DATA CENTER

Enhancing the Energy Efficiency and Use of Green Energy in Data Centers

Datacenter Performance Per Energy (DPPE) Enhances Energy Efficiency and Use of Green Energy in Data Centers

This booklet describes the datacenter performance per energy (DPPE) system developed by the Green IT Promotion Council (GIPC), introduces case studies, and explains how to use this metric.
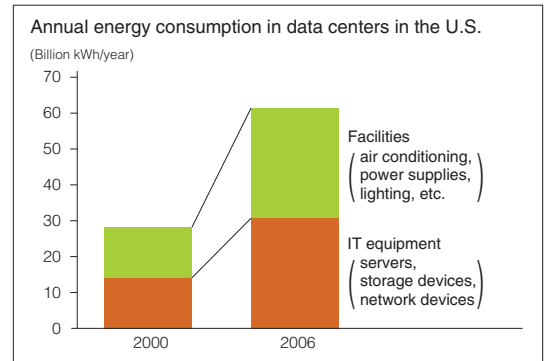
Green IT Promotion Council

Saving Energy and Using Green Energy in Data Centers

**There is an increasing need to save energy
and use green energy to reduce environmental impact and energy costs.**
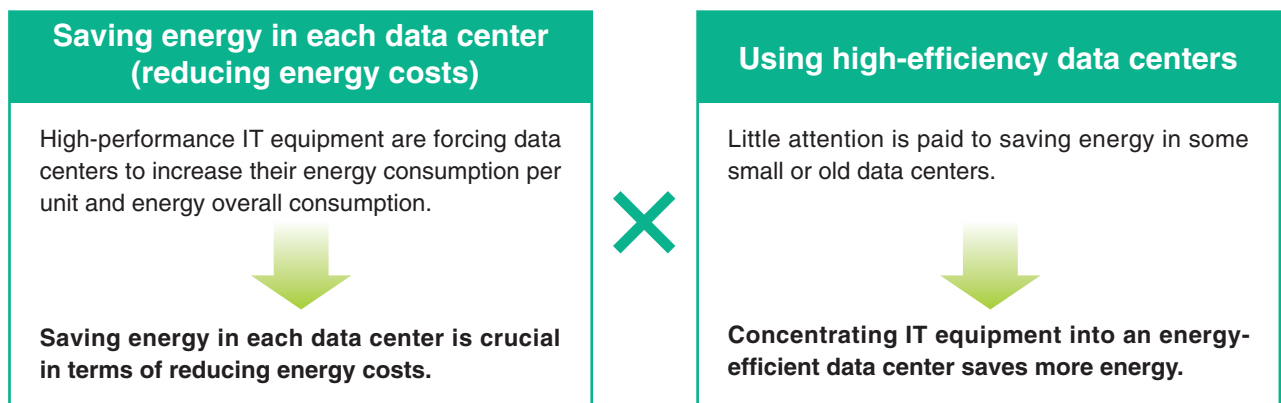
Data centers are consuming ever-more energy as their role expands.

- Information to be managed is drastically increasing due to the expansion of cloud computing services and smart phones.
- According to a report of the U.S. Environmental Protection Agency (EPA), the energy consumed by data centers in the U.S. doubled from 2000 to 2006.
- Urgent action must be taken to curb CO_2 emissions by raising energy efficiency.

Annual energy consumption in data centers in the U.S.

(Billion kWh/year)

Facilities
(air conditioning, power supplies, lighting, etc.)

IT equipment
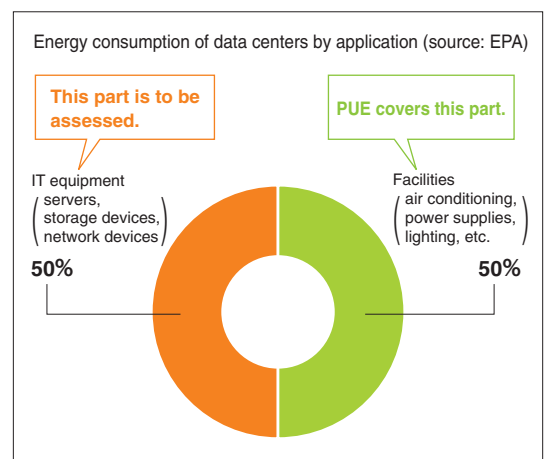(servers, storage devices, network devices)

Source: "Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431"
(US Environmental Protection Agency (EPA), 2007)

The key to high energy efficiency is to save energy in each data center (reducing energy costs) and to use high-efficiency data centers.

Saving energy in each data center (reducing energy costs)

High-performance IT equipment are forcing data centers to increase their energy consumption per unit and energy overall consumption.

Saving energy in each data center is crucial in terms of reducing energy costs.

Using high-efficiency data centers

Little attention is paid to saving energy in some small or old data centers.

Concentrating IT equipment into an energy-efficient data center saves more energy.

GIPC has worked hard to develop DPPE, a metric for measuring the efficiency of a data center as a whole.

- Before implementing any measures, the efficiency of the data center must be precisely quantified.
- The power usage effectiveness (PUE) is widely used to show the energy efficiency of a data center.
- However, PUE measures the energy efficiency of the facility itself. To improve the overall energy efficiency, it is necessary to improve the efficiency of both the facility and IT equipment.
- To achieve this, GIPC has been developing DPPE.

Energy consumption of data centers by application (source: EPA)

This part is to be assessed.

PUE covers this part.

IT equipment
(servers, storage devices, network devices)

50%

Facilities
(air conditioning, power supplies, lighting, etc.)

50%

Green IT Technologies for Enhancing Energy Efficiency of Data Centers

New green IT technologies for enhancing the energy efficiency
of data centers are emerging in Japan.
A wide variety of solutions won the 2012 Green IT Awards.

Enhancing energy efficiency of the facility including air conditioning, lighting, power supplies / Using green energy

2012 METI Minister's Awards

A power supply for data centers that achieves high efficiency by using a high-voltage direct current (HVDC) and a centralized DC power supply (reducing the number of power supply units of each IT equipment)
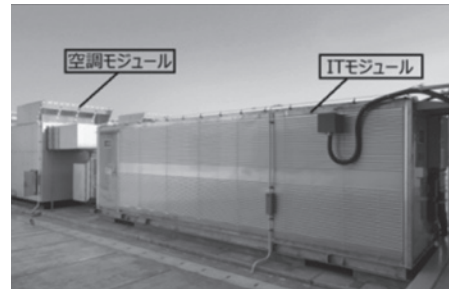
NTT Data Intellilink Corporation, Japan Radio Co., Ltd., and NTT Data Corporation
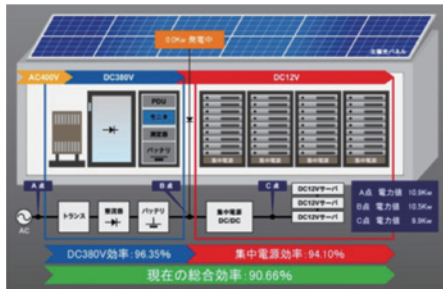
2012 METI Commerce and Information Policy Director-General's Awards

A container data unit cooled by open air at low cost that is suitable for cloud computing, easy to scale up, and efficiently accommodates servers

Internet Initiative Japan, Inc.

2012 Green IT Promotion Council Chairman's Awards

A container-type data center that reduces power by 75% compared with conventional types
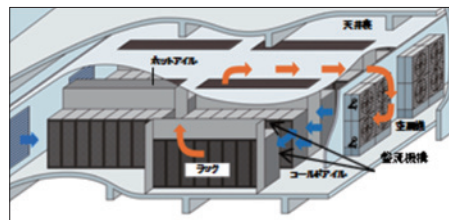
IPCORE Lab Inc. and NIPPON FRUEHAUF COMPANY, LTD.

2012 Green IT Award Judging Committee Special Awards

An air-conditioning system that blows cold air from the wall of the server room and uses only a third of the blast pressure of existing floor-blowing air-conditioning systems

Takasago Thermal Engineering Co., Ltd. and Kanden Energy Solution Co., Inc.

Energy saving of IT: using high energy efficiency IT equipment and improving the efficiency of operation by virtualization, etc

2012 METI Commerce and Information Policy Director-General's Awards

Servers are usually installed for each customer to provide security and reliability. Combining existing servers as a single virtual system substantially decreases the number of servers and power consumption.
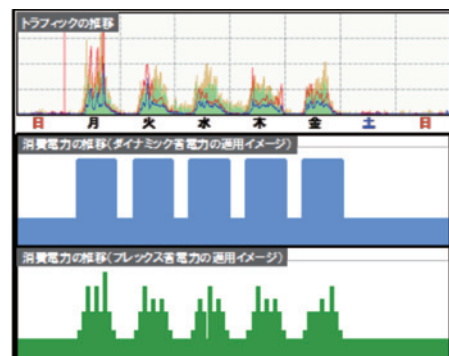
Fujitsu Limited
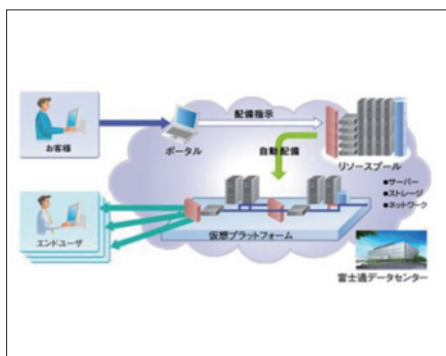
2012 Green IT Award Judging Committee Special Awards

A network system with the following two technologies: dynamic energy-saving technology that switches on/off the networking devices depending on the traffic, and flexible energy-saving technology that carefully controls power for surplus functions
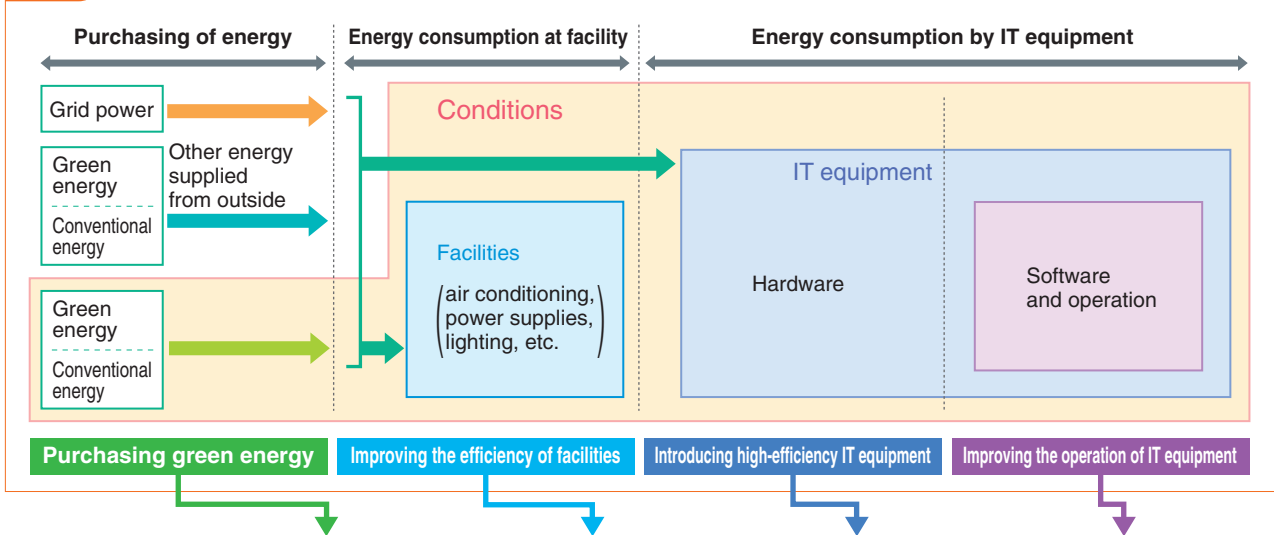
ALAXALA Networks Corporation

Outline of DPPE and How to Measure the Metric

The energy consumption in data centers can be measured in four phases. DPPE has four sub-metrics for each phase to comprehensively assess the energy efficiency.

1

The energy flow in data centers can be measured in four phases: purchasing of energy, use of facility, purchasing of IT equipment, and operation of IT equipment.

| Purchasing of energy | Energy consumption at facility | Energy consumption by IT equipment |

Grid power → Other energy supplied from outside

Green energy / Conventional energy →

Green energy / Conventional energy →

Conditions

Facilities (air conditioning, power supplies, lighting, etc.)

IT equipment — Hardware — Software and operation

Purchasing green energy | **Improving the efficiency of facilities** | **Introducing high-efficiency IT equipment** | **Improving the operation of IT equipment**

2

The efficiency in these four phases is calculated with corresponding metrics.

	Purchasing of energy	**Use of facility**	**Purchasing of IT equipment**	**Operation of IT equipment**
Sub-metric	Green Energy Coefficient **GEC**	Power Usage Effectiveness **PUE**	IT Equipment Efficiency **ITEE**	IT Equipment Utilization **ITEU**
Formula	Green energy / Total energy consumption of the data center	Total energy consumption of the data center / Total energy consumption of IT equipment	Total rated capacity of IT equipment / Total rated power of IT equipment	Actual energy consumption of IT equipment / Total rated power of IT equipment
Measurement	Actual measurement • The ratio of green energy to total energy consumption	Actual measurement • The ratio of total energy consumption to that of IT equipment	Specification values in catalogs • Energy efficiency values described in IT equipment catalogs	Combining actual values and specification values in catalogs • Utilization rate of IT equipment
Improvement	Introducing photovoltaic power systems, etc.	Improving the efficiency of air conditioning systems and power supply units	Introducing IT equipment with high energy efficiency performance	Improving the utilization rate of IT equipment and virtualizing

3

There are two assessment methods:
① The four sub-metrics are arranged on a spider web chart to easily identify problems.
② A comprehensive assessment based on the four sub-metrics can show the improvement over time.

3-1 Assessment with a spider web chart

A spider web chart with the four sub-metrics shows the efficiency of the data center.

A larger diamond shows higher efficiency.
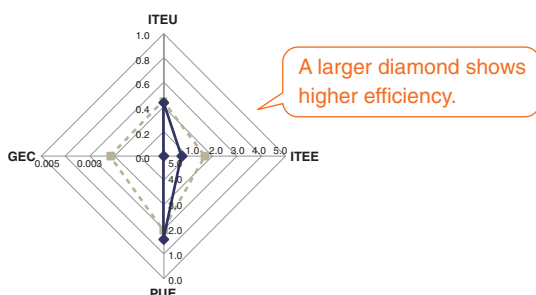
3-2 Comprehensive assessment of a data center

Productivity is obtained by dividing the amount of data processed by the energy consumption.
The comprehensive metric is calculated by the four sub-metrics to show the productivity:

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

Example $\quad 0.42 \times 0.48 \times (1 / 1.76) \times (1 / (1 - 0)) = 0.11$

* A larger DPPE indicates higher energy efficiency.

Assessment Examples

As a fiscal 2010/2011 project delegated by the Ministry of Economy, Trade and Industry, Japan (METI),
GIPC assessed the energy efficiency in several data centers in Japan.
The results clearly show the characteristics of the data centers, proving that DPPE is a useful assessment tool.

Old equipment but well-maintained
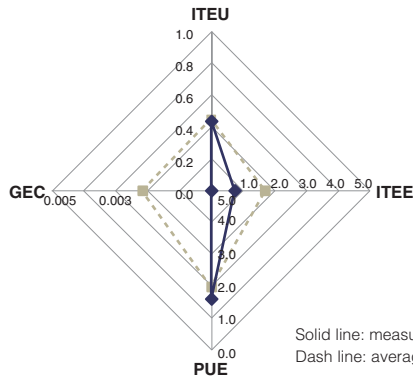
Solid line: measured value
Dash line: average value of the assessed data centers*

Assessment

- The small PUE indicates the high energy efficiency of the facility.

- The high ITEU indicates the high operational efficiency of the IT equipment.

- In contrast, a low ITEE shows the low energy efficiency of the IT equipment.

New equipment with low utilization rate
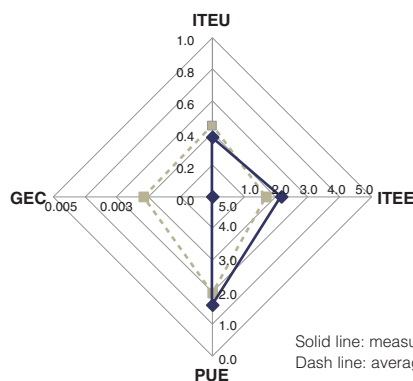
Solid line: measured value
Dash line: average value of the assessed data centers*

Assessment

- The small PUE indicates the high energy efficiency of the facility.

- The high ITEE indicates the appropriate use of high energy efficiency IT equipment.

- In contrast, the relatively low ITEU suggests that the operating rate of the IT equipment needs to be improved.

Changes in efficiency of a single data center in two years

Green: Fiscal 2010
Blue: Fiscal 2011
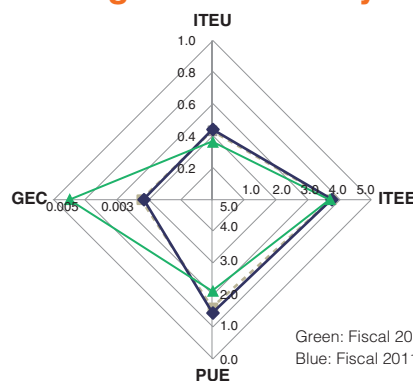
Assessment

- Almost the same ITEE values show no large changes in the IT equipment.

- The increased ITEU indicates the improved operating rate of the IT equipment.

- The PUE approaching 1 indicates the improved energy efficiency of the facility.

- The lower GEC may suggest no change in the amount of green energy even though the data center has expanded.

Note: ITEU and ITEE values vary depending on the configuration and operation of the IT equipment for the applications of the data center.

*Outline of DPPE measurement projects

- Verifying the effectiveness of DPPE as a METI project
- Fiscal 2010 to 2011
- Participants: ▶ More than 20 data centers in Japan and 2 data centers overseas (Singapore and Vietnam)
  ▶ Brokerage systems, banking systems, ASP systems, cloud services
- Measurements in accordance with the DPPE measurement guideline

■ Measurement result

Sub-metric	Average	Range
PUE	1.8	1.4 – 2.3
ITEE	1.6	0.1 – 3.9
ITEU	0.4	0.3 – 0.6
GEC	—	0 – 0.003

How to Use DPPE

**DPPE helps assess and effectively improve
the efficiency of an entire data center and individual sections.**

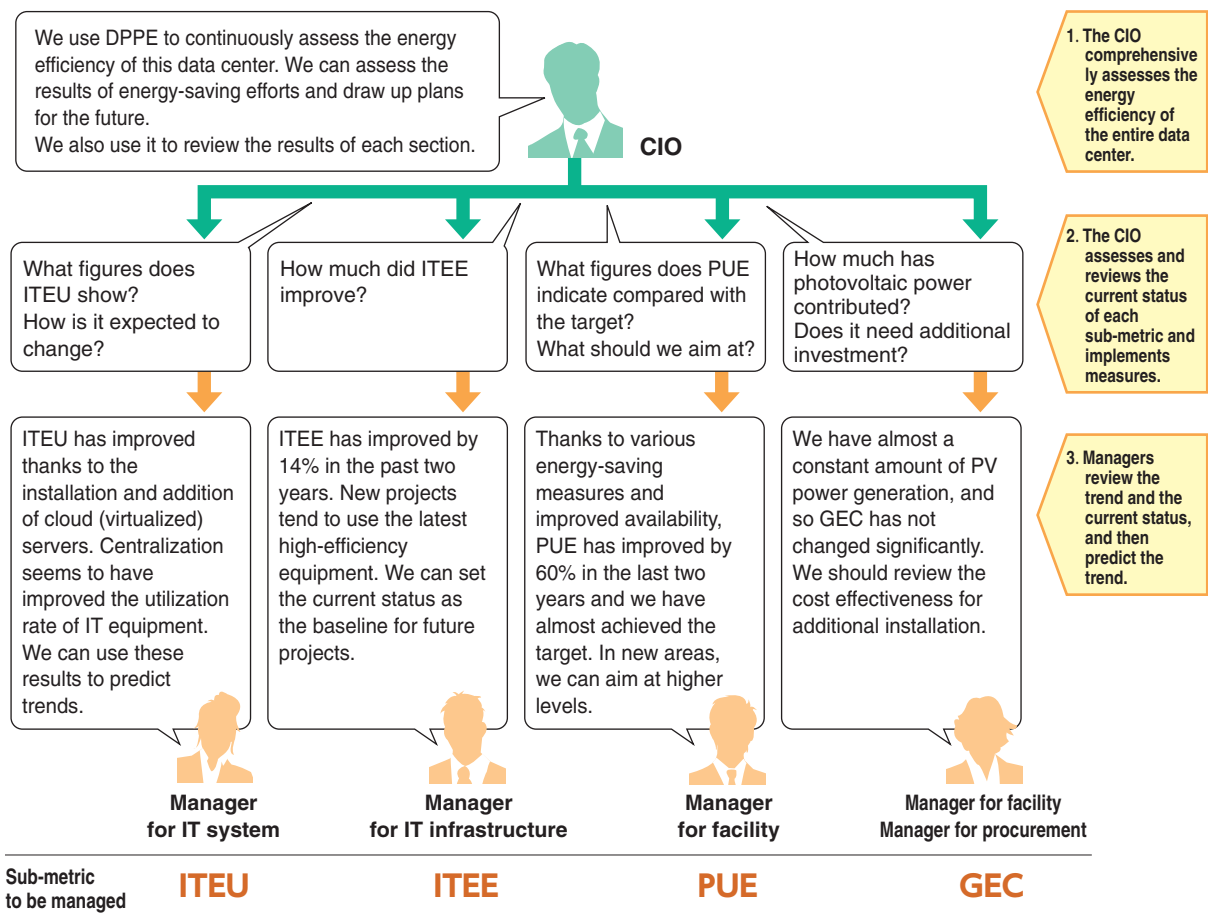## DPPE can be used to break down the assessment and measures.

- Identify the current status of energy efficiency of the data center by using DPPE.
- The CIO assesses the achievement of the overall goal and specific targets.
- Managers set respective targets and implement measures.

Usage of DPPE by Fujitsu Limited

FUJITSU

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

We use DPPE to continuously assess the energy efficiency of this data center. We can assess the results of energy-saving efforts and draw up plans for the future.
We also use it to review the results of each section.

CIO

1. The CIO comprehensively assesses the energy efficiency of the entire data center.

2. The CIO assesses and reviews the current status of each sub-metric and implements measures.

3. Managers review the trend and the current status, and then predict the trend.

What figures does ITEU show?
How is it expected to change?

How much did ITEE improve?

What figures does PUE indicate compared with the target?
What should we aim at?

How much has photovoltaic power contributed?
Does it need additional investment?

ITEU has improved thanks to the installation and addition of cloud (virtualized) servers. Centralization seems to have improved the utilization rate of IT equipment. We can use these results to predict trends.

ITEE has improved by 14% in the past two years. New projects tend to use the latest high-efficiency equipment. We can set the current status as the baseline for future projects.

Thanks to various energy-saving measures and improved availability, PUE has improved by 60% in the last two years and we have almost achieved the target. In new areas, we can aim at higher levels.

We have almost a constant amount of PV power generation, and so GEC has not changed significantly. We should review the cost effectiveness for additional installation.

Manager for IT system	**Manager for IT infrastructure**	**Manager for facility**	**Manager for facility Manager for procurement**
Sub-metric to be managed **ITEU**	**ITEE**	**PUE**	**GEC**

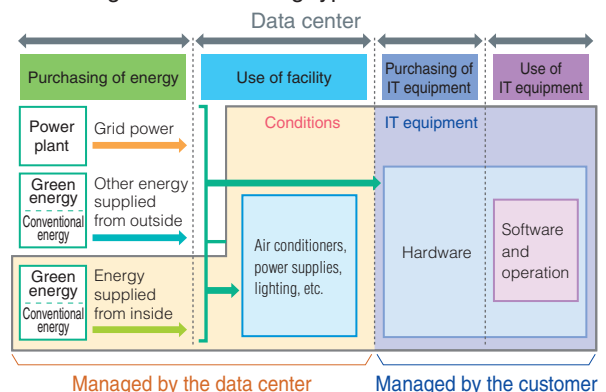## Housing-type data center

- Housing-type data centers, where IT equipment is brought in and managed by customers, can be assessed with PUE and GEC.
- The data center cannot improve the efficiency of customers' IT equipment.
- However, the data center can improve PUE and GEC; the sub-metrics of DPPE can be managed separately.

■ Management of housing-type data centers

Data center

Purchasing of energy	Use of facility	Purchasing of IT equipment	Use of IT equipment

Power plant — Grid power

Green energy / Conventional energy — Other energy supplied from outside

Conditions

IT equipment

Green energy / Conventional energy — Energy supplied from inside

Air conditioners, power supplies, lighting, etc.

Hardware

Software and operation

Managed by the data center | Managed by the customer

DPPE Q&A

Question	Answer
What is the optimum value of each sub-metric?	In theory, a smaller PUE and larger GEC and ITEU (as close to 1 as possible), and larger ITEE represent better efficiency. However, the configuration and operation of IT equipment vary depending on the characteristics of the data center. We recommend clarifying the situation and then setting appropriate targets.
Can DPPE be used for data centers powered by natural gas or other sources?	Yes. The Conference for Harmonizing Global Metrics for Data Centers, in which GIPC participated, has defined the method of measuring PUE for data centers with energy sources other than electricity. DPPE can be calculated based on it. See the DPPE manual for details.
Does the DPPE calculation take into account technologies of cloud computing or virtualization?	Yes. ITEU takes those technologies into account. This sub-metric assesses how efficiently the virtualization and other technologies use IT equipment and improve the utilization rate.
Which IT equipment is the target of ITEE and ITEU?	DPPE assesses the energy efficiency of IT equipment in the three categories: servers for calculation, storage devices for accumulation, and network devices for transmission. DPPE does not cover other kinds of IT equipment.
Measuring ITEE and ITEU seems to require efforts.	To measure ITEE and ITEU, you must refer to the list of IT equipment in the data center and the values of energy efficiency in catalogs. With much IT equipment, the work might require substantial manpower. The list of IT equipment should be well-maintained. GIPC is planning to develop support tools.

High-efficiency Data Centers Achieve High Energy Efficiency Society

High-efficiency data centers will help create a high energy efficiency society.
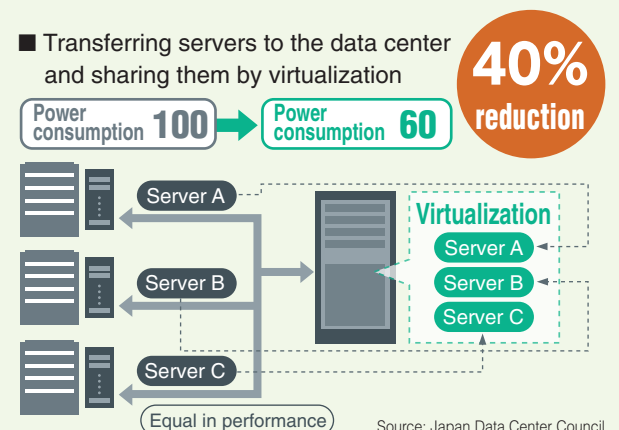
Enhancing energy efficiency by concentrating servers

Simply transferring servers from a space with low-efficiency air conditioning to the latest data center will substantially reduce the power consumption.

■ Enhancing energy efficiency by transferring servers

15% reduction

Conventional location — Data center
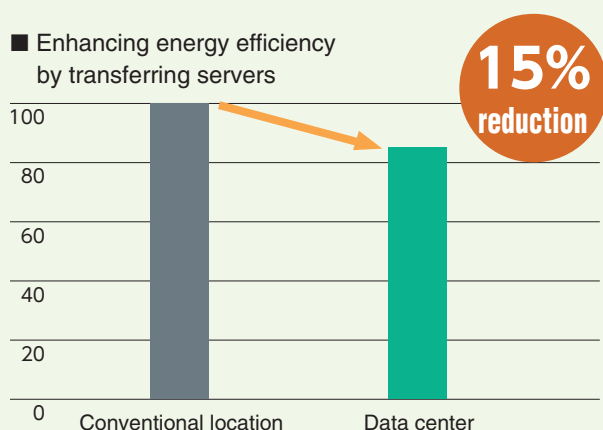
Enhancing energy efficiency by virtualization

Concentrating servers from individual offices into the data center and then sharing them will also significantly reduce the power consumption.

■ Transferring servers to the data center and sharing them by virtualization

40% reduction

Power consumption **100** → Power consumption **60**

Server A
Server B
Server C

Virtualization
Server A
Server B
Server C

Equal in performance

Source: Japan Data Center Council

DPPE Measuring Tool and Relevant Information

GIPC offers a tool and information regarding DPPE on its website at:

http://www.greenit-pc.jp/e/events/dppe/index.html

DPPE measurement guideline

The DPPE measurement guideline defines standardized methods of measuring DPPE at respective data centers and reporting the results.
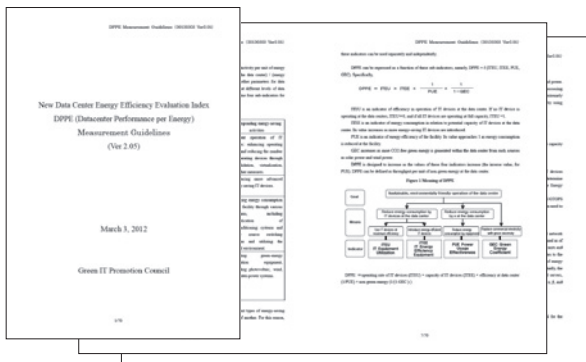
DPPE measuring tool

The DPPE measuring tool is a spreadsheet to calculate the value of metrics based on actual measured values.

DPPE manual

The DPPE manual describes the details of metrics to enhance the understanding of DPPE.

Other references

• "Guideline for PUE/DCiE measurement, ver. 2.2"
  Japan Data Center Council (http://www.jdcc.or.jp/english/index.html)

Global Standardization of DPPE

• GIPC and the METI are actively holding discussions with key public and private-sector entities from other regions (The Green Grid, Department of Energy, Environmental Protection Agency of the US, and EC Code of Conduct of Europe) in order to define effective metrics for measuring and assessing the energy efficiency of data centers. Since fiscal 2008, these organizations have regularly held international conferences and teleconferences to work together on the global standardization of energy efficiency metrics. GIPC and the METI propose DPPE in this discussion.

• GIPC and the METI are also actively promoting DPPE in ISO/IEC JTC1 SC39.

· EC Code of Conduct (EC CoC)

· The Green Grid (TGG)
· Department of Energy (DoE)
· Environmental Protection Agency (EPA)

· Ministry of Economy, Trade and Industry (METI)
· Green IT Promotion Council

Inquiries

For more details about DPPE and how to join, please contact us. The Green IT Promotion Council welcomes those who are interested in the development and promotion of DPPE.

Green IT Promotion Office / Environmental Affairs Department
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