Datacenter Performance Per Energy (DPPE)

October 5th, 2010

Survey and Evaluation Committee
Introduction

It is necessary to create a usable and agreeable Metrics to express energy efficiency of the entire data center with both IT equipments and Data Center infrastructure.

TGG created “PUE” metric is widely used and accepted throughout the world.

“Power Usage Effectiveness” (PUE) was introduced by The Green Grid in 2007.

However, there is an increasing need for a metric which could do more precise measurement of the entire data center.

PUE maybe understood as a metric which has a focus on the Data Center Infrastructure.

PUE = \[
\frac{\text{Overall consumption by Data Center}}{\text{Consumption by IT equipments}}
\]

Throughout the world, EPA Energy Star, EU Code of Conduct and such, the PUE is widely accepted as a current primary metric of the Data Center energy efficiency indicator.

<table>
<thead>
<tr>
<th>Category</th>
<th>Change in “PUE” number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure (Power, A/C etc)</td>
<td>Improvement on Energy Consumption \textbf{will change} PUE</td>
</tr>
<tr>
<td>IT Equipment (Server, Storage, NW)</td>
<td>Effort of Energy Consumption \textbf{will not} appear on PUE</td>
</tr>
</tbody>
</table>

– i.e. Highly Efficient IT Equipment will not necessary yield good PUE number.
Development of “DPPE”

DPPE is developed by the Green IT Promotion Council (GIPC) of Japan.

Outline of the DPPE development

Under “Survey & Evaluation Committee”, started as a sub working group in 2008 to discuss a new metric for the Data Center Energy Efficiency.

- Members:
  - NTT Data, Intel, Nomura Research Institute, Daiwa Institute of Research, IBM Japan, NEC, Fujitsu and others.
- MOU with The Green Grid for joint Collaboration

<table>
<thead>
<tr>
<th>Years</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Defined initial DPPE metrics Surveyed Japanese Data Centers</td>
</tr>
<tr>
<td>2009</td>
<td>Refined DPPE metrics Continuous discussion with TGG</td>
</tr>
<tr>
<td>2010</td>
<td>Developing measurement guideline Conducting measurement discussion with EU &amp; US</td>
</tr>
</tbody>
</table>
Our Scope of the Data Center Model

A Data Center is; Infrastructure with “Cooling” and “Electrical” Plant, and “IT” equipments are categorizing two types of different Hardware Groups, which are receiving and outputting both “Energy” and “Information Flow” (Data).
Concept of the DPPE

DPPE is designed to measure and indicate the Energy Efficiency of an entire Data Center, and it has 4 sub metrics for the specific area.

- Goals
  1. Energy efficiency of an entire Data Center could easily be calculated.
  2. Comparison of different Data Centers could be performed and studied.
  3. Comparison of a year-around energy status monitor is possible on a continuous base.

- “Data Center Performance Per Energy” (DPPE) is expressed as a function of four sub-metrics.
- Each of 4 sub-metrics could be used separately as an independent metric with a meaning.

\[
\text{Data Center Energy Efficiency} = f \left( \begin{array}{c}
\text{IT Equipment Energy Efficiency,} \\
\text{IT Equipment Utilization,} \\
\text{Power Usage Effectiveness,} \\
\text{Green Energy Coefficient}
\end{array} \right)
\]

\[
= \text{DPPE} \quad \text{“Datacenter Performance Per Energy”}
\]
Structure of DPPE (1):

The entire effort for the Data Center Energy Efficiency is broken down to the 4 sub tasks, and their associated specific metric is provided for each Energy Efficiency purpose.

To improve energy efficiency of Data Center as a whole

- Environment friendly, sustainable Data Center operation.

**Target**

**Realization method**

1. Improve energy efficiency of IT equipments in Data Center
   - Use introduced IT equipment with optimal efficiency

2. Install IT equipment with less energy consumption
   - Install IT equipment with less energy consumption

3. Reduce energy consumption of facilities in Data Center
   - Reduce % of energy Spend on facilities Versus total energy consumption

4. Replace grid electricity purpose with Green energy
   - Replace grid electricity purpose with Green energy

**Metrics**

- ITEU: IT Equipment Utilization
- ITEE: IT Equipment Energy Efficiency
- PUE: Power Usage Effectiveness
- GEC: Green Energy Coefficient
## Structure of DPPE (2):
Four sub-metrics proposed

4 Sub Metrics are defined for the specific areas and Energy Efficiency tasks and needs.

<table>
<thead>
<tr>
<th>Sub-metric Name</th>
<th>Basic Definition</th>
<th>Corresponding action</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT Equipment Utilization (ITEU)</td>
<td>( = ) IT equipment usage in DC</td>
<td>• Effective operation of IT equipment</td>
</tr>
<tr>
<td>IT Equipment Energy Efficiency (ITEE)</td>
<td>( \sum (\text{IT equipment rated capacity}) = \sum (\text{Rated Energy Consumption of IT equipment}) )</td>
<td>• Installation of energy efficient IT equipment</td>
</tr>
<tr>
<td>Power Usage Effectiveness (PUE)</td>
<td>( \frac{\text{DC Total Energy Consumption}}{\sum (\text{Energy Consumption of IT Equipment})} )</td>
<td>• Energy saving in facility</td>
</tr>
<tr>
<td>Green Energy Coefficient (GEC)</td>
<td>( = \frac{\text{Green energy}}{\text{DC Total Energy Consumption}} )</td>
<td>• Use of Green Energy</td>
</tr>
</tbody>
</table>

Note: DC : Data Center
Structure of DPPE (3): DPPE & its 4 sub metrics explained

DPPE, a total productivity of Datacenter, can be calculated, when all four sub metrics are measured.

The concept of DPPE is based on the following formula:

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

Note) DC power: Total power consumption of Data Center
DPPE is defined as a function of four sub-metrics.

Metric:

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

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.
(1) Building scale of Data Center

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine room area</td>
<td>1,200㎡</td>
</tr>
<tr>
<td># Rack installed</td>
<td>300 Racks</td>
</tr>
<tr>
<td># Rack operating</td>
<td>250 Racks</td>
</tr>
<tr>
<td></td>
<td>Power Spec Sum</td>
</tr>
<tr>
<td></td>
<td>= 1500kW</td>
</tr>
<tr>
<td>UPS Capacity</td>
<td>2500 kVA×2</td>
</tr>
</tbody>
</table>

(2) Power system chart Data Center

- Transformer
- Loss power 1,920kWh
- Loss power 72kWh
- 2500 kVA UPS
- PDU
- IT equipment
- Loss power 360kWh
- High voltage transformer
- Solar power
- CRAC
- 1,344kWh
- 6,000kWh
- 13,200kWh

(3) IT Equipment (in operation)

- Server 429 units
- Storage 420 sets
- NW Eqip. 84 sets

- Electrical energy on IT equipment: 13,200kWh
- Total energy consumption:
  \[(1,920 + 72 + 13,200 + 360 + 6,000) = 21,552\text{kWh} \]
  \[\Rightarrow \text{PUE} = \frac{13,200}{21,552} = 1.6\]
- GEC: 1,344/6,000 = 0.22
(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 (%)

5) DPPE = 0.36 × 3.9 × \( \frac{1}{1.6} \) × \( \frac{1}{1 - 0.062} \)

= 0.935

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.
Expression of DPPE

Express in Cobweb Chart

Example: Data Center of Company X

① IEU
② ITEE
③ 1/PUE
④ GEC
⑤ DPPE = 0.935
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.
In Feb. 2010, the 2nd International workshop of EU, U.S., and Japan was held. At the workshop all parties agreed to continue the work on establishing a method to measure the entire Data Center efficiency.

2nd workshop on metrics of DC energy efficiency

Discussion on metrics of DC energy efficiency

- 2 Feb 2010, in San Jose, Calif. U.S.
- Members:
  - Japan: METI, GIPC, JEITA
  - US: DOE, EPA, TGG
  - Europe: EC

Agreement

All agreed that IT Equipment inclusive of entire Data Center based metric is needed.

Desired Outcomes:

Effective energy efficiency metrics that:
1. Measure the actual IT work output of the data center compared to actual energy consumption. It is of note that in the process to define IT work output, the following interim measurements are being defined and/or validated:
   a. IT - Measure the potential IT work output compared to expected energy consumption; and measure operational utilization of IT equipment
   b. Data center facility and infrastructure - Measure the data center infrastructure efficiency (PUE)
2. Measure renewable energy technologies and re-use of energy to reduce carbon
In Japan, GIPC is doing the trial measurement of the DPPE to examine its usability and validate its method, also of its associated sub metrics. The definition and guideline of DPPE will be revised based on the result.

Outline

DPPE Measurement Trial to be planned within 2010 in Japan.

Jul-Aug: 1st phase of the measurement trial.

Sept: Analyze the 1st phase (measurements will continue until 6 months.)

Schedule

Subjects

Target subject Data Centers will be 20-30 in Japan.

- Mainly, GIPC, JDCC, JISA, ASPIC and others’ member Data Centers will be ask to participate.

Outline

Purpose

By measuring DPPE at actual DCs, find problems of DPPE, and verify the effectiveness of the metrics.

Measurement at actual Data Center

• Try to examine at as many different types
• Trial measurement will be at least 6 months
• Gather all issues with actual measuring task
• Gather different Data Center specifics data

Identify all issues

• Identify actual issue of measurement at the real Data Center.
• Try to cover Data Centers of different Service and Industry.

Validate all issues

• Seasonal factor
• Location specifics, Size, and other environmental issue effects.

Revise definition and guideline

Note: Japan Data Center Council (JDCC), Japan Information Technology Service Industry Association (JISA), ASP • SaaS Industry Consortium (ASPIC)
Japan, US and EU are now discussing on the definition and measurement guideline of datacenter energy efficiency metrics.

**Milestone**

**Japan**
- 2010
  - April: Develop the DPPE measurement guideline (with detailed proposal of PUE measurement)
  - May: Measure DPPE in Japan (and Singapore): 1st phase
  - June: Data Analysis
  - July: Measure DPPE in Japan (and Singapore): 2nd phase
  - August: Revise DPPE WP

**Taskforce Discussion**
- PUE: High Priority
  - (1) Identify/define the metric
  - (2) Define the process for measurement
  - (3) Define the process for measurement

- ERF & RER (#2)
  - (1) Identify/define the metric
  - (2) Define the process for measurement

- GEC
  - (1) Identify/define the metric
  - (2) Define the process for measurement
  - (3) Define the process for measurement

- ITEE & ITEU
  - (1) Identify/define the metric
  - (2) Define the process for measurement

- DPPE
  - Carbon metric (#2)
  - (1) Identify/define the metric
  - (2) Define the process for measurement
  - (3) Define the process for measurement

**Activities**

- Japan
  - WS (Milan)
  - WS (Japan)

**Note:** (1)–(3) show # in the “Goal” section of the agreement, while (#1), (#1a), (#1b) and (#2) # in the “Desired Outcomes” section.

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