Promoting Environmentally Conscious Datacenters

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The term "environmentally conscious datacenter" first appeared around 2007, followed by various initiatives in the industry. The Great East Japan Earthquake in 2011 highlighted the value of datacenters as important social infrastructure, particularly when there is an adverse impact of soaring energy prices. With this development as a backdrop, pursuing environmentally conscious datacenters has assumed significance as a long-term commitment. Fujitsu is pursuing this centering on three axes: achieving technological innovation to improve energy efficiency by focusing on the gap between the environmental aspects of information and communications technology (ICT) and features of datacenter facilities; improving environmental performance with a target shared among over 100 datacenters in the Fujitsu Group that are operated under diverse business and environmental conditions; and helping to standardize methods to assess environmental performance. This paper describes Fujitsu's initiatives in these three areas.

1. Introduction

Several years have passed since energy conservation and efficiency improvement of datacenters began to be talked about. In the wake of the Great East Japan Earthquake, it has been increasingly important as a theme from a social perspective and for Fujitsu as well. It is around 2007 that the term "environmentally conscious datacenter" first appeared, and it was followed by various initiatives in the industry.

In 2007, The Green Grid (TGG) of the U.S. announced power usage effectiveness (PUE)[note 1)], a measure of energy efficiency of a datacenter, and the Ministry of Economy, Trade and Industry of Japan held the first Green IT Initiative Meeting.[1)] The next year, the Japan Data Center Council (JDCC) was established, and it estimated that power consumption of ICT equipment would reach 20% of the total domestic power generation in 2025. It was also assumed that, with three-fourths of all servers in Tokyo installed in offices, transferring them to more energy efficient datacenters would reduce power consumption by 15% and virtualizing them would bring about another 25% reduction.[2)]

As enterprises' motivation to increase environmental consciousness in the industry increased in this way, no damage to datacenters caused by the Great East Japan Earthquake in 2011 was reported. This fact was presented in a lecture given outside Japan by the JDCC, and it was covered by many media organizations with admiration. The high reliability of datacenters in Japan, together with their importance as social infrastructure, was re-acknowledged.

At the same time, energy price raises by one electric utility company after another have been proven to cause a serious impact on the datacenter business, the energy consumption of which has been on the increase. With power shortages expected in the future, the promotion of environmentally conscious datacenters has become an important theme to be addressed from a long-term perspective that is directly linked to business soundness as well as social responsibility.

note 1) A measure of energy efficiency of a datacenter proposed by TGG. PUE is a quotient obtained by dividing the total datacenter energy by ICT equipment energy, and a smaller value (a value closer to 1.0) indicates a better energy efficiency of a datacenter.

2. Overall picture of Fujitsu's initiatives

Given these circumstances, Fujitsu is pursuing the theme of environmental consciousness by carrying out activities centering on three axes:

1) Technological innovation for environmentally conscious datacenters

While various approaches are taken by different businesses, activities carried out by Fujitsu, an ICT product vendor, have unique features. We take an approach to finding solutions by verifying the relationship between the environmental characteristics of ICT equipment itself and the center facility capabilities from two aspects to identify inherent gaps.

2) Promotion activities with concerted efforts of the whole Fujitsu Group

We have over 100 datacenters around the world in the Fujitsu Group, and they belong to the business domains of the respective regions and operate under different circumstances in terms of business characteristics, environmental characteristics, etc. In such conditions, we share environmental issues and targets and work on improving environmental performance from a global viewpoint.

3) Contribution to standardization of environmental performance assessment

Pursuit of environmental consciousness, which is a social theme, requires collaboration and cooperation between organizations including standardization of environmental performance assessment and coordination between the industry's intentions and policies. We are engaged in these activities on an industrial level that goes beyond the boundaries of companies.

Coordinating these three types of activities brings about a synergy. The following sections describe these activities.

3. Technological innovation for environmentally conscious datacenters

3.1 Pursuit of optimum solution

A datacenter is an aggregate of various facilities including electricity and air conditioning equipment as well as the building structure, and its value lies in ensuring stable operation of the ICT equipment installed inside. The principle role is played by the ICT equipment and the group of facilities must be optimized as much as necessary and sufficiently for stable operation of ICT equipment. Unfortunately, it cannot be positively said in reality that the respective facility vendors are constantly aware of the environmental characteristics of ICT equipment, trends in new technologies or the business concept of datacenter operators and reflect them in their products. At the basis of our activities lies the idea that closing the gaps between computers and facilities will lead to the optimum solution that allows both to make the most of their respective capabilities with the minimum amount of energy. Accordingly, Fujitsu establishes a collaborative relationship with each vendor, rather than just forming a relationship between a client and an undertaker of work, in the non-core fields for Fujitsu such as buildings, electricity and air conditioning.

In addition, Fujitsu regards an entire datacenter as one big computer function and brings together the skills and know-how of its own technology division including Fujitsu Laboratories to ensure core competitiveness. Furthermore, with Fujitsu FIP corporation, which is engaged in the planning, design, development, maintenance and operation of datacenter systems, we mutually share issues and know-how as a datacenter operator to pursue the best practices in the respective datacenters.

3.2 Change in cooling method (from closed to open type)

In 2009, Fujitsu put the Tatebayashi System Center building B in operation. In 2011, Fujitsu FIP corporation started operating the new Yokohama Datacenter. Both centers are environmentally conscious ones that incorporated the latest technologies at the time of their construction.

Both centers used a design based on a closed server room, as did many other datacenters in those days. Hot and cold aisles are clearly separated to prevent the drifting of hot air and to cool with the minimum required amount of cold air, thereby reducing the energy consumed by cooling equipment. Free cooling via a outside-air intake and a rooftop cooling tower is employed in some parts, but these methods have been regarded as supplementary to electric cooling. The centers are equipped with air conditioning facilities capable of cooling all loads of the ICT equipment throughout the year without using outside air.

Subsequently, datacenters with an open server

room design, which use a cooling method that directly takes advantage of the outside-air, have become a global trend. One reason in the background to this is the fact that ICT equipment's installation criteria with regards to temperature and humidity are generally being relaxed. Google Inc. and Facebook, Inc. of the U.S. already have centers in operation in which complete outside-air cooling that makes use of the locational characteristics has brought the PUE down to almost 1.0.

Fujitsu also employed full-scale outside-air cooling methods with the new building at the Akashi System Center (Akashi new facilities) in November 2013.

3.3 Activities in Akashi new facilities

The Akashi System Center has provided a diverse range of datacenters up to now to meet various business needs, including container datacenters and installation of a server room in an existing building. At the Akashi new facilities, we have worked on a new activity based on a concept of being able to build one datacenter after another in a short time using the same design in line with the expansion of business: We have constructed two types of modular datacenters—a medium-scale and a small-scale one—equipped with open server rooms that use outside-air cooling as the main form of air conditioning.

Using outside air, a means of cooling in summer in Japan, which is characterized by high temperature and humidity, posed a problem. In most regions of Japan, it is difficult to cool throughout the year only with outside air. While some attempts have been made such as using humidification cooling as in Facebook's datacenters, which are located in dry regions of the U.S., standard outside-air cooling methods that can deal with the summer in Japan are yet to be established. In order to maintain the server room temperature at or below 27°C, a commonly used method switches the cooling mode to electric, which consumes a large amount of energy, when the temperature of the outside air goes over 27°C. When servers take in air at 27°C and exhaust air at 37°C, electric cooling to account for the 10°C difference is required after the cooling mode is switched, regardless of the temperature of the outside air. Unlike this, at the Akashi facilities, outside air is taken in even if its temperature is higher than 27°C, as long as it is equal to or lower than the server exhaust air temperature, and electric cooling is used only for amount of difference from 27°C. When the temperature of the outside air is 30°C, for example, electric cooling only requires energy to lower 30°C to 27°C. This method has made it possible to extend the period when the outside air can be utilized, successfully achieving a reduction in the annual energy consumption. **Figure 1** shows the difference in energy consumption between the two methods.

When the outside-air cooling methods are introduced, ordering dedicated equipment for electric cooling as required according to the intake and conditions of the outside air causes disadvantages such as increased cost and building period. At the Akashi new facilities, combining simple outside-air intake equipment with a mass-produced, general-purpose package air conditioner has eliminated the disadvantages mentioned above. Dedicated equipment requires an integrated system to be built that consists of air intake equipment, a heat exchanger for electric cooling, a fan and such like, and they are serially connected. Meanwhile, the Akashi new facilities method uses ingenuity in the layout of the outside-air intake equipment and general-purpose package air conditioner, shape of ducting and location of the sensor for control so that only a loose connection is required between the two. Mutually independent operation of the outside-air intake equipment and general-purpose package air conditioner allows the system to mix airs of different temperatures, which ultimately makes it easier to maintain a constant server room temperature (**Figure 2**). This method is characterized by its ability to provide structures of the outside-air intake equipment only, general-purpose package air conditioner only and intermediates between them by combining on and off states of the respective air conditioning apparatus and

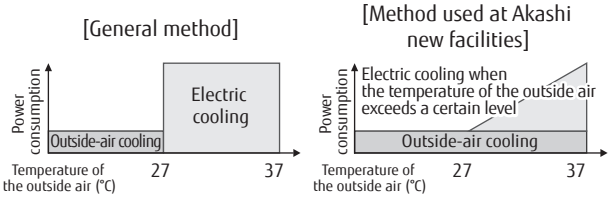


Figure 1
Difference in energy consumption.

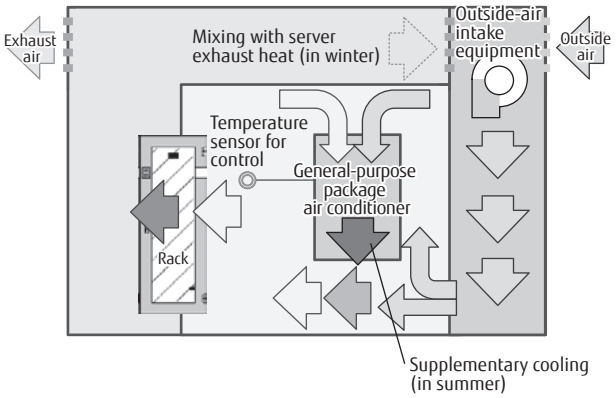


Figure 2
Overview of server room structure.

opening and closing of the dampers.

3.4 Cooling method using outside air

Datacenters of Fujitsu are based on a different design and operation concept from that of datacenters of cloud-based network service companies. Datacenters for cloud services have a number of the same type of servers, so that failure of some of them does not interrupt the service as a whole and the faulty devices are simply replaced. On the other hand, Fujitsu offers value by enabling non-stop operation as a commercial center that accommodates various ICT assets of customers. To actually employ outside-air cooling as described in the previous section, we conduct a close examination and analysis in terms of quality and operation and carry out coordination between different divisions.

1) Impact on ICT equipment

We have studied the impact of air temperature and humidity on ICT equipment through cooperation with the ICT product division, with the focus on investigating phenomena that may occur near the upper and lower limits, and redefined the tolerance based on it.

2) Design of air conditioner operation method

We have carried out pattern analysis using a few years' worth of hourly temperature and humidity data of the Akashi area and designed in detail which piece of equipment should be operated at how much capacity for each pattern.

3) Investigation of quality of outside air in Akashi area

We have conducted a year-round investigation of particles, corrosive gases and salt content on the premises and selected appropriate filters.

By obtaining technical corroboration through these activities and closely working with the division in charge of equipment operation to thoroughly discuss serviceability after start of operation, we have established a method and system that allows stable operation. Energy-saving technologies for datacenters is a field with large room for evolution and it is important not only to simply incorporate new technologies but also work on design for stable operation.

4. Promotion activities with concerted efforts of the whole Fujitsu Group

The Fujitsu Group established the Green Datacenter (GDC) Committee for the purpose of working to reduce environmental impact and costs and reliably implement the Environmental Action Plan, Stage VII (FY2013–2015).

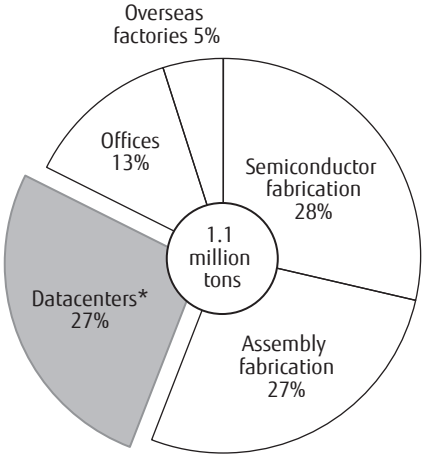
4.1 Background

The CO_2 emissions of the businesses of the Fujitsu Group (in FY2012) amounted to 1.1 million tons, of which datacenters accounted for 0.29 million tons in Japan and overseas. As shown in **Figure 3**, the percentage of the emissions of datacenters out of the total emissions was 27% (12% domestic + 15% overseas), and this amount cannot be overlooked as it is a large environmental impact caused by business. About datacenters, the CO_2 emissions of 19 datacenters in Japan increased at a rate of 8.1% in three years from FY2010 to FY2012 along with the boom in the cloud computing business and the absolute amount of CO_2 emissions are estimated to increase as well in the future.

In view of these situations, in the Fujitsu Group Environmental Action Plan, Stage VII, we have set a target of "Improve environmental performance of our major datacenters" for promoting environmentally conscious datacenters and established the GDC Committee for implementing the Environmental Action Plan.

4.2 Committee organization

As shown in **Figure 4**, the organization consists of the GDC Committee, GDC Working Group (GDCWG) and the Domestic and Overseas Sub-Working Groups (SWGs) with the Environmental Management Committee (chaired by the Company's President) at the core. The following describes the roles of the GDC Committee and



* "Datacenters" indicate 47 datacenters in Japan and overseas (19 in Japan, 28 in overseas)

Figure 3
Percentages of CO_2 emitted by various businesses (FY2012).

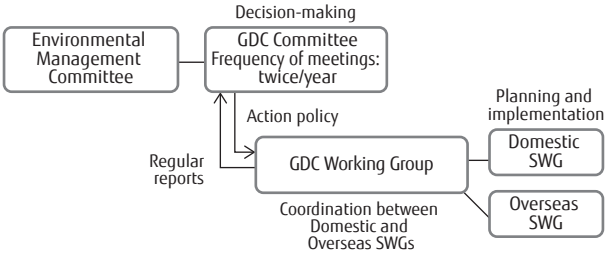


Figure 4
Operational structure of GDC Committee.

the lower organizations.

4.2.1 GDC Committee

The GDC Committee determines the action policy and is composed of the datacenter business division and the specialist division. The former regularly reports on quantity changes about business (such as the number of racks and area), the state of electric energy/cost, CO_2 emissions, water usage, the state of PUE/Datacenter Maturity Model (DCMM) and the state of greening investment plans. The latter reports on the present state and future outlook of energy cost, the state of development of energy-saving technologies, trends of other companies/customers and the state of utilization of the activity results. The missions of the GDC Committee are:

1) Promotion of accomplishment of the Environmental Action Plan, Stage VII

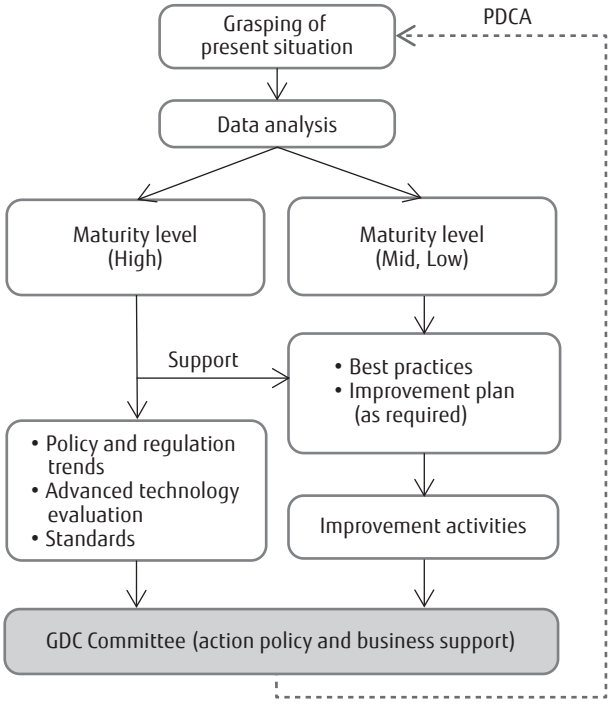


Figure 5
Activity flow of GDC Committee.

2) Set of the internal targets and the object datacenter's priorities and promotion of improvement activities
3) Reduction of energy procurement cost and expansion of green energy
4) Communication of the advanced GDC activities of the Fujitsu Group through the media and CSR Report

This section gives an explanation about 2) above. The internal targets of these activities are set as two categories of targets: common and individual ones.

- Common targets

Indices such as PUE are regularly measured in order to grasp the improvement level from the baseline year (**Figure 5**). In addition, tools to visualize the datacenter maturity level such as the DCMM are used to implement datacenter-specific measures including reduction of air conditioner power consumption by hot/cold air separation and reduction of air conditioning power consumption by use of outside-air cooling and exhaust heat.

- Individual targets

Indices such as W/m^2, W/sales, coefficient of

performance (COP)[note 2)] and water usage effectiveness (WUE)[note 3)] are selected according to the measures taken by the respective bases to engage in improvement activities.

- Priority of object datacenters

In order to be able to cover datacenters of the entire Fujitsu Group, we focus on datacenters of a medium or large scale to carry out activities. However, small-scale datacenters are also included if the bases are capable of management.

4.2.2 GDCWG and Domestic/Overseas SWGs

1) GDCWG

The GDCWG consists of the datacenter business division. It implements coordination activities between the GDC Committee and the Domestic and Overseas SWGs, applies the action policy to the SWGs and reports to the GDC Committee on the activities of the SWGs.

2) Domestic SWG

The Domestic SWG consists of the datacenter business division and the specialist division. The datacenter business division strives to continuously improve environmental performance by using the DCMM for visualizing the fields of improvement and making improvement plans. The specialist division works on the use of ICT for proposing environmental impact reduction, cost reduction and quality improvement activities.

3) Overseas SWG

With the Global Business Management Unit playing the role of the secretariat, the Overseas SWG consists of overseas group companies based in Europe and the Australian continent that operate datacenters.

As described above, the organization allows our activities to promote environmentally conscious datacenters. We intend to continue with the performance improvement activities for datacenter environments in domestic and overseas bases and work on building an even more efficient system.

note 2) Measure used as a rough indicator of energy consumption efficiency of air conditioning apparatus, etc. Represented as the cooling/heating capacity per kW of power consumption.

note 3) A measure of water usage efficiency of a datacenter proposed by TGG. WUE is a quotient obtained by dividing the annual water usage of a datacenter by the ICT equipment energy.[3)]

5. Contribution to standardization of environmental performance assessment

Promotion of building environmentally conscious datacenters requires the use of standardized metrics to quantitatively assess the energy saving performance and efficiency. One representative metric is PUE of TGG in which, at the time of proposal in 2007, the definitions of the point to be measured and the methods of measurement and calculation were not established and different companies used different interpretations for calculation.

Since the foundation of the JDCC, Fujitsu has taken part in formulating the guidelines for calculating PUE under uniform conditions. The contents of the guidelines have been internationally discussed through a task force of Japan, the U.S. and Europe with the participation of TGG, and such discussion has contributed to standardizing the measurement conditions and is widely known in the industry. At present, PUE is in the process of undergoing official international standardization by a WG under the Joint Technical Committee of the ISO/IEC, which are international standards. From Japan, Fujitsu is also taking part as a member under the initiative of the Japan Electronics and Information Technology Industries Association (JEITA).

As shown in **Figure 6**, Fujitsu uses the technological innovations of the individual datacenters as the starting points and connects them to the whole

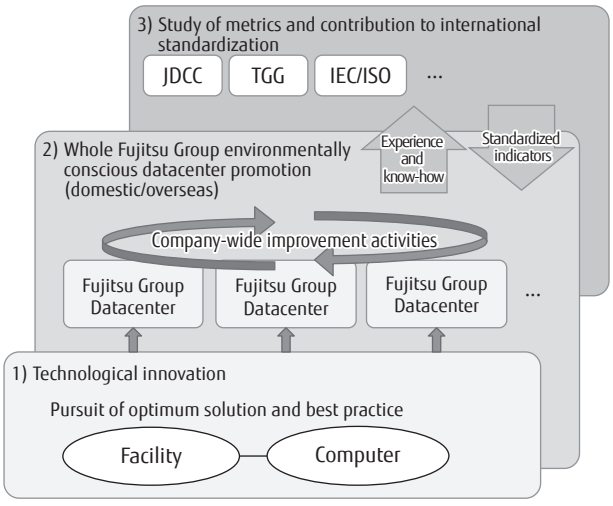


Figure 6
Relationship between three types of activities.

Fujitsu Group promotion activities. We make use of our experience and know-how in contributing to the establishment of industrial and international standards and feed back the standardized metrics to the internal improvement activities. In this way, we push ahead with the activities in a consistent manner as a whole.

6. Conclusion

This paper has described how we promote environmentally conscious datacenters by presenting three types of our activities: technological innovation, promotion of environmental performance improvement activities with concerted efforts of all datacenters in the Fujitsu Group and contribution to standardization of environmental performance assessment.

In the future, we intend to continue working on this theme from a long-term perspective.

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