Trends of Energy Saving in Data Centers and Fujitsu Group's Approach

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Tackling global environmental issues is a major challenge for ICT companies. The Fujitsu Group considers it an ICT company's responsibility not only to work on reducing the CO_2 emitted from its plants, but also to help reduce the CO_2 generated by ICT devices through their own energy-saving measures, and to utilize ICT to reduce CO_2 in all fields of society. The greater volume of information used by the Internet has unavoidably led to data centers consuming more power. Therefore, data centers must become more energy-efficient to reduce the load that the whole of society places on the environment. The Fujitsu Group has introduced a number of technologies to improve energy efficiency at data centers. These include technologies to conserve energy at its facilities such as efficient air conditioning, lighting and power supplies, as well as energy-saving ICT devices including servers, and technologies to integrate and virtualize ICT infrastructure.

1. Introduction

The Kyoto Protocol, which stipulates controls on greenhouse gas emissions, was passed in 1997 and the reduction of certain amounts of greenhouse gases was required by law for the first time in advanced nations between 2008 and 2012. At that time, Japan was assigned the obligation of a 6% reduction. Meanwhile, at the Hokkaido Toyako Summit held in July 2008, the goal of "a 50% reduction from the present level of global emissions of greenhouse gases by 2050" was declared by the leaders of the participating nations. In September 2009, Prime Minister Yukio Hatoyama declared at the United Nations Summit on Climate Change the goal of a 25% reduction of greenhouse gases (from the 1990 level).

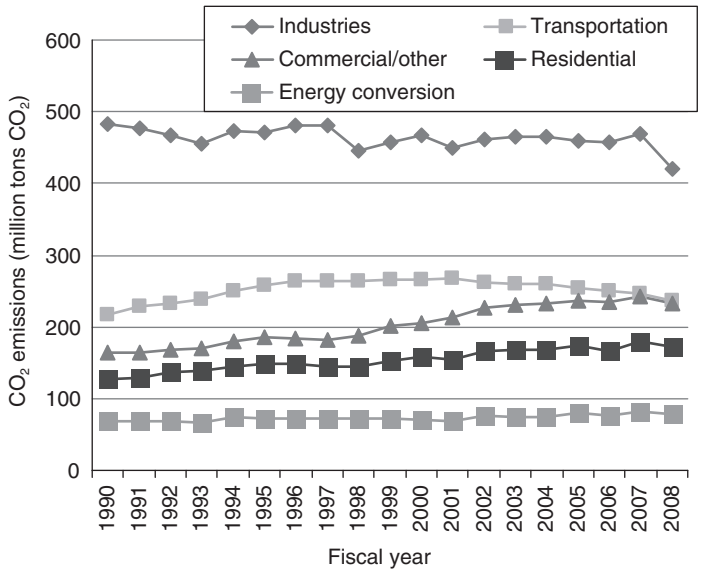
As greenhouse gas control is tightened in this way, CO_2 emissions for each sector in Japan (**Figure 1**)[1] are indicating a significant increase to 232 million tons from 164 million (preliminary figures) for the commercial/other sector, although the emissions for the industries sector including factories are on the decrease. The commercial/other sector includes data center and office operations and how to curb the CO_2 emissions in these fields is a key point for future measures against global warming.

The Fujitsu Group considers it important to make data centers more energy-efficient to reduce the load that the whole of society places on the environment and has been working on improving energy efficiency of the entire data center including facilities in addition to ICT devices.

This paper discusses the Fujitsu Group's activities along with recent trends in energy conservation at data centers.

2. Trends of data center business

The data center business has shown healthy growth even during the global recession that began in 2008.



Source: Based on Japan's National Greenhouse Gas Emissions in FY 2008
(The preliminary figures published by the Ministry of the Environment)

Figure 1
CO_2 emissions within each sector in Japan.

For example, IDC Japan says that the Internet data center (IDC) market size in 2008 grew to 346.8 billion yen, a 16.4% increase from the previous year, and estimates an annual growth rate of 10.0% until 2013.[2)]

The three major factors for this growth despite the recession are as follows:

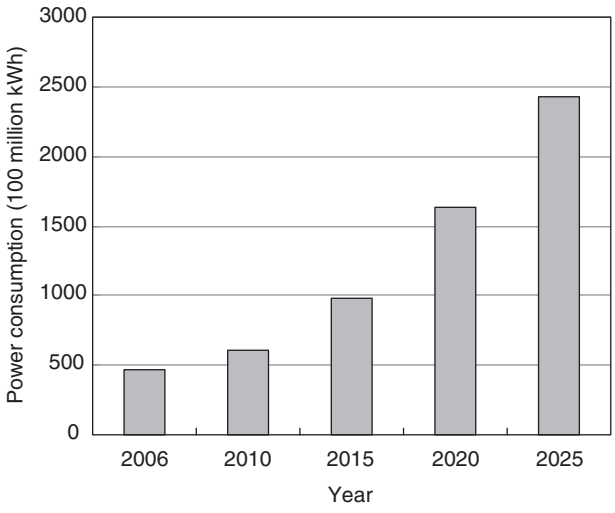
1) One fundamental factor is the explosive increase in the volume of information on the Internet. The Ministry of Economy, Trade and Industry (METI) estimates that the volume of information sent via the Internet in 2025 will be 190 times the present level. To meet these social requirements, the number of data centers is increasing.
2) More companies have come to think that, as "management without possession," using outsourcing services provided by data centers helps to reduce the total cost of ownership (TCO) and allows the construction of a more flexible ICT environment than owning and operating ICT devices themselves.
3) The regulations based on the environmental measures mentioned above have an influence. The revised Law concerning the Rational Use of Energy, commonly known as the Energy Conservation Law, enforced in 2009 requires energy management by each enterprise. This includes managing energy at offices, whose greenhouse gas emissions are increasing at a high rate, something that was previously done by each factory and place of business. The aim is to strengthen energy-saving measures by applying them in a wider scope. The revised Tokyo Metropolitan Ordinance on Environmental Preservation also imposes an obligation on large enterprises to reduce greenhouse gas emissions starting in 2010. This movement is expected to spread to outside Tokyo in the future, and this will mean that companies will be unable to survive unless they reduce the amount of energy consumed in their offices. Accordingly, there is a natural trend to outsource services as an attempt to farm out the operation of ICT infrastructure,

which accounts for a large portion of the energy consumed in office operations.

3. Estimation of electric power for ICT

As the data center business has been growing in this way, the increase in electric energy consumed at data centers has become a society-wide issue. Data provided by the METI on estimated power consumption indicate that, as shown in **Figure 2**, the power consumption of IT devices and systems is expected to increase by 5.2 times from approximately 47 billion kWh in 2006 to 240 billion kWh in 2025 as society grows more and more information-intensive.[3)]

In addition to the trend toward using office outsourcing services mentioned above, the transition of the whole of society to an information-intensive society will lead to ICT devices being further concentrated in data centers. Moreover, the greater number of ICT devices will also increase the power consumed at facilities for air conditioners and such like, meaning that data centers will consume more electric power than is attributable to the greater number of ICT devices alone. In general terms, for example, facilities consume 1.5 times the amount of power consumed by ICT devices, which means that however much power the ICT devices consume, the data center as a whole uses 2.5 times as much. That is, the percentage of power consumption of data centers in a country's entire power consumption will rapidly increase in the future, and making data centers "green," or more energy-efficient, is an essential measure against global warming.



Source: Based on materials from the 2nd meeting of the Green IT Initiative Conference, the Ministry of Economy, Trade and Industry

Figure 2
Estimated power consumption of IT devices and systems.

4. Indicator of greening

For greening of data centers, it is necessary to quantitatively evaluate their actual energy conservation performance. Techniques for evaluating the energy conservation performance of data centers are being studied by various industrial organizations both inside and outside Japan. Unfortunately, however, adequate indicators have yet to be established.

One representative indicator is PUE (Power Usage Effectiveness), as proposed by the Green Grid of the U.S. It is calculated by dividing the amount of power consumed by an entire data center by the power consumed by the ICT devices within it. PUE is simple to determine and the concept is easy to understand, which has led to it becoming popular around the world. However, it also has many problems, such as the fact that different evaluators face different measurement conditions, and the improvement in energy efficiency of ICT devices alone is leading to a higher PUE, making data centers actually look less energy-efficient. The Green Grid, the proposer, is considering how to improve such indicators from various perspectives.

In Japan, the Green IT Promotion Council is thinking about establishing DPPE (Datacenter Performance Per Energy) as a new indicator of energy efficiency at data centers to replace PUE. There are high hopes that DPPE will be an indicator that allows comprehensive evaluation of the energy efficiency of factors such as ICT devices

and facilities, operating conditions of ICT devices, and the amount of green power introduced. While this indicator is still being reviewed, it has a unique point, as compared with the existing techniques: the capability to comprehensively evaluate both a data center's energy-saving efforts and the attempt to incorporate green energy use. The indicator is intended to promote green energy use in the future and reward data center operators' efforts to use green energy. We hope it will be established at an early date so that Japan can take the initiative in this field.

5. Activities for greening of data centers

This section presents the activities that have actually been implemented for greening of data centers.

Greening of data centers can be roughly classified into greening of ICT devices and greening of facilities.

Greening of ICT devices can be achieved by conserving the amount of energy used by the ICT devices themselves and conserving energy through efficient operation. Energy conservation by the devices themselves can be evaluated, for example, by seeing whether or not they comply with the latest Energy Conservation Law. Conserving energy through efficient operation can be done in ways such as using a combination of ICT devices and middleware to visualize electric energy so that a device can be switched to power-saving mode according to the way it is being used and the time of day, introducing virtualization technology to eliminate unnecessary ICT devices, and concentrating operations on fewer devices and turning off some devices during low-load periods.

Regarding the greening of facilities, the point is to improve the efficiency of air conditioning, which accounts for more than half of the electric energy used at facilities. Among the major measures are technology for monitoring in detail and optimally controlling temperature in a server room, optimizing the formation of hot and cold aisles, optimizing the arrangement of air conditioners and air conditioner outlets by making use of thermal fluid simulation, introducing free cooling and cooling with outside air, adopting high-efficiency air conditioning equipment such as turbo refrigerators and introducing local air conditioning.

Other than air conditioning, possible measures include adopting high-efficiency power supply units, uninterruptible power supplies (UPSs) and transformers and reducing transmission losses by using high-voltage power distribution.

In the future, the introduction of green energy including photovoltaic power generation and reuse of exhaust heat generated at data centers by cogeneration and other means are expected to be important themes.

6. Fujitsu Group's activities

The Fujitsu Group started the Green Policy Innovation project in December 2007. It is aimed at reducing the environmental loads and CO_2 emissions of customers and society as a whole by providing green ICT.

The Green Policy Innovation is, as shown in **Figure 3**, intended to reduce the CO_2 emissions of the whole of society by offering to customers the green ICT technologies and know-how that the Fujitsu Group has developed. In December 2009, we globally extended this project, which started in 2007, and established the goal of contributing to a cumulative reduction of at least 15 million tons of CO_2 in Japan and overseas in the four years between fiscal 2009 and fiscal 2012. At present, we are pushing ahead with the development and provision of green ICT to achieve this goal. The reduction of CO_2 of customers and society as a whole by making data centers energy-efficient is a major pillar of this project. The reduction target includes the contributions resulting from the greening of the Fujitsu Group's data centers in Japan and overseas.

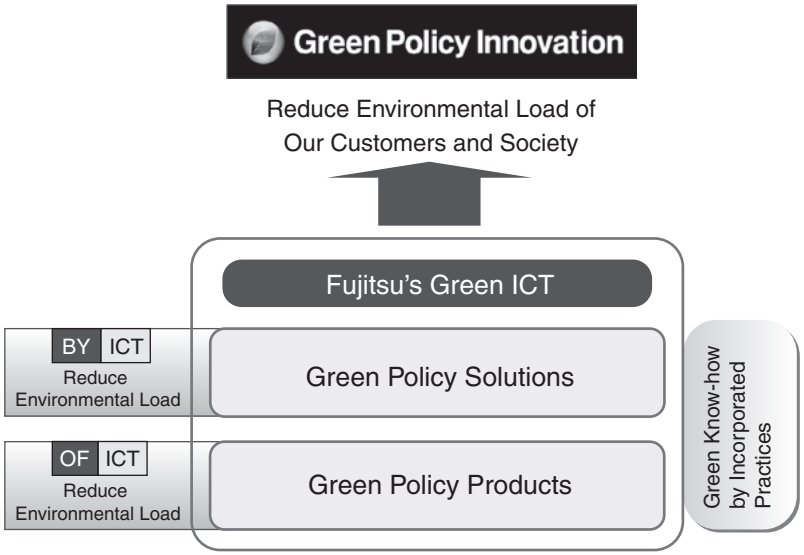


Figure 3
Green Policy Innovation.

Next, we would like to mention a specific case example relating to the greening of Fujitsu data centers.

Fujitsu manufactures many green ICT devices used at data centers, particularly representative of which is the PRIMERGY BX900 blade server (**Figure 4**). In terms of energy-saving performance, the product offers a power reduction effect of approximately 40% as compared with the existing models and has achieved the industry's top level of high-density mounting as well.

This server has earned the 2009 Minister of the Environment Award for the Prevention of Global Warming and the Review Board Special Award of the Green IT Award 2009.

Middleware for the optimum operation of ICT devices includes ServerView Resource Coordinator VE, which is capable of visualizing physical and virtual servers as server enclosure images and resource allocation best suited for server load.

A great many measures for green facilities have been put into practice in the new annex of the Tatebayashi System Center, which started operations in November 2009. For example, the energy-saving operation management system that takes advantage of the visualization of temperature and wind velocity, use of thermal fluid simulation from the design phase (**Figure 5**) and the optimization of air conditioning by local air conditioning[4] have been implemented. As an advanced technology, real-time multipoint temperature measurement using fiber optics[5] is also under consideration.

Figure 4
Blade server PRIMERGY BX900.

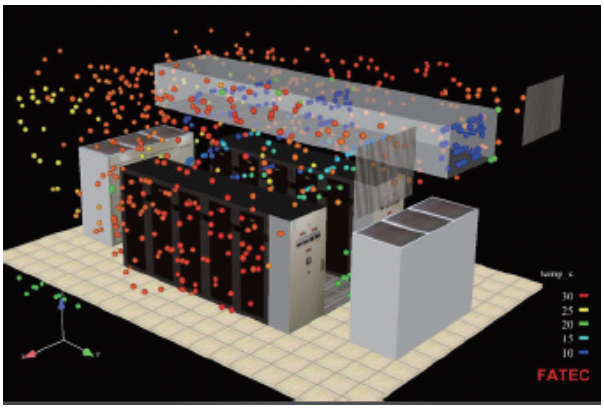


Figure 5
Example of thermal fluid simulation.

This technology uses fiber optics for real-time sensing of detailed temperature distribution in a data center. When used in combination with the air conditioning control system and thermal fluid simulation, it is capable of more effectively reducing the power needed for air conditioning.

Among case examples outside Japan, we would like to first present a data center in Sunnyvale in the U.S. This data center introduced fuel cells in August 2007 for the first time in Silicon Valley. Using Fujitsu's original evaluation technique to calculate its CO_2 reduction effect in relation to facilities, we see that it can reduce the power consumed by approximately 40% compared with typical data centers in four years.

A data center in London, England, is the only one in Europe that has been awarded the official Tier 3 certification by The Uptime Institute (TUI). It has adopted free cooling and high-efficiency UPSs while maintaining high robustness and reliability, successfully reducing the electric power usage to approximately half the level seen at conventional data centers. The Tier performance standards are a set of standards for grading the robustness and reliability of data center facilities. There are four levels from Tier 1 at the bottom to Tier 4 at the top. Generally, a higher Tier level requires more redundancy of the facilities, which tends to increase power usage, and the conditions of this indicator are difficult to meet while also having high energy-saving performance.

One example of activities to conduct in the future is to use the gallium-nitride high electron-mobility transistor (HEMT)[6] developed by Fujitsu Laboratories. We expect this will be useful in applications for power supply units and make them energy-efficient and also reduce power loss to approximately one-third of the conventional level. If it were applied to all servers in data centers, the power consumption would be reduced by 12% with the energy-saving effect of air conditioners resulting from the smaller amount of server heat generated taken into account, possibly leading to an annual CO_2 reduction effect of approximately 330 000 tons in the whole of Japan.

7. "By ICT" effect of data centers

Green ICT includes the "of ICT" and "by ICT" effect and the greening of data centers described so far is energy conservation of ICT devices and facilities in data centers, or the "of ICT" effect, as it is called.

Meanwhile, gathering ICT devices that customers arrange in a scattered way into a data center to operate them efficiently on behalf of customers, which is a basic service provided by a data center, means that the environmental loads of customers and the whole of society are reduced by using ICT and data centers. This is the so-called "by ICT" effect. That is, data centers are ICT facilities that have both the "of ICT" and "by ICT" effect.

In recent years, forms of solution more focused on services based on data centers such as SaaS/Cloud have been attracting attention. We expect the "by ICT" reduction effect to dramatically increase in the future.

Of the ICT solutions provided as "by ICT" solutions, Fujitsu has certified those producing a CO_2 reduction effect of 15% or higher as environmentally conscious solutions, and they

are posted on our Website. One example of an ICT solution relating to data centers is the SaaS-based e-learning system "e-Learning Navigware."[7] In one case of a staffing agency with about 5000 people, the CO_2 reduction effect proved to be extremely remarkable at 50%.

In this way, skillfully communicating the "by ICT" effect based on data centers will be another task for the future.

8. Conclusion

This paper has presented the trends of greening of data centers and Fujitsu's activities.

Fujitsu is one of the few companies capable of coordinating an entire range of offerings for the greening of data centers. They include solutions based on data centers as well as ICT devices, middleware and facilities at data centers. We are and will continue to be committed to reducing the environmental loads of customers and society as a whole by promoting the greening of data centers in Japan and overseas.

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