New Data Center Energy Efficiency Evaluation Index
DPPE (Datacenter Performance per Energy)
Measurement Guidelines
(Ver 2.05)

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Green IT Promotion Council

Table of Contents

1. Basic Concepts of the Guidelines

1.1. Necessity of a new energy efficiency evaluation indicator for data centers–DPPE

Information and communication technology (ICT) has been playing an essential role in removing waste in economic activities, making transportation more efficient and providing alternative means of transportation, and cutting CO2 emissions through achieving more effective use of energy. At the same time, however, electricity consumption has been increasing in line with growing application of ICT. Data centers, operating a large number of servers, annually consume tremendous amounts of electricity, and the consumption is growing annually. In our fight against global warming, we are strongly urged to improve energy efficiency at data centers in order to reduce CO2 emissions.

To enhance energy efficiency at data centers, we need first to evaluate data center efficiency quantitatively. Power Usage Effectiveness (PUE) is widely used as an energy efficiency indicator for data centers. PUE is used to measure the energy efficiency of a facility. This indicator alone is not sufficient to contribute to improving energy efficiency at data centers, because we need to improve the efficiency of both the facility and IT devices at a data center.

Green IT Promotion Council (GIPC) has proposed Datacenter Performance Per Energy (DPPE) as a new indicator to measure the energy efficiency of a data center as a whole. DPPE not only encompasses PUE, which measures the energy efficiency of the facility, but also includes an indicator that shows the efficiency of IT devices, that is, the total efficiency of the computing services at the data center. DPPE also includes the rate of utilization of green energy sources such as photovoltaic generation and wind generation. By using DPPE, the operator and users of a data center can objectively evaluate the data center as a whole, including its equipment and IT devices, and promote sustainable efficiency through improving equipment and devices and visualizing improvement results.

GIPC is working on the specifics of DPPE as an effective indicator for measuring the energy efficiency of a data center in cooperation with interested groups at home and abroad, including The Green Grid of the United States.

1.2. The purpose of the Guidelines

These Guidelines intend to deepen the understanding of DPPE and present methods for DPPE measurement and reporting required to conduct measurement at data centers.

DPPE is a new indicator established only recently and thus subject to potential problems. Currently, these Guidelines aim to achieve two objectives as follows.

(1) Establishing an effective indicator

An effective indicator should be established that is capable of evaluating the efficiency of data centers.

(2) Proposing a realistic measuring method

A realistic measuring method should be proposed that is appropriate to the actual status of data centers. In this respect, existing equipment should be utilized to the extent possible to build a measurement system. In fiscal 2010, a measurement demonstration was conducted to clarify issues and make required corrections. In the fiscal 2011 measurement demonstration, further issues will be identified and corrections made based thereon.

2. Outline of Datacenter Performance Per Energy (DPPE)

2.1. DPPE and sub-indicators

DPPE (Datacenter Performance Per Energy) is an indicator to show productivity per unit of energy consumed at a data center, as simply expressed by “DPPE＝(throughput at the data center) / (energy consumption).” It is required to define throughput, energy consumption, and other parameters for data centers. These parameters should be linked closely to energy-saving activities at different levels of data centers, including selection of IT devices and improvement in facilities. We define four sub-indicators for data centers.

Table 1 Sub-indicators constituting DPPE

Sub-indicator	Formula	Corresponding energy-saving activities
IT Equipment Utilization (ITEU)	= total energy consumption (actual measured electric energy) in IT devices / total rated energy consumption IT devices (rated electric energy)	Efficient operation of IT devices: enhancing operating rates and reducing the number of operating devices through consolidation, virtualization, and other measures.
IT Equipment Energy Efficiency (ITEE)	= total rated capacity of IT devices (rated) / total rated power (rated power) of IT devices	Introducing more advanced energy-saving IT devices.
Power Usage Effectiveness (PUE)	= total energy consumption at the data center (actual measurement) / total energy consumption in IT devices (actual measurement)	Reducing energy consumption at the facility through various measures, including sophistication of air-conditioning systems and power source switching systems and utilizing the natural environment.
Green Energy Coefficient (GEC)	= energy generated from green energy sources (natural energy sources such as photovoltaic and wind power) (actual measurement) / total energy consumption at the data center (actual measurement)	Installing green-energy generation equipment, including photovoltaic, wind, and water-power systems.

The four indicators (ITEU, ITEE, PUE, and GEC) reflect four independent types of energy-saving efforts. One type of energy-saving effort is designed to be free from any effect of another. For this reason, these indicators can be used separately and independently.

DPPE can be expressed as a function of these sub-indicators, namely, DPPE = f (ITEU, ITEE, PUE, GEC). Specifically,

$$\mathrm{DPPE} = \mathrm{ITEU} \times \mathrm{ITEE} \times \frac{1}{\mathrm{PUE}} \times \frac{1}{1-\mathrm{GEC}}$$

ITEU is an indicator of efficiency in operation of IT devices at the data center. If no IT device is operating at the data centers, ITEU＝0, and if all IT devices are operating at full capacity, ITEU =1.

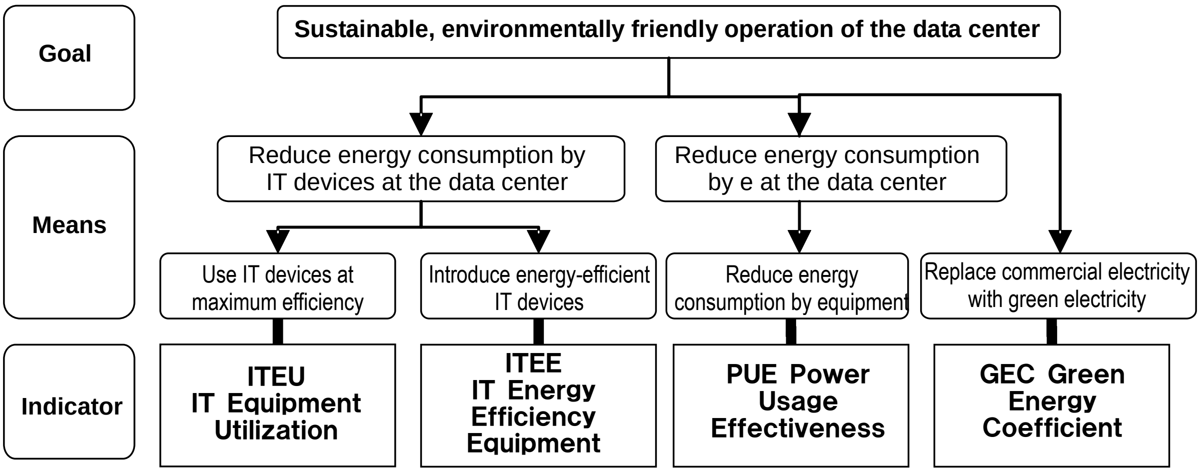
ITEE is an indicator of energy consumption in relation to potential capacity of IT devices at the data center. Its value increases as more energy-saving IT devices are introduced.

PUE is an indicator of energy efficiency of the facility. Its value approaches 1 as energy consumption is reduced at the facility.

GEC increases as more CO2-free green energy is generated within the data center from such sources as solar power and wind power.

DPPE is designed to increase as the values of these four indicators increase (the inverse value, for PUE). DPPE can be defined as throughput per unit of non-green energy at the data center.

Figure 1 Meaning of DPPE



DPPE ＝operating rate of IT devices (ITEU) × capacity of IT devices (ITEE) × efficiency at data center (1/PUE) × non-green energy (1/(1-GEC))

2.2. Outline of IT Equipment Utilization (ITEU)

ITEU shows the extent to which energy is saved by virtualization technology and operation technology, which enable efficient use of the potential capacity of IT devices. The value will prompt the reduction in the number of IT devices installed by making full efficient use of the minimum number of units.

ITEU tells us how effectively the capability of IT devices is used. In determining ITEU, it is desired to calculate the ratio of actual performance to rated performance, such as a server operating rate, by examining all individual IT devices, including servers, storage units, network devices, and other devices. In practice, it is almost impossible to measure the operating rates for all IT devices. As an alternative indicator, we should use the ratio of total measured electric energy to total rated electric energy in IT devices, because, with a higher operating rate of a device, the actual measured electric energy value approximates the rated electric energy value.

ITEU ＝ total measured energy consumption by IT devices [kWh] / total rated energy consumption in by IT devices [kWh]

The calculation of ITEU should cover all IT devices, composed of servers, storage units, network devices, and other devices. Redundant IT devices kept active should be included in ITEU calculation. On the other hand, devices kept on standby while the power is off should be excluded from calculation because no electricity consumption occurs while devices are idle. The measuring periods and measuring points for actual electric energy should be the same as those for PUE.

［Example of calculation］

The measured electric energy for IT devices was 396,000 kWh for the measuring period of 30 days. The total rated electric energy was1,080,000 kWh (=1500 kW×24 hours×30 days) . Then,

ITEU ＝ 396,000 [kWh] / 1,080,000[kWh] ＝ 0.367 ＝ 36.7 [%].

2.3. Outline of IT Equipment Energy Efficiency (ITEE)

ITEE is defined as the value of total rated capacity of an IT device divided by its total rated power. This indicator is designed to promote energy cuts through introduction of devices having high processing capacity per unit of electricity. As data centers handle a large variety of devices and services, it is extremely difficult to measure each device. For this reason, calculation should be made more simply by using energy-saving values provided in the specifications on IT device catalogs.

ITEE ＝ total rated capacity of IT device [Work] / total rated power of IT device [W]

Where,

Total rated capacity IT device [Work]＝α×Σ (server capacity [GTOPS])＋β×Σ (storage unit capacity [Gbyte])＋γ×Σ (network capacity [Gbps])

α＝7.72 [W/GTOPS], β＝0.0933 [W/Gbyte], γ＝7.14 [W/Gbps]

As of this moment, no internationally standardized method is available to compare IT devices (servers, storage units, and network devices (NW)) in capacity or energy efficiency in order to determine the total rated capacity of IT devices. In Japan, however, relevant catalogs are required by the Energy Saving Law to specify energy efficiency values. These values can be used for ITEE calculation.

In the 2007 version, service capacity was expressed in W/MTOPS, which was changed to W/GTOPS in the 2010 and later versions. For this reason, values used for energy efficiency in the 2007 version need to be converted using the following equation:

Energy efficiency in the 2010 version [W/GTOPS]

= Energy efficiency in the 2007 version [W/MGTOPS] x 100

Coefficients α, β, and γ are used to integrate the capacities of servers, storage units, and network devices. Coefficient α is defined as the inverse number of energy efficiency for standard servers used as of the year 2005. Similarly, β and γ are the inverse numbers of energy efficiency for standard storage units and network devices, respectively, used as of 2005. That is, “total rated capacity of IT devices” refers to the average capacity of servers, storage units, and network devices weighted by the reverse number of energy efficiency for 2005. When ITEE is calculated for servers, storage units, or network devices individually, the ITEE value would be the ratio in processing capacity per unit energy of such devices to standard servers, storage units, or network devices used in 2005 (total rated capacity / total rated power) . The same α, β, and γ values should be used for different data centers or for varying calculation periods.

［Calculation of coefficients α, β, and γ］

Coefficients α, β, γ are determined as follows.

The following energy efficiency values defined under the Energy Saving Law are used for the capacity of each device:

Table 2 Capacity of devices defined under the Energy Saving Law

	Capacity	Remark
Server	Composite theoretical performance	—
Storage unit	Memory capacity	—
Network device	Transfer capacity (throughput)	Currently under review

Table 3 provides Green IT Promotion Council's survey results[1]showing the standard capacity and electricity consumption of servers, storage units, and network devices in use as of 2005.

Table 3 Standard devices as of 2005

	Capacity (a)	Electricity consumption (b)	Processing capacity per unit energy (a / b)
Servers	36 GTOPS/ unit	278 W/unit	0.129 GTOPS/W
Storage units	300 Gbyte/unit	28 W/unit	10.7 Gbyte/W
Network devices	4.2 Gbps/port	30 W/port	0.14 Gbps/W

Because coefficients α, β, and γ are the inverse numbers of processing capacity per unit energy for standard devices,

Coefficient α for server ＝ 1/0.129 ＝7.72 [W/GTOPS]

Coefficient β for storage unit ＝ 1/10.7 ＝0.0933 [W/Gbyte]

Coefficient γ for network device ＝ 1/0.14 ＝7.14 [W/Gbps]

In ITEE calculation, IT devices constituting a data center are classified into three types–servers, storage units, and network devices. The value of rated capacity and rated power (or energy efficiency and rated power) used in ITEE calculation should be obtained from catalogs of respective devices. Such values are not available for some devices because they are so old that their catalogs were not legally required to contain relevant value information. Other devices cannot be classified into the three types. These devices shop be excluded from calculation of total rated capacity, and total rated power should be calculated by covering only the IT devices that have been used in the determination of total rated capacity as described above.

1 2008 Study Analysis Committee Report, Green IT Promotion Council

［Example of calculation］

The Energy Saving Law requires the catalog description of energy efficiency values, not the capacity of the IT device. For this reason, it is necessary to determine the capacity of servers and storage units by using rated power and energy efficiency.

Server: 420 [unit], maximum electricity consumption 209[W], energy efficiency 0.0016 [Category d]

209[W] / 0.0016[W/MTOPS] / 1000＝131 [GTOPS] / unit

Storage unit: 42 [unit], maximum electricity consumption 4620 [W], energy efficiency 0.025 [AAA]

4,620 [W] / 0.025 [W/Gbyte] =184,800 [Gbyte]/unit

The capacity of network devices is to be defined in the future under the Energy Saving Law. Temporarily, the capacity of a network device is calculated using an assignable speed (not the wire speed) per port.

Network: 84 [unit], maximum electricity consumption 145[W], maximum communication rate of 1 [Gbps], 24 ports per unit

(All ports can be set for 10/100 Mbps, and 14 of them can be set for 1Gbps.)

10×0.1 [Gbps]＋14×1 [Gbps]＝15 [Gbps]/unit

ITEE can be calculated using the capacity of an IT device multiplied by the number of devices.

ITEE ＝(7.72 [W/GTOPS]×130 [GTOPS]×420 [unit]

＋0.00933 [W/Gbyte]×184,800 [Gbyte]×42 [unit]

＋7.14 [W/Gbps]×15 [Gbps]×84 [unit])

/ (209[W]×420[unit]＋4,620[W]×42[unit]＋145[w]×84[unit])

＝3.98

2.4. Outline of Power Usage Effectiveness (PUE)

PUE was first proposed in 2007 by The Green Grid (TGG) , a U.S. group, as an indicator of energy efficiency at data centers. This indicator permits the easy measurement and estimation of energy efficiency at a data center to enable determination on the necessity of energy efficiency improvement.

The concept of PUE/DCiE is based on the white paper provided by TGG and the agreement at the February 2011 international conference (Global Coordination for Indicators Related to Energy Efficiency at Data Centers). Measurement conditions are established as a standard for Japan Data Center Council (JDCC) .

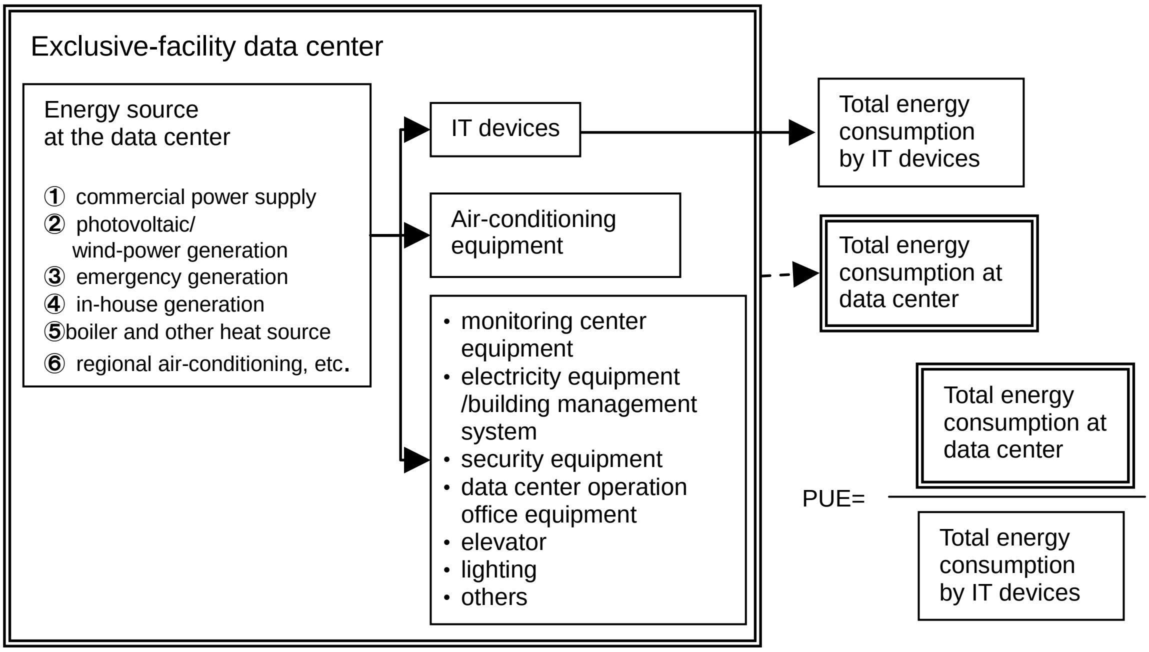
PUE is a value of total energy consumption at a data center divided by energy consumption by IT devices (electricity consumption) . This indicator shows a ratio in energy consumption of a data center to IT devices.

PUE = total energy consumption by data center [kWh] / total energy consumption by IT devices [kWh]

A lower PUE value indicates higher energy efficiency.

PUE is at least 1.0. As the PUE value approaches 1.0, energy efficiency increases at the data center.

Figure 2　PUE for a dedicated data center



(1) Types of energy sources at data centers and measuring points for total energy consumption

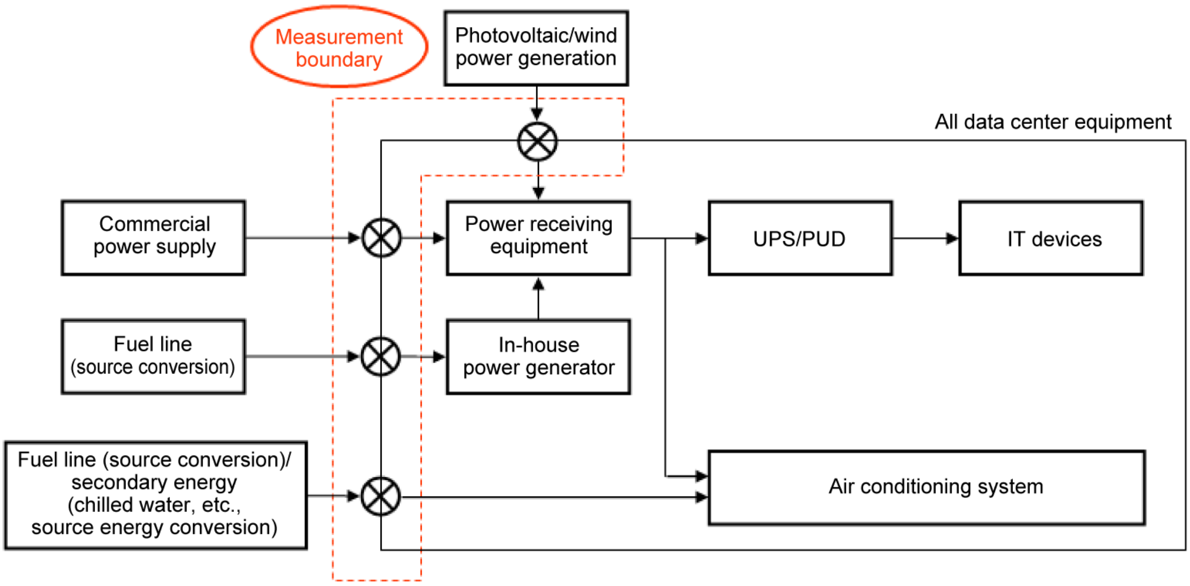
Total energy consumption at a data center includes the amount of energy consumed by air-conditioning, lighting, and other infrastructure configurations, in addition to the amount of energy consumed by IT devices.

To determine total energy consumption at a data center, it is necessary to make measurement on the boundary between the data center and external facilities (that is, a utility handoff, where the responsibility for utilities is passed from one entity to another) and include all energy sources (e.g. commercial electricity, heavy oil, gas) in the measurement.

(Refer to Figure 3 Interface between the data center facilities and outside (Utility handoff)

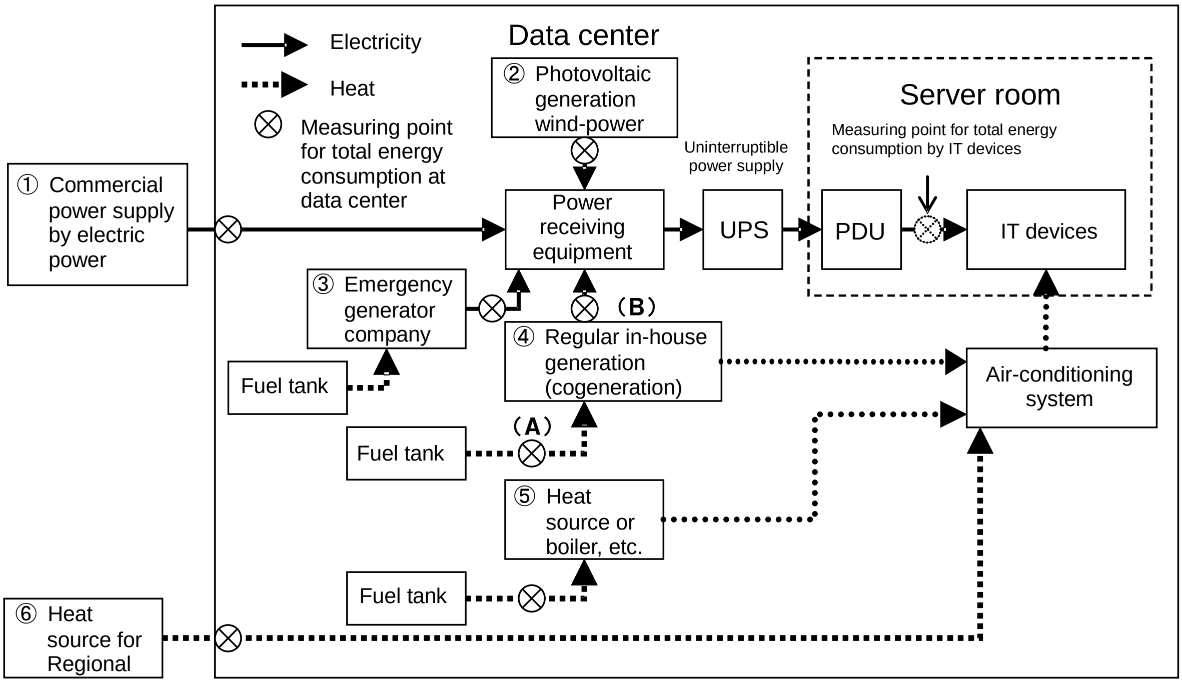
Measurement should be made for total source energy (initial energy measured by volume of oil, gas, and other natural as described later) in electricity consumption (kWh) .

Figure 3 Boundary between the data center facilities and outside



Data centers use energy obtained from several sources: (a) electricity from electric power suppliers, (b) electricity from photovoltaic generation and wind generation, (c) electricity from emergency power generators, (d) electricity from other in-house power generation units, such as cogeneration systems, (e) heat for air-conditioning from gas-based or oil-based boilers and in-house cogeneration systems, and (f) heat and other energy sources than electricity from regional air-conditioning systems.

Figure 4 Types of energy sources at data centers



To calculate PUE, it is required to determine total energy from all these sources. For calculation, a common unit needs to be applied to electricity and other energy sources. [kWh] should be used as the basic unit. To convert [kWh] into [GJ], the following formula should be used:

To represent other energy sources than electricity in [kWh], the calorific values by energy source as expressed in [kWh] should be used as provided in Exhibit 1 (Related to Article 4) to the Enforcement Regulation for the Energy Saving Law. (See Exhibit.)

Total energy consumption at a data center should be calculated basically as electric energy measured when the power supplies are turned on at the data center (input side on the power receiving equipment, output of photovoltaic and wind generation, and output of emergency electricity generators, in-house generation systems, including cogeneration units). Electrical loss in power generation or transmission should not be taken into account.

Energy in other sources than electricity, such as boilers, should be calculated based on fuel consumption and other parameters.

Types of energy sources and total energy

Energy sources consumed should include electricity, fuels (e.g. heavy oil, gas), and secondary energy sources (e.g. chilled water from local heating and cooling).

Specifically, it is to be noted that cooling equipment and power generation systems use heavy oil, gas, and other energy sources.

(Source energy amount)

In these guidelines, total energy is generally expressed in electric energy after energy from all sources is aggregated. To produce 1 kWh of commercial electricity (a), about three times the energy (source conversion factor δ) is used, after talking into consideration the power generation efficiency of power plants and transmission loss caused between the power plant to the data center. This three-time energy is called “source energy amount.”

Energy amounts at a data center are evaluated basically in source energy amount, as agreed upon at the February 2011 international conference (previously mentioned).

For fuels, energy consumed at the data center is counted as source energy after the amounts of heavy oil or other fuels are converted into electric energy in kWh (b).

For secondary energy sources (c), including chilled water for regional heating and cooling, energy (source conversion factor δ) consumed to produce the chilled water is converted into electric energy in kWh.

(Aggregation of source energy amount)

The total source energy amount can be expressed by the following equation:

Total energy consumption = δ x (a) + (b) + ε x (c)

This total value is 3 times the commercial electric energy. For this reason, electric energy is seemingly tripled at data centers, where commercial electric energy represents the majority of energy consumption, resulting in PUE greater than prior PUE for TGG.

To make the above equation compatible with prior PUE, the following equation has been formulated based on the conventional commercial electric energy value (value shown on the wattmeter) to enable source conversion.

Total energy consumption = (a) + (1/ δ) x (b) + (ε / δ) x (c)

The February 2011 international conference (previously mentioned) agreed to use the following values globally as source energy conversion factors:

*Source energy conversion factor for commercial electric energy: =>1.0

*Source energy conversion factor for fuels: 1/ δ =>0.35

*Source energy conversion factor for secondary energy sources: ε / δ =>0.40

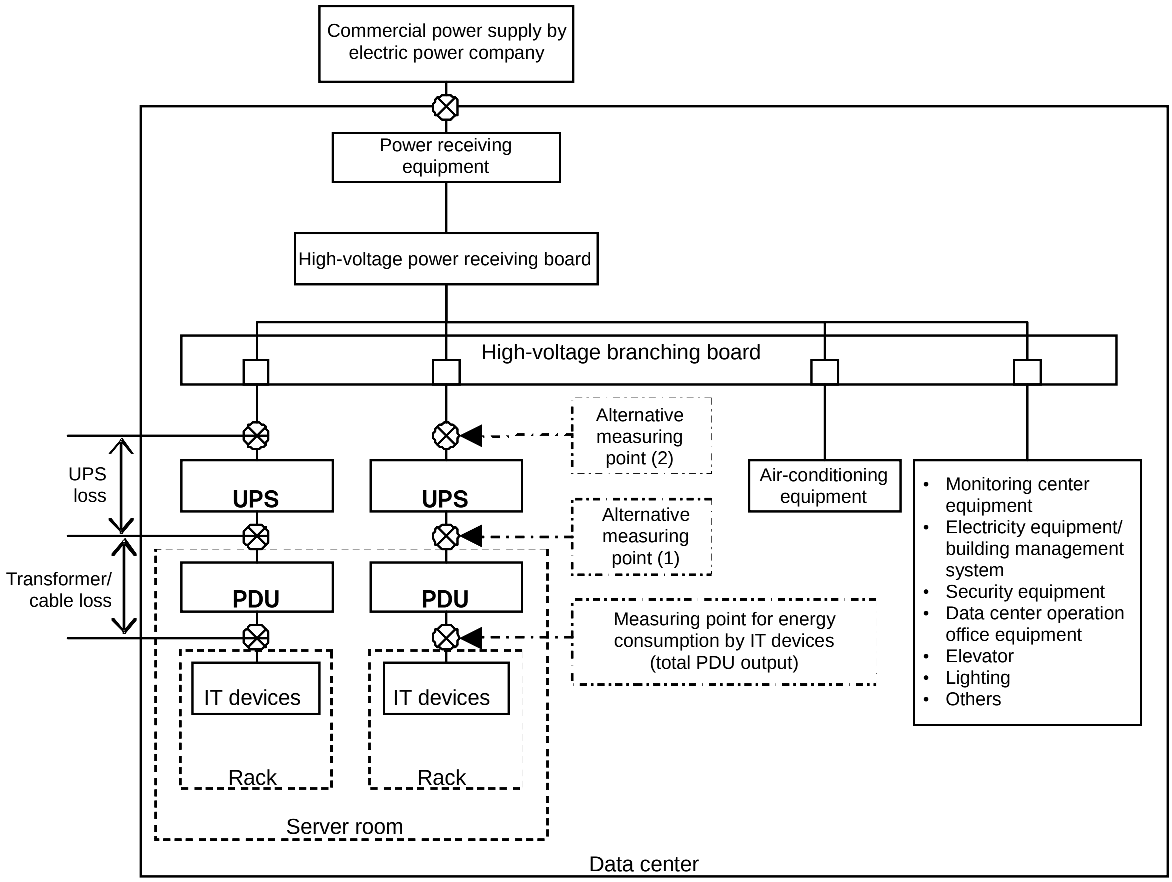
Table 4 Source energy conversion factor by energy source

Energy source	Source energy conversion factor
Commercial electric energy	1.0
Gas (natural gas, city gas, etc.)	0.35
Class-A heavy oil, light oil, etc.	0.35
Other fuel	0.35
Chilled water, etc. (regional heating and cooling)	0.40

(2) Measuring points for total energy consumption by IT devices

Energy consumption by IT devices should be measured at the output of the power distribution unit (PDU) (in measurement at the UPS output, electricity loss incurred between the UPS and IT devices should be taken into account). If there are multiple step-down transformers between a measuring point and an IT device, loss in the transformer and the cable should be considered. If measurement is unfeasible at the PDU output, follow 3.5.2 (3) “Measuring total energy consumption by IT devices.”

Figure 5 Measuring points for energy consumption by IT devices



*Measurement of the power factor

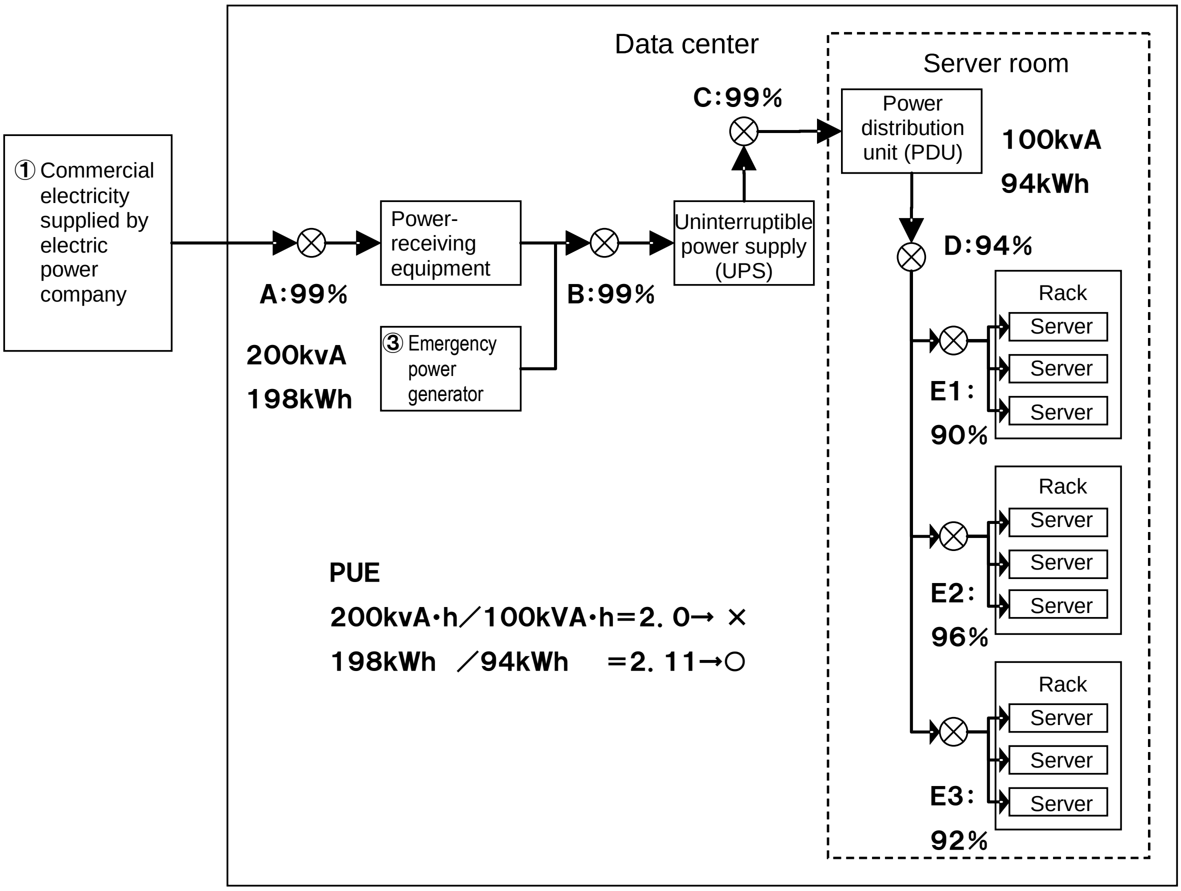
Actual total electricity consumption (kW) by IT devices is calculated by voltage (V) × current (A) × power factor (%). This is different from KVA＝voltage (V) × current (A). Thus, it is desirable to take the power factor into consideration to determine PUE.

From measurement data based on samples, it is known that the power factor for IT devices varies by some percentage points (in some cases, by scores of percentage points), depending on the type and the load.

If calculated without the power factor taken into account, the total energy consumption value total energy consumption (electric energy [kVAh]) by IT devices can be larger than it ought to be and can substantially affect the PUE calculation results.

To avoid this deviation, we need to take the power factor into consideration, instead of using current [A]×voltage [V] to determine total energy consumption (electric energy [kWh]) by IT devices.

Figure 6 Measurement of the power factor at the data center



Example: Electric power of 200kVA at the data centers; apparent power of 100kVA of IT devices

Power factor of 100% (without the power factor being taken into account) : PUE =200 [kVA] / (100 [kVA]*100%) =2.00

Power factor of 96%: PUE =200 [kVA] / (100 [kVA]*96%) = 2.08

Power factor of 90%: PUE =200 [kVA] / (100 [kVA]*90%) = 2.22

Total energy consumption (electric energy) by IT devices should be measured in an totaled value. Thus, it is desired to take the power factor, in addition to current and voltage, in determining electric energy. The problem is that few instruments are available for measuring the power factor, preventing continuous measurement at data centers of electric energy with the power factor.

The power factor value varies, depending on how the IT device system is configured after the PDU. However, sample-based measurement data have suggested that little change occurs with time. For this reason, total energy consumption by IT devices may be determined by multiplying an electric energy value obtained from continuous measurements with current and voltage by the average value of power factor temporarily measured with a handy terminal or similar tool. If the power factor is not known or immeasurable, it is recommended to use 95% as the power factor.

Table 5 Example of power factor obtained from sample-based measurement data

Ave	Var	Max	Min
95.8%	46.6%	100%	64%

(3) Determination of total energy consumption at complex-facility data centers

Many data centers are of the complex-facility type, which consists of data center floors and other unrelated office floors. To determine a PUE value commonly applicable to multiple data centers, it is necessary to determine total energy consumption by the data center functions on the basis of total energy consumption by the whole building, which includes non-data center functions.

For complex-facility data centers, the functions (floors) within the building must be categorized into three types—data center functions, non-data center functions, and shared functions. Shared functions are equipment and floors shared and used for management, maintenance, and operation of data center and non-data center functions combined. These shared functions may include a building management system, security equipment, shared-floor air-conditioning equipment, elevators, and lighting, in addition to halls, hallways, restrooms, and shared meeting rooms.

Definition of “shared component” of a complex facility

A “shared component” of a complex facility refers to equipment and devices, such as shared air-conditioning systems, that are used by multiple sections of data centers and other complex facilities for the purpose of controlling and maintaining such facilities. Similarly, an area such as halls, passages, washroom, and shared meeting rooms, is also a shared component.

At complex-facility data centers, it is required to measure energy consumption of components exclusive to data center functions.

Energy consumption by shared functions is allocated between data center functions and non-data center functions (general offices, etc.). In determining total energy consumption by the data center, the energy consumption attributed to data centers functions is added to the energy consumption by exclusive data center functions.

Allocation at a complex facility (refer to Figure 7 “Configuration of a complex facility data center”)

If energy amounts can be measured for the data center section, they do not need to be allocated as set forth below. Such energy amounts should be used.

a. Allocation to the exclusive components

・The determination of energy consumption by air-conditioning systems in the data center section should comply with TGG’s White Paper No.14, and the energy consumption should be divided using the energy consumption ratio between IT devices and the other devices (in the office section). (※It is to be noted, however, that this allocation method may cause significant errors, depending on the load and type of air-conditioning systems.)

・Lighting should be allocated using the area ratio between the data center section and the other sections (excluding shared components).

b. Allocation of shared components

・Energy consumption by air-conditioning systems in electrical room s or other areas should be allocated using the energy consumption ratio between IT devices in the exclusive components and other devices (in the office section).

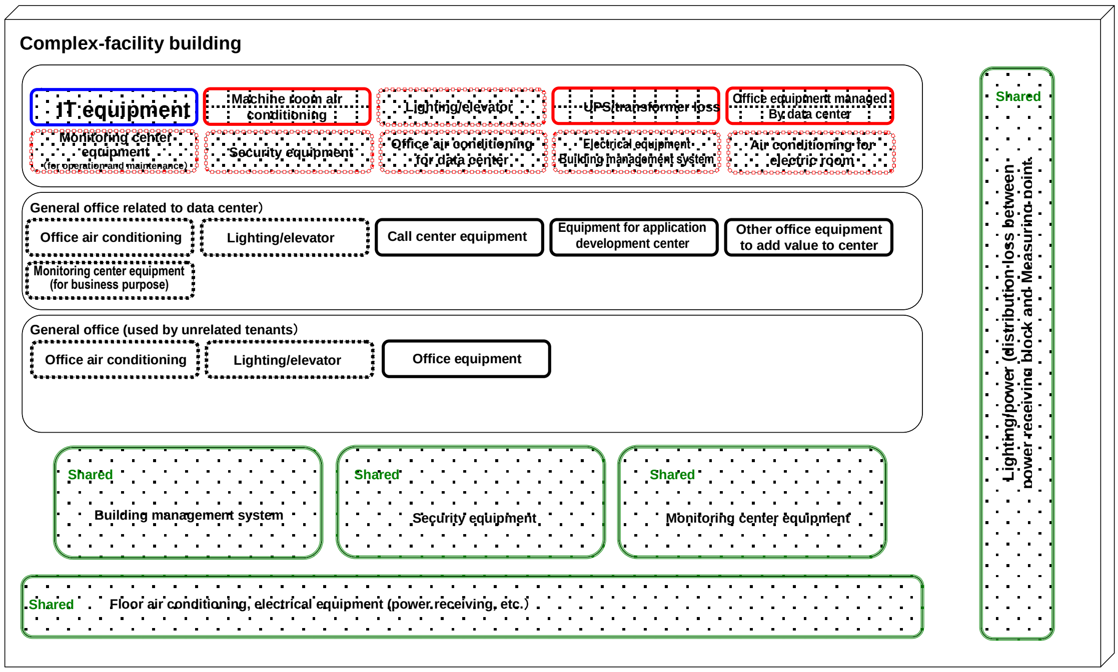
・Shared components, such as passage lighting and elevators, should be allocated using the area ratio between the exclusive components and the other sections (offices, etc.).

[Summary]

The following figure shows a configuration of a complex-facility data center. Equipment and devices consuming energy in a complex facility that encompasses a data center are classified as IT devices, equipment exclusive to the data center, and shared equipment of the complex facility.

Shared equipment of the complex facility is divided between shared equipment to be allocated to the data center and shared equipment not to be allocated to the data center.

The following figure is an example of the configuration of a data center within a complex facility as classified using the classification method as shown below.



◆Classification method

: IT devices

: Equipment exclusive to the data center

: Shared equipment to be allocated to the data center (sections are allocated for calculation)

: Shared equipment of the complex facility

: Shared equipment not to be allocated to the data center (sections are allocated for calculation)

: Equipment not allocated to the data center

◆Shared components, such as air-conditioning systems, and power loss are allocated based on energy consumption.

◆Other shared components (including elevators, electricity for lighting, building management systems) are allocated based on the floor area.

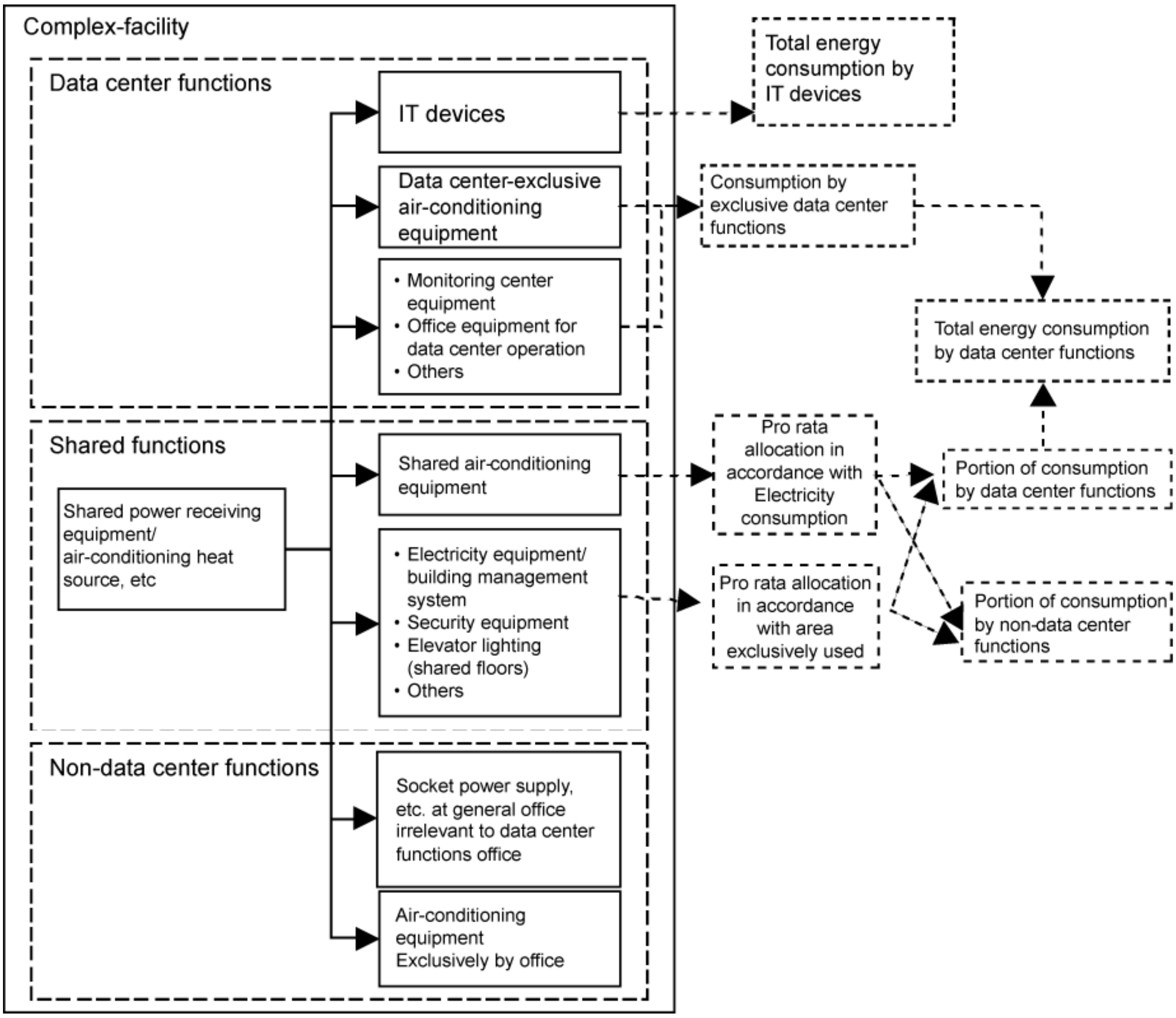
Figure 7 Configuration of a complex-facility data center
(Relation between shared components and exclusive components)

Some data centers have an exclusive facility (building), and others use shared energy equipment. In addition to these data centers, some use both shared energy equipment and exclusive energy equipment, which mutually exchange electricity and heat sources. Some others are known to have energy equipment for data center functions, shared functions, and non-data center functions. The PUE value varies widely depending on the method used to calculate total energy consumption. To compare PUE values for different types of data centers, we need an established calculation rule to integrate energy measurements and to appropriately allocate energy consumption by shared functions.

The energy block chart provided in a Chart shows an integration and allocation rule in accordance with the principle described above.

For complex-facility data centers, the calculation procedure may be simplified by integrating all energy consumption by shared functions with energy consumption by data center functions. In this case, however, the PUE value is lower than actual levels.

Figure 8 A complex-facility data center and the determination of total energy consumption



Energy consumption by lighting, elevators, and other equipment in the shared function should be divided pro rata in accordance with the area occupied by the data center functions and the non-data center function (excluding shared portions such as halls, hallways, restrooms, and meeting rooms) .

Energy consumption by the air-conditioning systems and other equipment in the shared functions, such as the building management system, building monitoring center, and electrical rooms, should be divided pro rata in accordance with electric energy consumed between the data center function using IT devices and related equipment and the non-data center function using office equipment.

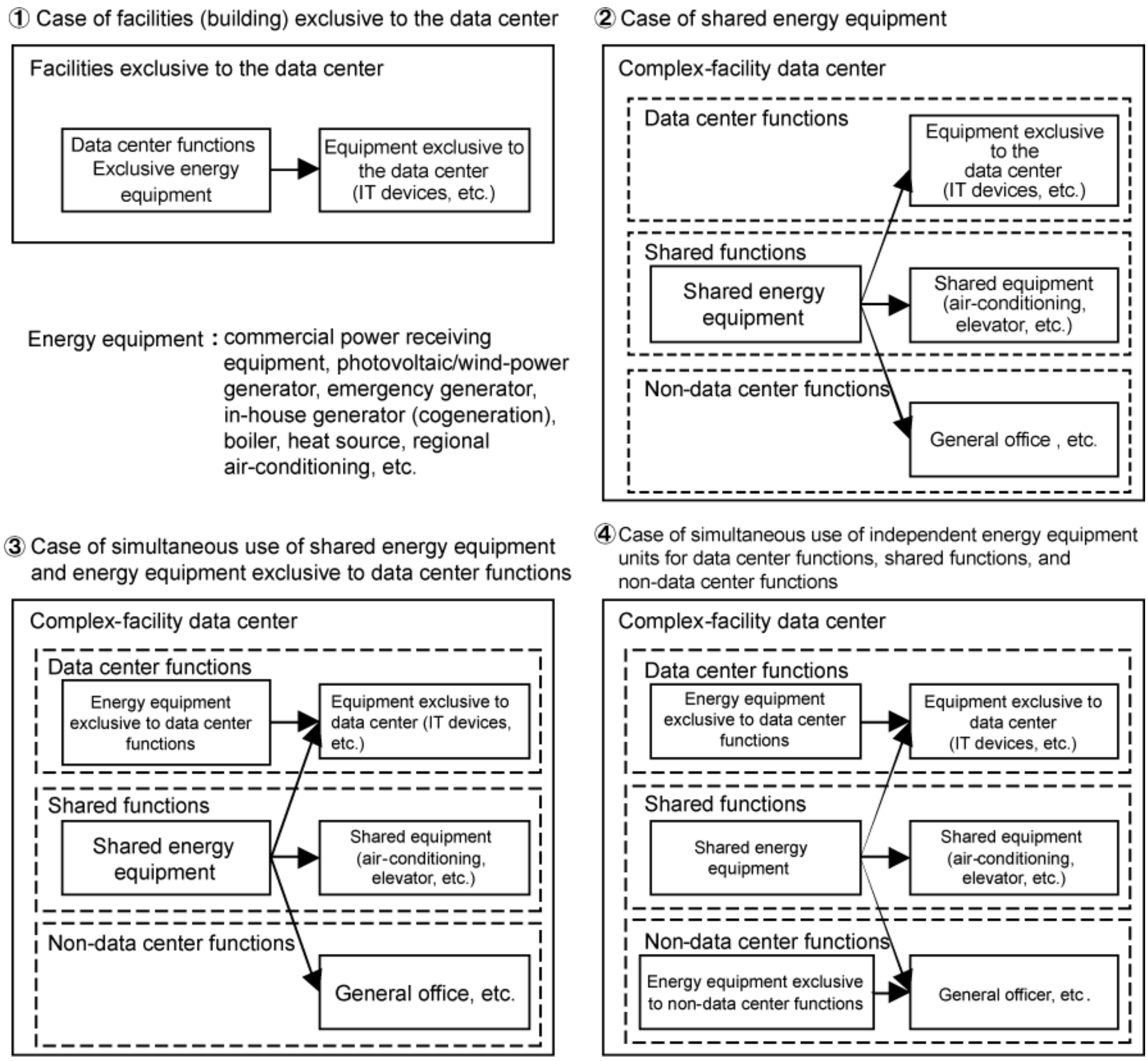
If it is difficult to determine energy consumption by shared air conditioning at a complex-facility data center, the following tool may be useful:

－Tenant Air Conditioning Energy Estimation Tool (annual version)

URL：http://www.eccj.or.jp/bldg-actool/index.html

(The Energy Conservation Center, Japan, Energy Audit Department)

Figure 9 Classification of data centers by the existence of shared energy equipment



［Example of calculation］

Assuming electric energy received by data center of 350,000 [kWh], electricity from photovoltaic generation of 40,000 [kWh], fuel (Type-A heavy oil) consumption by boilers for air-conditioning of 20.3 kiloliters [kl], and energy consumption by IT devices of 30,000 [kWh], the following value can be obtained:

PUE＝(350,000 [kWh]＋40,000 [kWh]＋20.3 [kl] × 10,861 [kWh/kl]) / (30,000[kWh]

＝ 2.03

[Reference] DciE (DataCenter infraconfiguration Efficiency)

DCiE is an indicator equivalent to PUE.

DciE is the inverse number of PUE.

DciE = total energy consumption by IT devices [kWh] / total energy consumption at the data center [kWh] [%]

DciE is expressed in percentage. Its value does not exceed 100%. The greater the value, the higher energy efficiency at the data center. The inverse number of PUE is used to calculate DPPE. DPPE can be calculated easier when DciE is measured. But PUE should be used as a sub-indicator because it is used more commonly.

2.5. Outline of Green Energy Coefficient (GEC)

GEC is a value of consumption of green energy produced by photovoltaic or wind generation on the premises of the data center divided by total energy consumption at the data center.

GEC ＝ the amount of green energy generated and used on the premises of the data center [kWh]
/ total energy consumption at the data center [kWh]

*Green energy: energy generated by using such natural energy sources as solar light and wind

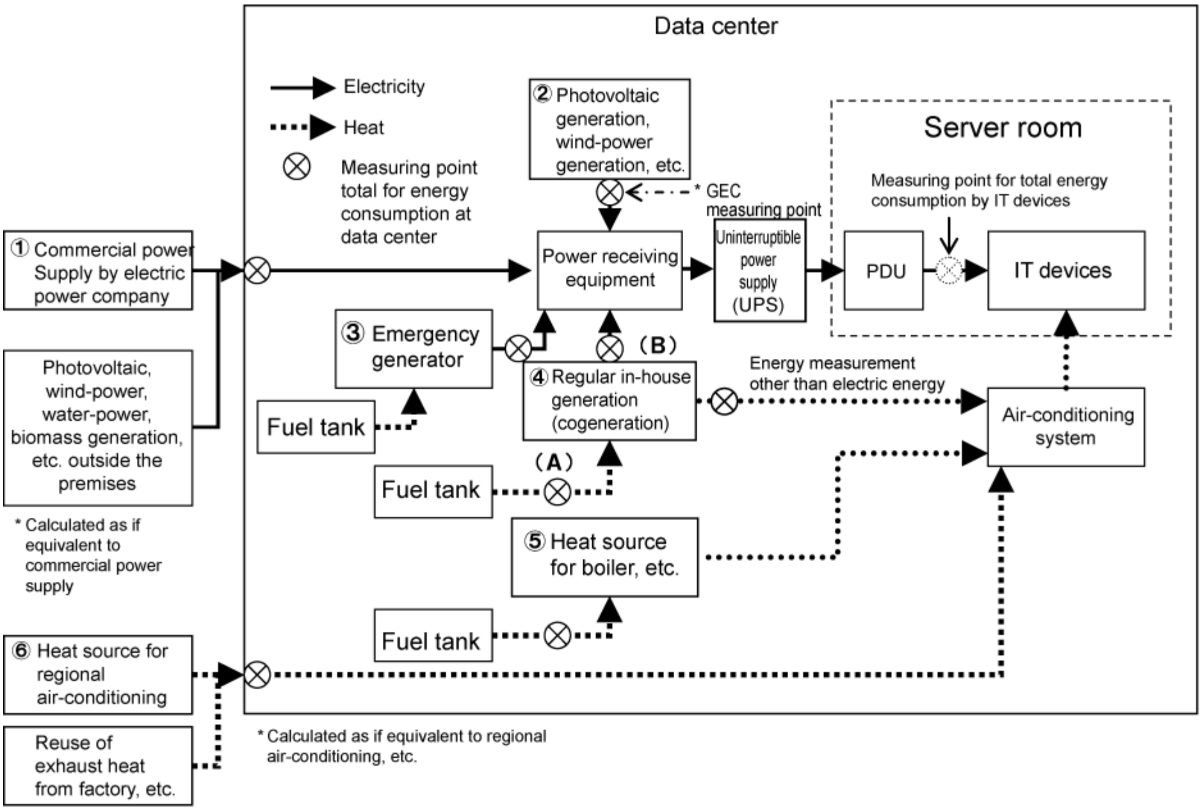
Unit [kWh] should be used as the basic unit to be compatible with the calculation of total energy consumption.

GEC should only cover green energy (electric energy and other types of energy) produced and consumed on the premises of the data center. GEC is an indicator designed to encourage the data center operator to introduce power-generating units based on natural energy sources. Green electricity produced outside the premises of the data center and provided to it on a commercial basis is not included in the indicator.

On the other hand, energy produced using exhaust heat from equipment at the data center is included in green energy.

Energy produced on the premises of the data center by using exhaust heat that is discharged from equipment used for other purposes (e.g. boilers for manufacturing) is not counted as green energy as energy thus obtained is deemed to be used as heat sources for boilers and regional air-conditioning. Instead, such energy is included in calculation of total energy consumption at the data center.

Figure 10 GEC measuring points and treatment of green electricity and exhaust heat



［Example of calculation］

Assuming electric energy received by data center of 350,000 [kWh], electricity from photovoltaic generation of 40,000 [kWh], and fuel (Type-A heavy oil) consumption by boilers for air-conditioning of 20.3 [kl], the following value can be obtained:

$$GEC = 40{,}000[kWh] / (350{,}000[kWh] + 40{,}000[kWh] + 20.3\ [kl] \times 10{,}861\ [kWh/kl]$$
$$= 0.0655 = 6.6\%$$

2.6. Outline of Data Center Performance Per Energy (DPPE)

DPPE is defined as throughput per unit of non-green energy. This value is expressed in the following formula using the four indicators defined above:

DPPE ＝ ITEU × ITEE × (1/PUE) × (1/(1−GEC))

［Example of calculation］

The sub-indicator values obtained are as follows.

ITEU ＝ 0.367

ITEE ＝ 4.02

PUE ＝ 2.03

GEC ＝ 0.0655

DPPE ＝ 0.367 × 4.02 × (1/2.03) × (1 / (1−0.0655))

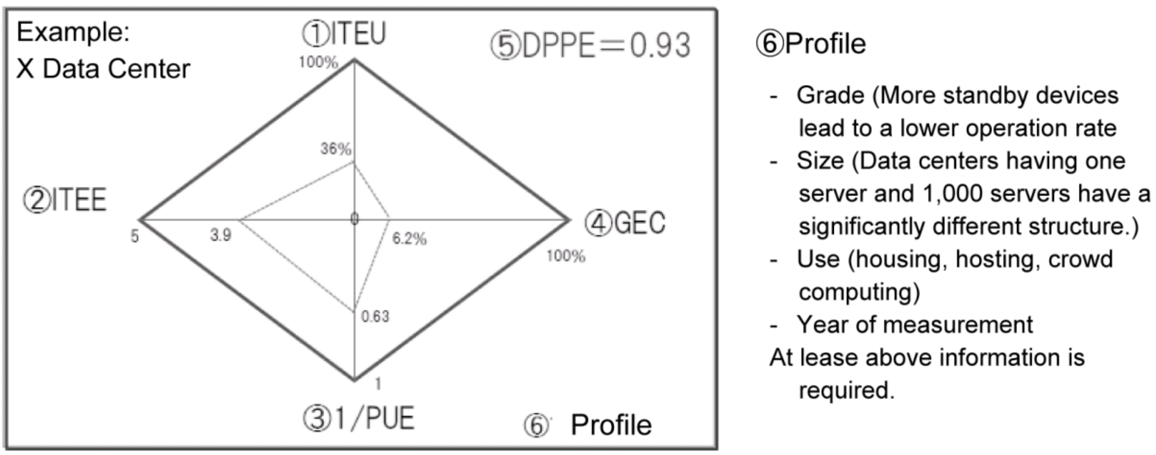
＝ 0.78.

The values of DPPE, ITEU, ITEE, PUE, and GEC should be calculated to at least two places of decimals by rounding them.

DPPE is an totaled indicator determined on the basis of four indicators and thus the value by itself represents a total efficiency. DPPE enables us to identify the status of each energy-saving activity at a data center.

DPPE and its sub-indicators should be indicated together with profile information on such matters as type, grade, and size of the data center.

Figure 11 Example of expressing DPPE and sub-indicators



Currently, as device configuration information is managed insufficiently at data centers, it is extremely difficult to measure rated power and energy efficiency for all IT devices at data centers, specifically in ITEU and ITEE for a data center as a whole.

In practice, PUE and GEC are measured for the data center as a whole, while ITEU and ITEE are measured only for some measurable IT devices, which can cause a difference among data centers in the measurement range for IT devices.

DPPE thus calculated does not represent the energy efficiency of all computing services at the data center. DPPE is instead thought to represent the energy efficiency of computing services by IT devices that have undergone ITEU and ITEE measurement.

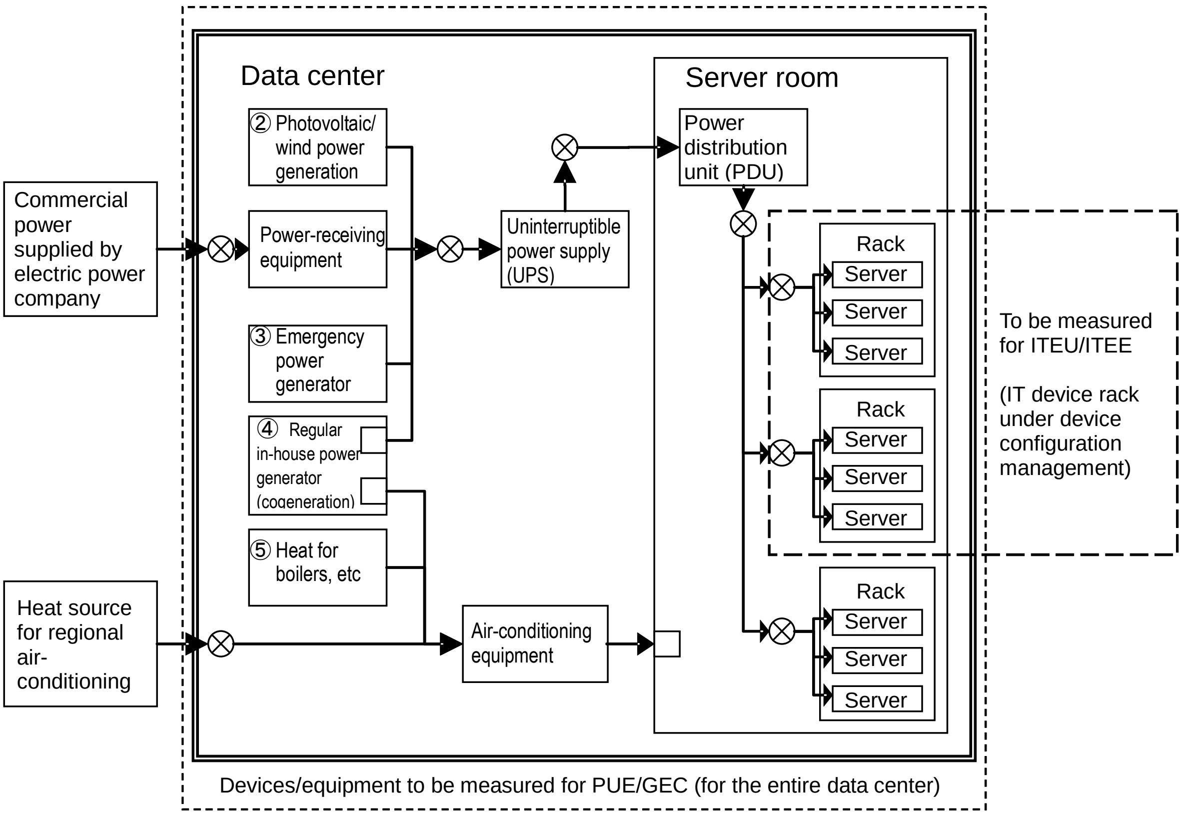


Figure 12 Difference in measurement range between ITEU/ITEE and PUE/GEC

$$\mathrm{DPPE} = \mathrm{ITEU} \times \mathrm{ITEE} \times \frac{1}{\mathrm{PUE}} \times \frac{1}{1-\mathrm{GEC}}$$

ITEU × ITEE: Measured by IT device under device configuration management

$\frac{1}{PUE} \times \frac{1}{1-GEC}$: Measurement covering the entire data center

DPPE for computing services using IT device

3. Measurement Guidelines

3.1. Definition of “data center”

3.1.1 Data center building

A data center refers to a space that exclusively accommodates and manages ICT devices, such as servers, storage units, and network devices, together with a space that accommodates devices for supporting these devices and their operations.

A data center may be either an exclusive facility, which is built as a building designed for exclusive use by the data center and possesses only data-center functions within it, or a complex-facility, which is accommodated within a building designed for other purposes than for the use by the data center and thus possesses non-data-center functions as well.

These Guidelines cover both exclusive-facility and complex-facility data centers.

[Outilne]

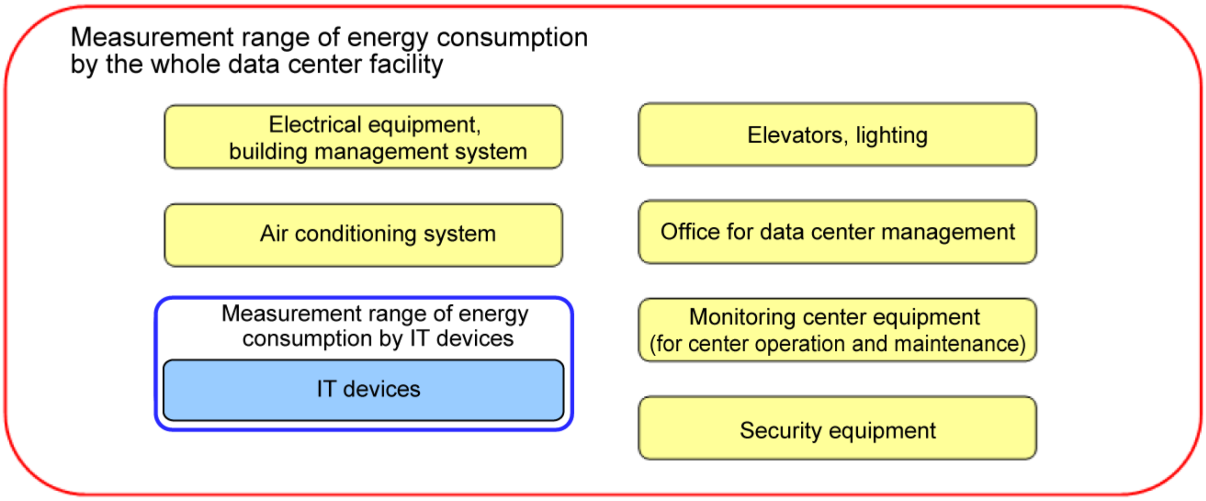
The following figure defines an exclusive-facility data center and a complex facility data center.
elements of equipment and device consuming energy within an exclusive-facility data center or within a complex facility encompassing a data center are divided into three categories, those subject to measurement of energy consumption by IT devices, those subject to measurement of energy consumption by the whole data center facilities, and those not subject to measurement.

In these Guidelines, the data center comprises those subject to measurement of energy consumption by IT devices and those subject to measurement of energy consumption by the whole data center facility, as shown below.

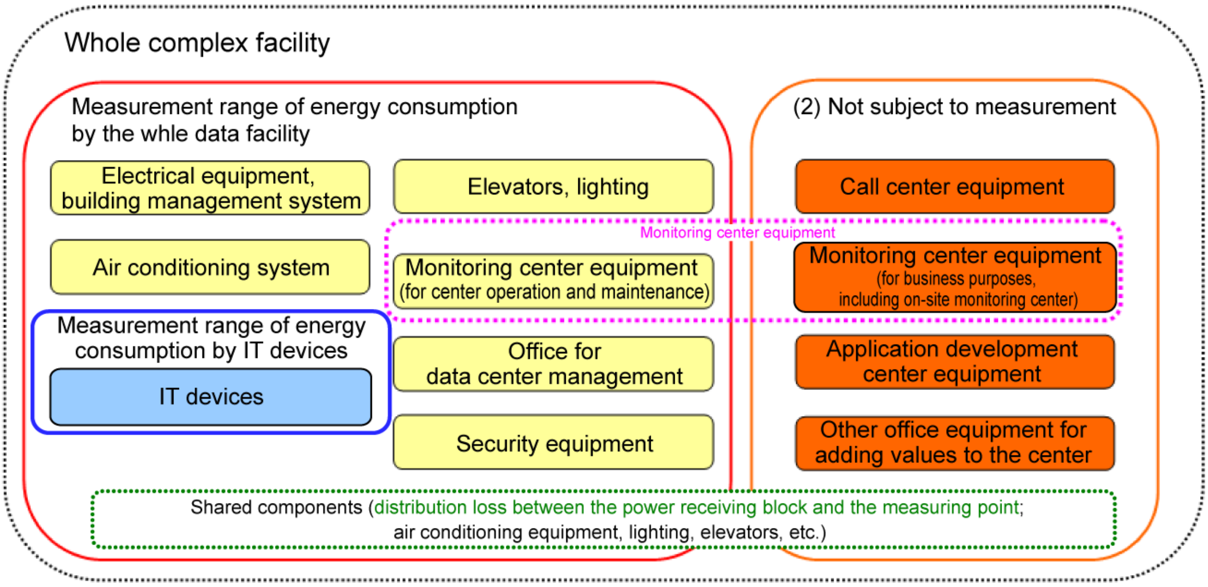
[Description]

・Blue frame (double frame)：shows the measurement range of energy consumption by IT devices.
・Red frame (boldfaced frame)：shows the measurement range of energy consumption by the whole data center facility.
・Orange frame (solid line)：shows the range not subject to measurement.
・Dotted frame：shows shared equipment and devices to be allocated.
※ In these guidelines, the blue frame (double frame) and the red frame (boldfaced frame) constitute a “data center.”

Pattern 1：Exclusive-facility data center



Pattern 2： Complex-facility data center



[Allocation of energy to shared components]
■ Air conditioning equipment, electricity loss, etc, are allocated at a energy consumption ratio between IT devices at the data center and (①) and equipment not subject to measurement at the whole data center facility (in the orange frame).
■ Lighting and elevators are allocated at an area ratio between ① and ②.

Figure 13: Definition of “data center”

3.1.2 Definition of data-center functions

“Data-center functions” refers to functions indispensable to maintain services at data centers. A monitoring center aimed to monitor system operations should be included among the data-center functions. But this definition does not apply to monitoring-center functions that offer services independent of the operation of the data center, such as onsite monitoring services. That is, independent call centers not associated with data-center functions are not a data-center function.

“Non-data-center functions” refers to offices, commercial floors, and similar facilities not associated with any service at the data center. Even if operated by a data center, office functions intended to enhance the added value of the data center, such as the sales department, general affairs department, and application development environment (e.g. standalone computers in the program development office) are non-data-center functions.

Any function used jointly by a data-center functions and a non-data-center function (e.g. shared power supply equipment, shared air-conditioning systems, and shared elevators) is a “shared function.”

At a complex-facility, exclusive equipment to the data center, such as an exclusive electrical room, UPS room, and air-conditioning control room, is included among the data-center functions.

A call center or any other components independent of data-center functions are not call-center functions.

Rooms performing system monitoring (including a monitoring center) are call-center functions if they are incidental to the data center and operating to maintain its functions, but monitoring centers are not included among the functions if they are part of business, such as on-site monitoring services, and independent of the data center.

Office functions intended to add values to the data center are excluded (e.g. sales department and general affairs department).

Facilities for application development are excluded.

Under Figure 13 (Definition of “data center”), the data center includes electrical rooms, UPS rooms, air-conditioning machinery rooms, and their equipment if they are used for a complex-facility data center and thus in the measurement range.

3.2. Recording data-center profiles

3.2.1 Necessity of recording data-center profiles

The values of DPPE and its sub-indicator can vary widely even among data centers operating on the same specifications, depending on their environment and operation purpose. The values can also differ significantly, depending on what kind of equipment is used and how the operations are managed, even if the data centers are in a similar environment and used and run in a similar manner.

To compare data centers, it is important to obtain such profile information. In this respect, we need to measure DPPE and its sub-indicators and simultaneously record the measurements and make available such records together with indicator, as necessary.

Relevant data-center profile items are set out in Exhibit.

3.2.2 Necessity of the configuration management of IT devices and the recording of configuration management of equipment and devices

Any change in the configuration of IT devices, such as the introduction of new IT device, definitely affects ITEU and ITEE. In addition, any change in a load can affect PUE and GEC. For this reason, it is required to regularly manage the configuration of IT devices.

Because such factors in data-center equipment and devices as electricity supply architecture, cooling architecture, redundant level, and equipment layout also substantially affect the data-center efficiency, configuration management and recording of changes in such equipment and devices is essential.

3.3. Measuring IT Equipment Utilization (ITEU)

3.3.1 Definition of ITEU

ITEU ＝ total measured energy consumption by IT devices [kWh]
/ total rated energy consumption by IT devices [kWh]

ITEU ＝ Σ(IT-EPE_n) / Σ(IT-EPEspec_n)

IT-EPE_n [kWh]: measured electricity consumption by IT devices

Σ(IT-EPE_n) [kWh]: total measured electricity consumption by all IT devices within the measurement range

IT-EPEspec_n [kWh]: rated power of IT devices multiplied by the measuring period (rated electric energy)

Σ(IT-EPEspec_n) [kWh]: total rated electric energy of all IT devices within the measurement range

3.3.2 Measuring method for ITEU

(1) Selecting IT devices for measurement range

The measurement zone should be determined on the basis of the rated power obtained in IT device configuration management by floor, by PDU, by rack, or by other unit and to the extent that actual measurement of electricity consumption is feasible.

(2) Measuring IT-EPE_n

By using a wattmeter on PDU connected to IT devices, electricity consumption by IT devices (IT-EPE_n [kWh]) should be measured for the measuring period.

In measuring electric energy, the power factor should be simultaneously measured to determine electric energy by effective electric power.

Effective electric power (VA) ＝ current (A) ×voltage (V) ×power factor (%)

For the measurement range, IT-EPE_n values should be aggregated to determine Σ(IT-EPE_n) [kWh].

If in measurement of only currents and voltages, the power factor cannot be obtained and thus electric energy cannot be determined accurately, then the hypothetical power factor of 95% should be used to determine the effective electric energy. Relevant records should be maintained for evidence. IT devices under power suspension are not counted in calculation of rated electricity consumption.

(3) Measuring IT-EPEspec_n

Using the device configuration management register, the maximum rated power should be obtained for all IT devices installed within the measurement zone. If no such register is established, the maximum rated power should be obtained from the nameplate or catalog for devices.

To determine electric energy IT-EPEspec_n [kWh], multiply the maximum rated power by number of hours during the measuring period.

IT-EPEspec [kWh] = rated power [kW] × measuring period [h]

For the measurement zone, IT-EPEspec_n values should be aggregated to determine Σ (IT-EPEspec_n) [kWh].

It is to be noted that different vendors use different rated power values.

(4) Calculating ITEU

ITEU should be determined from Σ(IT-EPE_n) and Σ(IT-EPEspec_n).

ITEU ＝ Σ(IT-EPE_n) / Σ(IT-EPEspec_n)

In the calculation, the measured electric energy Σ(IT-EPE_n) and the rated electric energy Σ(IT-EPEspec_n) must cover the same IT devices.

If IT devices have a redundancy, the rated electric energy should be calculated only for the active IT devices, if they are an active standby (cold standby) type, and for all IT devices, if they are a full-time dual (hot standby) type.

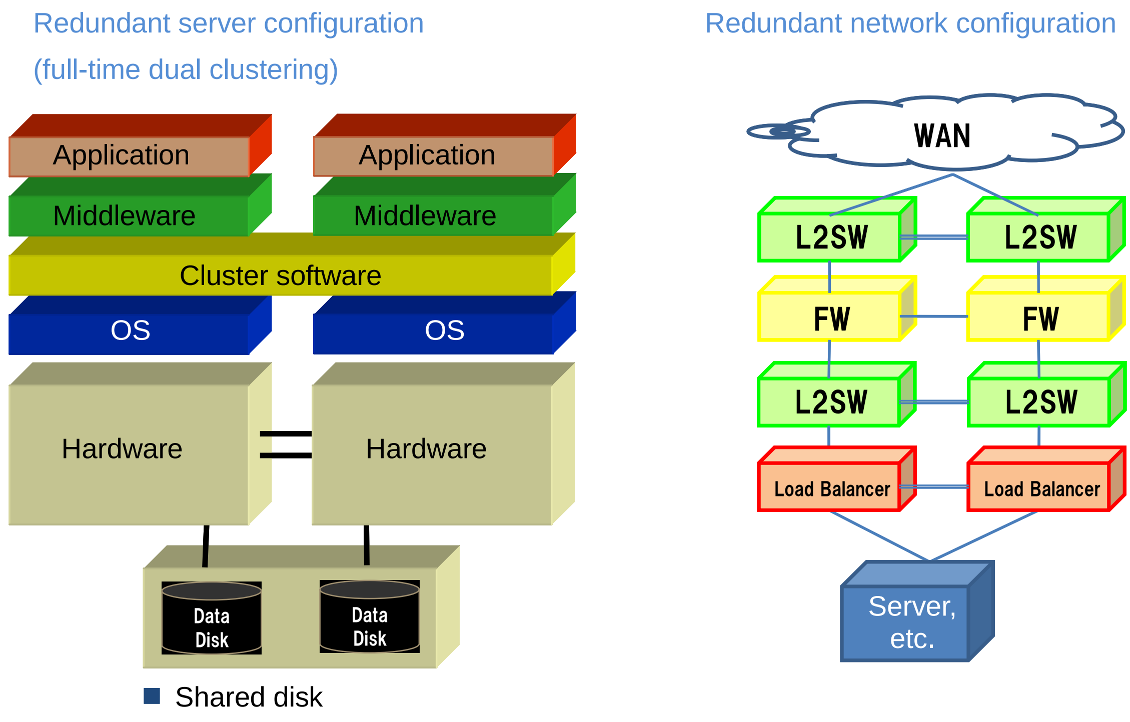
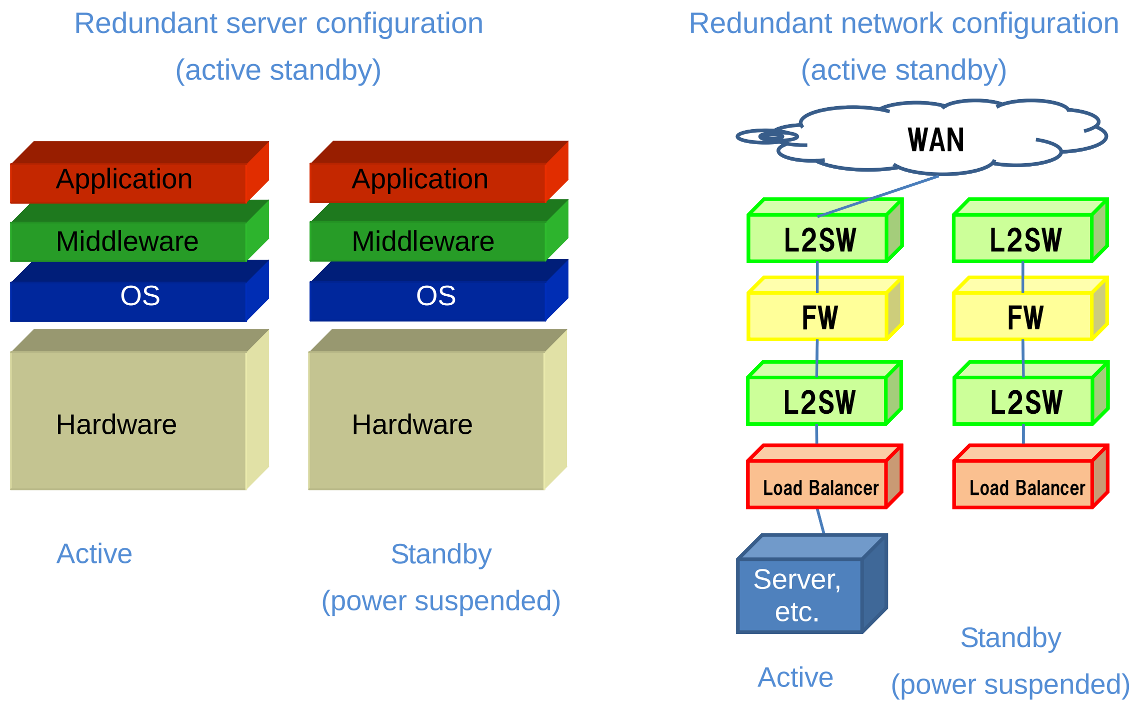


Figure 14 Full-time dual redundancy configuration



IT devices in power-off mode are not included in calculation of rated electricity consumption.

Figure 15 Active-standby redundancy configuration

3.3.3 Measuring period and measuring frequency for ITEU

(1) Measuring period

ITEU should be measured and calculated on a monthly basis (00:00 of the first day through 24:00 of the last days of the month).

For publication or comparison, ITEU should be provided, as a rule, in an totaled value covering the whole year. Any measuring period shorter than one year should be defined.

(2) Measuring frequency

Total energy consumption (total electricity consumption [kWh]) by IT devices should be measured in a continuously totaled value (totaled electricity consumption).

The power factor of IT devices should be taken into account in measurement of electric energy by effective electric power. If an accurate electric energy [kWh] value reflecting the power factor is not obtained (only continuous voltage [V] and current [A] values can be measured), a power factor value measured temporarily in the past (or a power factor assumed for calculation) may be used to determine electric energy [kWh] with voltage [V] and current [A]. If the power factor is not known or cannot be measured, the value 95% should be used.

If totaled values cannot be measured throughout the measuring period because of the unavailability of an integrating meter (e.g. integrating wattmeter) or for any other reason, the totaled values should be determined by using either of the following methods:

(a) Select one day within the measurement month, continuously measure and record instantaneous values (using an instantaneous power meter) throughout the day to determine the totaled value for the day, and multiply the value by the number of days of the month to determine the totaled value for the month.
(b) Select one day within the measurement month, measure and record an instantaneous value (using an instantaneous power meter) once for the day, convert it into a 24-hour value, and then multiply the value by the number of days of the month to determine the totaled value for the month.

The method taken, (a) or (b) above, should be clarified together with the measured values. As with the integrating meter, the power factor should be taken into account in the measurement using either of the methods.

To determine total rated energy consumption by IT devices [kWh], convert the rated power value obtained from device configuration management as of the end of the month into a 24-hour value, and multiply the 24-hour value by the number of days of the month to obtain the monthly value.

＜Treatment in calculation of servers switched off for energy-saving and other purposes＞

If servers are kept switched off for energy-saving and other purposes, the saved rated energy consumption corresponding to the suspension should be excluded from ITEU calculation (total rated energy consumption by IT devices [kWh]).

In these guidelines, “power suspension” refers to S4=Hibernation or S5=Power Off in the ACPI specification, and international standard for PC/AT-compatible power supplies . In sleep mode, servers are not excluded from calculation because their components keep consuming electricity.

The ACPI definitions are provided below.

The TCPI specifications should apply to Linux or Unix systems, for which no definitions are established.

S0 : Power On

S1 : Sleep or standby mode. The system shifts to energy saving mode by suspending the processing functions of the system, such as interrupts, while CPU maintains device and register context and cache context. Only a few operations are carried out during the time as power management events. The system can be resumed smoothly.

S2 : Same as S1 except that Suspend CPU and system memory loses cache context.

S3 : Sleep mode, also called “Suspend to RAM.” The register context and all other, except system memory, are lost. Before entering suspend-to-RAM, the OS writes register context to the memory and place the recovery vector at a certain place in FACS. Restoration is made from the reset status. The system finally returns to operation status by rewriting the register.

S4 : Hibernation, also called “Suspend to Disk.” The memory contents are written to the disk before being lost, in a state equivalent to a switch-off. The boot loader or the OS detects the presence of hibernation contents and rewrites the memory contents.

S5 : Soft Off. A minimum amount of electricity is provided in a sate equivalent to a shutdown. Recovery is made by rebooting. Full cut-off of the power supply is called “G3: Mechanical Off.”

In preparing an ITEU sheet, “hours during which electricity is not supplied to devices” should be totalized and recorded in the “Total suspension time” column.

(Example)

If five model-A servers operate as follows,

Server 1： suspended every weekend between 23:00 (Saturday) and 18:00 (Sunday),

Servers 2 & 3： not suspended, and

Servers 4 & 5: suspended daily between 0:00 and 7:00,

then, monthly suspension time is $(19 \times 4 + 0 \times 2 + 7 \times 30 \times 2) = 496$ hours.

If servers vary in operation time to cause more time for calculation, lines may be added to the sheet to record figures for each server.

＜Treatment of devices without a catalog＞

If devices are not accompanied by a catalog, they may be excluded from ITEE calculation because of difficulty collecting necessary data.

＜Treatment of blade servers＞

If rated power is available for both the chassis and the blade, the maximum rated power (of the chassis) should be recorded.

If blades having different CPUs are housed in the same chassis, each blade should be treated as one unit of server, and calculation should be made for energy efficiency of each CPU.

＜Treatment of storage＞

If disk drives have different energy efficiency values, the maximum configuration of modules should be used for calculation.

3.4. Measuring IT Equipment Energy Efficiency (ITEE)

3.4.1 Definition of ITEE

ITEE ＝ total rated capacity of IT devices [W] / total rated power of IT devices [W]

$$ITEE = \Sigma(\alpha \times Xn\_server + \beta \times Xn\_storage + \gamma \times Xn\_nw) / \Sigma(EPn\_server + EPn\_storage + EPn\_nw)$$

Xn_server [GTOPS]: rated capacity of servers
Xn_storage [Gbyte]: rated capacity of storage unit
Xn_nw [Gbps]: rated capacity of network device
EPn_server[W]: rated power of Xn_server
EPn_storage[W]: rated power of Xn_storage storage unit
EPn_nw[W]: rated power of Xn_nw network device
α＝7.72[W/GTOPS]
β＝0.093 3 [W/Gbyte]
γ＝7.14[W/Gbps]

3.4.2 Measuring method for ITEE

（1） Selecting IT devices for measurement

The measurement zone should be determined on the basis of the rated power obtained in IT device configuration management, by floor, by PDU, by rack, or by other unit and to the extent that actual measurement of electricity consumption is feasible.

The IT devices should be classified into three types–servers, storage units, and network devices. The other devices should be categorized as “IT devices,”

（2） Calculating the rated capacity of IT devices Xn_server, Xn _storage, and Xn _nw

The rated capacity should be determined on the basis of “energy efficiency” and the maximum rated power specified by the Energy Saving Law and on respective IT device catalogs.

Xn_server [GTOPS]= EPn_server[W] / energy efficiency of Xn_server [W/Gtops]
Xn_storage [Gbyte]= EPn_storage[W] / energy efficiency of Xn_storage [W/Gbyte]
Xn_nw [Gbps]= total throughput of Xn_nw (number of ports × total maximum speeds) [Gbps]

In the 2007 version, server performance was expressed in W/MTOPS. In the 2010 version W/GTOPS is used instead. For this reason, to use energy efficiency values provided in the 2007 version, they need to be converted using the following equation:

Energy efficiency in the 2010 version [W/GTOPS]
＝ Energy efficiency in the 2007 version［W/MTOPS］ × 1,000

The total throughput of devices should be used provisionally as the energy efficiency of network devices.

For each server, storage unit, and network device, α, β, and γ should be multiplied to determine the total rated capacity Xn for all servers, storage units, and network devices.

Total rated capacity $\Sigma(Xn)$ [W] ＝ $\Sigma(\alpha \times Xn\_server + \beta \times Xn\_storage + \gamma \times Xn\_nw)$.

The other IT devices should be excluded from the calculation of rated capacity.

（3） Calculating the rated power of IT devices

The device configuration management register should be checked for the maximum rated power of all servers, storage units, and network devices installed within the measurement zone. If a register is not established, check the nameplates or catalogs for devices.

The other IT devices should be excluded from the calculation of rated capacity.

Total rated power EPn should be determined for all servers, storage units, and network devices installed within the measurement zone.

Total rated power $\Sigma(EPn) = \Sigma(EPn\_server + EPn\_storage + EPn\_nw)$

（4） Calculating ITEE

ITEE should be calculated using total rated capacity $\Sigma(Xn)$ and total rated power $\Sigma(EPn)$.

$ITEE = \Sigma(Xn) / \Sigma(EPn)$

Total rated capacity $\Sigma(Xn)$ and total rated power $\Sigma(EPn)$ must cover the same IT devices in calculation.

If IT devices have a redundancy, the rated capacity and the rated power should be calculated only for the active IT devices, if they are an active standby (cold standby) type, and for all IT devices, if they are a full-time dual (hot standby) type.

3.4.3 Measuring period and measuring frequency for ITEE

（1） Measuring period

ITEE should be measured and calculated on a monthly basis (00:00 of the first day through 24:00 of the last days of the month) .

For publication or comparison, the ITEE value should be, as a rule, the 12-month average of ITEE values. Any measuring period shorter than one year should be defined.

（2） Measuring frequency

For total rated capacity and total rated power [W] of IT devices, the value calculated from device configuration management as of the end of the month should be used as the ITEE value for the month.

＜Treatment of devices without a catalog＞

If devices are not accompanied by a catalog, they may be excluded from ITEE calculation because of difficulty collecting necessary data.

＜Treatment of blade servers＞

If rated power is available for both the chassis and the blade, the maximum rated power (of the chassis) should be recorded.

If blades having different CPUs are housed in the same chassis, each blade should be treated as one unit of server and calculation should be made by energy efficiency of each CPU.

＜Treatment of storage＞

If disk drives have different energy efficiency values, the maximum configuration of modules should be used for calculation.

＜Network devices＞

If the actual number of ports mounted is unknown, the maximum number of ports stated in the catalog may be entered.

3.5. Measuring Power Usage Effectiveness (PUE)

3.5.1 Defining PUE

PUE = total energy consumption by data centers [kWh] / total energy consumption by IT devices [kWh]

PUE ＝ D_T_JE / IT_T_EPE

D_T_E [kWh]: total energy consumption by data center
IT_T_EPE [kWh]: total energy consumption by IT devices

3.5.2 Measuring method for PUE

（1） Selecting data-center functions
(Refer to Exhibit 2)

(i) **Energy consumption by IT devices** (Refer to Exhibit 2: Energy allocation at a complex facility)

・The following loads are defined as energy consumption by IT devices (electric energy):
  ー all IT equipment, including servers, storage devices, and network devices, and
  ー supplementary devices such as KVM switches, monitors, and workstations/notebook PCs.

(ii) **Energy consumption by the whole facility** (Refer to Exhibit 2: Energy allocation at a complex facility)

・In addition to energy consumption by the IT devices (electric energy) listed in the preceding paragraph, the energy consumption by the whole facility covers various devices that support such IT equipment and devices.

・Elements supporting IT equipment and devices：
  (a) electricity supply components such as UPS, switches, power generators, PDUs, and batteries and transmission loss,
  (b) cooling systems and components such as freezers, computer-room air conditioners (CRACs), direct expansion cooling units, pumps, and cooling towers,
  (c) other components, such as data-center lighting.

・Any personal computers, copiers, printers, fax machines, and other devices installed in the office area for office use should be included in calculation of energy consumption by the whole facility.

・Measurements obtained for electrical and other energy-consuming devices should be totalized to constitute energy consumption by the whole facility. Energy consumption should be represented in electric energy (kWh) after undergoing source energy conversion (described later).

（2） Total energy consumption at the data center: measurement of D_T_E

(i) **Basic concept on measurement**

1) **Data centers using only electricity as an energy source**

・For data centers using only electricity, measurement should be made only for electric energy (a) and total consumption should be expressed in kWh.

(Basically, total electric energy measured on power receiving equipment should be used as electric energy of the whole facility. Electricity generated by photovoltaic generation or wind power generation should be added to the calculation.)

(a) [kWh]

・ If commonly used in-house power generators are applied, fuel consumption by the power generator should be converted into electric energy (kWh) (b) and multiplied by the source energy conversion factor to obtain total consumption.

(Refer to 2.3.1 (1) (b))

(a)＋(b)×0.35 [kWh]

(Note)

Energy consumed by emergency in-house power generators in trial runs should not be counted. If emergency in-house power generators are used in an emergency, electric energy (kWh) generated should be counted.

If the electric energy generated by emergency in-house power generators is known by using a meter, electric energy during power outage should be estimated on the basis of commercial electric energy generated before and after the power outage.

2) **Data centers consuming multiple energy sources**

・For data centers using electricity and other energy sources, measured energy amounts should be converted to electric energy (kWh) by using the Energy Conversion Table and multiplied by the source energy conversion factor.

(Refer to Table 4 Energy Conversion Factor by Energy Source)

(Refer to Exhibit 1 Energy Conversion Table)

(Example) Data center using commercial electricity (a: kWh) and type-A heavy oil (B：kL):

(a)[kWh]＋B[kL]×39.1[GJ/ kL]×278[kWh /GJ]×0.35：[kWh]

(ii) **Unit of conversion for energy amount for publication**

・Total energy consumption by the data center should be expressed in electric energy [kWh].

(iii) **Energy measurement and totaling energy amounts**

1) **Basic concept for measuring instruments**

・Measuring instruments used should comply with the TGG concept. The measurement error range of existing measuring instruments should be expressly defined.

・Existing measuring instruments may be used because any commercial measuring instrument may have a measurement error of only several percent.

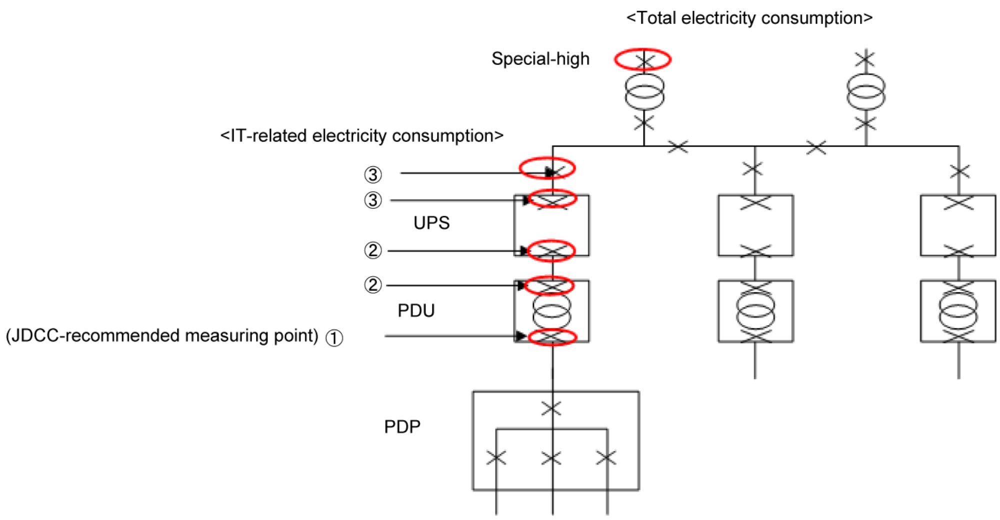
2) **Measurement using an integrating meter**

・Measurement using an integrating meter is recommended.

3) **Measurement of electricity consumption without an integrating meter**

- If an integrating meter is not installed on the PDU or UPS outlet, measurement should be made with the nearest upstream integrating meter. Loss in each device should be subtracted from the measurements obtained.(Refer to Figure 16 Using an upstream meter)
- If measurements thus obtained are not suitable for use, instantaneous values (to be measured at least once a month) should be converted into total annual electricity consumption.(Refer to Figure 17 Converting instantaneous values into total electricity consumption)
- If a clamp-type meter is in place for 24 hours for a period of 365 days, the measuring instrument is deemed to be in place at all times.

◆ If measurement is impossible at measuring point ① when using an upstream measuring instrument, then make measurement at measuring point ②.
If measurement is impossible at measuring point ②, then make measurement at measuring point ③.



Loss conversion for the use of an upstream meter

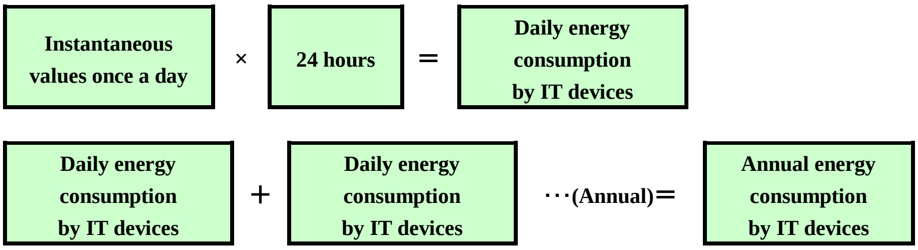
Measurement table for upstream meter − **Loss in PDU and UPS** ＝ **Energy consumption by IT devices**

※ Use a predetermined value as the conversion factor (targeted at 3% for step-down transformer and 2 to 4% for cable loss).
If values appear to be larger at actual sites than at measuring points, actual loss should be calculated from instantaneous values that are obtained upstream/downstream from PDU and UPS. (Refer to Figure 25 Treating loss in step-down transformers, etc.)

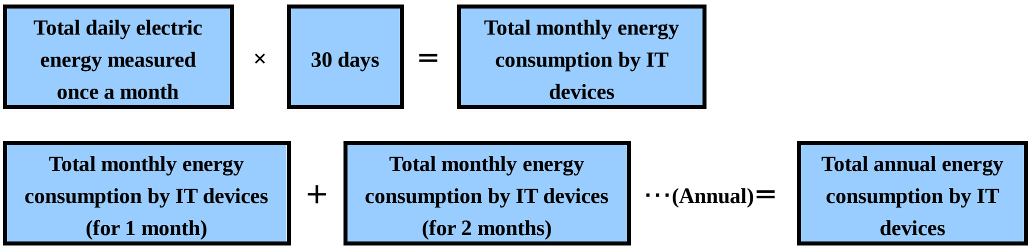
Figure 16 Using an upstream meter

Converting instantaneous values into total annual electric energy

(1) Daily measurement



(2) Monthly measurement



◆ Errors from three units of measuring instruments should be handled as follows. Priority should be given to a measuring method that is subject to fewer errors.

	Error	Gravity of error
Use of an upstream meter	Loss error in UPS, PDU, and wiring	Minor (measurement of actual loss possible)
Measured once a day	Daily IT load fluctuation error	Minor to medium
Measured once a month	Monthly IT load fluctuation error	Medium to major

Figure 17 Converting instantaneous values into total electricity consumption

(iv) Conversion to total electricity consumption

1) Converting values from upstream integrating meters into total electric energy:

(Refer to Figure 16 Using an upstream meter)

･If measurement is made using measuring instrument located upstream from the PDU outlet as recommended by these Guidelines, loss (e.g. transformer loss) caused between the measuring instrument and the PDU output should be subtracted.

･A predetermined value should be used as the conversion factor.

(Targeted at 3% for step-down transformer and 2 to 4% for cable loss)

(Refer to Figure 25 Treating loss in step-down transformers, etc.)

･ If values appear to be larger at actual sites than at measuring points, actual loss should be calculated from instantaneous values that are obtained upstream/downstream from PDU and UPS. (Evidence should be maintained.)

2) Converting current values into total annual electric energy

(Refer to Figure 17 Converting instantaneous values into total electricity consumption.)

･Measurement should be made at least once a day to obtain instantaneous values (visually or by reading a meter), which should be totaled and converted into 24-hour electricity consumption.) The 24-hour values should be totaled to obtain annual electricity consumption.

・Measurement should be made once a month to obtain total daily electric energy. The value should be converted into monthly electricity consumption. The monthly electricity consumption should be totaled to obtain annual electricity consumption

3) **Measuring the power factor for converting instantaneous values into total electricity**

(Refer to Figure 18 Power factor)

・Total electricity consumption can be obtained from instantaneous values by [voltage (V) × electric current (A) × power factor (%)]. Thus, the power factor needs to be measured. If the power factor cannot be determined, the value of 95% is recommended.

※ Measurement the power factor

Actual total electricity consumption (kW) by IT devices is calculate by voltage (V)×electric current (A)×power factor (%), unlike KVA＝voltage (V)×electric current (A).

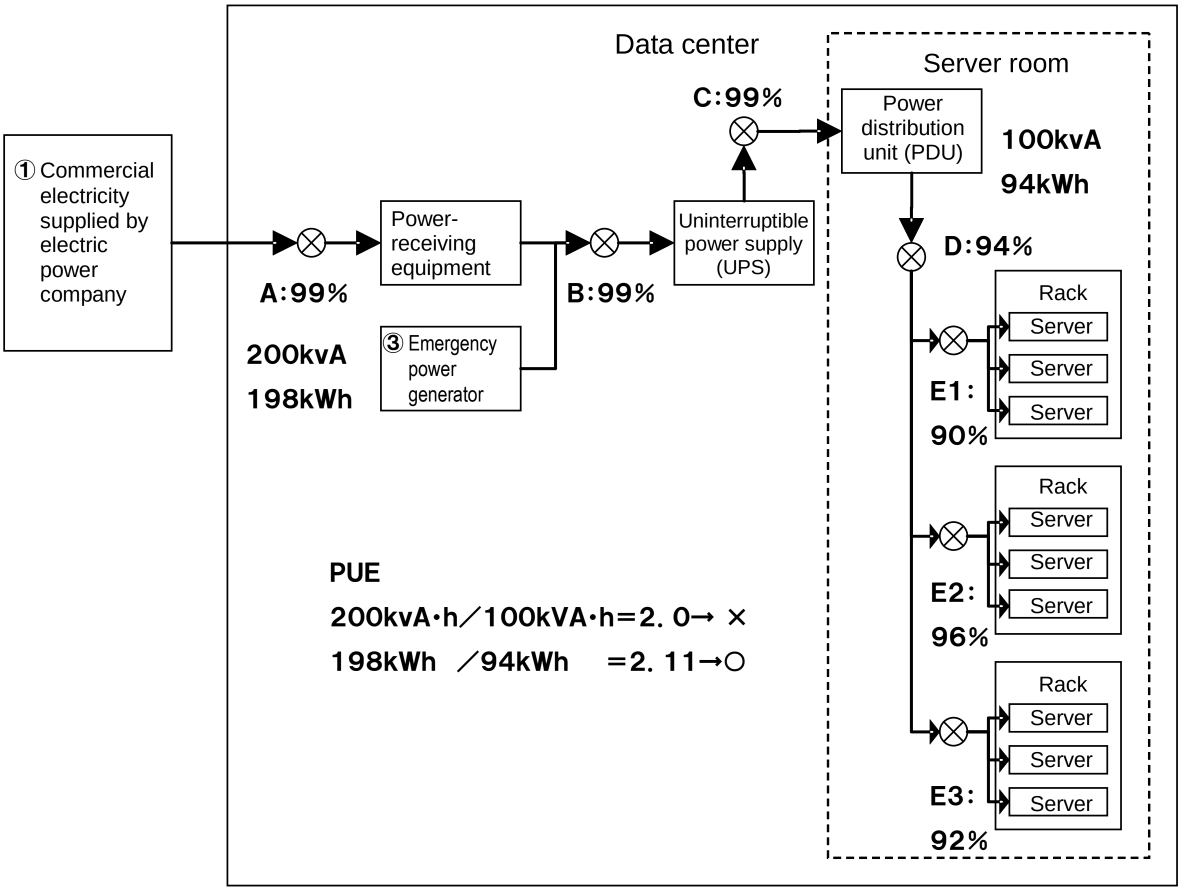
Thus, the power factor should be taken into consideration when calculating PUE.

On the basis of sample measurement data, it is known that the power factor for IT devices varies by some percent (ten or more percent in some cases) depending on the type and load.

If the power factor is not used in determining total energy consumption by IT devices (electric energy [kVAh]), the resulting total energy consumption by IT devices is larger than it really is.

For this reason, to measure total energy consumption by IT devices (electric energy [kWh]), the power factor should be taken into account, instead of using electric current [A] × voltage [V].

Measuring the power factor for data centers



Example: Power at data center 200kVA; apparent electricity for IT devices 100kVA

At power factor of 100% (power factor not considered) PUE=200[kVA]/(100[kVA]*100%)=2.00

At power factor of 96% PUE=200[kVA]/(100[kVA]*96%) =2.08

At power factor of 90% PUE=200[kVA]/(100[kVA]*90%) =2.22

It is desirable to measure total energy consumption by IT devices (electric energy) using a continuous method. Thus, the power factor, in addition to electric current and voltage, should be taken into account in measurement of electric energy. Unfortunately, few measuring instruments are available to permit measurement of power factor. This fact suggests that data centers do not conduct continuous measurement to determine the power factor.

The power factor varies depending on how IT devices are configured after PDU within the system. But the power factor is known from measurement data to change little with time. For this reason, total energy consumption by IT devices may be determined by multiplying the electric energy continuously measured with an electric current and a voltage by the average power factor value obtained in the past from temporary measurement with a handy terminal. If the power factor is not known or immeasurable, a recommended value of 95% should be used.

Example of power factor from sample measurement data

Ave	Var	Max	Min
95.8%	46.6%	100%	64%

Figure 18 Power factor

(v) **Measuring and converting other energy sources than electricity**

(Refer to Exhibit 1 Energy conversion table)

- If the data center makes chilled water with gas or heavy oil or purchases chilled water from heat providers, the following method should be used for calculating quantities of heat.
- For equipment using other energy sources than electricity, energy should be measured for each piece of equipment and converted into electric energy, which should then be multiplied by the source energy conversion factor and integrated with electric energy consumed by electricity-powered equipment.
- The following shows how to measure different types of equipment.

＜Example of measurement＞

1) **Gas (LPG)**

- Measuring instrument：flowmeter (integrating meter)
- Measuring point：freezer inlet
- Heat quantity conversion：Monthly heat consumption is determined on the basis of total consumption for preceding months using measurements with a flowmeter (integrating meter), and it is then converted into electric energy [kWh] and multiplied by the source energy conversion factor.

B［t］×50.2［GJ/t］×278[kWh /GJ]×0.35：[kWh]

2) **Heavy oil (Type-A heavy oil)**

- Measuring instrument：integrating meter or volumes of heavy oil purchased
- Measuring point：Receiving line from the oil tank
- Heat quantity conversion：Monthly heat consumption is determined on the basis of total consumption for preceding months using measurements with flowmeter (integrating meter), and it is then converted into electric energy [kWh] and multiplied by the source energy conversion factor.

B［kL］×39.1［GJ/ kL]×278[kWh /GJ]×0.35：[kWh]

3) **Heat provider (Urban type)**

- Measuring instrument：heat quantity meter (chilled water and warm water), steam flowmeter, or return water flowmeter (steam)
- Measuring point：consumer’s receiving facility
- Heat quantity conversion：For chilled water and warm water, heat quantity is calculated from the readings on the heat quantity meter. For steam, the enthalpy of return water is subtracted from the enthalpy of steam corresponding to pressure and temperature. Heat quantity is determined by multiplying the value obtained by steam quality. If the steam and the return water are of the same quantity (that is, there is no direct steam), then the return water quantity may be used.

(Refer to 2-3-3-(c) Equation for steam heat quantity)

The value obtained should be converted into electric energy [kWh] and the source energy conversion factor.

C［GJ］×278[kWh /GJ]×0.4：[kWh]

If the electric energy conversion factor is available from the heat provider, the factor may be used.

At international conferences, the common conversion factor is used as a rule to make international comparison of PUE. However, a conversion factor available from the heat provider may be used to make comparison within the Japanese market or track any chronological changes at the data center.

Steam heat quantity [kJ]

＝steam quantity [kg]×(enthalpy of steam [kJ/kg]－enthalpy of return water [kJ/kg])

＝return water quantity [m^3] × weight volume ratio of return water temperature [kg/m^3] × (steam enthalpy [kJ/kg]－enthalpy of return water [kJ/kg])

(Reference)

Steam pressure： 8 k-G (886 kPa) at return water temperature of 60℃

・Enthalpy of steam 2772 kJ/kg

・Enthalpy of return water 251.15 kJ/kg

・Weight volume ratio of return water temperature (60℃) 983kg/ m^3

For reference, Table 6 and Table 7 show "Saturated water table－Temperature basis" and "Saturated water table－Pressure basis."

(Excerpt from Air-Conditioning and Sanitary Engineering Handbook, 13th edition)

In practice, for chilled water /warm water /steam, heat quantities should be determined based on recorded purchases from heat providers.

Figure 19 Equation for steam heat quantity

Table 6　Saturated water table – Temperature basis

Table 3-1　Saturated water table – Temperature basis (Japan Air-Conditioning and Refrigeration Institute, 1998)

Temperature [℃] t	Temperature [K] T	Pressure [kPa] P	Specific volume [m³/kg] v'	Specific volume [m³/kg] v''	Specific enthalpy [kJ/kg] h'	Specific enthalpy [kJ/kg] h''	Specific enthalpy [kJ/kg] r	Specific entropy [kJ/(kg·K)] s'	Specific entropy [kJ/(kg·K)] s''
0	273.15	0.611 2	0.001 000 2	206.14	−0.04	2 500.89	2 500.93	−0.000 2	9.155 8
0.01	273.16	0.611 7	0.001 000 2	206.00	0.00	2 500.91	2 500.91	0.000 0	9.155 5
5	278.15	0.872 6	0.001 000 1	147.02	21.02	2 510.07	2 489.05	0.076 3	9.024 9
10	283.15	1.228 2	0.001 000 3	106.31	42.02	2 519.23	2 477.21	0.151 1	8.899 8
15	288.15	1.705 7	0.001 000 9	77.881	62.98	2 528.36	2 465.38	0.224 5	8.780 4
20	293.15	2.339 2	0.001 001 8	57.761	83.92	2 537.47	2 453.55	0.296 5	8.666 1
25	298.15	3.169 7	0.001 003 0	43.341	104.84	2 546.54	2 441.70	0.367 3	8.556 8
30	303.15	4.246 7	0.001 004 4	32.882	125.75	2 555.58	2 429.83	0.436 8	8.452 1
35	308.15	5.628 6	0.001 006 0	25.208	146.64	2 564.58	2 417.94	0.505 2	8.351 8
40	313.15	7.384 4	0.001 007 9	19.517	167.57	2 573.54	2 406.00	0.572 4	8.255 7
45	318.15	9.594 4	0.001 009 9	15.253	188.44	2 582.45	2 394.01	0.638 6	8.163 4
50	323.15	12.351	0.001 012 1	12.028	209.34	2 591.31	2 381.97	0.703 8	8.074 9
55	328.15	15.761	0.001 014 5	9.564 9	230.24	2 600.11	2 369.87	0.768 0	7.989 9
60	333.15	19.946	0.001 017 1	7.667 7	251.15	2 608.85	2 357.70	0.831 2	7.908 2
65	338.15	25.041	0.001 019 9	6.193 8	272.08	2 617.51	2 345.43	0.893 5	7.829 6
70	343.15	31.201	0.001 022 8	5.039 7	293.02	2 626.10	2 333.08	0.955 0	7.754 0
75	348.15	38.595	0.001 025 8	4.129 1	313.97	2 634.60	2 320.63	1.015 6	7.681 2
80	353.15	47.415	0.001 029 0	3.405 3	334.95	2 643.01	2 308.06	1.075 4	7.611 0
85	358.15	57.867	0.001 032 4	2.825 9	355.95	2 651.33	2 295.38	1.134 4	7.543 4
90	363.15	70.182	0.001 035 9	2.359 1	376.97	2 659.53	2 282.56	1.192 7	7.478 1
95	368.15	84.609	0.001 039 6	1.980 6	398.02	2 667.61	2 269.59	1.250 2	7.415 0
100	373.15	101.42	0.001 043 5	1.671 9	419.10	2 675.57	2 256.47	1.307 0	7.354 1
110	383.15	143.38	0.001 051 6	1.209 4	461.36	2 691.07	2 229.71	1.418 7	7.238 0
120	393.15	198.67	0.001 060 3	0.891 30	503.78	2 705.93	2 202.15	1.527 8	7.129 1
130	403.15	270.26	0.001 069 7	0.668 08	546.39	2 720.09	2 173.70	1.634 6	7.026 4
140	413.15	361.50	0.001 079 8	0.508 52	589.20	2 733.44	2 144.24	1.739 3	6.929 3
150	423.15	476.10	0.001 090 5	0.392 50	632.25	2 745.92	2 113.67	1.842 0	6.837 0
160	433.15	618.14	0.001 102 0	0.306 82	675.57	2 757.43	2 081.86	1.942 8	6.749 1
170	443.15	792.05	0.001 114 3	0.242 62	719.21	2 767.89	2 048.68	2.041 9	6.664 9
180	453.15	1 002.6	0.001 127 4	0.193 86	763.19	2 777.22	2 014.03	2.139 5	6.584 1
190	463.15	1 255.0	0.001 141 4	0.156 38	807.57	2 785.31	1 977.74	2.235 8	6.506 0
200	473.15	1 554.7	0.001 156 5	0.127 22	852.39	2 792.06	1 939.67	2.330 8	6.430 3
210	483.15	1 907.4	0.001 172 7	0.104 30	897.73	2 797.35	1 899.62	2.424 8	6.356 5
220	493.15	2 319.3	0.001 190 2	0.086 101	943.64	2 801.05	1 857.41	2.517 8	6.284 2
230	503.15	2 796.8	0.001 209 0	0.071 510	990.21	2 803.01	1 812.80	2.610 2	6.213 1
240	513.15	3 346.7	0.001 229 5	0.059 710	1 037.52	2 803.06	1 765.54	2.701 9	6.142 5
250	523.15	3 975.9	0.001 251 7	0.050 087	1 085.69	2 801.01	1 715.32	2.793 4	6.072 2
260	533.15	4 692.1	0.001 276 1	0.042 175	1 134.83	2 796.64	1 661.81	2.884 7	6.001 7
270	543.15	5 502.8	0.001 303 0	0.035 622	1 185.09	2 789.69	1 604.60	2.976 2	5.930 4
280	553.15	6 416.5	0.001 332 8	0.030 154	1 236.67	2 779.82	1 543.15	3.068 1	5.857 8
290	563.15	7 441.6	0.001 366 3	0.025 557	1 289.80	2 766.63	1 476.83	3.160 8	5.783 2
300	573.15	8 587.7	0.001 404 2	0.021 663	1 344.77	2 749.57	1 404.80	3.254 7	5.705 8
310	583.15	9 864.7	0.001 447 9	0.018 339	1 402.00	2 727.92	1 325.92	3.350 6	5.624 3
320	593.15	11 284	0.001 499 1	0.015 476	1 462.05	2 700.67	1 238.62	3.449 1	5.537 3
330	603.15	12 858	0.001 560 6	0.012 984	1 525.74	2 666.25	1 140.51	3.551 6	5.442 5
340	613.15	14 600	0.001 637 5	0.010 784	1 594.45	2 622.07	1 027.62	3.659 9	5.335 9
350	623.15	16 529	0.001 740 1	0.008 800 9	1 670.86	2 563.59	892.73	3.778 3	5.210 9
360	633.15	18 666	0.001 894 5	0.006 944 9	1 761.49	2 480.99	719.50	3.916 4	5.052 7
370	643.15	21 043	0.002 222 1	0.004 946 2	1 892.64	2 333.50	440.86	4.114 2	4.799 6
373.946	647.096	22 064	0.003 105 59	0.003 105 59	2 087.55	2 087.55	0.00	4.412 0	4.412 0

Note　The state at 0℃ is a metastable state, and the stable state is solid.

(Excerpt from Air-Conditioning and Sanitary Engineering Handbook, 13th edition)

Table 7 Saturated water table – Pressure basis

Table 3-2 Saturated water table – Pressure basis (Japan Air-Conditioning and Refrigeration Institute, 1998)

Pressure [kPa]	Temperature [°C]	Specific volume [m³/kg]		Specific enthalpy [kJ/kg]			Specific entropy [kJ/(kg・K)]	
P	t	v'	v''	h'	h''	r	s'	s''
1	6.970	0.001 000 1	129.18	29.30	2 513.68	2 484.38	0.105 9	8.974 9
2	17.495	0.001 001 4	66.990	73.43	2 532.91	2 459.48	0.260 6	8.722 7
3	24.080	0.001 002 8	45.655	100.99	2 544.88	2 443.89	0.354 3	8.576 6
4	28.962	0.001 004 1	34.792	121.40	2 553.71	2 432.31	0.422 4	8.473 5
5	32.875	0.001 005 3	28.186	137.77	2 560.77	2 423.00	0.476 3	8.393 9
6	36.160	0.001 006 4	23.734	151.49	2 566.67	2 415.18	0.520 9	8.329 1
7	39.001	0.001 007 5	20.525	163.37	2 571.76	2 408.39	0.559 1	8.274 6
8	41.510	0.001 008 5	18.099	173.85	2 576.24	2 402.39	0.592 5	8.227 4
9	43.762	0.001 009 4	16.200	183.26	2 580.25	2 396.99	0.622 3	8.185 9
10	45.808	0.001 010 3	14.671	191.81	2 583.89	2 392.08	0.649 2	8.148 9
20	60.059	0.001 017 1	7.648 2	251.40	2 608.95	2 357.55	0.832 0	7.907 2
30	69.095	0.001 022 2	5.228 6	289.23	2 624.55	2 335.32	0.943 9	7.767 5
50	81.317	0.001 029 9	3.240 1	340.48	2 645.21	2 304.73	1.091 0	7.593 0
70	89.932	0.001 035 9	2.364 9	376.68	2 659.42	2 282.74	1.191 9	7.479 0
100	99.606	0.001 043 1	1.694 0	417.44	2 674.95	2 257.51	1.302 6	7.358 8
150	111.350	0.001 052 7	1.159 4	467.08	2 693.11	2 226.03	1.433 5	7.222 9
200	120.212	0.001 060 5	0.885 74	504.68	2 706.24	2 201.56	1.530 1	7.126 9
300	133.525	0.001 073 2	0.605 79	561.46	2 724.89	2 163.43	1.671 8	6.991 6
400	143.613	0.001 083 6	0.462 39	604.72	2 738.06	2 133.34	1.776 6	6.895 4
500	151.836	0.001 092 6	0.374 80	640.19	2 748.11	2 107.92	1.860 6	6.820 6
600	158.832	0.001 100 6	0.315 58	670.50	2 756.14	2 085.64	1.931 1	6.759 2
700	164.953	0.001 108 0	0.272 76	697.14	2 762.75	2 065.61	1.992 1	6.707 0
800	170.414	0.001 114 8	0.240 33	721.02	2 768.30	2 047.28	2.046 0	6.661 5
900	175.358	0.001 121 2	0.214 87	742.72	2 773.04	2 030.32	2.094 4	6.621 2
1 000	179.886	0.001 127 2	0.194 35	762.68	2 777.12	2 014.44	2.138 4	6.585 0
1 200	187.965	0.001 138 5	0.163 25	798.50	2 783.77	1 985.27	2.216 3	6.521 7
1 400	195.047	0.001 148 9	0.140 77	830.13	2 788.89	1 958.76	2.283 9	6.467 5
1 600	201.378	0.001 158 7	0.123 73	858.61	2 792.88	1 934.27	2.343 8	6.420 0
1 800	207.120	0.001 167 9	0.110 36	884.61	2 795.99	1 911.38	2.397 8	6.377 6
2 000	212.385	0.001 176 8	0.099 581	908.62	2 798.38	1 889.76	2.447 0	6.339 2
2 200	217.256	0.001 185 2	0.090 695	930.98	2 800.20	1 869.22	2.492 4	6.304 0
2 400	221.795	0.001 193 4	0.083 242	951.95	2 801.54	1 849.59	2.534 4	6.271 4
2 600	226.052	0.001 201 4	0.076 897	971.74	2 802.45	1 830.71	2.573 8	6.241 1
2 800	230.063	0.001 209 1	0.071 428	990.50	2 803.02	1 812.52	2.610 7	6.212 6
3 000	233.858	0.001 216 7	0.066 664	1 008.37	2 803.26	1 794.89	2.645 6	6.185 8
3 500	242.562	0.001 235 0	0.057 058	1 049.78	2 802.74	1 752.96	2.725 4	6.124 5
4 000	250.358	0.001 252 6	0.049 777	1 087.43	2 800.90	1 713.47	2.796 7	6.069 7
5 000	263.943	0.001 286 4	0.039 446	1 154.50	2 794.23	1 639.73	2.920 7	5.973 7
6 000	275.586	0.001 319 3	0.032 449	1 213.73	2 784.56	1 570.83	3.027 4	5.890 1
7 000	285.830	0.001 351 9	0.027 380	1 267.44	2 772.57	1 505.13	3.122 0	5.814 6
8 000	295.009	0.001 384 7	0.023 528	1 317.08	2 758.61	1 441.53	3.207 7	5.744 8
9 000	303.347	0.001 418 1	0.020 493	1 363.65	2 742.88	1 379.23	3.286 6	5.679 0
10 000	310.999	0.001 452 6	0.018 034	1 407.87	2 725.47	1 317.60	3.360 3	5.615 9
12 000	324.678	0.001 526 3	0.014 269	1 491.33	2 685.58	1 194.25	3.496 5	5.494 1
14 000	336.669	0.001 609 7	0.011 489	1 570.88	2 638.09	1 067.21	3.623 0	5.373 0
16 000	347.357	0.001 709 5	0.009 308 1	1 649.67	2 580.80	931.13	3.745 7	5.246 3
18 000	356.992	0.001 839 5	0.007 498 7	1 732.02	2 509.53	777.51	3.871 7	5.105 5
20 000	365.746	0.002 038 6	0.005 858 3	1 827.10	2 411.39	584.29	4.015 4	4.929 9
22 000	373.707	0.002 750 4	0.003 576 6	2 021.92	2 164.18	142.26	4.310 9	4.530 8
22 064	373.946	0.003 105 59	0.003 105 59	2 087.55	2 087.55	0.00	4.412 0	4.412 0

(Excerpt from Air-Conditioning and Sanitary Engineering Handbook, 13th edition)

(vi) **Combining method of energy quantity**

1) Types of energy sources at data centers

- Input energy to data centers contains commercial electricity from electric power suppliers, naturally generated electricity such as photovoltaic generation, fuel energy (oil, gas etc.) and secondary energy (heat source) such as chilled water supplied from regional air-conditioning suppliers.
- Electric energy is input into almost all equipment of data center, and fuel energy is inputted mainly into air-conditioning equipment and in-house power generation equipment (for emergency and normal). Chilled water supplied from regional air-conditioning suppliers is input into air-conditioning equipment.
- (Refer to Figure 20 Energy source model of data center)

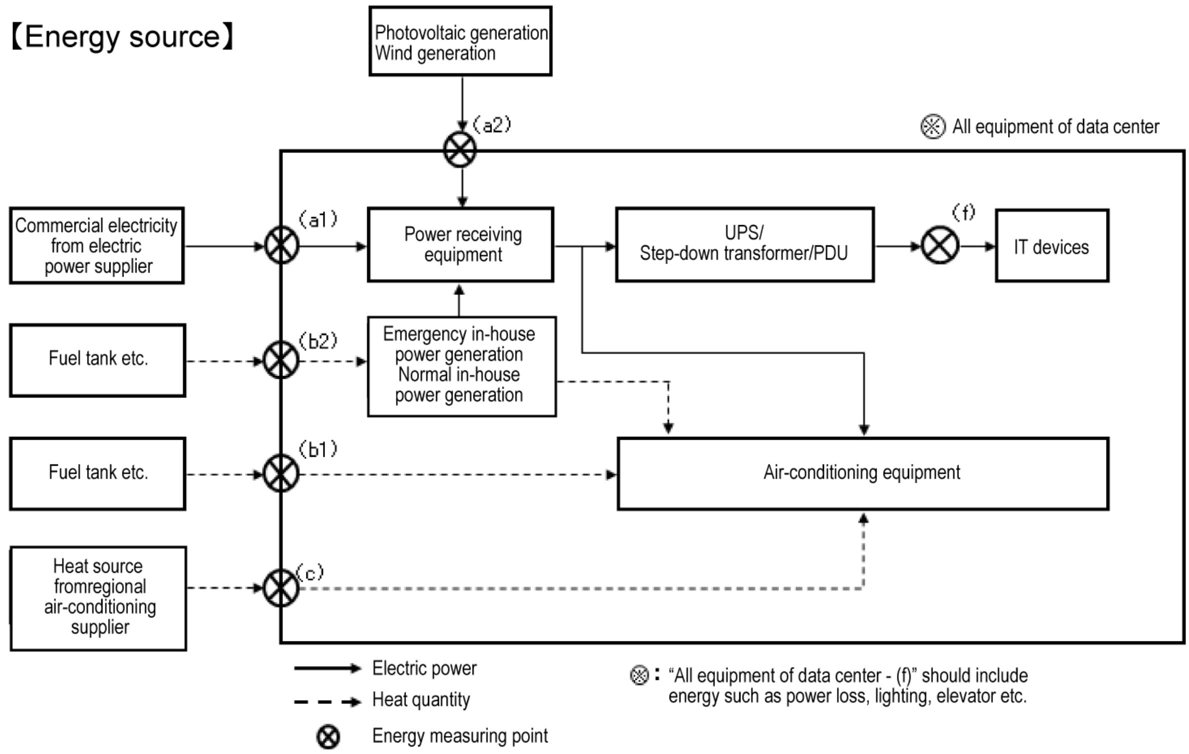
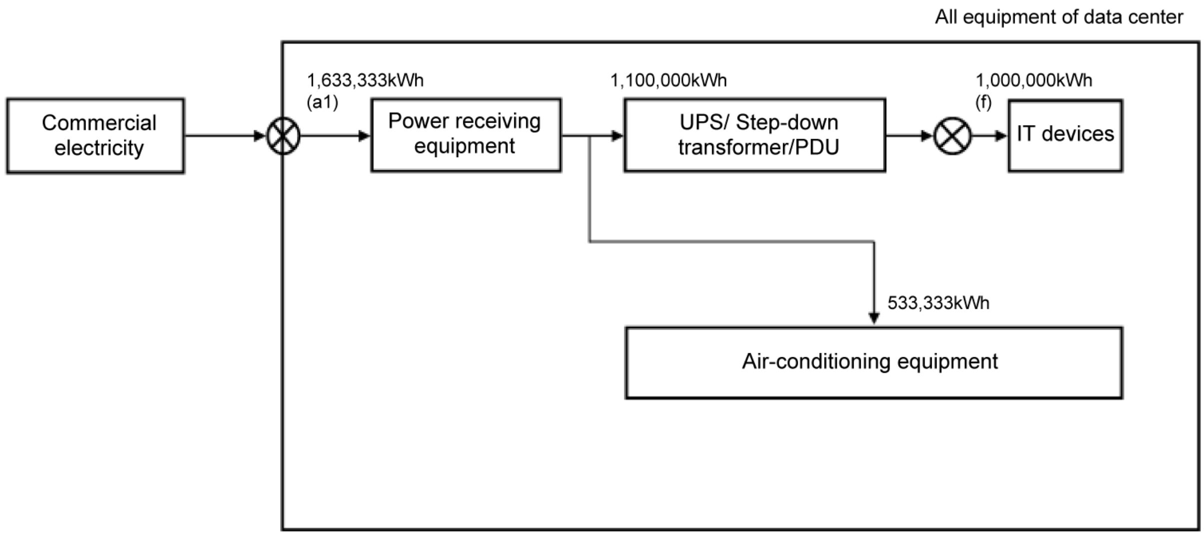


Figure 20 Energy source model of data center

2) Combining the energy for all equipment of data center

- To calculate energy amount for all equipment of data center, these types of input energy are combined by converting into source energy.
- (Refer to Table 4 Source energy conversion coefficient by energy types)
- Combining methods are shown in from Figure 21 to Figure 24 for examples according to the typical energy configuration pattern.
- The source energy conversion coefficient of commercial electricity 1.0, that of fuel energy is 0.35 and that of heat source of chilled water etc. supplied from regional air-conditioning suppliers is 0.40. These energies are combined by multiplying their respective coefficients.

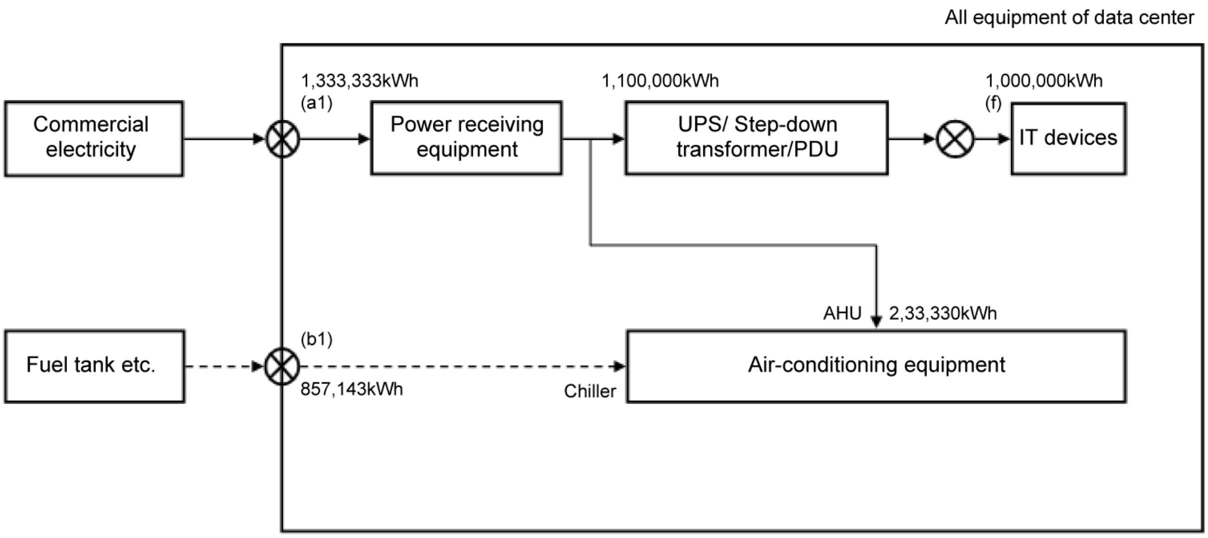


・Energy amount for all equipment of data center (a1) = 1,633,333kWh

・Energy amount for IT devices (f) = 1,000,000kWh

・PUE = $\frac{1,633,333}{1,000,000}$ = 1.63

Figure 21 Combining the energy of data center (Commercial electricity alone)

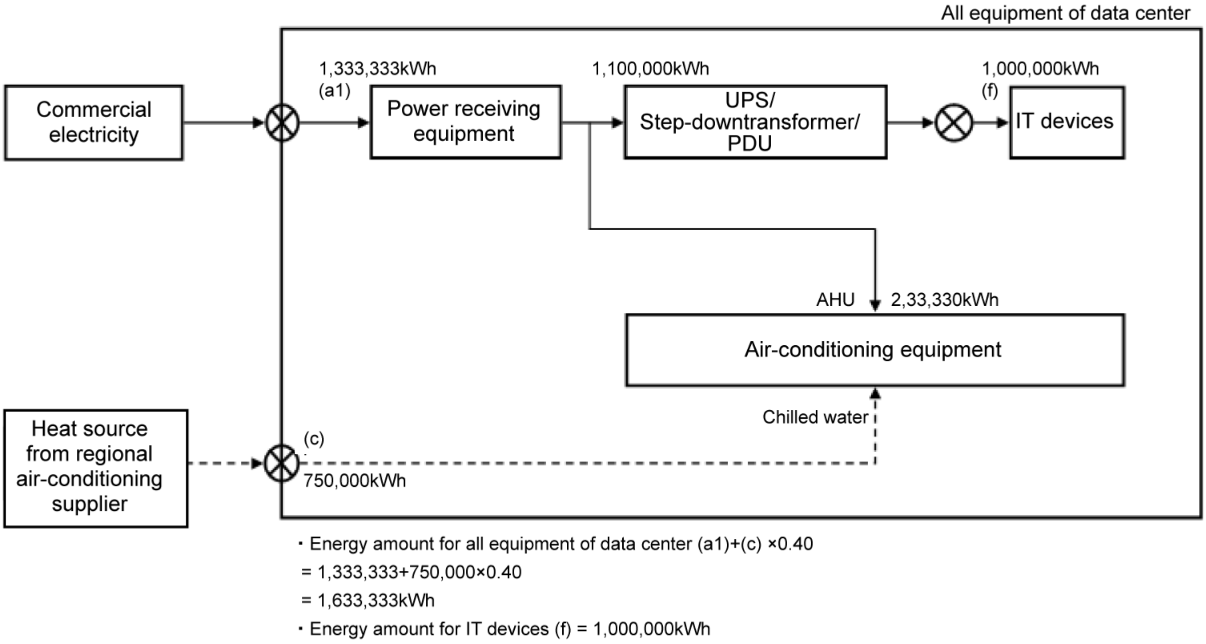


・Energy amount for all equipment of data center (a1)+(b1) ×0.35
= 1,333,333+857,135×0.35
= 1,633,333kWh

・Energy amount for IT devices (f) = 1,000,000kWh

・PUE = $\frac{1,633,333}{1,000,000}$ = 1.63

Figure 22 Combining the energy of data center (Commercial electricity + Chiller fuel)



・PUE = $\frac{1,633,333}{1,000,000}$ = 1.63

Figure 23 Combining the energy of data center
(Commercial electricity + regional air-conditioning: Chiller)

3) Combining the energy for all equipment of data center

- The method for combining the electricity generated in data center (in site) (in-house power generation, photovoltaic generation etc.) is shown in reference: Figure 24
- The point of combing energy is as follows:
- Combine commercial electricity/photovoltaic generation by multiplying source energy conversion coefficient 1.0.
- Combine normal in-house power generation by multiplying source energy conversion coefficient 0.35.

(Note)

The energy of in-house power generation consumed for test operation should not be combined. If the emergency in-house power generator (Emergency in-house power generation) is used for emergency, the generated electricity (kWh) should be combined.

If the generated electricity of the emergency in-house power generation is known by meter etc, the value should be combined. If it cannot be measured, the electricity during the power outage should be combined by assuming the amount of electricity by referencing the amount of commercial electricity before and after power outage.

- When calculating the PUE, the power generation efficiency of the whole data center (site) should be considered.
- The consumed energy of IT devices should be converted to source energy by considering the power generation efficiency.

(Source conversion coefficient of IT power: SCR)

＊Source conversion coefficient of the whole data center

＝ Source-converted energy amount input into site from power system

/ Electric energy amount generated in site

＝ Source conversion coefficient of IT power: (SCR)

＊PUE ＝ Energy amount of all equipment of data center

∕ Energy amount of IT devices×SCR

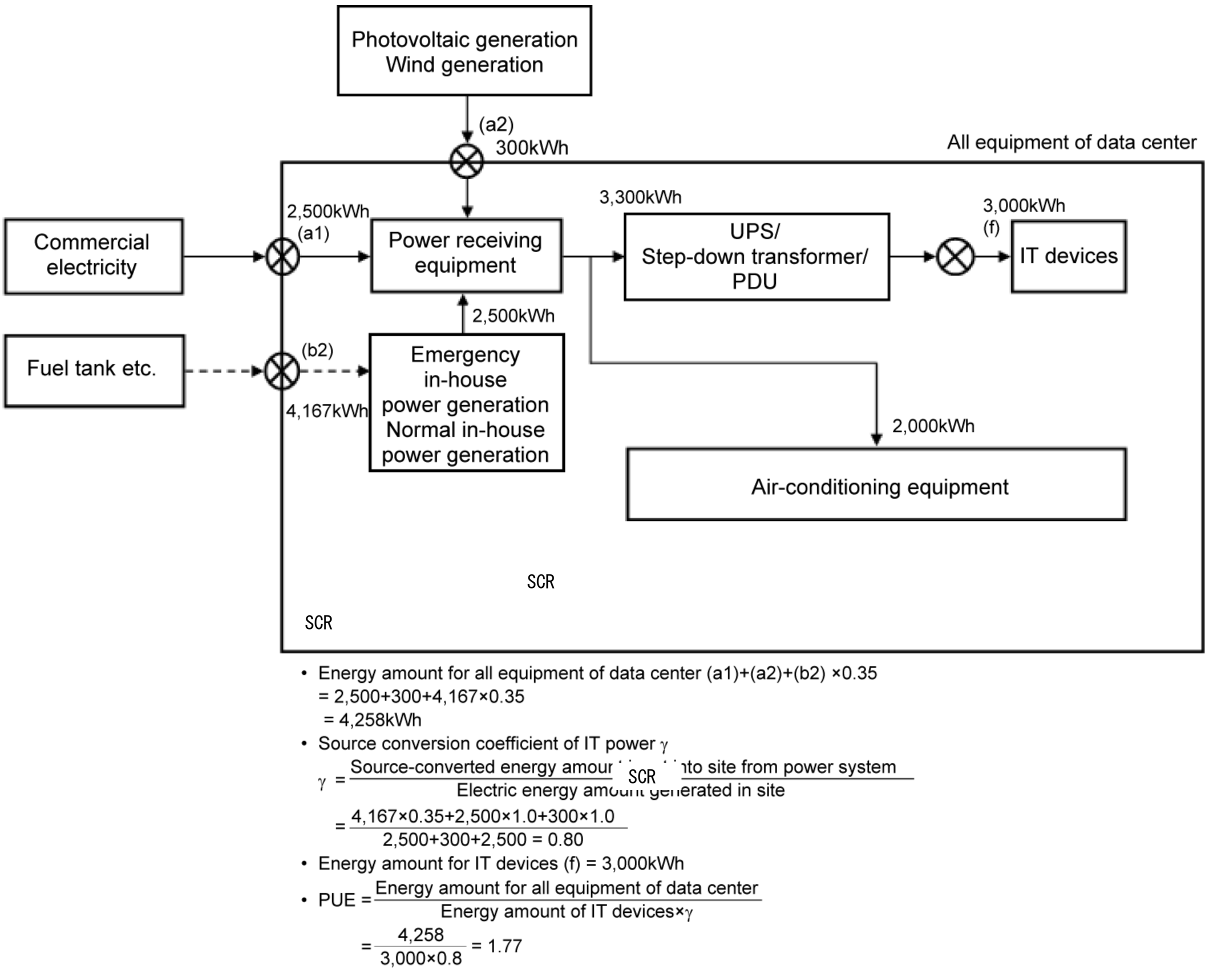


Figure 24 Combining the energy of data center

(Commercial electricity + Photovoltaic generation + In-house power generation)

(vii) Treatment of error of data measured by measuring instrument

- To determine the overall power usage trend, measuring instruments whose maximum error rate is +/-2% are recommended.
- Represent that the data is assumed to include error.
- The relationship between the error of measuring instruments and the affected error of whole PUE should be referred to 'Table 8 Treatment of error of data measured by measuring instrument'.

Table 8 Treatment of error of data measured by measuring instrument
(In the case of the center using electric power only)

◆Total electricity for facility should be '100', electricity for IT devices should be '50', and PUE = 2.0 should be true value.

The fluctuation range of PUE value is as follows under the same accuracy (error) of measuring instruments.

Instrument usage	Accuracy		Total electricity for facility	Electricity for IT devices	PUE	Error	Remarks
							Verification tolerance of combined instrument
—	0.0%		100	50	2.00	0%	
kWh Ultraprecise instrument	0.2%	+0.2% -0.2%	100.2 99.8	49.9 50.1	2.01 1.99	1%	±0.6%
kWh Specially precise instrument	0.5%	+0.5% -0.5%	100.5 99.5	49.75 50.25	2.02 1.98	2%	±1.2%
kWh, MM, CT Precise instrument	1.0%	+1.0% -1.0%	101.0 99.0	49.5 50.5	2.04 1.96	4%	±2.0%
kWh, MM, CT Normal instrument	2.0%	+2.0% -2.0%	102.0 98.0	49.0 51.0	2.08 1.92	8%	±2.0%

(viii) Complex-facility

In the case of a complex-facility data center, part of energy consumed by the data center functions is mixed up to the energy consumption by the shared functions. Thus, energy consumption by the shared functions should be allocated pro rata in accordance with the allocation method defined in a Chart, and then the total energy consumption by the data-center functions should be determined.

In the case of the complex-facility data center, to simplify the calculation, the entire amount of energy consumed by the shared functions may be treated as the energy consumption by the data center function. In this case, however, PUE would be worse than it ought to be.

（3） Total energy consumption by IT devices: measurement of IT_T_JE

As a rule, electricity consumption [kWh] should be measured on the PDU output point using a power meter on the PDU (power distribution unit) connected to the IT devices.

If measurement is infeasible on the PDU output point, measurement may be made on the PDU input point. The value thus obtained should be used as the PDU output value if the PDU does not have a step-down transformer.

If the PDU contains a step-down transformer, loss in the step-down transformer should be counted.

If measurement is infeasible on the PDU input and output points, measurement may be made on the UPS output point. Loss of the step-down transformer, cable etc. located up to the PDU output should be counted. The value thus obtained should be used as the PDU output value.

If measurement is infeasible on the UPS output point, the loss value of UPS, the step-down transformer, cable etc. located from the point measurable by an integrating wattmeter to PDU output should be indicated and counted.

In the case when measurement is made on the UPS output point, if the conversion loss is difficult to evaluate, the loss value of the transformer should be 3%. Similarly, the wiring loss value of cables should be 2% if they are 60 meters long or less. If cables are 120 meters long or less, the loss value should be 3%. If cables are longer than120 meters, the loss value should be 4%.

However, the loss value differs depending on the manufacturer, type, or length. A larger loss value (lower efficiency) should be applied. (Review the cable specifications and other conditions from each manufacturer.)

If conversion loss and efficiency can be estimated on the basis of catalog values, measured values etc, the values thus obtained should take precedence.

Values approximating the actual values should be used irrespective of efficiency. However, the evidence of loss counting should be retained.

The operator may use his/her own calculation method to determine the loss values if such use is evidenced in a document.

The above requirements should apply to values on specifications for UPS and step-down transformers.

If measured on the power receiving side from the UPS, the loss in the UPS, the high-voltage transformer etc. located up to the UPS output side may vary due to load on IT devices. In this case, loss rates appropriate to the load should be obtained from manufacturers of the UPS etc. and used for calculation.

In measurement of electric energy, the power factor should be measured simultaneously, and electric energy in effective electric power should be measured.

Effective electric energy (W)＝current (A)×voltage (V)×power factor (%)

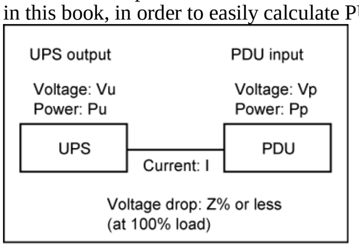
All IT devices in the data center should be counted.

The amount of energy (kWh conversion) should be determined by multiplying electricity consumption by the energy conversion coefficient.

If measurement is made with only current and voltage, the power factor cannot be measured in real time, and thus electric energy cannot be measured accurately, then the effective electric energy should be determined by multiplying the measured value of power factor which was periodically measured in the past or the hypothetical power factor of 95%. Such method used should be recorded and retained as evidence.

■ About wiring loss

The wiring loss between UPS and PDU differs largely depending on wiring type, wiring length or current value, and the installation condition and specification of UPS and PDU in the data center are various. Therefore, it is difficult to specify uniformly the wiring loss, but in this book, in order to easily calculate PUE, we determined the wiring loss, and the outline is described below.



In the Figure above,
From Voltage drop is Z% or less $Vu-Vp \leqq (Z/100)*Vu \rightarrow Vu/Vp \leqq 100/(100-Z)$
If we let the wiring loss $P' = Pu-Pp$
The wiring loss for PDU input

$$P'/Pp = (Pu-Pp)/Pp = 1.73*I(Vu-Vp)/1.73*I*Vp) = (Vu-Vp)/Vp$$
$$\leqq (100/(100-Z))-1$$

The voltage drop in the low-voltage wiring is described in the interior wiring provision 1301-1 that the voltage drop in the low-voltage wiring shall be 2% or less in main line and branch circuit, respectively. However, if the electricity is supplied from the transformer in electricity use place, the voltage drop may be 3% or less. Therefore, if we let the voltage drop at the time of 100% load to be Z＝3%

Wiring loss $P'/Pp \leqq (100/97)-1 = 3.1\%$

Voltage drop and current value are proportional. Therefore, at the time of 50% load, the voltage drop becomes 1.5%.

The wiring loss rate in this case, calculating in the same way above,

Wiring loss $P'/Pp \leqq (100/98.5)-1 = 1.6\%$

As described above, the voltage drop at the time of 100% load becomes 3.1% or less, and at the time of 50% load becomes 1.8% or less.

Therefore, supposing the average load factor of data center is about 50%, we estimate that the wiring loss is 2% of the transformer capacity installed in PDU.

In addition, the voltage drop in the case that wiring length is 60m of more is described in the Table of the interior wiring provision 1301-1.

Voltage drop in the case when line length is more than 60m

Wiring length	Pressure drop
120m or less	5% or less
200m or less	6% or less
More than 200m	7% or less

Hence, the voltage drop at the time of 50% load becomes 2.6% (120m or less), 3.1% (200m or less) and 3.7% (more then 200m). Therefore, we determine the wiring loss conversion value between UPS and PDU as following table.

Wiring loss conversion value between UPS and PDU when calculating PUE

Wiring length	Wiring loss
60m or less	2%
120m or less	3%
More than 120m	4%

■ About the conversion loss of low-voltage transformer

The low-voltage transformer used in PDU is principally a low-pressure transformer. The conversion loss of low-voltage transformer is various depending on manufacturer, transformer type etc. Therefore, it is difficult to specify uniformly the conversion loss, but in this book, in order to easily calculate PUE, we specify that the conversion loss is 3%, and the outline is described below.

Typical example of conversion loss of low-voltage transformer

Transformer specification			A company	B company	C company	
	Capacity		100kVA	100kVA	250kVA	
	Input voltage		3ϕ210V	3ϕ210V	3ϕ415V	
	Output voltage		1ϕ210-150V	1ϕ210-150V	1ϕ210-150V	1ϕ210-150V
Transformer efficiency (%)	Load factor	10%	95.07	95.5	-	-
		20%	97.22	97.4	-	-
		30%	97.84	98	-	-
		40%	98.68	98.2	98.18	98.02
		50%	98.13	98.3	98.09	97.9
		60%	98.12	98.3	97.95	97.72
		70%	98.06	98.2	97.77	97.51
		80%	97.97	98.1	97.59	97.28
		90%	97.86	98.1	97.38	97.05
		100%	97.74	98	97.17	96.8
Remark			Mold transformer	Mold transformer	K-factor transformer Transformer efficiency at K = 13	

※Differ depending on installation and specification condition.

Hereby, the conversion efficiency is exceed 97% if load factor is 20% or more, and it is 98% more or less if load factor is 50%. Hence, we estimate that the conversion loss of low-voltage transformer is 3%.

Figure 25 Treatment of loss of step-down transformer etc.

（4） Calculating PUE

PUE should be calculated using total energy consumption D_T_E at the data center and total energy consumption of IT devices IT_T_EP.

3.5.3 Measuring period and measuring frequency for PUE

（1） Measuring period

PUE should be measured and calculated on a monthly basis (from 00:00 of the first day to 24:00 of the last day of the month).

For publication or comparison, PUE should be provided, as a rule, in an integrated value of energy consumption covering the whole year. Any measuring period shorter than one year should be defined.

（2） Measuring frequency

At least, the measuring period should be on a monthly basis. (Integrated value on a monthly basis should be determined.)

If annually-integrated energy amount (electric energy) cannot be measured, it should be determined as follows.

- If an integrated instrument is not installed at PDU output point or UPS output point, measurement should be performed at the nearest integrated instrument among the instruments installed upstream. From the value thus obtained, subtract the loss value of each equipment, and the value thus obtained should be used. If the measured value cannot be used, converting the instantaneous value or the integrated power of a day into the annually-integrated energy amount following the method as shown below, and the value thus obtained should be used.
- In the case when integrated energy amount is converted from the value of the integrated instrument installed upstream, the measuring frequency should refer to the measuring frequency described above.
- In the case when the annually-integrated energy amount is converted from the instantaneous value, measure the instantaneous value once a day, and convert the value into the value for 24 hours. The value thus obtained should be the integrated value of the day. The accumulated value for a year should be the annually-integrated energy amount.
- In the case when the annually-integrated energy amount is converted from the integrated power of a day, measure the integrated energy amount for a day once a month, and convert the value into the value for a month (multiply the value by the number of days of the month). The value thus obtained should be the integrated value of the month. The accumulated value for a year should be the annually-integrated energy amount.

Any method of above by which the measurement was performed should be clarified together with the measured values.

3.6. Measuring Green Energy Coefficient (GEC)

3.6.1 Definition of GEC

GEC ＝ green energy generated and used on the premises of the data center [kWh] / total energy consumption at the data center [kWh]

*Green energy: energy generated from natural sources such as photovoltaic generation and wind generation

GEC ＝ D_G2_EPE / D_T_E

D_G2_EPE [kWh]: the amount of green energy (natural energy) generated and used on the premises of the data center

D_T_E [kWh]: total energy consumption at the data center (same as D_T_E for PUE)

3.6.2 GEC measuring method

（1） Green energy: measurement of D_G2_E

Electric energy [kWh] generated during the measuring period should be measured using a power meter installed on the photovoltaic or wind power generation units.

（2） Measuring total energy consumption D_T_E at the data center

The same procedure should be taken as with PUE.

Electricity consumption [kWh] should be measured using a power meter on the power-receiving equipment at the data center.

Energy consumption of other sources than electricity, such as fuel, should be separately measured using a fuel meter or any other meter.

To determine the energy amount (kWh conversion), the electricity consumption or fuel consumption value should be multiplied by the energy conversion coefficient shown in Exhibit.

（3） Calculating GEC

GEC should be calculated using D_G2_EPEnd D_T_E.

3.6.3 Measuring period and measuring frequency for GEC

（1） Measuring period

GEC should be measured and calculated on a monthly basis (from 00:00 of the first day to 24:00 of the last day of the month).

For publication or comparison, GEC should be provided, as a rule, in an integrated value of energy consumption covering the whole year. Any measuring period shorter than one year should be defined.

（2） Measuring frequency

As a rule, green energy (e.g. electricity generated by photovoltaic generation) and total energy consumption (electric energy) at the data center should be measured using continuous integrated values (integrated electric energy).

If integrated measurements cannot be obtained for the entire measuring period because of the unavailability of an integrating-type measuring instrument (e.g. integrating power meter) or for any other reason, one of the following methods should be used to determine integrated values.

(i) Select one day within the measurement month, continuously measure and record instantaneous values (using an instantaneous power meter) throughout the day to determine the integrated value for the day, and multiply the value by the number of days of the month to determine the integrated value for the month.

(ii) Select one day within the measurement month, measure and record an instantaneous value (using an instantaneous power meter) once for the day, convert it into a 24-hour value, and then multiply the value by the number of days of the month to determine the integrated value for the month.

The method taken, (i) or (ii) above, should be specified together with the measured values.

3.7. Measuring Data Center Performance per Energy (DPPE)

3.7.1 Definition of DPPE

$$DPPE = ITEU \times ITEE \times (1/PUE) \times (1/(1-GEC))$$

3.7.2 Calculation method for DPPE

（1） Selecting the measurement range

The measurement zone should be determined by floor, by PDU, by rack, or by other unit to the extent that ITEU and ITEE can be measured and calculated in IT device configuration management.

（2） Measuring ITEU and ITEE

ITEU and ITEE should be measured and calculated.

ITEU and ITEE should cover the same IT devices.

（3） Measuring PUE and GEC

PUE and GEC should be measured and calculated.

PUE and GEC should cover the entire data center.

（4） Calculating DPPE

DPPE should be calculated for the data center as a whole and for each system on the basis of ITEU, ITEE, PUE, and GEC.

ITEU, ITEE , PUE, and GEC should cover the same measuring period.

3.7.3 Measuring period and measuring frequency for DPPE

（1） Measuring period

DPPE should be measured and calculated on a monthly basis (from 00:00 of the first day to 24:00 of the last days of the month).

For publication or comparison, DPPE should be provided, as a rule, in an integrated value covering the whole year. Any measuring period shorter than one year should be defined.

（2） Measuring frequency

Monthly DPPE values should be calculated using the sub-indicator values for each month. DPPE should be calculated on the basis of integrated value on each sub-indicator covering the whole year. The measuring frequency for each sub-indicator should follow the method specified in preceding sections.

4. Reporting

4.1. Recording measurements and retaining the records

Monthly ITEU, ITEE, PUE, GEC, and DPPE values measured and the coefficients used in calculation should be retained in a record.

Data center ID information, measuring periods, external environments, data-center profile information, IT device profile information (device configuration management) as specified in Exhibit should also be recorded and retained.

Data should be recorded in electronic media for future analysis.

4.1.1 Basic concept of measuring instruments

Measuring instruments should comply with the TGG concept.

The measurement error range should be defined for the existing measuring instruments.

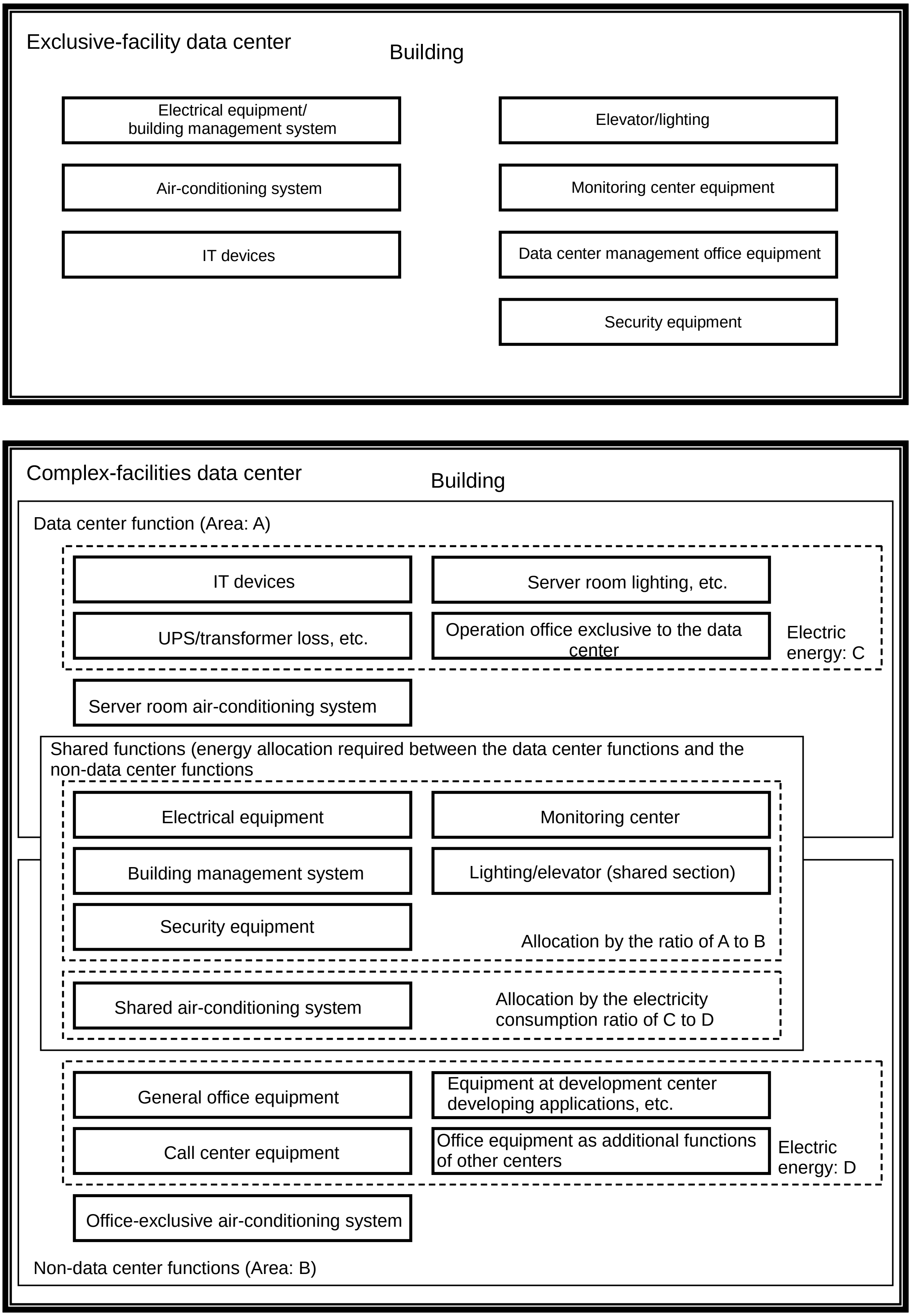
Commercially available measuring instruments may be used because they have an error range of less than 10%.

(Exhibit 1) Energy Conversion Table

Type of energy source			Consumption			Conversion coefficient (kWh conversion)		Remark
				Unit		Value	Unit	
Fuel and heat	Crude oil		1	kl	=	10,611	kWh	
	Crude oil condensate (NGL)		1	kl	=	9,806	kWh	
	Benzin (gasoline)		1	kl	=	9,611	kWh	
	Naphtha		1	kl	=	9,472	kWh	
	Kerosene		1	kl	=	10,194	kWh	
	Light oil		1	kl	=	10,611	kWh	
	A heavy oil		1	kl	=	10,861	kWh	
	B/C heavy oil		1	kl	=	11,583	kWh	
	Petroleum asphalt		1	t	=	11,639	kWh	
	Petroleum coke		1	t	=	9,889	kWh	
	Petroleum gas	Liquefied petroleum gas (LPG)	1	t	=	13,944	kWh	
		Petroleum-based hydrocarbon gas	1	thousands of m3	=	12,472	kWh	
	Combustibl e natural gas	Liquefied natural gas (LNG)	1	t	=	15,139	kWh	
		Other combustible natural gas	1	thousands of m3	=	11,361	kWh	
	Coal	Coal coke	1	t	=	8,028	kWh	
		Steam coal	1	t	=	7,389	kWh	
		Stone coal	1	t	=	7,556	kWh	
	Coal coke		1	t	=	8,361	kWh	
	Coal tar		1	t	=	10,361	kWh	
	Coke-oven gas		1	thousands of m3	=	5,861	kWh	
	Blast furnace gas		1	thousands of m3	=	947	kWh	
	Converter gas		1	thousands of m3	=	2,336	kWh	
	City gas		1	thousands of m3	=	12,500	kWh	Calorific values varies among gas companies
	Industrial steam		1	GJ	=	278	kWh	Use the value shown on the left or measured values
	Other steam		1	GJ	=	278		
	Warm water		1	GJ	=	278		
	Cold water		1	GJ	=	278		

Electricity Electric energy	1	kWh	=	1	kWh	

Chart 2 Definition of “data center”



(Exhibit 2) Energy allocation for the complex-facility data center

The table below details the energy components of the exclusive-facility and the complex-facility. These components are classified into three types; “components included in data center”, “components which are allocated pro rata in accordance with the ratio of area, equipments etc.” and “components excluded”. Classification is performed in accordance with the class symbol below, and thereby the components of energy consumed by the exclusive-facility and the complex-facility data center are clarified.

Component				Electricity for whole facility: Exclusive -facility	Complex-facility: DC section	Complex-facility: DC related	Complex-facility: Other than DC	Study items
Facility	Electricity							
		Power receiving equipment (including VCB combination by automatic control)		○	−	−	−	
		In-house power generator		○	□	□	■	For normal generator, calculate used energy during the calculating period. For emergency generator, generator, calculate used energy excluding energy used for inspection etc.
		Transformer, distribution board and cables for lamp and power	General use (excluding for IT devices)	○	□	□	■	・Allocate pro rata in accordance with energy ratio (according to b. in air-conditioning). ・Include all if they are installed as exclusive equipment for DC.
		Transformer, distribution board and cables for air-conditioning	General use (excluding for IT devices)	○	□	□	■	
		Lamp circuit for lighting, OA, outlet etc.	General use (excluding for IT devices)	○	□	□	■	・Allocate pro rata in accordance with the ratio of area occupied by the equipment.
		Battery, D/C power source equipment		○	−	□	■	・Allocate pro rata in accordance with energy ratio (according to b. in air-conditioning). ・Include all if they are installed as exclusive equipment for DC.
		Transformer for IT devices (high voltage)	For IT devices	○	○	−	−	If measurement is infeasible at the PDU output, calculate by estimating the loss in the step-down transformer, cables etc. (Conversion rule is described in 'measuring point' in chapter 2 clause 3 item 4 in the main text)
		UPS (for IT devices)	For IT devices	○	○	−	−	
		Transformer (step-down transformer)	For IT devices	○	○	−	−	
		Power distribution unit (PDU)	For IT devices	○	○	−	−	
		Rack power distribution unit (RDU), breaker board	For IT devices	○	○	−	−	
		Power cables	For IT devices	○	○	−	−	
	Air-conditioning (HVAC)							
		Cooling tower, cooling-water pump Cooling equipment, cold-water pump Server room air-conditioning equipment (CRAC) Server room equipment for temperature and humidity control (CRAH) Dry-cooling equipment Air-supply fan, ventilation (air-return) fan Air economizer, water side economizer Humidifier Cooling system (line, rack, chassis type)		○	□	□	■	About allocation for the complex-facility a. Method of allocation for the exclusive section ・Energy consumption of air conditioning for the data center section should be allocated pro rata based on the ratio of electric consumption of IT devices in the data center section and that of OA in the other sections (office section etc.) in compliance with the white paper #14 of TGG. b. Method of allocation for the shared section ・Energy consumption of air conditioning for the electric room etc. should be allocated pro rata based on the ratio of electric consumption of IT devices in the exclusive section and that of OA in the other sections (office section etc.) * All energy components of air conditioning for server room, data center office etc. should be included in the data center section.
	Security equipment							
		Access control system, monitoring system such as ITV Fire-extinguishing equipment, leak detection sensor Security server/equipment		○	□	□	■	・Shared equipment should be allocated pro rata based on the ratio of occupied area ratio.
	Building management system							
		Data center control server/equipment Probe/sensor		○	□	□	■	・Shared equipment should be allocated pro rata based on the ratio of occupied area ratio.
	Other shared area							
		Elevator Electricity consumption of lightening etc. of shared section such as lobby, shared conference room, hall way and restroom		○	□	□	■	・For the complex-facility, the ratio of occupied area should be used for pro rata allocation.
	Electric consumption of office and other area							
		Data-center operation office equipment		○	−	□	■	・Pro rata allocation method should depend on each electric component.
		Development center equipment, including application	General office (data-center related)		−	■	■	
		Office portion intended to enhance the value of the data center (general affairs division, sales division etc.)	General office (data-center related)		−	■	■	
		Help desk / call center equipment (independent of data center functions)	General office (data-center related)		−	■	■	
		General office equipment	General office (other corporate tenants)		−	■	■	
		Monitoring center equipment (intended to maintain data center function)	Shared equipment	○	−	□	■	
		Monitoring center equipment (Independent as business such as on-site monitoring service)	Shared equipment		−	□	■	
IT equipment	Computer devices							
		Server		○	○	−	−	
	Network devices							
		Switch, router		○	○	−	−	
	IT support system							
		Printer		○	○	−	−	
		PC/workstation		○	○	−	−	
		Remote control (KVM, console etc.)		○	○	−	−	
	Other devices							
		Security encryption, storage encryption, appliance etc.		○	○	−	−	
	Storage							
		Storage devices − switch, storage array		○	○	−	−	
		Backup devices − media, virtual media library		○	○	−	−	
	Communication							
		All kinds of communication devices		○	○	−	−	

【Class symbol】

○	Components included in data center
□	Components included in data center section by the pro rata allocation according to the ratio of area, equipments etc.
■	Components not included in data center section by the pro rata allocation according to the ratio of area, equipments etc.
−	Components excluded

【Classification of complex-facility】

DC section	Data center section including server room, UPS exclusive to IT devices, air-conditioning mechanical room etc.
DC related	Data center associated section including data center operation office etc.
Other than DC	Non-data-center section including general office for general affairs division, sales division other companies etc.

From 2.3.4 (2) in the main text
There is the other method that the energy for the shared section, general office area etc. may be included in the energy consumption for the whole data center facility to simplify the calculation of energy for the shared section of the whole complex-facility which should be included in the data center.
In this case, PUE/DCiE would be worse than it ought to be.

【Pro rata allocation method】

Allocation by energy:	Pro rata allocation should be based on the ratio of electric consumption of IT devices in the data center section and that of OA in the other sections (office section etc.)
Allocation by occupied area:	Pro rata allocation should be based on the ratio of area of data center section and that of the other sections such as office section (excluding shared section such as hall, hall way, restroom, shared conference room etc.)

(Exhibit 3) Facility Standard level (For reference in recording a data-center profile)
Data Center Facility Standard Digest Version 2010.10. 18 Established by Japan Data Center

◆ Japan Data Center Council (JDCC) Data Center Facility Standard Rev.14 2010.05.26

● Base item

Category	No.	Evaluation item		Tier 1	Tier 2	Tier 3	Tier 4
Building	1	Purpose of the building（Is the ＊A “single tenant” refer to one who owns, manages or controls such		Multi-purpose Multi-tenants acceptable	Multi-purpose Multi-tenants acceptable	Multi-purpose Single tenant	DC-exclusive DC-related multi-tenant
	2	Safety against earthquake risk Probable maximum loss (PML) from (a 10% exceedance probability of loss in 50		PML 25-30%, exclusive or	PML 20-25%, exclusive or	PML 10-20%, exclusive or	PML Less than 10% or
		※1：Superhigh-rise seismic-isolation buildings under the Standards on Comprehensive Aseismic Planning for Government Facilities and Explanatory Remarks on the Standards (edited by Construction Ministry, 1996) are categorized into Class I. ※2：Estimated seismic intensity that will occur in the coming 50 years with a probability of 10% (National Seismic hazard Map, the Ministry of Education, Culture, Sports）	Seismic intensity 6 lower or less ※2	In compliance with the pre-1981 Building Standards Law（Aseismic reinforcement is not required by aseismic diagnosis results. If required, it has already been implemented.）		In compliance with the Building Standards Law, amended June 1981	In compliance with the Building Standards Law amended June 1981, and aseismic performance must be equivalent to Class II※1 ☐
			Seismic intensity 6 higher or more※2	In compliance with the pre-1981 Building Standards Law（Aseismic reinforcement is not required by aseismic diagnosis results. If required, it has already been implemented.）	In compliance with the Building Standards Law, amended June 1981	In compliance with the Building Standards Law amended June 1981, and aseismic performance must be equivalent to Class II※1	In compliance with the Building Standards Law amended June 1981, and aseismic performance must be equivalent to Class I※1
security —	3	Security control level Is security control performed by level – premises and building, DC room area, server room, and racks?		Server room	Server room	Building /server room	Premises /building /server room /racks
Electricity Electricity equipme	4	A redundancy for power receiving circuit		Single circuit	Multi-circuit	Multi-circuit（SNW, reserve line for main circuit, loop）	
	5	Redundancy for power supply route （Input to UPS from power receiving		Single route	Single route	Multi-route	Multi-route
	6	Redundancy for power supply route （UPS～server room PDU）		Single route	Single route	Multi-route	Multi-route
	7	Redundancy for in-house generator ＊Reserve power supply is equivalent to		Not specified	N	N	N+1
	8	Redundancy for UPS unit		N	N	N＋1	N+2 *If N=1, 2N is equivalent to Tier 4
Air-conditioning system	9	Redundancy for heat source equipment / air-conditioning equipment		N	N	N＋1	N+2 *If N=1, 2N is equivalent to Tier 4
	10	Heat source equipment for air- Redundancy for power supply route		Single route	Single route	Multi-route	Multi-route
Communi..	11	Incoming line Redundancy for carrier		Single line Single carrier	Multi-line single carrier	Multi-line Multi-carrier	Multi-line Multi-carrier
	12	Redundancy for network route inside building		Single route	Multi-route	Multi-route	Multi-route
Unit Operation	13	Control system		Not specified	Not specified	Constant control for 8 hours or more	Constant control for 24 hours × 365 days
	14	Operation management framework and operation（including operator training programs, etc.）		No operation management rule is established, personnel are distributed in accordance with the operation system	The operation management rule and the personnel development rule are established and implemented	ISO27001 has been obtained, or operation is implemented in accordance with the FISC（operation） standard	ISO27001 has been obtained, or operation is implemented in accordance with the FISC（operation） standard

* Refer when write in the data center profile (PUE/GEC write-in calculation sheet No.23)
* This facility standard was made a study by Japan Data Center Council and is subject to change without notice.

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