy management process, the zones of infrastructure sub-systems inside the data centre shall be defined. This zoning depends on the technical design of the data centre.

For most of the data centres in post-commissioning and in operation, the zoning in Figure C.1 applies.

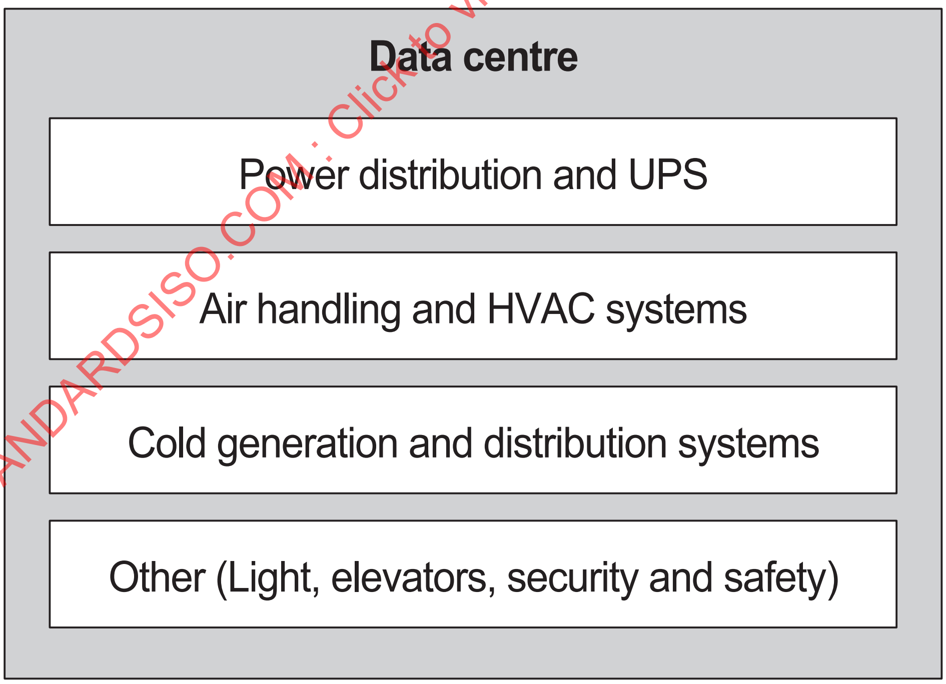


Figure C.1 — Zoning for a data centre

Whether or not the zone “other” shall be included depends on the significance of the energy use of that zone. It may be ignored in the beginning and included at a later stage of the energy management process, when the efficiency of the main zones has reached a level that the zone “other” becomes relevant.

In case the cooling is provided by DX systems, air handling and cooling cannot be separated. Therefore, the zoning of Figure C.2 is a better approach.

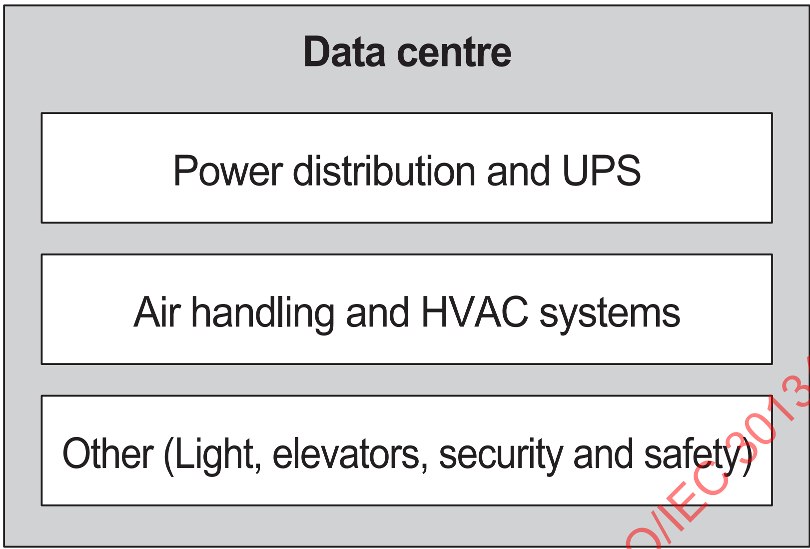


Figure C.2 — Zoning for a data centre using DX cooling

In case water is used for an additional cooling system and water transportation and treatment uses a significant amount of energy, the zoning of Figure C.3 is a good approach.

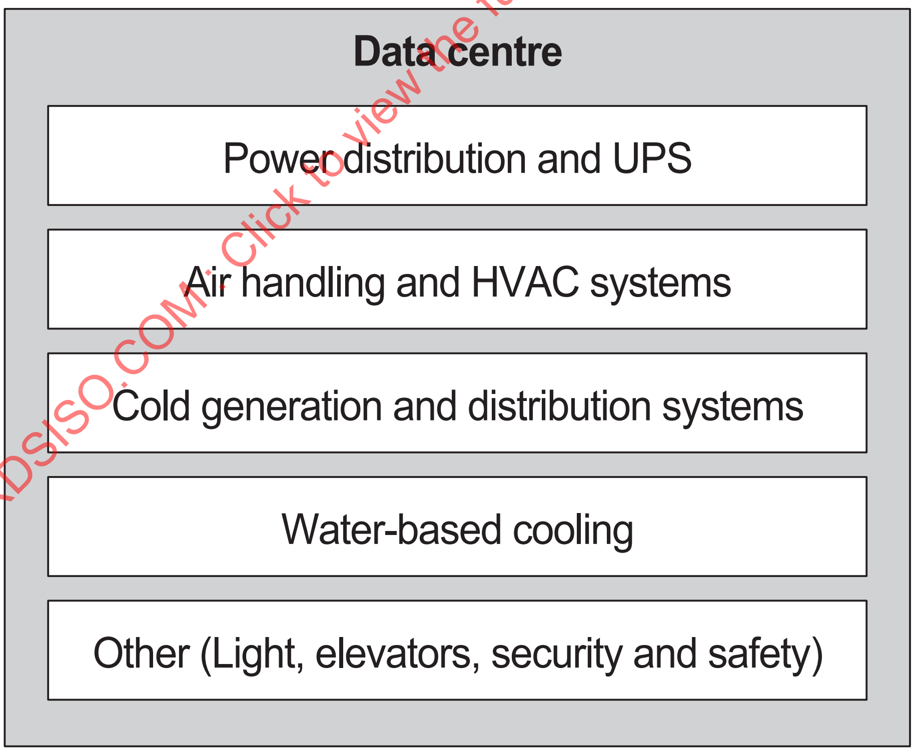


Figure C.3 — Zoning for a data centre using water

This part of ISO/IEC 30134 does not specify a method for defining a zone, but any zone shall be

— suitable for the task of the desired energy management process, and

— where appropriate, adjusted according to the progress of maturity of the energy management process.