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Takao SHIINO

Nomura Research Institute

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To date, Japan's data center businesses have offered services to enterprises and individuals in the domestic market. However, Japan is beginning to see the launch of global competition. In the country-by-country ranking of risks for locating data centers, Japan was evaluated as presenting the world's second highest risk for locating a data center and ranks 19th among 20 leading and emerging markets. The factors identified as major risks include natural disasters and energy costs. Even though major risks were identified for the country as a whole, efforts by individual data center owners and operators can mitigate the identified risks. If international recognition can be obtained on the mitigated risks based on globally standardized metrics, Japan's data centers could attain a competitive advantage.

To measure the degree of preparedness for natural disasters, the Japan Data Center Council established its own Tier Standard. This standard evaluates the extent to which risks were mitigated after considering the specific seismic hazards at the site of a data center.

To deal with high energy costs, it is necessary to promote the improvement of energy efficiency so as to prevent increases in energy costs and to increase the ability to deal with restricted power supplies. To achieve these goals, the Datacenter Performance Per Energy (DPPE) metric proposed by Japan's Green IT Promotion Council is considered effective. In the 2010 measurement project conducted by the Green IT Promotion Council, DPPE values were collected extensively from data centers in production in Japan and other Asian countries. These measurements clarified the current energy efficiency level and potential improvements of each data center. The author hopes that the DPPE metric proposed by Japan will be accepted as the international standard, thereby gaining its global recognition.

There are categories about which Japan's strengths were recognized in the country-by-country comparison of risks for locating data centers. They are political stability and a lack of inflation. These strengths should be highlighted as competitive advantages. At the same time, individual data centers should make respective efforts to fully compensate for identified weaknesses and the results of such efforts should be measured and certified based on internationally accepted criteria. These approaches are necessary to increase the international competitiveness of Japan's data centers.

I Data Center Business Enters the Era of Global Competition

1 An increasing number of global data center users

A data center is defined as a building dedicated for housing a number of large computers (up to several tens of thousands). With a total floor space ranging from several thousand to several tens of thousands of square meters, large data centers are equivalent to or even bigger than 4- to 5-story supermarkets. The large number of computers installed in a data center process data that are related to people's everyday lives such as bank transactions, airplane reservations, weather forecasts, mobile phone emails, blogs and social networking services (SNS). These computers also perform business-critical data processing such as automobile designing, order processing and financial accounting.

To date, data center businesses have offered services to enterprises and individuals in the domestic market. However, Japan is beginning to see the launch of worldwide competition with corporate activities becoming increasingly globalized and individual consumers increasingly using globally standardized services.

One example of global enterprise activities is the supply chain of the manufacturing industry. As was revealed in 2011 by the impact of the Great East Japan Earthquake and Thailand's large-scale floods, the supply chain of the manufacturing industry extends over many countries in Southeast Asia. As such, the necessity to use a single system to manage the flow of processes from production and inventory to sales across the countries involved has been increasing.

The same situation can be seen for accounting systems. More and more companies have adopted global accounting standards because head offices in Japan and local subsidiaries in other countries must follow uniform accounting procedures, which are necessitated by the adoption of the Sarbanes-Oxley (SOX) Act and the International Financial Reporting Standards (IFRS). Therefore, it has become inefficient for multinational companies that have sales offices and service centers in countries in Southeast Asia to establish separate data centers or server rooms in each country. Companies are moving in the direction of setting up a cloud computing system center in a single country. This center, where all servers are installed, provides information services such as a common business processing system and a common office automation (OA) system including that for emails to each country.

In the case of a trading company specializing in electronic components, which has eight bases in Asia, the company decided to consolidate its IT (information technology) services that were formerly provided at each site into its Hong Kong data center. This data center provides a business processing system such as that for order processing and accounting to sites in each country. In the case of FamilyMart, which operates a convenience store franchise chain in Japan, the company has been successful in increasing the number of its stores in other Asian countries such as Taiwan, South Korea and Thailand. For future participation in the markets of other countries such as Vietnam and Russia, the company has started to build an intra-company cloud computing system with the capacity of handling up to several hundred stores at the initial stage. This Japan-based data center will provide a business processing system to each country via a network.

2 Competition in attracting data centers begins in Asia

In the past, leading multinational IT services companies that offered cloud computing services initially to general users and then to corporate users as well, such as Amazon.com, Google and Salesforce.com, provided services to users all over the world from their respective data centers in the U.S. Recently, however, they have been shifting their approaches to establishing data centers in Europe and Asia in addition to those in the U.S. and providing services from multiple sites throughout the world. In line with this strategy, they are studying which country offers the best location for data centers in Asia.

In the fields of ports and airports, Asian countries have been enhancing their competitiveness to become airline hubs and/or hub ports, with Singapore winning this position as a hub port and Singapore and South Korea becoming airline hubs. Japan is said to lag behind these countries in acquiring such positions. In the area of data centers, as one of the most advanced IT countries, Japan should take the lead. Nevertheless, each Asian country has already initiated efforts to attract data centers as part of its national strategy.

For example, Singapore, which has already established its position as a logistics hub, is now striving to become a data hub by drawing on the following strengths.

(1) Enhanced infrastructure necessary for IT such as communications networks and electric power
(2) Low possibility of natural disasters such as earthquakes and typhoons
(3) Strengthened government support measures

In 2006, the Singapore government launched the Intelligent Nation 2015 (iN2015) info-communications master plan. Based on this master plan, the government is developing a communications infrastructure and setting up a data center park. In this park, the government plans to construct six data center buildings by 2012 on an area of 12 hectares and provide a total of 120,000 square meters of data center rack space to data center operators. The government also plans to offer tax incentives to companies using these data centers.

In the past, China constructed software parks to promote the development of its software industry and has been working to attract software companies. Currently, there are about 50 national-level, province-level and city-level software parks in China. Such parks are also being constructed in rural cities, and competition has begun among municipalities. In order to enhance the value of a software park, plans are being formulated to construct large-scale data centers. If many large-scale data centers are constructed in China, surplus capacities beyond the domestic demand will be created. Based on such capacities, it is highly likely that China will leverage its high cost competitiveness to provide services to companies in other countries.

In Japan, movement toward the strengthening of Japan's international competitiveness is slow. In the past, Japanese industries have been said to face quadruple difficulties in increasing international competitiveness that constitute adverse conditions as compared to nearby competing countries. They are:

(1) High corporate tax rates
(2) Severe employment-related regulations
(3) Environmental restrictions such as reductions in greenhouse gas emissions
(4) Disadvantageous competitive position in terms of trade conditions such as those relating to Economic Partnership Agreements (EPA)

Besides these difficulties, additional blows were dealt. The Great East Japan Earthquake on March 11, 2011, triggered the issue of restricted energy supplies, which is the fifth difficulty. The financial confusion in the U.S. and Europe caused super-strong yen, which is the sixth difficulty. In the same way as most Japanese industries, data center businesses are also burdened with these six-fold difficulties in global competition.

To date, data centers have contributed to increased efficiency in society overall, improved convenience and enhanced lifestyles. Because people recognize these achievements, the demand for data centers has continued to increase. In response to such increasing demand, energy consumption has also increased to provide a wider variety of information services. It is highly likely that such increasing demand for information services will further grow toward the creation of a more enhanced, secure and safer society, which will eventually lead to further expansion of the demand for energy. The six-fold difficulties such as restricted energy supplies lie heavily on such expanded demand. As such, data center businesses face a major challenge of how to increase international competitiveness under these restrictions.

3 International comparison of data center locations

In June 2011, Cushman & Wakefield, a leading global real estate company, and hurleypalmerflatt, a leading multi-disciplinary consultancy, published the Data Center Risk Index (the C&W report; Table 1). According to this index, Japan was evaluated as presenting the world's second highest risk for locating a data center and ranks 19th among 20 leading and emerging markets. Other countries identified as presenting high risks include Poland, Ireland, China and India. The top five countries with low risks are the U.S., Canada, Germany, Hong Kong and the UK.

The index weighed 11 risk categories to score 20 countries in terms of risks for locating data centers, which are energy (cost per kWh), international bandwidth (Mbit/s), ease of doing business, corporate tax, labor, political stability, sustainability, natural disasters, GDP per capita, inflation and water (availability per capita).

In the case of Japan, the factors identified as major risks include natural disasters (the lowest rank), energy cost (19th) and sustainability (15th in terms of use of renewable energy). On the other hand, the factors that received a good score included inflation (2nd) and political stability (4th). Ironically, the factors that are considered major problems in Japan, that is, deflation and political stagnation, contributed to earning good scores.

In Asia, five countries are evaluated in the index. They are Hong Kong, Singapore, China, India and Japan. Among them, Hong Kong ranks highest (4th), reflecting ease of doing business (2nd), low corporate tax (4th) and low labor cost (4th). Singapore ranks in the middle (11th) among 20 countries. While Singapore scored high in terms of ease of doing business (1st), low corporate tax (6th) and low labor cost (6th), the country ranked low in terms of sustainability (20th) and water availability (19th), which led to the lowering of the country's total score.

However, it should be noted that this risk index is based on the characteristics of a country as a whole, and does not take into account those of individual data centers. Accordingly, data center owners and operators should take sufficient measures to mitigate the risks that are identified as major risks for the country as a whole. It is important to make known the results of such measures to users throughout the world. In other words, Japan's data centers should take proactive actions against the high risk factors inherent in Japan such as natural disasters and high energy costs. After taking such actions, they should publish the results upon comparison with relevant official international standards.

Table 1. Country-by-country ranking of risks for locating data centers

Rank	Total score	Country	Rank in terms of three risk categories		
			Energy cost	Corporate tax	Natural disasters
1	100	U.S.	7	19	17
2	91	Canada	6	4	9
3	86	Germany	11	3	7
4	85	Hong Kong	16	4	19
5	82	UK	15	12	14
6	81	Sweden	8	11	2
7	80	Qatar	2	1	1
8	78	South Africa	1	12	5
9	76	France	12	17	12
10	73	Australia	5	14	11
11	71	Singapore	14	6	13
12	70	Brazil	4	18	6
13	67	Netherlands	17	9	10
14	64	Spain	9	14	8
15	62	Russia	3	8	15
16	61	Poland	13	7	3
17	60	Ireland	20	2	4
18	56	China	18	9	16
19	54	Japan	19	14	20
20	51	India	10	19	18

Source: Compiled based on "Data Center Risk Index" published by Cushman & Wakefield and hurleypalmerflatt in June 2011.

II Measures Necessary to Improve the International Competitiveness of Japan's Data Centers

1 Natural disaster risk management for data centers

The C&W report identified Japan as being at high risk for natural disasters. Nevertheless, as a result of the Great East Japan Earthquake on March 11, 2011, Japan's data centers have proved to be highly reliable. As described in the report, even though hit by violent earthquake tremors, Japan's data centers suffered no major damage and information processing services continued without interruption. As might be expected because of well-established disaster preparedness programs, no damage was inflicted by tsunami on data centers. Even in the face of subsequent planned power outages that were initiated on March 15 and continued for nearly one month, backup power generators enabled uninterrupted, continuous service. While data centers owned and operated by Nomura Research Institute (NRI) also experienced power outages, emergency backup power generators were used to continue information services to customers, and no problems occurred.

The Data Center Site Infrastructure Tier Standard prepared by the Uptime Institute in the U.S. is well known as having the criteria for evaluating the reliability of data centers during natural disasters and other failures. By considering the particular characteristics of the natural disasters to which Japan is susceptible, the Japan Data Center Council established its own definitions of Tiers 1 to 4. As shown in Table 2, Japan's version of the tier standard assumes four service levels and defines the requirements for equipment to achieve each level.

For example, "Tier 4," the highest level, assumes the user's operation reliability to be 99.99 percent or above. To achieve such high reliability, a building that houses the data center must be a dedicated building for the data center. In terms of probable maximum loss (or PML, explained below), it must be less than 10 percent to ensure safety against earthquake risk. According to Japan's Building Standards Law, data centers must comply with this Law, which was revised in June 1981 and which requires data centers to meet Class II aseismic performance.

The term PML or "probable maximum loss" is the maximum expected loss calculated in consideration of four aspects concerning the relevant data center site, that is, seismic hazard, ground stability, the building's seismic resistance and the equipment's seismic resistance. PML is used globally as the standard for assessing earthquake risks in the insurance and real estate industries,

Table 2. Japan's data center reliability assessment standard

Service levels	
Tier 4	• A very high level of disaster resistance is provided in which data integrity is secured and service availability is ensured against disasters such as earthquakes and fires. • A higher level of redundant equipment configuration is provided so that computing services can be continuously offered even if simultaneous faults occur in some components during the time some facilities are temporarily suspended due to equipment failure or maintenance. • Access to a site, building, server rooms and IT equipment within racks is controlled. • The assumed end users' operation reliability is 99.99% or greater.
Tier 3	• Security at a higher level than that for general buildings is maintained against disasters such as earthquakes and fires. • A redundant equipment structure is provided so that computing services can be offered continuously even while some facilities are temporarily suspended due to equipment maintenance, etc. • Access to a building and server rooms is controlled. • The assumed end users' operation reliability is 99.98% or greater.
Tier 2	• Security at a level that is required of general buildings is maintained against disasters such as earthquakes and fires. • Facilities are available to offer computing services continuously even during long power outages. • Access to server rooms is controlled. • The assumed end users' operation reliability is 99.75% or greater.
Tier 1	• Security at a level that is required of general buildings is maintained against disasters such as earthquakes and fires. • Facilities are available to offer computing services continuously even during momentary power outages. • Access to server rooms is controlled. • The assumed end users' operation reliability is 99.67% or greater.

Source: Japan Data Center Council, "Data Center Facility Standard," July 2010.

thus making it easy to compare such risks with those in other countries. For example, a PML of less than 10 percent means a high aseismic level in which no repairs are necessary and no business interruptions are caused with only minor damage if an earthquake occurs. The Building Standards Law also imposes higher standards on data centers that are located at sites that are prone to experience major earthquakes. If a data center is to be constructed at a site where an earthquake with a seismic intensity of 6 or greater is assumed to occur with a probability of 10 percent within a 50-year period, an aseismic performance equivalent to Class I, which is one level higher than Class II, which is required for data centers at other sites, is required to meet Tier 4 conditions.

Whichever standard is used, PML or the Building Standards Law, Japan's earthquake resistant standard required of data centers has been established by incorporating the earthquake risk of each data center location, thereby ensuring the reliability of each data center. In addition to buildings, the Tier 4 requirements to achieve a user operation reliability of 99.99 percent also include the need to provide redundant power supply routes for "power receiving equipment → uninterruptible power supply (UPS) → server room power distribution panel." Such redundancy is required to withstand any failure of power supplies from drop-wire terminals to IT equipment, air conditioning systems, communications equipment, etc.

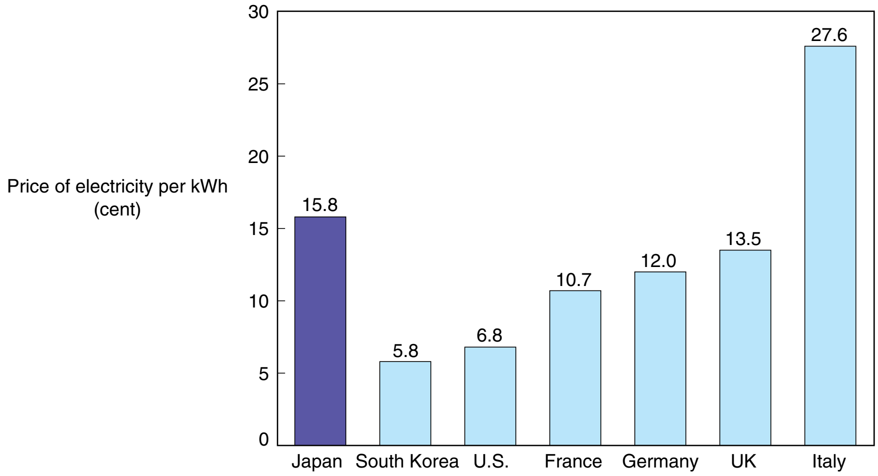
While the risk of natural disasters, which is the biggest factor affecting the country-by-country evaluation of risks for locating data centers, is inherent in Japan, all data centers located in Japan are sufficiently prepared against this risk, and methods of evaluation are firmly established. Japan should make efforts to focus the world's attention on Japan's own reliability standard that includes natural disasters and on the fact that no damage/interruption was caused by the Great East Japan Earthquake. In so doing, the aim is for the world to recognize the high level of efforts toward reducing/avoiding the risks faced by each individual data center.

2 Dealing with data center energy risks

(1) Data center energy risks

There is concern over another high risk factor in data centers, which is related to the utilization of energy. As shown in Figure 1, the prices of electricity in Japan have already been higher than those in other countries. Even the price of electricity for industrial use is 15.8 cents per kilowatt-hour (kWh). As a future risk, the prices that are already high are expected to further increase with a shift of power sources from nuclear power to fossil fuel and renewable energy. On top of such price increases, another risk facing the supply of power in Japan is that other power sources will not be able to fully compensate for the loss caused by the cessation of the operation of nuclear power plants and will be unable to sufficiently meet future increases in demand for power consumed by data centers. Actually, in the summer of 2011, the government asked businesses to reduce peak electricity consumption by 25 percent. While the percentage of reduction was subsequently lessened to 15 percent, nevertheless, data center businesses were allowed to consume electricity up to the peak level of electricity consumption during the preceding year (2010). Therefore, any increase in energy consumption from 2010 was covered by energy-saving efforts.

Figure 1. International comparison of industrial electricity prices (2009)



Source: Report on the results of a survey (survey on the cost structure, etc. of electricity businesses in other countries) conducted at the request of the Ministry of Economy, Trade and Industry.

The key measure for avoiding these risks of high energy costs and restricted power supplies is the efficient use of energy. Developing and using advanced energy-efficient technologies and focusing on efficient energy use in operating data centers will improve the energy productivity of data centers in Japan to levels higher than those in other countries. Such improvement will eventually contribute to avoiding energy risks and increasing international competitiveness.

How to measure and improve the energy efficiency of data centers is expected to become important not only from the perspective of avoiding risks but also from the standpoint of meeting external requirements.

(2) Assessment system for data center energy efficiency

One of the external requirements for energy efficiency is government action. The Ministry of Land, Infrastructure, Transport and Tourism is working towards legally requiring houses and buildings to comply with energy efficiency standards to reduce greenhouse gas (GHG) emissions. Although energy efficiency standards are currently in place, compliance with such standards is not mandatory. The ministry plans to make such compliance mandatory by 2020 on a phased basis, starting from large, Type 1 specified buildings (buildings with interior space of 2,000 m^2 or more). Therefore, large-scale data centers having such sizable space are likely to be required to comply with the energy efficiency standards starting in the target year of 2013, which is the first phase.

As a tool for assessing and rating a building's environmental performance, Japan developed and adopted the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) in 2001. CASBEE covers comprehensive environmental performance including not only energy efficiency but also the use of resources and materials causing lower loads on the environment, comfortableness of the indoor environment, and consideration of the landscape. When requiring compliance with energy efficiency standards, it is not yet known whether compliance with just energy efficiency from among the CASBEE categories will become mandatory.

The meaning of the utilization of electricity differs largely between data centers and ordinary buildings that are covered by CASBEE. In ordinary buildings and households, the principal purpose is to conduct business activities or to inhabit, and electricity is used by support facilities such as air-conditioners and lights. However, the primary purpose of IT equipment such as servers installed in data centers is information processing by equipment that uses electricity. Accordingly, electricity is considered a "raw material" in producing IT services. If production output increases, the demand for electricity also increases in proportion to the increase in production. Because of this characteristic, the Leadership in Energy and Environmental Design (LEED) in the U.S. and the Building Research Establishment Environmental Assessment Method (BREEAM) in the UK, which are energy efficiency standards for buildings, offer separate versions for data centers. Therefore, how data centers are handled in Japan's standard is noteworthy.

In 2011, the British Computer Society, the Chartered Institute for IT (an IT-related industry association) in the UK, launched the Certified Energy Efficient Datacentre Award (known as CEEDA). CEEDA ratings are available in the UK as well as in other countries. Depending on the level of energy efficiency of a data center, a checked organization (data center) receives a Gold, Silver or Bronze Award. An independent CEEDA-certified assessor visits a data center that applied for assessment and checks about 50 items on site including equipment, procedures, activities, etc. The check items cover key areas such as air conditioning and power supply systems of the data center, energy efficiency of installed IT equipment, energy efficient operation procedures and organizational structure. Currently, the coverage of CEEDA assessments has expanded from the UK to other European countries and South America. The institute is now considering cooperation with the U.S. Department of Energy.

With the worldwide spread of such rating and accrediting systems for data center energy efficiency, Japan's data centers will also be increasingly exposed to international comparison. Japan's data centers must be prepared to adapt to international standards of energy efficiency rating systems.

(3) Requirement for reporting data center energy consumption

Another external requirement is a request by customers for reporting energy consumption data and the level of energy efficiency performance. Because of this requirement, energy-related data will be increasingly disclosed.

Regarding the reporting of carbon dioxide (CO_2) emissions by large companies, the World Resources Institute (WRI), a U.S.-based environmental think tank, and the World Business Council for Sustainable Development (WBCSD), a coalition of transnational corporations that advocate for sustainable development, are working together to lead the use of the "GHG Protocol Corporate Standard" as the global standard. In October 2011, the Corporate Value Chain Accounting and Reporting Standard (known as the Scope 3 Standard) was launched, which covers emissions from the entire value chain including the upstream and downstream of corporate value chains. While reporting standards have already been available for direct CO_2 emissions from sources that are owned or controlled by companies (Scope 1 Standard) and for indirect CO_2 emissions from the consumption of purchased electricity, etc. by companies (Scope 2 Standard), this time, the Scope 3 Standard was simultaneously launched in New York and London. The Scope 3 Standard is not a compulsory reporting standard. However, with multinational companies such as Citigroup and DuPont starting to use this standard for reporting, it is likely to be a de facto standard for the method of reporting CO_2 emissions by companies all over the world.

When a company intends to use the Scope 3 Standard to report its CO_2 emissions, it must also ask its upstream and downstream transacting companies to report on their CO_2 emissions (or consumed electricity) to manufacture the company's products or services. Data center operators that either house customers' servers or offer information processing will be required to report the amount of consumed electricity to each customer company that requires the disclosure based on the Scope 3 Standard. Therefore, in the case of server housing and colocation services, a data center operator must report the amount of electricity consumed by a customer's server as well as by support facilities such as air conditioning and power supply systems.

When a server is shared by multiple customers in the shape of a cloud computing system or a joint-use system, the amount of electricity consumed must be divided based on an appropriate rule in proportion to the amount of service provided to each customer. For such calculations, various factors such as the power consumption rates of support facilities and the basic unit of electricity consumption for processing a certain amount of information are made clear. These clarified calculation units will eventually enable comparisons with other data centers. On the part of customers, those that are engaged in the types of businesses entailing a high percentage of power consumption by a data center as clarified through reporting based on the Scope 3 Standard will eventually require data center operators to improve energy efficiency. In industries where power consumption by data centers is expected to account for a large percentage of the total power consumed in business activities such as the financial industry and Internet-related service industries, further measures will become necessary to improve energy efficiency.

III Ways of Improving the Energy Efficiency of Data Centers

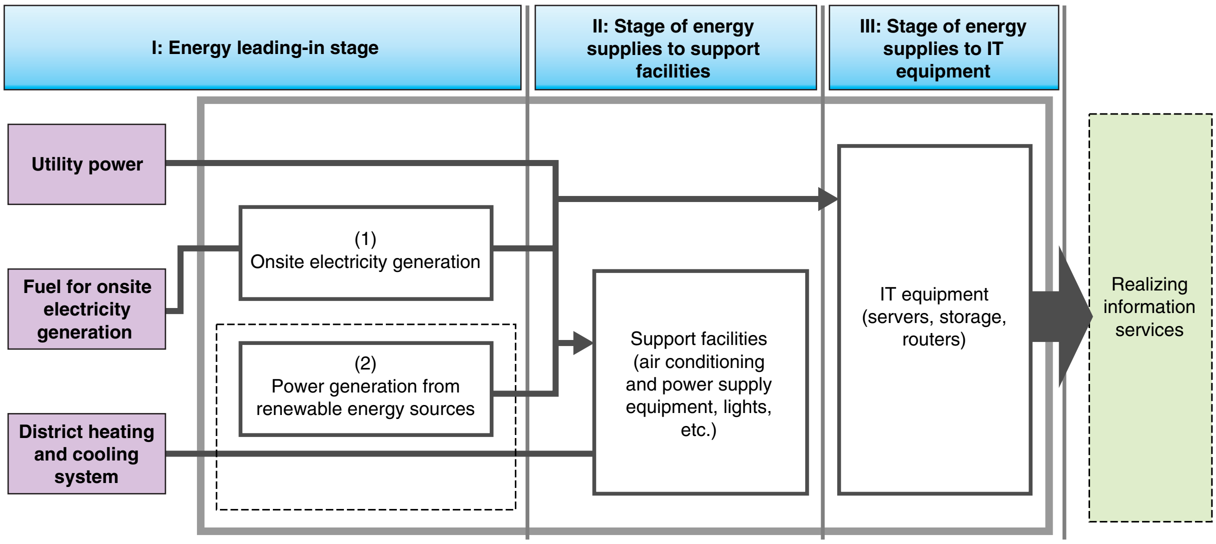
When the consumption of energy in data centers and the flow of energy are considered, there appear to be three main stages, as shown in Figure 2.

First, at the "energy leading-in" stage (Stage I), power is usually taken from a commercial supply that is provided by a power utility at a high voltage (60,000 volts). In addition, diesel or gas is required to generate electricity on-site. When a district heating and cooling facility is available nearby, chilled water for cooling is supplied to the building. A district heating and cooling company often has cogeneration equipment that simultaneously generates heat and power, offering high energy conversion efficiency. For a data center, having such a facility as a source of energy that is separate and distinct from the electric power utility offers the advantage of reducing energy risks. To reduce CO_2 emissions to mitigate climate change, data centers can also introduce sources of renewable energy such as solar and wind power.

The energy that the data center draws then moves to the stage of "energy supplies to support facilities" (Stage II). These support facilities consist mostly of the air conditioning equipment that is used to expel the heat generated by servers, and they are responsible for around half of all the energy that is consumed by a data center.

Finally, at the stage of "energy supplies to IT equipment" (Stage III), power is provided to IT equipment, whereby servers, storage, routers and so on operate to provide information services to users.

Figure 2. Flow of energy in a data center



Because energy flows as described above, the energy consumption and CO_2 emissions of the entire data center can be addressed in the following three ways.

(1) Switching energy sources used in the data center to green energy sources that produce power with very little or no CO_2 emissions
(2) Improving the energy efficiency of support facilities needed by data center operation such as air conditioning and power supply equipment
(3) Improving the energy efficiency of the IT equipment used in the data center

Let's look at each of these three approaches, below.

1 Switching to green energy sources

Switching to low-carbon energy sources is a very effective way of reducing the CO_2 emissions of a data center. This area is beginning to see the adoption of green sources of energy such as solar, wind and hydro power. In addition to these renewable energy sources, the introduction of cogeneration equipment provides an effective way of increasing energy utilization efficiency by using both heat and electric power. In Europe, because large amounts of energy are used for heating, the adoption of low-carbon energy sources is promoted with a focus on cogeneration.

2 Improving the energy efficiency of a data center's support facilities

Any energy conservation efforts in a data center need to take into account support facilities that are required for operation. That is, the energy efficiency of the equipment used to cool the center must be improved, along with that used to convert and distribute power.

Approaches that do not require major investments include the removal of unnecessary cabling, piping and equipment from the data center, as well as improving the flow of the cold air supply and waste heat recovery. On the other hand, effective investments would include the introduction of highly efficient equipment such as inverter-type air-conditioner chillers. In those locations where the outside air is cold, cold air can be drawn in to enable free cooling. In Japan, where this free cooling is only available in the winter, studies are being made on building data centers underground to use cold air and water that is available underground.

3 Improving the energy efficiency of IT equipment

The energy efficiency of the IT equipment installed in a data center can be improved in the following ways:

(1) Replacing servers with ones using the latest energy-saving CPUs such as quad core CPUs (CPUs with four processing circuits)
(2) Reducing power consumption by using smaller hard disks
(3) Reducing the number of server and storage units by employing virtualization technology
(4) Cutting server power consumption when in idle mode by using energy management software

Within a server, the CPU accounts for 30 percent of total power consumption, with the remaining 70 percent being consumed by hard disks, power supplies, fans, and so on. Therefore, to reduce total power consumption, it is effective to improve the efficiency of these devices or to share these devices. Furthermore, because a server CPU is in idle mode for more than 70 percent of the time, the consolidation of servers to increase the rate of utilization is an effective means of improving energy efficiency.

Server consolidation means that one large-scale server is divided into multiple virtual servers by virtualization technology, and the existing application software is operated on these virtual servers. Because conventional small-scale servers are procured based on the capacity required for the peak load that each must handle, they often operate at only 10 to 15 percent of their peak capacity. If the average rate of utilization is increased by consolidating these servers, overall efficiency will also increase. Because servers sometimes consume about 30 percent of electricity even in idle mode as compared to peak times, such consolidation is clearly effective. Similarly, moves have already been started to use virtualization technology for storage devices. The integration of storage devices is equally effective.

During the summer of 2011, a shortfall in electricity generating capacity led to the threat of major power outages. To avoid such outages, an urgent request to reduce peak power consumption was issued. In our survey, when asked about how they dealt with this request, the data centers responded that they had implemented their power-saving measures earlier than planned. Unfortunately, given that there were only two months between the time the request was issued and the summer of 2011 when power-saving measures were needed, the measures actually taken were limited to only the following, which could be adopted quickly.

(1) Saving power for lighting, elevators, and so on used in common spaces
(2) Shutting down servers that were not in full-time operation
(3) Switching to non-commercial sources of energy such as gas-powered air-conditioning and chilled ground water
(4) Raising the temperature setting of server room air conditioning
(5) Using onsite power generators

These urgent measures have contributed to a further increase in the energy efficiency of Japanese data centers. Furthermore, in order to respond to restricted energy supplies in the next fiscal year, investment is being made for mid-term power-saving measures.

IV Globalizing Data Center Energy Efficiency Metrics

To measure and evaluate the effects of measures to improve the energy efficiency of data centers as described in Chapter III and to promote the international recognition of Japan's high data center competitiveness, there is a need for internationally accepted metrics. Japan's Green IT Promotion Council has proposed its Datacenter Performance Per Energy (DPPE) metric to Europe and the U.S.

The main feature of DPPE is that the energy-saving roles of all stakeholders involved in the operation of data centers such as computer users, IT equipment manufacturers, data center builders and data center owners are respectively defined and indexed, and that the improvement in the energy efficiency of data centers is vigorously promoted by the combined efforts of all concerned stakeholders. The data center energy efficiency metric that has been proposed in the U.S. involves the ratio obtained by dividing total data center power consumption by electricity consumed by IT equipment. This metric is meant to reduce the power consumption of support facilities such as air conditioning and power supply systems. As a result, there has been no method of indicating the energy-saving roles of computer users and IT equipment manufacturers, such that there is a limit in achieving improved energy efficiency.

1 Comparison of overall fuel economy indicators between data centers and automobiles

To better understand the way in which DPPE is meant to improve energy efficiency in data centers, it is useful to consider the metaphor of automobile fuel efficiency. The improved fuel efficiency of Japanese cars has not come about solely through the efforts of car manufacturers. Rather, progress has been made by involving automobile manufacturers, component manufacturers, materials manufacturers, fleet operators and the drivers themselves.

Car manufacturers develop fuel-efficient engines and bodies, while component and materials manufacturers set out to design and develop new materials with the goal of reducing weight. In addition, engine control technologies and systems are developed in order to realize high levels of fuel efficiency. Fleet operators strive to load their vehicles in the most efficient ways, and formulate and implement energy-saving operating plans that take routes and travel time frames into consideration, while drivers are conscious of the need for energy conservation and adopt a style of eco-driving. The synergetic effect of these combined efforts—from the development and manufacture of automobiles through to how they are actually used—brings about considerable reductions in energy consumption and CO_2 emissions.

There are two main approaches to improving the fuel efficiency of automobiles. One involves improving the design of the body, while the other focuses on improving the engine. By improving the design of the body, lighter components and parts can be realized along with improved body aerodynamics. In a data center, body improvement is equivalent to improving the energy efficiency of air conditioning and power supply facilities that are associated with a building.

However, in the same way as there are limits to the degree of improvement in fuel efficiency that can be gained just by improving a vehicle's body, the energy efficiency of a data center can be improved only so much by working on the air conditioning and power supply facilities. In the case of automobiles, which burn fuel, significant improvements in fuel economy can be achieved by improving the engine, which is central to enabling cars to perform their primary function of traveling on the road. In a data center, a car's engine is equivalent to the servers and other IT equipment that perform data processing, all of which must be the primary target of the efforts to improve energy efficiency. In other words, it is vital to deploy as many high energy-efficient IT devices as possible. After deploying such devices, in the same way as drivers try to adopt a style of eco-driving by not taking off rapidly, accelerating suddenly or braking sharply, it is important for users of IT equipment to adopt the optimum way of using the equipment so that even higher levels of energy efficiency can be attained.

2 The four sub-metrics of the Datacenter Performance Per Energy (DPPE) metric

Based on the above-mentioned concept, the DPPE metric being proposed by Japan consists of the four sub-metrics listed in Table 3. These sub-metrics have been designed to reflect the energy-saving efforts of the four main stakeholders involved in data centers. The efforts to improve the energy efficiency of IT equipment installed in a data center such as computers, storage and network devices include the following:

(1) Developing and introducing highly energy-efficient equipment in much the same way as energy-efficient home appliances, which have sold well thanks to Japan's "Eco-points" subsidies (manufacturer efforts)

(2) The users who purchased such equipment operate it in the most energy-efficient way (user efforts)

(3) Providing highly energy-efficient facilities, thereby reducing the amount of energy being drawn for cooling and power supplies (facility supplier efforts)

(4) At the same time, data centers produce their own carbon-neutral electric power such as through solar- and wind-powered generation to reduce CO_2 emissions

Looking at these efforts in detail, for the introduction of highly energy-efficient IT equipment, as described in manufacturer efforts (1), values for the energy-efficient performance of IT equipment installed in a data center are taken from the values that are stipulated under Japan's Law on the Rational Use of Energy and published in catalogs. Japan proposes the ITEE (IT Equipment Energy Efficiency) sub-metric, which is the weighted average of the published values using rated power consumption and is the representative value for the entire data center. These energy efficiency indicators for IT equipment are stipulated in Japan's Law as mentioned above. Japan's goal is to spread, worldwide, the concept in which the weighted average of the catalog performance of IT equipment installed in a data center is calculated and used as an indicator.

For using purchased IT equipment in the most energy-efficient way, as described in user efforts (2), Japan proposes the ITEU (IT Equipment Utilization) sub-metric. When IT equipment is merely turned on, it draws between 10 percent and 50 percent of its peak power consumption. Therefore, it is important to stop the supply of power to unnecessary or under-utilized equipment, while ensuring the energy efficiency of the overall utilization. The ITEU sub-metric indicates how close the equipment is to this optimum performance.

For the efficiency of data center facilities, as described in facility supplier efforts (3), Japan agrees to use the PUE (Power Usage Effectiveness) indicator, which is advocated by The Green Grid, a U.S.-based organization dedicated to improving energy efficiency in data centers.

PUE is calculated by the following formula:

Table 3. Sub-metrics consisting of the Datacenter Performance Per Energy (DPPE) metric

Sub-metric	Calculation formula	Corresponding action measures
1. ITEE (IT Equipment Energy Efficiency)	$=\dfrac{\Sigma\,\text{(Total IT equipment capacity)}}{\Sigma\,\text{(Total IT equipment energy consumption)}}$	Introducing energy-efficient IT equipment
2. ITEU (IT Equipment Utilization)	= Data center's IT equipment utilization rate	Effective use of IT equipment, virtualization, etc.
3. PUE (Power Usage Effectiveness)	$=\dfrac{\text{Total data center energy consumption}}{\text{Electricity consumed by IT equipment}}$	Improving energy efficiency of support facilities, improving the efficiency of air conditioning and power supply systems
4. GEC (Green Energy Coefficient)	$=\dfrac{\text{Green energy}}{\text{Total data center energy consumption}}$	Introducing solar power generation systems, etc.

Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

PUE = Total data center energy consumption/Total electricity consumed by IT equipment

The PUE is a ratio that expresses the proportion of electricity consumed by IT equipment to total data center energy consumption. "PUE = 1.0" means the status where nothing other than IT equipment requires electricity. Actually, however, devices such as cooling equipment and power supply equipment also consume large amounts of electricity. When IT equipment is responsible for about 30 percent of total data center power consumption, the PUE value is 3.3 (1/0.3). Effective means of improving the PUE value include, for example, replacing current air conditioners with highly energy-efficient ones, which requires investment. Operational measures that can be effective without requiring such investment include rearranging the layout of server floors to improve the (heating and cooling) air flow.

For using renewable energy, as described in (4), a submetric called the GEC (Green Energy Coefficient) is used to indicate the amount of renewable energy that is generated within the data center relative to the overall data center energy consumption. In Japan, even if solar panels are installed, electricity generation using solar panels is limited. However, in the U.S., some data centers claim to produce all their electricity from solar panels. On a worldwide scale, the use of solar panels definitely presents great potential.

As such, if IT equipment manufacturers, users, building facility manufacturers and power suppliers all play their respective roles in improving energy-efficient, low-carbon performance for data center operations, significant CO_2 reductions can be attained. For example, if users increase their utilization efficiency by 20 percent, equipment manufacturers improve their energy efficiency by 20 percent, building facility manufacturers improve their energy efficiency by 20 percent, and power utilities increase the ratio of low-carbon power by 20 percent, this data center could theoretically achieve a CO_2 reduction of $0.8 \times 0.8 \times 0.8 \times 0.8 \times \fallingdotseq 0.4$, or about 60 percent, with the overall low-carbon ratio experiencing a two-fold increase or more.

If this were possible, even if there were a two-fold increase in global demand for computer processing, there would be no increase in the energy consumption or CO_2 emissions of the world's data centers. Of course, not every entity will become 20 percent more efficient, and the pace of improvement will vary with the speed at which technology advances and according to the status of each data center. If the situation were managed in such a way that an average improvement of 20 percent could be achieved, overall CO_2 emissions could be reduced by 60 percent. It is in this way that Japan promotes the improvement of energy efficiency, with every concerned stakeholders making an all-out attempt to realize significant reductions.

V Japan's Data Center Energy Efficiency in 2010

1 Results of DPPE measurements in 2010

At the request of the Ministry of Economy, Trade and Industry, the Green IT Promotion Council conducted measurements of four sub-metrics consisting of the DPPE metric to both verify the data center energy efficiency metrics and evaluate the energy efficiency of Japan's data centers.

As shown in Table 4, 25 data centers owned and operated by 20 domestic enterprises were measured as well as two data centers of two overseas enterprises. The measurements were performed between July 2010 and January 2011, and enabled clarification of the detailed specifications of the IT equipment. For those data centers for which ITEE and ITEU measurements were possible, the four sub-metrics were measured once per month. For data centers other than these, monthly PUE measurements were performed. The scale of the data centers that participated in this measurement project varied widely, with floor spaces between 64 m^2 at the minimum and 145,000 m^2 at the maximum. This measurement project was the world's first in that the energy efficiency of not only the support facilities but also the

Table 4. Outline of data center DPPE measurement project in 2010

Number of participating companies	20 domestic companies and 2 overseas companies
Number of participating data centers	25 domestic data centers (dedicated, collocated with offices or unknown) and 2 overseas data centers
Project period	July 2010 – January 2011
Outline of participating data centers • Number of data centers by region	2 in Hokkaido, Tohoku and Hokuriku; 11 in Kanto; 2 in Tokai, Chubu and Kinki; 3 in Chugoku, Shikoku, Kyushu and Okinawa; 7 in unspecified areas; 2 in other countries (Singapore and Vietnam)
• Year of construction of data centers	1988 – 2009
• Total floor space	64 – 145,201 m^2
• Server room floor space	About 11 – 16,500 m^2

Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

IT equipment was measured for data centers in production.

The main characteristic of DPPE is that it measures and evaluates the energy efficiency of a data center for four individual means of conserving energy. By using sub-metrics that can be employed for comparison based on a particular characteristic of each data center such as "old or new," "centered on online or centered on batch," "business-to-business (B to B) or business-to-consumer (B to C)," one can determine where individual data centers can improve. Through the use of the four sub-metrics, the degree of improvement possible with each of the following four methods can be determined along with the degree of improvement in energy efficiency that is theoretically possible.

(1) Has energy consumption of the support facilities in the data center been minimized? (PUE measurements)
(2) Is renewable energy used as much as possible instead of utility power? (GEC measurements)
(3) Has highly energy-efficient IT equipment been introduced? (ITEE measurements)
(4) Is the installed IT equipment being used to its maximum efficiency? (ITEU measurements)

(1) Results of PUE measurements

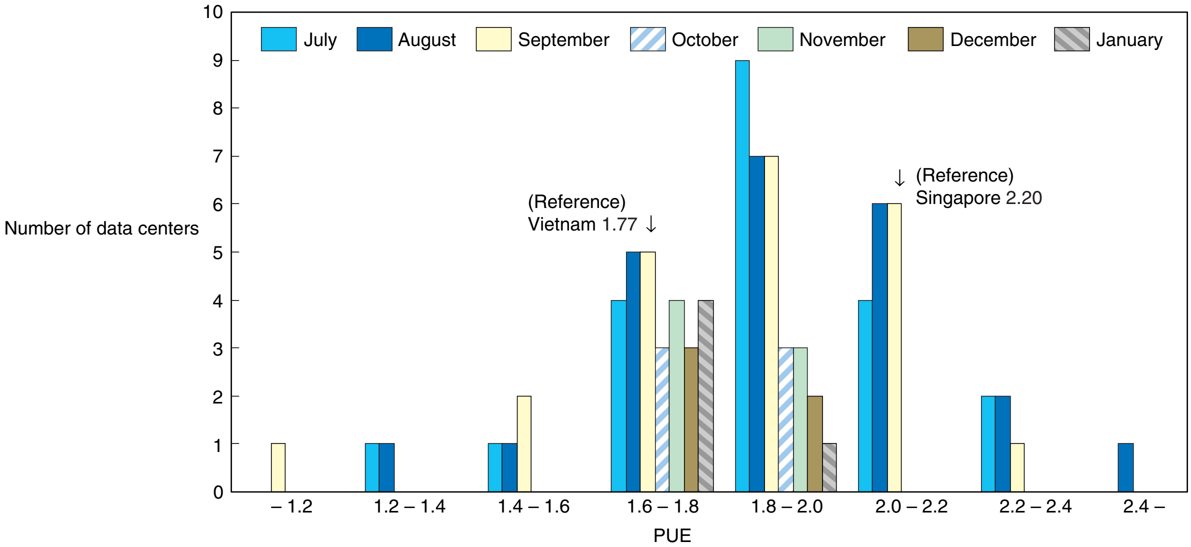
This study looked at Japan's data centers by means of the PUE sub-metric, which indicates the energy efficiency of support facilities. It was found that the PUE values were distributed as shown in Figure 3, with values of 1.8 to 2.0 being the most common. These findings clearly indicate that almost half of the total power consumption of data centers can be attributed to support facilities such as air-conditioning equipment. Because the data was collected during the summer, which was the hottest part of the year, the yearly average would be somewhat better and is expected to be on the order of 1.8. In fact, although the number of samples was limited, this study did see that the average value for November and December was 1.78 to 1.79, which was less than 1.8, as shown in Figure 4.

A look at the values achieved by data centers in other countries, which were measured at the same time, shows that the average for Singapore is 2.20 and that for Vietnam is 1.77—not a significant difference, although Singapore's performance is somewhat worse. Regarding U.S. data centers, data compiled by the U.S. Environmental Protection Agency (EPA) shows a range of 1.25 to 3.75 and an average of 1.91—a value that is not dissimilar to that of Japan. In terms of best practices, the U.S. and Japan are again very similar, achieving a value of around 1.2.

As such, the energy efficiency of support facilities installed in a data center has significantly improved from the level of several years ago when the PUE value was 3, meaning that support facilities accounted for 2/3 of the total power consumed in a data center. This trend of improvement is seen worldwide. Since 2007, when the U.S. The Green Grid introduced the PUE metric, a cycle of measuring PUE values and improving efficiency based on measured values started. This PUE metric is significant in that it contributed to worldwide improvements based on such a cycle.

This study also analyzed the relationship between PUE values and the scale of data centers. Three factors of data center scale were examined. These were (1) floor space, (2) total power consumption of the data center and (3) power consumption of the IT equipment installed in the data center. In the U.S., the EPA issued a report that the PUE values of large data centers are smaller because they benefit from support facilities such as air conditioning equipment having higher energy efficiency. However, in Japan, no correlation between PUE

Figure 3. PUE values of Japanese data centers



Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

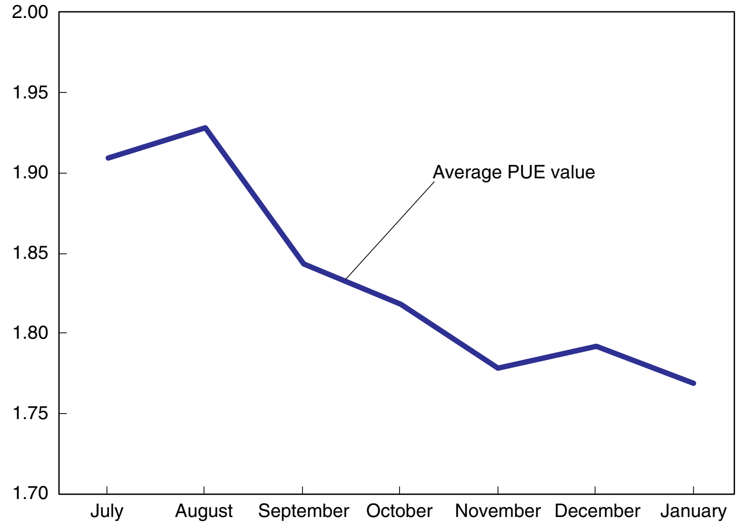
values and the scale of data centers can be seen. Regardless of scale, the average PUE value is around 1.9. Nevertheless, for small data centers, the PUE value ranges widely from 1.2 to 2.4, while for large data centers, the range is narrower, being between 1.8 and 2.1. The reason for this convergence is thought to be that larger data centers are more suitably managed as commercial data centers offering information services to many customers than are smaller ones that are often operated by a single company for its own business activities.

While the above PUE values were obtained from data centers currently in production, relatively good values have been announced for centers that are in the planning stage. Data centers currently being planned or built by Microsoft, Amazon.com and Facebook will have a PUE value of around 1.1, with support facilities that consume very little energy, thus realizing an improvement on the order of 40 percent over current average PUE values. To attain this level of performance, these data centers are located in the northern part of the United States, where they can make effective use of cold outside air and water.

(2) Results of GEC measurements

As shown in Table 5, values for the GEC sub-metric could be obtained at four data centers. This sub-metric

Figure 4. Monthly changes in PUE values in Japanese data centers



Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

Table 5. GEC values of Japanese data centers

		Data center			
		A	B	C	D
Type of renewable energy	Data center space	PV	PV	PV	PV
	Office and other common space	—	PV	—	—
Amount of generated renewable energy (GJ)	November		1,454		
	October		1,780		
	September	972	1,836	1,125	2,175
	August	2,302	2,264	1,414	2,640
	July	1,990	1,984	1,198	2,470
GEC	November		0.0018		
	October		0.0022		
	September	0.0019	0.0022	0.0001	0.0045
	August	0.0043	0.0025	0.0002	0.0052
	July	0.0038	0.0023	0.0001	0.0051
	Average	0.0033	0.0022	0.0001	0.0049

Notes: PV = photovoltaic power generation, GJ = gigajoule.
Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

measures the degree of use of renewable sources such as solar power. At all of these data centers, the amount of renewable energy being used was small, accounting for less than 1 percent of their total energy consumption.

According to the report on the amount of renewable energy produced at Data Center B in the five months between July and November, the maximum output was in August. In November, however, output fell to around 60 percent of that in August. Therefore, it is clear that the amount of electrical power produced by renewable energy varies widely from month to month. Currently, to promote the use of green energy, international conferences are examining the inclusion of "Renewable Energy Certificates," which are purchased by data centers, into the calculation of GEC. These certificates are issued for electricity generated by using renewable energy in a location other than at the data center. This would allow Japanese data centers to further improve their GEC values.

(3) Results of ITEE measurements

The ITEE value, which indicates the average energy efficiency of all the IT equipment in a data center, was measured at eight data centers in Japan. As shown in Table 6, the ITEE values for Japanese data centers range from 0.48 to 3.68, with the largest being nearly eight times that of the smallest. By definition, a data center for which the overall average energy efficiency of the IT equipment is equivalent to the 2005 average value has an ITEE value of 1. However, a data center with a value of 0.48 is considered to have an energy efficiency of about half the average. Conversely, a data center that is assumed to be equipped with the very latest IT equipment has an energy efficiency of about four times the average. For the eight data centers that were measured, the average ITEE value was 1.52, an improvement of about 50 percent over the 2005 average.

While the ITEE value indicates the average energy efficiency of all the IT equipment installed in a data center, Figure 5 shows the annual change in the energy efficiency of only the servers. As new-model servers are released every year, they offer a level of efficiency that is a 30-percent improvement over the model they replace. Although not all the servers in a data center can be replaced at one time, regular replacement on a five-year cycle will result in 20 percent of all the servers in the center benefiting from improvements in energy efficiency every five years. Because of such improvements, the ITEE value for the data center as a whole will increase by around 30 percent each year. To improve the ITEE value in this way, it is important that the servers be regularly replaced with units offering the highest level of energy efficiency.

Of the eight data centers examined, Center B was found to have the highest ITEE value at 3.68, due to its having new servers for hosting. A breakdown of the ITEE values for individual equipment in the center shows that the servers have a value of 3.71, the value for storage is 2.97 and the value for network devices is 6.91—all three values being relatively high. For Data Center C, on the other hand, the ITEE value was a very low 0.48, despite the center being intended for hosting. If the equipment in Center C were replaced with that having the same level of energy efficiency as that installed in Center B, Center C's energy efficiency would be increased by around eightfold. This means that the total power consumption would theoretically be reduced to one-eighth. In the case of Data Center G, storage equipment presents a particularly bad ITEE value of 0.04, which suppressed the overall ITEE value. If this storage could be replaced with equipment offering a much higher level of energy efficiency, the ITEE value could be doubled and the overall power consumption could, theoretically, be halved.

Table 6. ITEE values of Japanese data centers

Data center	Total rated capacity (Work)	Total rated power consumption (W)	ITEE (September)	ITEE equipment		
				Servers	Storage equipment	Network equipment
A	416,823	194,692	2.14	1.69	3.10	2.43
B	2,927,349	795,017	3.68	3.71	2.97	6.91
C	14,729	30,688	0.48	0.48	–	0.48
D	7,264	5,108	1.42	1.64	3.01	0.10
E	7,830	5,534	1.41	1.44	1.39	0.95
F	4,930	4,163	1.18	2.29	–	0.35
G	117,601	108,630	1.08	4.07	0.04	3.52
H	87,640	112,268	0.78	0.78	1.09	0.48
I (Singapore)	92,568	34,656	2.67	3.82	–	1.34
J (Vietnam)	30,040	38,957	0.84	0.76	–	1.64

Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

For reference, the values for the data centers in Singapore and Vietnam are shown as I and J in Table 6. Possibly, because the center in Singapore had installed new servers in a new data center, the ITEE value is high, at 2.67.

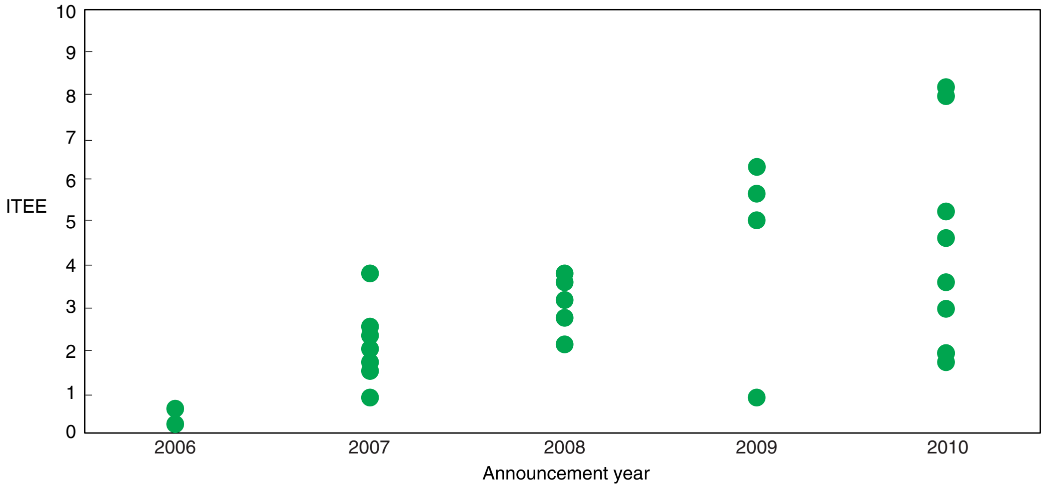
The usage/purpose of a data center primarily determines the type of servers that it can employ, making it difficult for all data centers to attain a high ITEE value of 3 to 4. However, as in the case of Data Center B, if the data center can install a considerable amount of highly energy-efficient equipment, the international competitiveness of Japan's data centers would be enhanced. Furthermore, the ITEE values of IT equipment vary even if the same CPU is employed. For example, in the case of servers, values change according to the structure of the power source and airflow. Therefore, expectation is given to the ingenuity of Japanese server manufacturers to enable the offering of servers with higher levels of energy efficiency.

(4) Results of ITEU measurements

Table 7 lists the results of measuring ITEU values, which indicate the rate of use of IT equipment.

By and large, the ITEU values were found to be between 0.3 and 0.6, with none of the data centers exhibiting any great month-to-month change. The study also looked at the relationships between the values and the scale of data centers, and found no correlation. In the case of small data centers, however, the ITEU values varied widely between 0.3 and 0.6, while for large

Figure 5. Annual changes in the energy efficiency of servers alone



Source: Compiled based on the catalogs of server manufacturers.

Table 7. ITEU values of Japanese data centers

Usage/purpose of data center		Average	Month with smallest value	Month with largest value
A	Financial service	0.57	0.56	0.58
B	Hosting service	0.42	0.42	0.42
C	Hosting service	0.33	0.30	0.36
D	Housing service	0.41	0.40	0.42
E	ASP system	0.49	0.48	0.50
F	Common IT platform service	0.36	0.36	0.36
G	Order entry management system	0.31	0.31	0.31
H	Internet data center	0.34	0.34	0.35
I	Solution evaluation/verification system	0.28	0.26	0.31
J	IT outsourcing	0.44	0.43	0.44
K	ITEU measurement	0.43	0.42	0.43
L	ITEU measurement	0.48	0.48	0.48
Reference	M: Singapore (value for three months (July to September))	0.61	–	–
	N: Vietnam (value on October 21 only)	0.40	–	–

Note: ASP = application service provider.
Source: Japan Electronics and Information Technology Industries Association (JEITA), “2010 Report on the Promotion of Green IT,” March 2011.

data centers the spread was only between 0.4 and 0.5. The upper limit for a large data center running a variety of types of systems was found to be around 0.5, with any further improvement in the overall utilization rate assumed difficult.

The maximum power rating in IT equipment catalogs is known to be normally much more loosely designed than the measured peak power that is consumed by the server when its CPU operates at 100 percent capacity. A close look at several servers reveals that they are provided with power supplies that are capable of providing twice the actual peak power of the CPUs, and it is this maximum power rating that is often listed in the catalog. Therefore, it appears that the ITEU value of 0.5 or 50 percent represents nearly the upper limit.

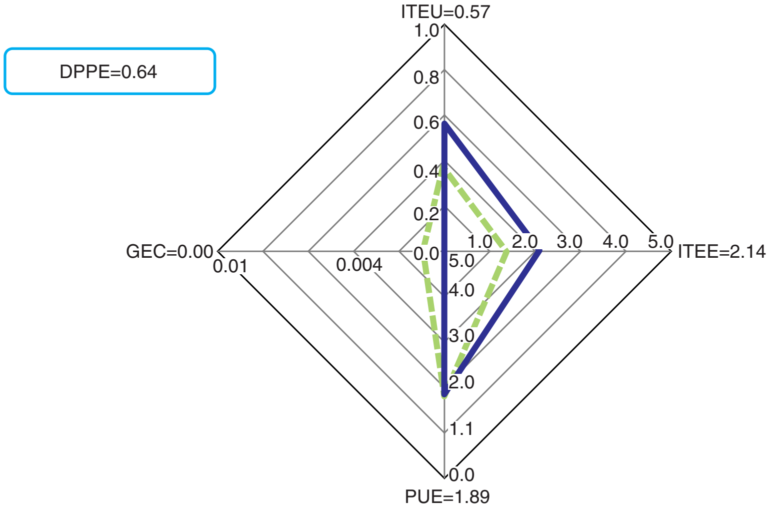
A look at how the ITEU value changes with the usage/purpose of the data center shows that systems that are continuously handling transactions such as financial systems have a higher ITEU. As such, if single application software is in constant use, utilization is very efficient. However, for systems that are used as needed such as ordering systems and systems for evaluating and verifying solutions, the average utilization is lower, with an ITEU value of around 0.3. However, if these systems with a low operating efficiency can be successfully consolidated on a virtual platform, overall efficiency can be increased. The application of virtualization technology is also one of the means of increasing the international competitiveness of Japan's data centers.

2 Potential for Improving the Performance of Japan's Data Centers

Based on the measurement results for the four sub-metrics, the DPPE value was calculated and the four sub-metric values were plotted on a spider chart.

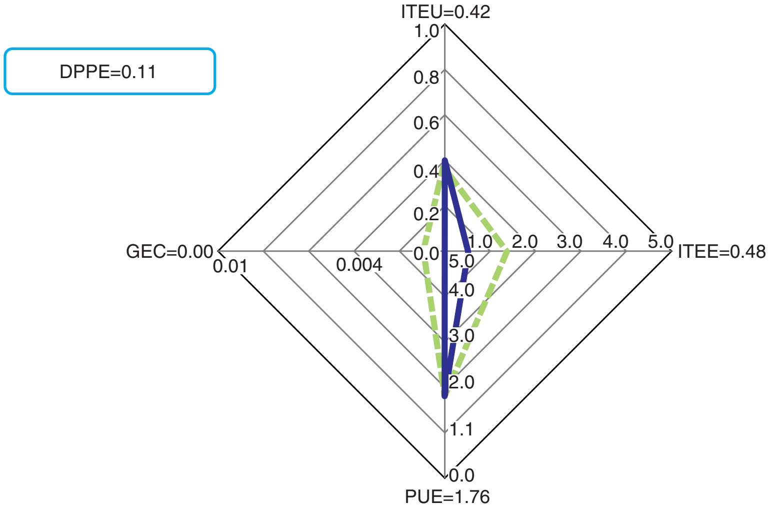
As shown in Figure 6, Data Center A has the highest DPPE value, at 0.64. Because the center is always

Figure 6. Energy efficiency of Data Center A



Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

Figure 7. Energy efficiency of Data Center B



Source: Japan Electronics and Information Technology Industries Association (JEITA), "2010 Report on the Promotion of Green IT," March 2011.

running a financial system at a high rate of utilization, its level of performance is above average, with an ITEE value of 2.14 and an ITEU value of 0.57. Because the PUE value is still 1.89, possible methods of improving energy efficiency include increasing the utilization of support facilities, replacing such facilities, or relocating to a new-type data center. If such measures were taken, a significant improvement (20 – 30 percent) could be achieved. Because the center does not use any renewable energy, the GEC value is 0. However, if the center were relocated to an area where such energy could be introduced, this would be another way of realizing further improvement.

Figure 7 is a spider chart for Data Center B, for which the DPPE value is low, at 0.11. This center's ITEU value is 0.42 and the PUE is 1.76, both of which are relatively good and above-average values. This data center appears to have been subject to ongoing improvements with respect to the utilization of its IT equipment and the operation of support facilities such as air-conditioning equipment. On the other hand, the relatively low ITEE value of 0.48 indicates that the IT equipment itself has not been updated. Therefore, if the IT equipment were to be replaced with the latest, high energy-efficient units, the energy efficiency of the entire center could be significantly improved several times over.

In this way, by improving the energy-saving performance of the IT equipment itself, as measured by means of the ITEE and ITEU values, major improvements in energy efficiency can be achieved. For example, consider the possible degree of improvement based on the average values obtained through the measurements of the energy-saving performances of data centers. Suppose the ITEE value achieves a 100 percent improvement from 1.5 to 3.0; the ITEU value achieves a 25 percent improvement from 0.4 to 0.5; the PUE value achieves a 20 percent improvement from 1.8 to 1.5; and the GEC value achieves a 10 percent improvement from 0 to 0.1. From these values, overall data center efficiency can be calculated by taking their product, that is, ($2 \times 1.25 \times 1.2 \times 1.1 = 3.3$) —a roughly three-fold improvement in efficiency.

3 Toward improving international competitiveness

(1) Enabling international comparisons through the standardization of metrics

As discussed above, in order to strengthen the competitiveness of Japanese data centers within Asia, it is important to take appropriate measures after understanding the weaknesses inherent in Japan such as the risk of natural disasters and energy risks, and to publish the results of such measures by means of metrics that are accepted internationally.

Regarding the methods to be used to evaluate the risks presented by natural disasters, the Japanese version of the tier standard that was established by the Japan Data Center Council must be made much more widely known. Regarding energy risks, Japanese data centers should be evaluated based on globally accepted energy efficiency assessment systems in terms of policies that promote the improvement of energy efficiency, improvement structure, management methods and so on. At the same time, it is necessary to promote the wide use of the DPPE metric for measurements of energy efficiency and the reporting of measured values. For this purpose, the Green IT Promotion Council also conducted the DPPE measurement project in 2011 in the same way as it did in 2010. In 2011, a greater number of data centers participated in the project. Further efforts to increase international recognition include ongoing dialog between the Japanese, U.S. and European governments and industrial associations through regular conference calls and face-to-face meetings in an attempt to attain global harmonization.

(2) Further improving international competitiveness

This paper has discussed measures that can be adopted at the level of individual data centers to improve the international competitiveness of Japan's data centers within Asia. These measures are intended to address the two main weaknesses that were evaluated as presenting high risks, namely, "natural disasters" and "energy costs." On the other hand, from the perspective of strengthening competitiveness, it is important to further enhance the strengths of the data centers and publicize such strengths to the world. Because this goal must be attained by the country as a whole, cooperation among industrial associations and other related organizations would be most effective. From among the data indicated in the "Data Center Risk Index" published by Cushman & Wakefield and hurleypalmerflatt, which was introduced in Table 1, Chapter I, the data that relate to five Asian countries were extracted. These countries were then re-ranked according to all risk categories. The results are listed in Table 8. Of the 11 risk categories, Japan placed first (presenting the lowest risk) in three categories and attained first rank in the largest number of categories (three). Singapore also attained first rank in three categories.

Japan's first-place ranking in "political stability" reflects the evaluation that there are no sudden changes in policies and in systems/regulations. This assessment implies the advantage of being able to ensure stable data center operations and safe data storage. In comparison, in China, systems and regulations can change suddenly, and there have been many foreign-affiliated companies operating in China that have experienced the confusion that such changes caused. Such changes are unlikely to occur in Japan.

Japan is also first in terms of "inflation." No inflation means that costs are very unlikely to rise suddenly, which is another advantage. Once a customer (user)

Table 8. Ranking of risks for locating data centers in five Asian countries (rank within five countries)

Rank	Score	Country	Energy cost	International bandwidth	Ease of doing business	Corporate tax	Labor cost	Political stability	Sustainability	Natural disasters	GDP per capita	Inflation	Water availability per capita
1	85	Hong Kong	3	1	2	1	3	2	4	4	3	2	2
2	71	Singapore	2	4	1	2	4	4	5	1	1	4	5
3	56	China	4	3	4	3	1	5	2	2	4	3	2
4	54	Japan	5	2	3	4	5	1	3	5	2	1	1
5	51	India	1	5	5	5	2	3	1	3	5	5	4

Source: Compiled based on "Data Center Risk Index" published by Cushman & Wakefield and hurleypalmerflatt.

locates its systems in a data center, relocating such systems to another center would incur major costs and risks. Therefore, the fact that the charges for using a data center are stable is very important for the user to continue its business operations stably. In fact, many foreign-affiliated companies operating in China and India have been forced to change their strategies due to the rapidly rising labor costs in those countries.

Furthermore, Japan also placed first for "water availability." Of the five countries, Japan is the most northerly, with cold winters, such that the availability of cold water and outside air for data center cooling is a major competitive advantage.

These strengths should be used skillfully. As for the indicated risks, individual data centers should make respective efforts to fully compensate for such weaknesses and the results of their actions should be internationally recognized. In so doing, it would be possible to increase the international competitiveness of Japan's data centers.

Immediately after writing this paper, the author had the opportunity to visit data centers in Singapore, Vietnam and the U.S. In Singapore, I visited four data centers. The operators of all four data centers stressed their high international competitiveness. That is, they pointed out their freedom from natural disasters, the stability of their electricity supplies, and their position as an international telecommunications hub. The author visited data centers that were operated by a communications company, a U.S. company, a local company and a Japanese company, and saw that they were all aware of global competition. Through these visits, the author reaffirmed his belief that Japan's data centers must move from an era of domestic competition to one of global competition.

Takao SHIINO is an NRI counselor and the chairman of the Environment Department of the Japan Information Technology Services Industry Association (JISA). His specialties include management strategy and IT strategy.

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Inquiries to: Corporate Communications Department
Nomura Research Institute, Ltd.
E-mail: nri-papers@nri.co.jp