International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

L.1302

(11/2015)

SERIES L: ENVIRONMENT AND ICTS, CLIMATE CHANGE, E-WASTE, ENERGY EFFICIENCY; CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

Assessment of energy efficiency on infrastructure in data centres and telecom centres

Recommendation ITU-T L.1302

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Assessment of energy efficiency on infrastructure in data centres and telecom centres

Summary

Recommendation ITU-T L.1302 specifies an energy efficiency assessment methodology for data centres and telecom centres, test equipment accuracy requirements, assessment period, assessment conditions and calculation methods.

Concerning the data centres and telecom centres, the Recommendation considers assessment methods for the efficiency of the whole data centre/telecom centre and of a part of the data centre/telecom centre.

As the main energy-consuming infrastructure in data centres and telecom centres are the power feeding system (power supply system) and the cooling system, this Recommendation covers energy efficiency measurement methodologies for both types of systems.

The Recommendation takes into account methodologies and best practices currently in use or under development in networks, and data centres and telecom centres.

This Recommendation is aimed at reducing the negative impact of data centres and telecom centres through by providing methodologies for energy efficiency assessment. It is commonly recognized that data centres and telecom centres will have an ever-increasing impact on the environment in the future. The application of the assessment methods defined in this Recommendation can help owners and managers to build future data centres and telecom centres, or improve existing ones, that will operate in an environmentally responsible manner.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T L.1302	2015-11-29	5	11.1002/1000/12630

Keywords

Cooling system, data centre, energy efficiency, power feeding system, telecom centre.

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FOREWORD

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Assessment of energy efficiency on infrastructure in data centre and telecom centre

1 Scope

This Recommendation specifies an energy efficiency assessment methodology of the infrastructure of data centres and telecom centres under running conditions. The assessment methodology includes an assessment methodology of the energy efficiency for the whole data centre/telecom centre infrastructure (or facility), for a partial data centre/telecom centre infrastructure (or facility), for the power feeding system and for the cooling system.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T L.1200] Recommendation ITU-T L.1200 (2012), *Direct current power feeding interface up to 400 V at the input to telecommunication and ICT equipment*.

[ITU-T L.1201] Recommendation ITU-T L.1201 (2014), *Architecture of power feeding systems of up to 400 VDC*.

[ITU-T L.1202] Recommendation ITU-T L.1202 (2015), *Methodologies for evaluating the performance of up to 400 VDC power feeding system and its environmental impact*.

[ITU-T L.1300] Recommendation ITU-T L.1300 (2014), *Best practices for green data centres*.

[ITU-T L.1320] Recommendation ITU-T L.1320 (2014), *Energy efficiency metrics and measurement for power and cooling equipment for telecommunications and data centres*.

[IEC 60038] IEC 60038:2009, *IEC Standard Voltages*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 energy [b-ISO 16818]: Capacity for doing work; having several forms that may be transformed from one to another, such as thermal (heat), mechanical (work), electrical or chemical, and is expressed in Joule. For the purpose of this Recommendation, energy will be expressed in Watt-hours (Wh) or kilo Watt-hours (kWh).

3.1.2 power [b-ISO 16818]: Rate at which energy is transmitted.

3.1.3 PUE [b-ISO/IEC 30134-2]: Ratio of the data centre total energy consumption to information technology equipment energy consumption, calculated, measured or assessed across the same period.

3.1.4 pPUE [b-ISO/IEC 30134-2]: Derivative of PUE, which is the ratio of the total energy consumption within a defined boundary to the information technology equipment energy consumption

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 infrastructure (**facility)**: Equipment that supports information and communication technology (ICT) equipment, e.g., power delivery components and cooling system components.

3.2.2 ICT equipment: Information and communication equipment (e.g., computing, storage and network equipment) used in data centres.

3.2.3 power feeding system: Power source to which information and communication technology (ICT) equipment and facilities are intended to be connected, such as an UPS, a backup generator, etc.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AC Alternating Current

CLF Cooling Load Factor

DC Direct Current

EER Energy Efficiency Ratio

HV High Voltage

IT Information Technology

LV Low Voltage

MV Medium Voltage

pCLF partial Cooling Load Factor

PDU Power Distribution Unit

PLF Power Load Factor

PUE Power Usage Effectiveness

UPS Uninterruptible Power Supply

5 Conventions

None.

6 Architecture of data centre or telecom centre energy consumption

The architecture of data centres and telecom centres is illustrated in Figure 1.

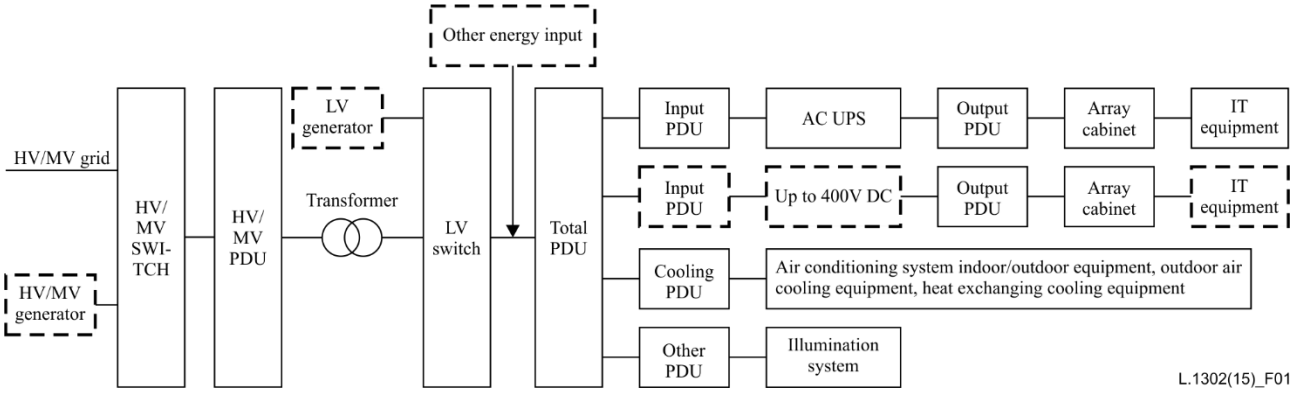


Figure 1 – Example of the architecture of a data centre energy consumption

Input energy: Grid, generator or any other source of energy.

AC power distribution system: High voltage or medium voltage distribution, transformer, power distribution cabinet, distribution cable, cooling system power distribution, safety power distribution, illumination power distribution, array cabinet, IT equipment cabinet power distribution, etc.

Uninterruptible Power Supply (UPS) system: UPS equipment and battery strings, etc.

Up to 400 V DC system: Up to 400 V DC equipment and battery strings, etc.

Cooling system: Air conditioner (including indoor and outdoor equipment), cooling tower, pump, outdoor air equipment, heat exchanging equipment, etc.

Other equipment: illumination equipment, safety equipment, anti-fire equipment, sensors, monitoring system, etc.

The energy saving scheme mentioned in [ITU-T L.1300] should be applied as much as possible in data centres and telecom centres to reduce the negative impact of data centres and telecom centres on climate.

7 Whole data centre and telecom centre energy efficiency measurement methodology

7.1 Test instrument requirements

The accuracy of the testing equipment shall comply with the following requirements:

Item	Accuracy
Temperature	–0.5°C～+0.5°C
Humidity	–5.0%～+5.0%
Voltage	–1.0%～+1.0%
Current	–1.0%～+1.0%
Power	–3.0%～+3.0%
Energy	Class 1

NOTE – Class 1 is for energy measurement accuracy and should refer to [IEC 62053-21] class 1.

7.2 Assessment period and frequency

1) Assessment period

The assessment period should be of twelve months, considering that the cooling system energy efficiency varies according to the outside temperature. The power feeding system energy efficiency also differs depending on the load rate.

If the assessment period is not of twelve months, a justification of the assessment period used is required and should be documented in the final report.

2) Assessment frequency

Continuous measurement is needed, and energy consumption is required to be measured at least every 30 minutes. Given the conditions, if assessment is done in a discontinuous way, it should be done in accordance with the following requirements:

In the case of discontinuous measurement, energy consumption should be measured at least every 30 minutes, and assessment should be done at least once every hour. In addition, assessment should be done at least twice per day at least three days in one month.

If discontinuous measurement is being applied, justification of assessment frequency needs to be provided.

7.3 Assessment conditions

The assessment should cover whole year running conditions. If using discontinuous methods, it should be in accordance with following requirements:

1) Load conditions

   The assessment should cover busy hours and idle hours, so that it is done on different load conditions.

2) Environmental conditions

   The assessment should cover all seasons, so that it is done under different environmental conditions.

7.4 Measurement methods

Measurements of energy consumption and energy efficiency should be carried out once the whole data centre/telecom centre has reached a stable operation state.

The normal operation of the data centre or telecom centre should not be affected by the energy efficiency assessment activities. The power meter should be installed after data centre/telecom centre has been put in operation. Measuring voltage clamps and current probes should be used to avoid affecting the operation.

The power meter used should comply with clause 7.1.

The assessment period and frequency should be in accordance with clause 7.2.

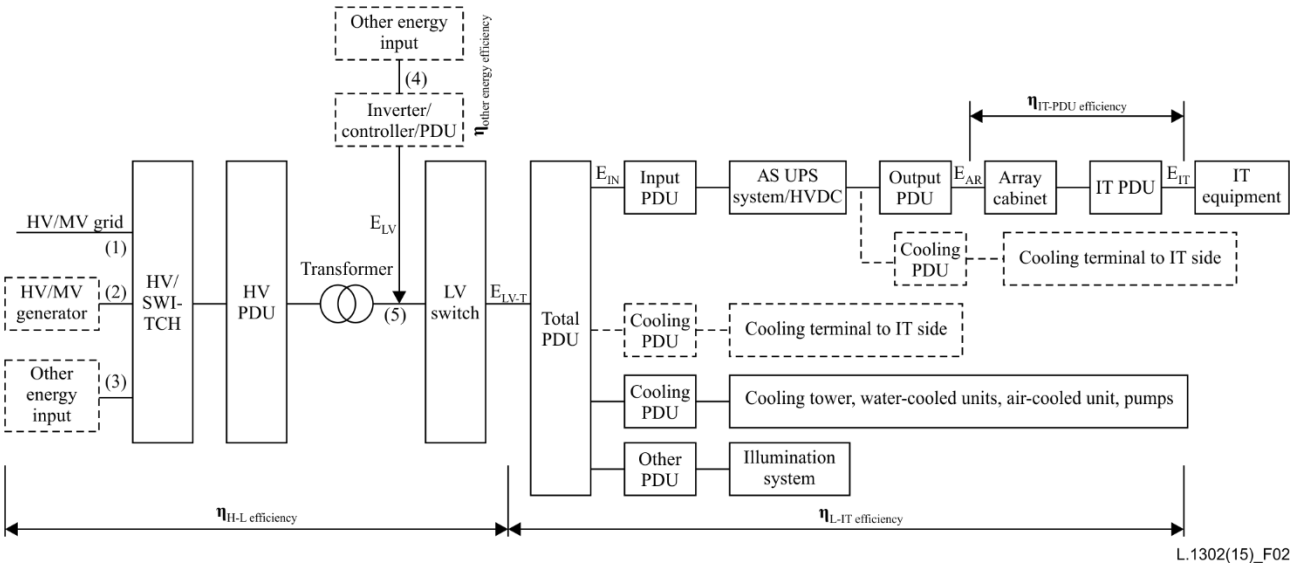
The assessment conditions should be in accordance with clause 7.3. As energy consumption and energy efficiency in the data centre/telecom centre are affected by environmental and load conditions, including room and outside temperature, room and outside humidity and load rate, these conditions and parameters need to be documented in the energy efficiency report.

The measurement points and calculation of energy efficiency should be accordance with clause 7.5 of this Recommendation.

7.5 Energy efficiency measurement points and calculation methods

The power input of data centres and telecom centres can be high voltage (HV), medium voltage (MV) or low voltage (LV). Different types of data centre and telecom centre for the measurement of the whole energy efficiency are shown in Figure 2 and Figure 3.

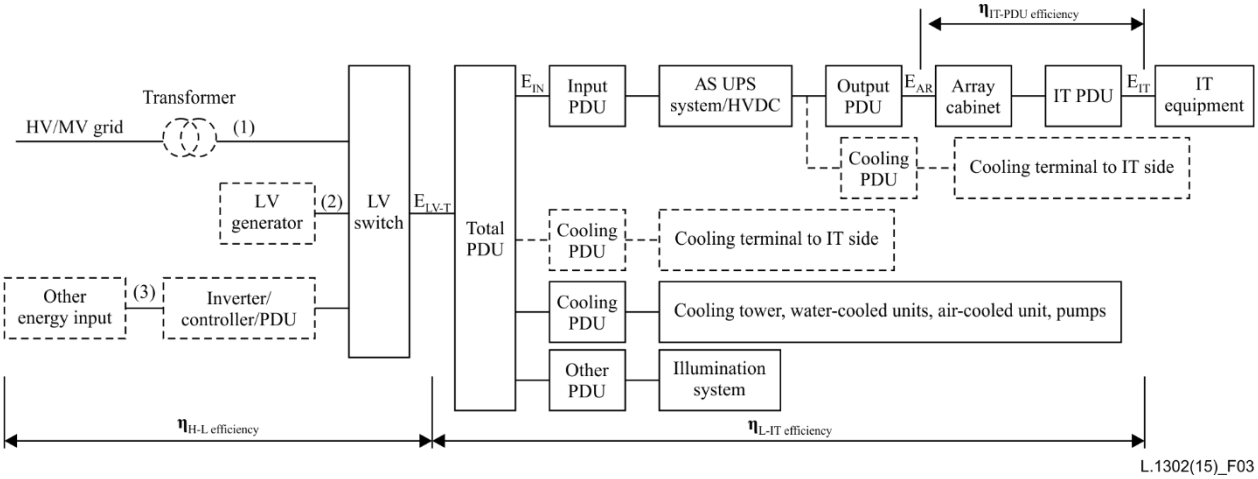
1) High voltage/medium voltage input data centre and telecom centre structure



NOTE 1 – Dotted lines indicate that the connection is optional.
NOTE 2 – Definition of HV/MV should be in accordance with [IEC 60038].

Figure 2 – Example of HV/MV input data centre/telecom centre energy consumption structure

2) Low voltage input data centre and telecom centre structure



NOTE 1 – Dotted line indicate that the connection is optional.
NOTE 2 – Definition of LV should be in accordance with [IEC 60038].

Figure 3 – Example of LV input data centre/telecom centre energy consumption structure

The calculation of power usage effectiveness (PUE) should be in accordance with the following formula:

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

E_{IT} should be measured at the IT equipment input terminal. If it is impracticable to measure the energy on all IT input terminals in normal working conditions, the energy can be calculated as:

$$E_{IT} = E_{AR} * \eta_{IT\text{-}PDU\ efficiency}$$

$\eta_{IT\text{-}PDU\ efficiency}$ can be calculated by measuring the voltage drop from array cabinet to IT rack.

The measurement of E_{DC} can be divided in the following two cases:

1) High voltage/medium voltage input data centre and telecom centre

$$E_{DC} = E_{(1)} + E_{(2)} + E_{(3)} + E_{(4)}$$

where:

$E_{(1)}$, $E_{(2)}$, $E_{(3)}$, $E_{(4)}$ are the energy consumption at points (1), (2), (3) and (4) in Figure 2. The unit of measurement is kWh.

If high voltage input points, such as (1), (2) and (3) in Figure 2, cannot be measured, energy consumption at those points can be calculated as:

$$E_{DC} = E_{LV\text{-}T}/\eta_{H\text{-}L\ efficiency}$$

where:

$E_{LV\text{-}T}$ is energy consumption at point (5) in Figure 2. The unit of measurement is kWh

$\eta_{H\text{-}L\ efficiency}$ is energy efficiency of energy distribution system from high voltage to low voltage, taking into account all conversion losses.

2) Low voltage input data centre/telecom centre

The calculation of E_{DC} is as follows.

$$E_{DC} = E_{(1)}/\eta_{tranformer} + E_{(2)} + E_{(3)}$$

where:

$E_{(1)}$, $E_{(2)}$, $E_{(3)}$ is the energy consumption at points (1), (2) and (3) in Figure 3. The unit of measurement is kWh

$\eta_{tranformer}$ is the energy efficiency of the transformer.

7.6 Partial data centre and telecom centre energy efficiency

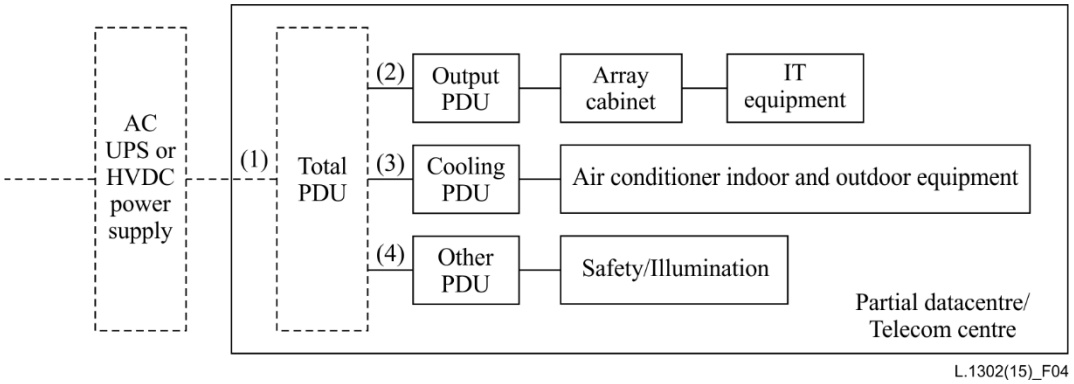
Partial data centre and telecom centre energy efficiency should be calculated according to the following formula:

$$pPUE = E_{pDC}/E_{IT}$$

The measurement method for E_{IT} should be in accordance with clause 7.5.

Considering that a partial data centre/telecom centre, such as one room in the data centre/telecom centre, may or may not have one total power distribution panel, the measurement method of the total energy consumption for a partial data centre/telecom centre, $E_{pDC,}$ can be classified according to the different possibilities as follows:

1) Cooling system outdoor equipment is connected to the room total power distribution panel. This is depicted in Figure 4.



NOTE – Dotted lines indicate that the connection is optional.

Figure 4 – Air conditioning system connected to room PDU

If there is a total distribution panel in the room,

$$E_{pDC} = E_{(1)}$$

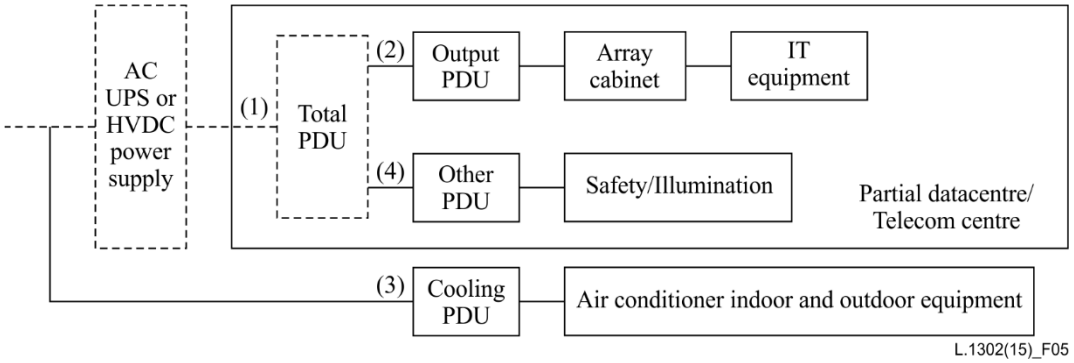
else,

$$E_{pDC} = E_{(2)} + E_{(3)} + E_{(4)}$$

Where:

$E_{(1)}$, $E_{(2)}$, $E_{(3)}$, $E_{(4)}$ is the energy consumption at points (1), (2), (3) and (4) in Figure 4. The unit of measurement is kWh.

2) Cooling system outdoor equipment capacity is small and independent, and is connected to another PDU. This is depicted in Figure 5.



NOTE – Dotted lines indicate that the connection is optional.

Figure 5 – Air conditioning system connected to another PDU

If there is a total distribution panel in the room,

$$E_{pDC} = E_{(1)} + E_{(3)}$$

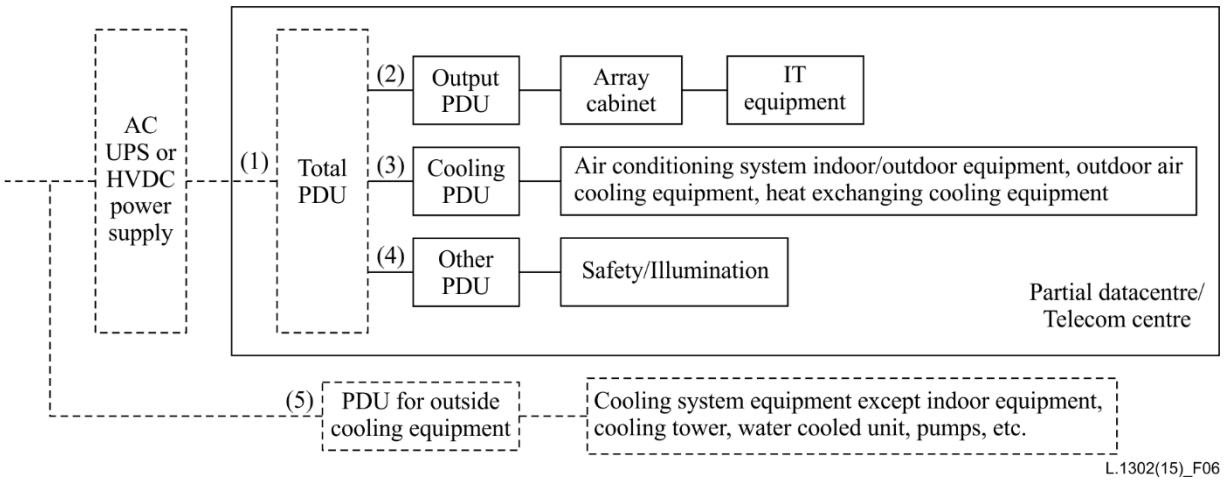
else,

$$E_{pDC} = E_{(2)} + E_{(3)} + E_{(4)}$$

where:

$E_{(1)}$, $E_{(2)}$, $E_{(3)}$, $E_{(4)}$ is the energy consumption at points (1), (2), (3) and (4) in Figure 5, the unit is kWh.

3) Cooling system outdoor part consists of pumps, cooling tower, etc. in a big data centre/telecom centre. This is depicted in Figure 6.



NOTE – Dotted line indicates that the connection is optional.

Figure 6 – Cooling system outdoor unit as part of the public sector system

If there is a total distribution panel in the room,

$$E_{pDC} = E_{(1)} + E_{cool\text{-}out}$$

else,

$$E_{pDC} = E_{(2)} + E_{(3)} + E_{(4)} + E_{cool\text{-}out}$$

where:

$$E_{cool\text{-}out} = K_{cool} * E_{whole\text{-}cool\text{-}out}$$

$$K_{cool} = CP_{room}/CP_{whole\text{-}DC/TC}$$

$$E_{whole\text{-}cool\text{-}out} = E_{(5)}$$

and:

$E_{(1)}$, $E_{(2)}$, $E_{(3)}$, $E_{(4)}$ are the energy consumption at points (1), (2), (3) and (4) in Figure 6. The unit of measurement is kWh

CP_{room} is the rated cooling capacity of air conditioner or other cooling equipment in the room, the unit is kWh

$CP_{whole\text{-}DC/TC}$ is the rated cooling capacity of whole data centre/telecom centre, the unit is kWh

$E_{whole\text{-}cool\text{-}out}$ is energy efficiency of cooling system outside cooling tower/water-cooled units/air-cooled unit etc. for whole data centre and telecom centre.

8 Power feeding system energy efficiency measurement methodology

8.1 Test instrument requirements

The accuracy of the testing equipment shall comply with the following requirements:

Item	Accuracy
Voltage	–1.0%～+1.0%
Current	–1.0%～+1.0%
Power	–3.0%～+3.0%
Energy	Class 1

8.2 Assessment period and frequency

1) Assessment period

The assessment period should be of twelve months, considering that the power feeding system energy efficiency varies depending on the load rate.

If the assessment period is not of twelve months, a justification of the assessment period used is required and should be documented in the final report.

2) Assessment frequency

Continuous measurement is needed, and energy consumption is required to be measured at least every 30 minutes. Given the conditions, if assessment is done in a discontinuous way, it should be done in accordance with the following requirements:

In the case of discontinuous measurement, energy consumption should be measured at least every 30 minutes, and assessment should be done at least once every hour. In addition, assessment should be done at least twice per day at least three days in one month.

If discontinuous measurement is being applied, justification of assessment frequency needs to be provided.

8.3 Assessment conditions

The assessment should cover whole year running conditions. If using discontinuous methods, it should cover busy hours and idle hours, such that the assessment is done under different load conditions.

8.4 Measurement methods

Measurements of energy consumption and energy efficiency should be carried out once the power system has reached a stable operation state.

Normal operation should not be affected by the energy efficiency assessment of the power feeding system. The power meter should be installed after the power feeding system has been put in operation. Measuring voltage clamps and current probes should be used to avoid affecting the operation.

The accuracy of the instrument used for the assessment should comply with clause 8.1.

The assessment period and frequency should be in accordance with clause 8.2.

The assessment conditions should be in accordance with clause 8.3. As energy consumption and energy efficiency of the power feeding system are affected by load conditions, the load rate needs to be documented in the power feeding system energy efficiency report.

The measurement points and calculation of energy efficiency should be accordance with clause 8.5.

8.5 Energy efficiency measurement points and calculation methods

The power equipment energy efficiency measurement methods should comply with [ITU-T L.1320]. The whole system measurement should comply with [ITU-T L.1200], [ITU-T L.1201] and [ITU-T L.1202].

The power feeding system energy efficiency of the data centre/telecom centre, $\eta_{Whole\_DC\_POWER}$, is calculated with following formula:

$$\eta_{Whole\_DC\_POWER} = E_{IT}/E_{input\_power}$$

PLF of the power feeding system is calculated with following formula:

$$PLF = E_{power\text{-}consumption}/E_{IT} = (E_{input\_power} - E_{IT})/E_{IT}$$

The measurement of E_{IT} should comply with clause 7.5.

The measurement of E_{input_power} depends on the following different situations:

1) Only grid input data centre and telecom centre

The system structure in shown in Figure 2 and Figure 3.

If the input energy in high voltage point is measureable, the input energy can be directly calculated as:

$$E_{input\_power} = E_{(1)}$$

else, the input energy can be obtained as:

$$E_{input\_power} = E_{IN}/(\eta_{H\text{-}IN\ efficiency} * \eta_{tpdu})$$

where:

$\eta_{H\text{-}INefficiency}$ is the power efficiency of high voltage to power feeding system input distribution part in the whole data centre/telecom centre.

2) Grid and other energy input data centre/telecom centre

If there is renewable energy or some other energy sources connected low voltage switches,

$$E_{input\_power\text{-}} = E_{IN}/((\eta_{H\text{-}L\ efficiency} * r1 + \eta_{other\ energy\ efficiency} * r2) * \eta_{tpdu})$$

where:

r1 is input energy rate of the main input energy

r2 is input energy rate of the other input energy

$\eta_{other\ energy\ efficiency}$ is energy efficiency of other energy sources.

9 Cooling system energy efficiency measurement methodology

9.1 Test instrument requirements

The accuracy of the testing equipment shall comply with the following requirements:

Item	Accuracy
Temperature	–0.5°C+0.5°C
Humidity	–5.0%～+5.0%
Voltage	–1.0%～+1.0%
Current	–1.0%～+1.0%
Power	–3.0%～+3.0%
Energy	Class 1

9.2 Assessment period and frequency

1) Assessment period

The assessment period should be of twelve months, considering that the cooling system energy efficiency varies depending of outside temperature.

If the assessment period is not of twelve months, a justification of the assessment period used is required and should be documented in the final report.

2) Assessment frequency

Continuous measurement is needed, and energy consumption is required to be recorded at least every 30 minutes. Given the conditions, if assessment is done for discontinuous way, it should be done in accordance with following requirements:

In the case of discontinuous measurement, energy consumption should be measured at least every 30 minutes, and assessment should be done at least once every hour. In addition assessment should be done at least twice per day and at least three days in one month.

If discontinuous assessment is being applied, justification of assessment frequency needs to be provided.

9.3 Assessment conditions

The assessment should cover whole year running conditions. If using discontinuous methods, it should be in accordance with the following requirements:

1) Load conditions

The assessment should cover busy hours and idle hours, so as to do the assessment on different load conditions.

2) Environmental conditions

The assessment should cover all seasons, so that the assessment is done under different environmental conditions.

9.4 Measurement methods

Measurements of energy consumption and energy efficiency should be carried out once cooling operation has reached a stable state.

Normal operation should not be affected by the energy efficiency assessment of the cooling system. The power meter should be installed after the cooling system has been put in operation. Measuring voltage clamps and current probes should be used to avoid affecting the operation.

The power meter used should comply with clause 9.1.

The assessment period and frequency should be in accordance with clause 9.2.

The assessment conditions should be in accordance with clause 9.3. As energy consumption and energy efficiency of the cooling system are affected by environmental conditions, including room and outside temperature, and room and outside humidity, these conditions and parameters need to be documented in the energy efficiency report.

The measurement points and calculation of energy efficiency should be accordance with clause 9.5.

9.5 Energy efficiency measurement points and calculation methods

The cooling equipment energy efficiency measurement methods should comply with [ITU-T L.1320].

As it is difficult to measure online cooling system parameters, such as output air volume and energy efficiency ratio (EER) in data centres/telecom centres, it is recommended that factor CLF be used instead of EER.

The whole data centre/telecom centre CLF should be measured and calculated according to:

$$CLF = E_C/E_{IT}$$

where:

Ec is energy consumption of the whole cooling system. The measurement unit is kWh.

The measurement of E_{IT} should be in accordance with clause 7.5.

The partial data centre/telecom centre pCLF should be measured and calculated according to:

$$pCLF = E_{PC}/E_{IT}$$

where:

E_{pc} is energy consumption of partial data centre and telecom centre cooling system, the unit is kWh.

Given the different structures of data centres/telecom centres, Epc can be calculated depending on the structure, and using the same classification as for pPUE.

1) Partial data centre/telecom centre with the structure shown in Figure 4:

$$E_{PC} = E_{(3)}$$

2) Partial data centre/telecom centre with the structure shown in Figure 5:

$$E_{PC} = E_{(3)}$$

3) Partial data centre/telecom centre with the structure shown in Figure 6:

$$E_{PC} = E_{(3)} + E_{cool\text{-}out}$$

The measurement of E_{IT} should be in accordance with clause 7.5.

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Printed in Switzerland
Geneva, 2016