

Concept of Datacenter Performance per Energy (DPPE)

February 2010



グリーンIT推進協議会
Green IT Promotion Council



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Objective and Background

Details of Developing Metrics



Establishment of Green IT Promotion Council

Toward the formation of a “society sustaining both environmental preservation and economic growth”, Japan's Ministry of Economy, Trade and Industry (METI) is pursuing the Green IT Initiative. Pivoting on technological strengths in *monozukuri* (product innovation) and environmental/energy conservation, this initiative seeks reformation in all areas of production, society and lifestyles. Japanese industry has embraced this initiative and established the Green IT Promotion Council as a place to strengthen ties between industry, the government and academia.

- **Establishment: 1 February 2008**
- **Title: Green IT Promotion Council**
- **Member companies, institutions and groups: 290**
(also includes foreign firms)

【 Initial members: 】

- Japan Electronics and Information Technology Industries Association (JEITA)
- The Japan Electrical Manufacturers' Association (JEMA)
- Japan Electric Measuring Instruments Manufacturers' Association (JEMIMA)
- Communications and Information network Association of Japan (CIAJ)
- Japan Business Machine and Information System Industries Association (JBMIA)
- Japan Information Technology Services Industry Association (JISA)
- Japan Users Association of Information Systems (JUAS)





Activities of Green IT Promotion Council

- ✓ **Strengthening linkages with relevant offshore groups, Organization of International Symposium**
- ✓ **Contribution of new technologies and IT to the environment, education and awareness-raising concerning environment/IT management**
- ✓ **Identification of IT and Electronics technologies thought to be highly effective in energy-saving, etc., and roadmap formulation**
- ✓ **Quantitative surveys and analysis on the contribution to reduction of the environmental burden (possible CO2 emission reductions, etc.)**

Strong links will be formed with the “Green IT Initiative”.



Industry–government–university linkages will be strengthened through partnership among the IT and electronics industry, research institutes, universities and governments.

International partnership will be pursued through links with offshore fora and various types of information–sharing.



Communicate to the wider world

Green IT Promotion Council partnership with USA and other international organization for promoting Green IT.

✓ Partnerships with International organization

◆ May, 2008

The Green Grid (USA)

Climate Savers Computing Initiative (USA)

◆ January, 2009

KOREA Green Business IT Association (KOREA)

◆ June, 2009

Digital Energy Solutions Campaign (USA)

For the future, Green IT Promotion Council will enter into partnership with EU organization to cooperate for preventing global warming such as introduction of both activities and formulating and diffusing energy efficient matrix.



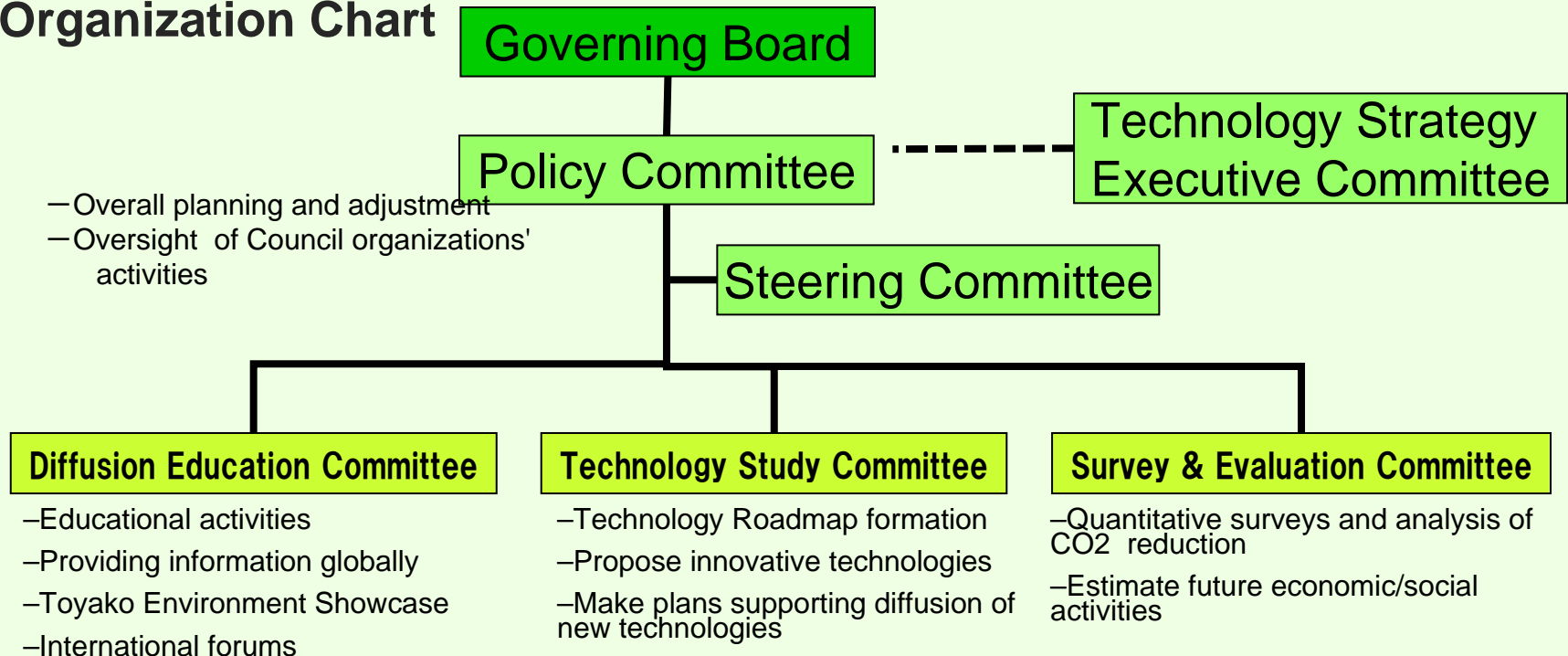


Structure of the Green IT Promotion Council

Three committees have been established to promote specific activities

- **Diffusion Education Committee,**
- **Technology Study Committee,**
- **Survey & Evaluation Committee: New Metrics for Data Center**

Organization Chart





Establishing New Metrics for Data Centers

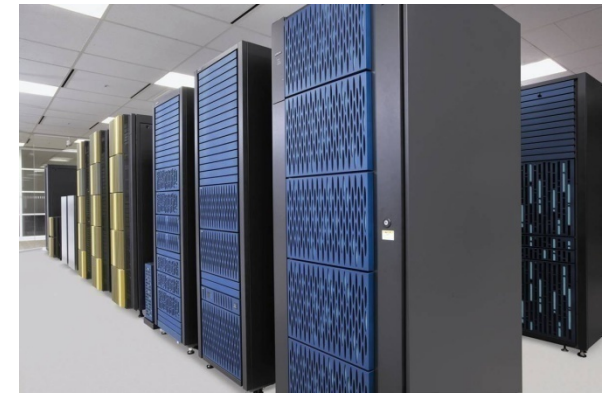
Current metrics and issues

$$\text{PUE (Power Usage Effectiveness)} = \frac{\text{Overall consumption by data centers}}{\text{Consumption by IT equipment}}$$

PUE is used by many companies

⇒ However, PUE is related to the **facility efficiency** of data centers

A new metrics for total data center productivity is required!



Study sample: DPPE (Datacenter Performance Per Energy)

$$\text{DPPE} = \text{function} \left(\begin{array}{l} \text{IT Equipment Utilization} \\ \text{Total energy consumption} \\ \quad - \text{ Natural electric energy} \end{array} \right) \left(\begin{array}{l} \text{IT equipment Efficiency} \\ \text{Power Usage Effectiveness} \end{array} \right)$$

Working with MOU partner The Green Grid, we are now studying a new energy efficiency metrics that express total productivity of data centers.



1st Workshop on Metrics of DC Energy Efficiency

- Workshop of private-sector experts organized by the Japanese, US and European governments.

- 26 March 2009 US Department of Energy, Washington D.C.

- Members: Japan: METI, Embassy of Japan, GIPC, JEITA
 US: Department of Energy,
 Environmental Protection Agency, TGG
 Europe: European Commission, UK government

- Introduction and discussion of energy efficiency metrics in Japan, the US and Europe

US: ENERGY STAR, PUE

Europe: Code of Conduct

Japan: DPPE





TGG-GIPC Tokyo Meeting 2009 on Data Center Energy Efficiency Metrics

Discussion of new metrics, DPPE

Date: October 10, 2009 (Sat) 13:00 – 16:00 (3 hours)
Venue: Makuhari Messe International Conference Hall



TGG-GIPC Tokyo Meeting



2nd Workshop on Metrics of DC Energy Efficiency

- Workshop of private-sector experts organized by the Japanese, US and European governments.

- 2 Feb 2010 San Jose, USA

- Members: Japan: METI, GIPC, JEITA
 US: Department of Energy,
 Environmental Protection Agency, TGG
 Europe: European Commission

- Discussion of energy efficiency metrics in Japan, US and Europe

- Review of Program Progress

- US: ENERGY STAR, PUE

- Europe: Code of Conduct

- Japan: DPPE





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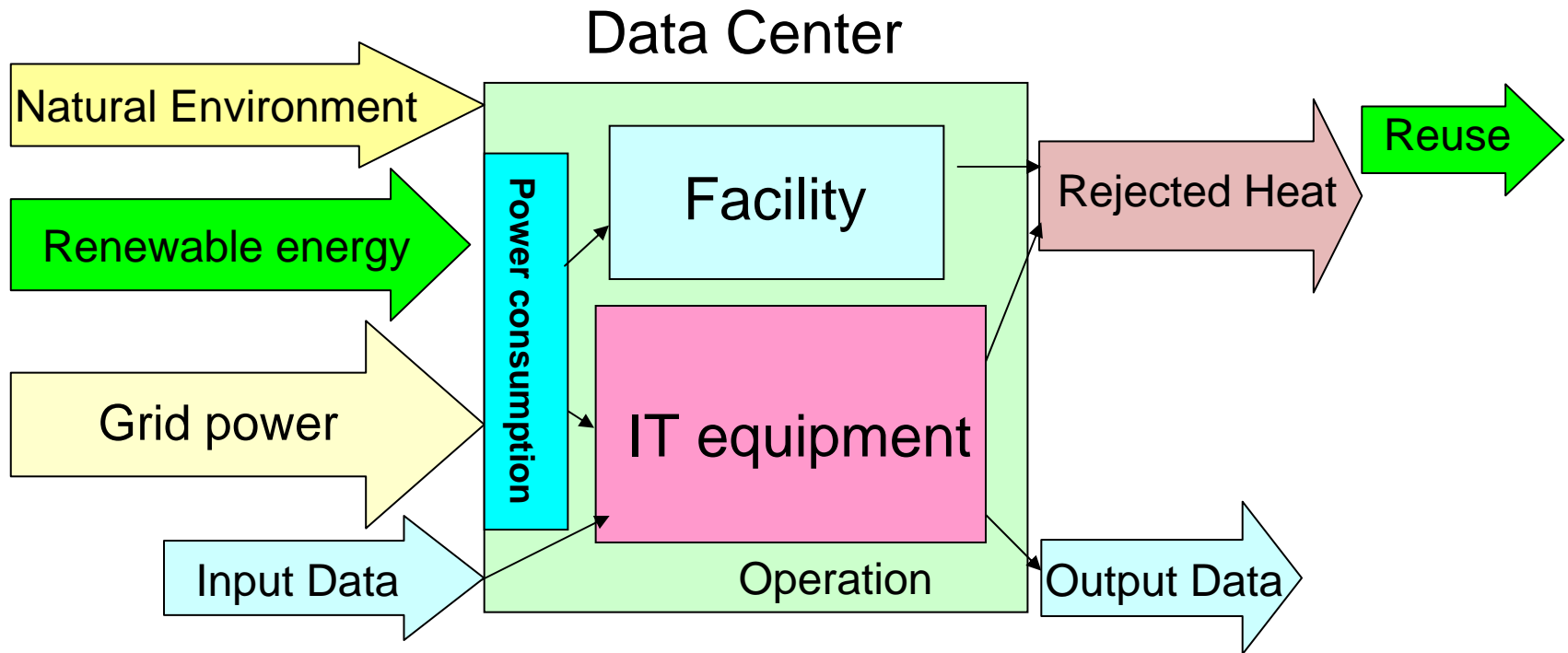
Objective and Background

Details of Developing Metrics



1 Concept

(1) Our Scope of Data Center Model





1 Concept

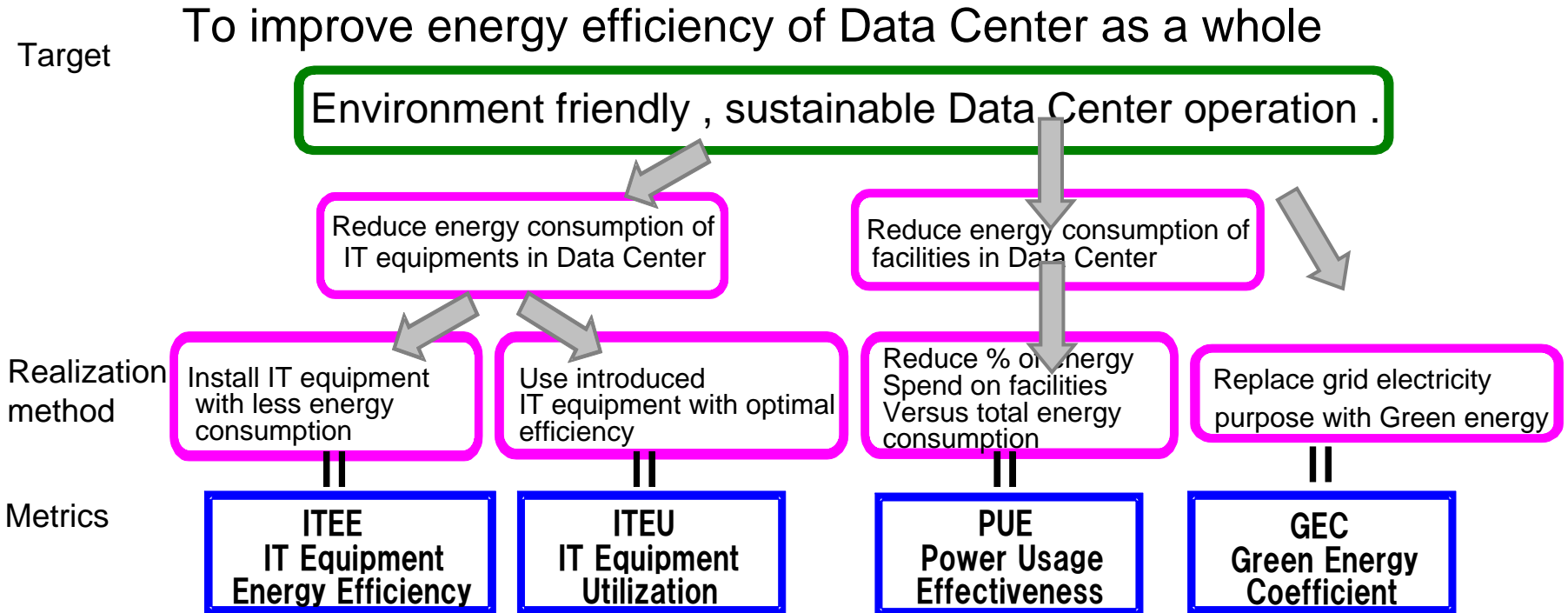
(2) Concept of DPPE (Datacenter Performance Per Energy)

- Data Center Performance Per Energy shall be as below:
 - (1) Energy efficiency of Data Centers can be calculated easily.
 - (2) Comparison between different Data Centers is possible.
 - (3) Comparison of year-round energy status is possible on continuous basis.
- Data Center Performance Per Energy (DPPE) is expressed as a function of four sub-metrics.
- Each of 4 sub-metrics can be used also as an individual metric.

$$\begin{aligned} \text{Data Center} \\ \text{energy efficiency} &= \mathbf{f} \left(\begin{array}{cccc} \text{Sub-metric 1} & \text{Sub-metric 2} & \text{Sub-metric 3} & \text{Sub-metric 4} \\ \text{IT Equipment} & \text{IT Equipment} & \text{Power Usage} & \text{Green} \\ \text{Energy Efficiency,} & \text{Utilization} & \text{Effectiveness} & \text{Energy Coefficient} \end{array} \right) \\ &= \mathbf{DPPE} \quad (\text{Datacenter Performance Per Energy}) \end{aligned}$$



2. Structure of Metrics (DPPE)



Sub-metrics may be added for better recognition of data center energy efficiency



2. Structure of Metrics (DPPE)

4 sub-metrics proposed

Sub-metric Name	Calculation formula (Draft)	Corresponding action
IT Equipment Utilization (ITEU)	= IT equipment usage in DC	<ul style="list-style-type: none">• Effective operation of IT equipment
IT Equipment Energy Efficiency (ITEE)	$\frac{\sum (\text{IT equipment rated capacity})}{\sum (\text{Rated Energy Consumption of IT equipment})}$	<ul style="list-style-type: none">• Installation of energy efficient IT equipment
Power Usage Effectiveness (PUE)	$\frac{\text{DC Total Energy Consumption}}{\sum (\text{Energy Consumption of IT Equipment})}$	<ul style="list-style-type: none">• Energy saving in facility
Green Energy Coefficient (GEC)	$= \frac{\text{Green energy}}{\text{DC Total Energy Consumption}}$	<ul style="list-style-type: none">• Use of Green Energy

Note) DC : Data Center



2. Structure of metrics (DPPE)

DPPE (Datacenter Performance Per Energy)

DPPE means production per energy in a Data Center.

It is possible to calculate DPPE from 4 sub-metrics.

The concept is based on the following formula:

$$\text{DPPE} = \frac{\text{DC Work}}{\text{DC energy} - \text{Green energy}} = \frac{\text{IT equipment work rate} \times \text{IT equipment work Capacity}}{\text{DC energy} - \text{Green energy}}$$

$$= \left[\text{IT equipment work rate} \right] \times \left[\frac{\text{IT equipment work capacity}}{\cancel{\text{IT equipment energy}}} \right] \times \left[\frac{\cancel{\text{IT equipment energy}}}{\cancel{\text{DC energy}}} \right] \times \left[\frac{\cancel{\text{DC energy}}}{\text{DC energy} - \text{Green energy}} \right]$$

Note) DC power: Total power consumption of Data Center



3.1 ITEU (IT Equipment Utilization)

ITEU is a sub-metric to promote reduction in energy consumption by Improving utilization ratio of IT equipment and to limit surplus equipment investment.

It is a metric to evaluate efforts in design and operation of Data Center

Metric:

Total measured energy (kWh) of all IT Equipment

Total specification energy (kWh)(nameplate power rating) of all the IT Equipment



3.1 ITEU (IT Equipment Utilization)

Reference Data Center of Company X used in Calculation Example

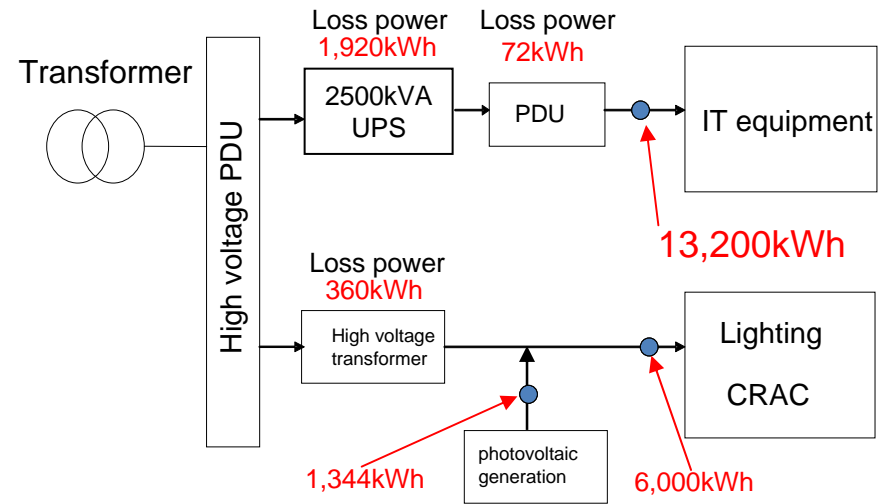
(1) Building scale of Data Center

Item	Specification
Machine room area	1,200m ²
# Rack installed	300 Racks
# Rack operating	250 Racks
UPS Capacity	2500 kVA×2

(3) IT Equipment (in operation)

Server 429 units
 Storage 420 sets
 NW Equip. 84 sets

(2) Power system chart Data Center





3.1 ITEU (IT Equipment Utilization)

Calculation example: (Actual measurement value in Data Center of Company X :
All energy is electric power.)

(1) Total measured energy (kWh) of all IT Equipment

Measurement of power level of all IT equipment = 13,200kWh

(2) Total specification energy (kWh)(nameplate power rating) of all the
IT Equipment

Total max rated power for 250 racks was calculated based on Rack Management Ledger =1,500kW
(Total of rated power for accommodated equipments is managed per each rack)

Max total power of all IT equipment =1,500kW × 24h = 36,000kWh

(3) Calculation result

$$\text{ITEU} = \frac{13,200\text{kWh}}{36,000\text{kWh}} = 0.36 \text{ (36\%)}$$

Note) calculation is average value (kwh) for one month .



3.2 ITEE (IT Equipment Energy Efficiency)

ITEE represents an average of energy efficiency specific to the IT equipment. It is a metric showing efforts to procure energy saving equipments . It represents energy efficiency of IT equipments in a whole Data Center comprehensively with a single metric.

Metric:

$$\text{ITEE} = \frac{\text{Total IT Equipment Work capacity}}{\text{Total specification energy (kWh) of all the IT Equipment}}$$

$$\text{Total IT equipment Work capacity} = \alpha \cdot \Sigma \text{ server capacity} + \beta \cdot \Sigma \text{ Storage capacity} + \gamma \cdot \Sigma \text{ NW capacity}$$

Comment:

Denominator is the rated power (max. power cited in specification sheet) to eliminate ambiguity.

Published value is used also for “capacity” in the numerator.



3.2 ITEE (IT Equipment Energy Efficiency)

Reference: Example of concept for calculating capacity (Example of server):

It is impossible for data center operators to measure capacity of each equipment. Instead, values cited in specification sheets are available. They are the values guaranteed and published on website etc. by quasi-public agencies.

- In case of using “energy consumption efficiency” defined in Japan .

Energy consumption efficiency (W/MTOPS) are cited in specification sheet (catalogue etc.) in conformance with Energy Conservation Law. It is possible to use these values for calculation.

To be specific, reciprocal number of energy consumption efficiency is multiplied by rated power to approximate MTOPS. (Because “W” of energy consumption efficiency represents the power during idling, it is larger than the actual MTOPS.)

- In case of using values such as SPEC power, SPEC int etc.:

Quasi-capacity is calculated by multiplying published value by rated power.

- In case of using SERT:

To be completed in October 2010? Please let us know the details.



3.2 ITEE (IT Equipment Energy Efficiency)

Example of calculation (Actual measurement value in Data Center of Company X)

Specifications for server, storage and network

Server:iR110a-1(3G)420 units Max. power consumption 209W, energy consumption efficiency 0.0016(Category d)
 $209 / 0.0016 / 1000 = 130 \text{GTOPS}$ ITEE=4.8

Storage:iStorageD3(113T)42 units power consumption 4620W, energy consumption efficiency 0.025(AAA)
 $4620 / 0.025 = 185000 \text{Gbyte} = 185 \text{Tbyte}$ ITEE=3.6

NW:IP8800(SW Capacity 136G)84 units power consumption 145W Using 1G by 15 Ports /unit
NW capacity $1 \text{G} \times 15 = 15 \text{G}$ ITEE=2.6

$$\text{ITEE} = \frac{7.75 \times (130 \times 420) + 0.09 \times (185 \times 1000 \times 42) + 26 \times (1 \times 15 \times 84)}{209 \times 420 + 4620 \times 2 + 145 \times 84}$$
$$= 3.9$$



3.3 PUE (Power Usage Effectiveness)

PUE (I/DCiE) by TGG is used as a metric for Data Center facility.
Specific measurement method is under consultation with TGG currently.

Metric:

$$\text{PUE} = \frac{\text{DC Energy Consumption (kwh)}}{\text{Energy Consumption IT Equipment (kwh)}}$$

Example of calculation : (Actual measurement value in Data center of company X)

(Example using power)

$$\begin{aligned} \text{PUE} &= \frac{\text{DC Energy Consumption (kwh)}}{\text{Energy Consumption IT Equipment (kwh)}} = \frac{13,200 + 360 + 1,920 + 72 + 6,000}{13,200} \\ &= 1.6 \end{aligned}$$



3.4 GEC (Green Energy Coefficient)

Provide ratio of renewable energy generated on-site to total energy consumed

Metric:

$$\text{GEC} = \frac{\text{Total Measured Green Energy (kWh)}}{\text{Total Measured DC Energy Consumption (kWh)}}$$

Comment:

- Because GEC is an metric for encouraging Data Center operators to use renewable energies, Green Power purchased from external organization is not included in this metric.
- Power generated by using exhaust heat from the Data Center is included in Green energy.



3.4 GEC (Green Energy Coefficient)

Calculation example: (Actual measurement value in Data Center of Company X)

Power level is used for measurement values.

$$\begin{aligned} \text{GEC} &= \frac{\text{Green power (kWh)}}{\text{DC Total power consumption (kWh)}} \\ &= \frac{1,344}{13,200+360+1,920+72+6,000} \\ &= 0.062 \text{ (6.2\%)} \end{aligned}$$

Comment:

“This metric does not contribute to improvement of Data Center efficiency, but it contributes to reduction of CO₂ emission. Which purpose should be considered for a metric?”

→ It is considered as an improvement of energy efficiency based on the aspect that it reduces the grid power consumption.



3.5 DPPE (Data Center Performance Per Energy)

DPPE is defined as a function of four sub-metrics.

Metric:

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

Comment:

- The purpose of expressing DPPE as a product of each sub-metric is to calculate DC capacity per non-green power.
- Because DPPE becomes infinite when GEC=1, the maximum value for GEC should be limited to 0.8 when calculating DPPE.



3.5 DPPE (Data Center Performance Per Energy)

(1) DPPE using calculation examples of sub-metrics so far explained

1) ITEU = 36 (%)

2) ITEE = 3.9

3) PUE = 1.6

4) GEC = 6.2 (%)

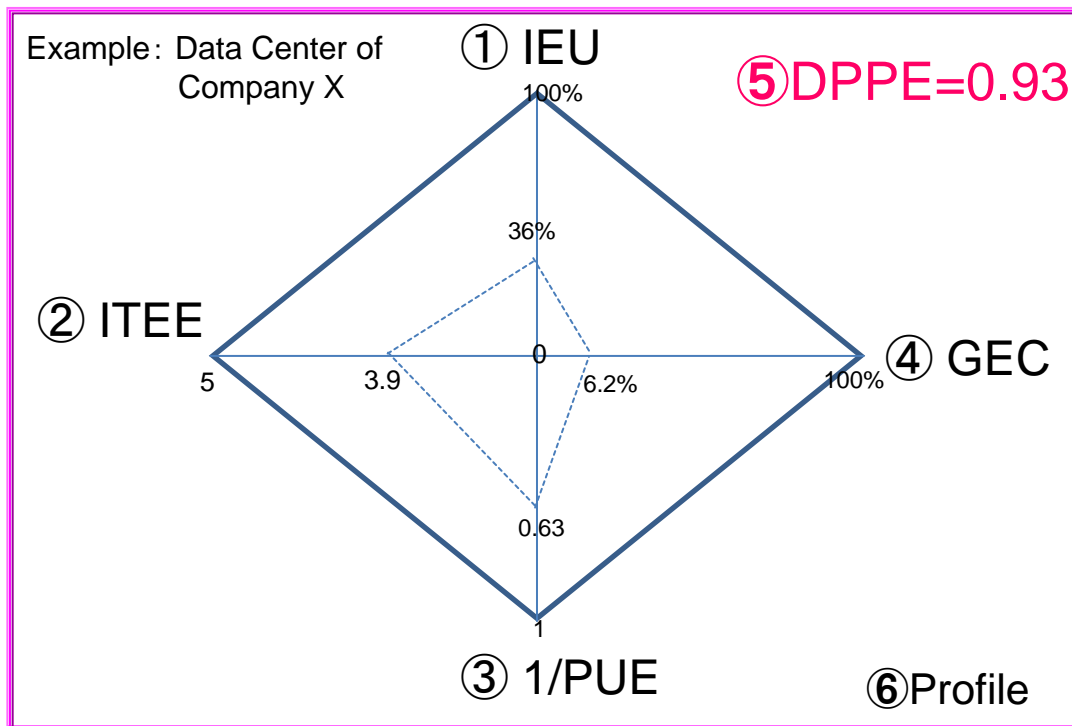
$$\begin{aligned} 5) DPPE &= 0.36 \times 3.9 \times \frac{1}{1.6} \times \frac{1}{1 - 0.062} \\ &= 0.935 \end{aligned}$$

Data Center in this example is not the energy saving type based on the state-of-the-art techniques but an example using techniques of 3-4 years ago.



3.6 Data Center evaluation method (Example 1)

Express in Cobweb Chart



⑥ Profile

Information including

- Grade
(Operation rate is decreasing with more stand-by equipments.)
- Scale
(The structure is totally different between data center with just 1 unit of server and the center with 10000 units of servers.)
- Application (Housing, hosting, cloud)
- Year of measurement

are necessary.



Discussion on Criteria of DC Efficiency

- GIPC is finalizing a draft checklists for criteria of DC efficiency.
- Member companies are developing the draft checklists based on discussions in GIPC. Suitable methods for improving energy-efficiency are collected from the Green Grid's (TGG's) white papers and suggestions of member companies.
- The criteria consists of the following categories: metrics, IT equipment, facility, operation, utilization of renewable energy and waste heat etc.

Draft Criteria for Green DC and corresponding TGG-WP

[metrics]

- PUE (#1,6,14,22), DCP (#13,15,18), DPPE (drawn up by GIPC) } #10

[IT equipment]

-server (criteria for Law Concerning the Rational Use of Energy, Japan, SPEC),
-storage and router (criteria for Law Concerning the Rational Use of Energy, Japan)

[facility (transformer, UPS, cooling, fan, lighting etc.)]

- high efficiency cooling system
 - air cooling facility by injecting outside air } #11
 - water cooling by using sea water
 - waste heat utilization facility
 - efficiency improvement on power feeding facility
 - installation of high voltage (over 300V) DC power feeding system (efficiency) } #4, #16
 - efficiency improvement on existing AC power feeding system (efficiency)
 - power supply unit (PSU)(CSC1/80Plus)
 - efficiency improvement on other facility
 - Renewal to LED illumination
- Groupings: #3, #21 (for cooling and power feeding); #2, #7 (for power feeding and other facility)

[operation]

- dynamic cooling optimization system using heat sensor (WP is prepared by TGG)
- dynamic optimization system using electric sensor (WP is prepared by TGG)
- improvement of equipment utilization by visualization (installation rate) (#19)
- organizational theory (#9)

[utilization of renewable energy, re-utilization of heat, and collocation]

- utilization of green energy
 - utilization of waste heat
 - collocation between powerhouse
- Issues to be discussed

1 : rating

2 : promotion of IT equipment for energy saving

Numbers in this figure such as "#10" indicates a number of TGG white papers.

3 : promotion of high efficient energy use