# Technology for Constructing Environmentally Friendly Data Centers and Fujitsu's Approach

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**In recent years, IT devices such as servers have come to have high performance and be highly integrated and their processing performance has greatly improved. Because of that, they are consuming more power and emitting more heat. It should be noted that there is an increase not only in the energy needed to power high-density racks, but also in the energy used to cool them. Against this background, Fujitsu has developed an overall framework of technology for constructing environmentally friendly data centers. Based on this framework, Fujitsu is promoting technological development and application. In this paper, we overview our technology and introduce our approach in the new annex of the Tatebayashi System Center located in Gunma Prefecture in Japan.**

## 1. Introduction

In recent years, IT devices such as servers have become more advanced in terms of their performance and degree of integration, and this has dramatically improved their processing performance. At the same time, however, power consumption and heat generation along with it have increased. Blade servers, in particular, consume electric power of a few to a few dozen kW per enclosure. For the future data center business, the power supply capacity per server rack must be designed to allow for several times the supply of conventional devices. It should also be noted that use of high-density racks does not only require larger power supply capacity but also increased energy for cooling them.

With these factors in the background, conserving energy at data centers, which consume large amounts of energy, or constructing environmentally friendly data centers, is a problem that needs urgent attention for data center outsourcing vendors.

This paper outlines the technology for realizing environmentally friendly data centers and presents Fujitsu's approaches to that end.

## 2. Elements of environmentally friendly data centers

Fujitsu sees the following three points as the elements required of environmentally friendly data centers:

1) Stable operation

IT systems have now become indispensable to the business of companies. For customers, one purpose of outsourcing their IT assets is to ensure business continuity. What they want is the value of ensured security at a necessary level, complete disaster measures and continued operation with an uninterrupted system. Data centers exist to continuously provide this value.

Accordingly, hindrance to on-site operation or deteriorated operational quality as a result of simply seeking energy conservation without the guarantee of stability is unacceptable. Ideally, contributions to the environment should be made while striving to further improve operational

quality.

2) Environmental contribution

While providing the value described in the previous subsection, data centers as physical facilities must be environmentally friendly. In a direct sense, this means reducing the emissions of greenhouse gases (especially $CO_2$). To provide the same value, there are demands for data centers to minimize the amount of energy they consume (especially electric power). If data centers are to consume the same amount of energy, environmental contributions should be made by using energy that is as clean as possible. In addition, they also need a way to conserve power supply as far as possible. They can achieve this by improving their space efficiency and reducing their electric power loss. To see environmental issues from an even wider perspective, there are many things to consider such as the non-use of ozone-depleting substances or lead compounds and disposal of waste oil, wastewater treatment, noise reduction and refuse disposal.

3) Visualization of environmental contribution

Up to now, it has been thought that customer satisfaction will be achievable by continuing to provide the value of stable operation at a high level. From now on, approaches to environmental issues will be an important element of management for customer companies as well. If customers find out that outsourcing to data centers makes more contributions to the environment than operating IT devices themselves, they will find a new value in data centers.

It is not sufficient for data centers to achieve energy conservation. They have to continuously prove to customers and society that they are capable of making contributions to the environment.

## 3. Construction technology

There are various ways to classify technologies and measures for constructing environmentally friendly data centers. Some examples include:

1) Classification by purpose
- To reduce energy consumption of IT devices
- To reduce energy consumption of facilities

2) Classification by means
- Introduction of high-efficiency equipment
- Efficient operation by optimized control

3) Classification by cost
- Schemes not involving investment
- Improvement involving investment

4) Classification by the degree of effect
- Measures producing a large effect
- Measures producing a small effect

All of these ways of classification contain factors to be considered when studying measures. Generally, two or more ways of classification are combined when making an overall decision, for example a data center operator may decide to start with measures that are low cost although they have a small effect.

Before specifically examining individual measures, it is important to establish the scope of such measures at an upper stage. Fujitsu has classified measures into seven categories and created an overall framework of measures (**Figure 1**). Making use of this framework allows us to conduct exhaustive feasibility studies at an upper stage and helps us to establish the scope of measures.

## 4. Basic concept

This section describes the respective categories of the overall framework.

1) Visualization

Visualization technology is positioned as the basis of all technologies and measures. Specifically, visualization means detailed measurement and visualization of the status of power utilization for each application and the air conditioning in the server room. Although visualization itself does not achieve energy conservation, visualized information is an indispensable input for implementing the measures to be explained in 2) and the following

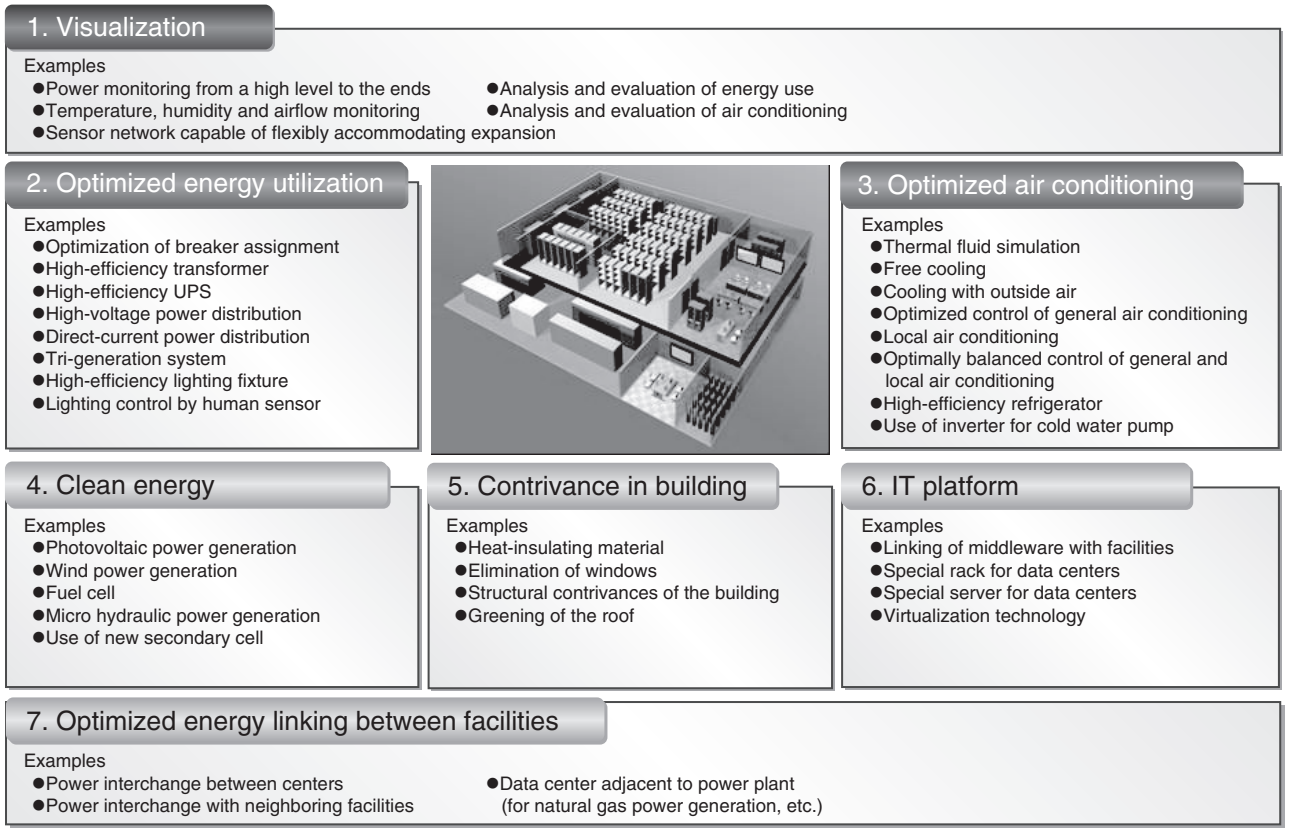


Figure 1
Overall framework of technology for constructing environmentally friendly data centers.

subsections. The technology is also important for managing the continuous improvement of PDCA at the center and for visualizing contributions to the environment so that they can be demonstrated to the outside.

At the core of visualization are various sensor technologies, sensor network technologies and IT for gathering statistics and analyzing information obtained by measurement. At data centers in general, the number of IT devices in operation gradually increases, which requires the sensor network to be flexibly scalable and simply configurable. In addition, the architecture must be designed so that a local failure is prevented from affecting the entire network. Furthermore, it would not make sense if the sensors and related devices themselves consumed a large amount of energy, so energy-conserving types are required.

2) Optimized utilization of energy

This mainly means measures with power supply devices. For data centers, which continuously consume vast amounts of electric power 24 hours a day, 7 days a week, a minor loss in power may lead to a significant economic loss. For power supply devices including transformers and uninterruptible power supplies (UPSs), high-efficiency models should be selected whenever possible.

Making the power distribution system redundant reduces the load on each system and increases the loss ratio of the individual devices. We expect power supply device vendors to develop products that minimize losses with the load in actual operation applied, as well as in the catalog specifications.

One means of reducing power loss that has been attracting attention in recent years is distribution by direct current. Supplying power

as direct current to IT devices reduces the number of DC-AC conversions, which allows conversion losses to be reduced. However, direct-current distribution at data centers requires high voltage in view of the transmission distance, and has problems in terms of safety and stable supply. In addition, IT devices that can run on direct current are not very widespread at present but some companies have partially started to work on using direct current. Fujitsu is also conducting studies for its use.

In addition to reducing losses, using the given electric power to its full capacity without causing waste leads to a reduction in the size of the devices themselves, and this leads to increased space efficiency. These measures can also be regarded as contributions to energy conservation in a broad sense. One example is a technology to use a breaker for an IT device at a level that is barely within the control value with reference to the capacity of the device. This is enabled by taking detailed measurements of the effective power of the device.

3) Optimized air conditioning

Traditionally, data centers consumed energy equivalent to or larger than that for IT devices for facilities other than IT devices. Most of the energy consumption was for cooling. Limiting the energy used for cooling is key to reducing the total energy consumption.

A method of arranging rows of server racks facing each other to separate hot aisles from cold aisles has already become popular. Still, the airflow in a server room may change depending on the scale of the server room, air conditioning method (locations of cooling air outlets), aisle capping method (whether to cap hot or cold aisles) and other factors. Thermal fluid simulation technology helps to achieve an optimum layout by simulating the airflow under various conditions before constructing a server room. Specifically, simulation can be used to optimize the arrangement of server racks, locations of openings and rate of opening area of the floor grill panels (for under-floor air conditioning), locations of local air conditioners (for local air conditioning) and sensor mounting locations.

The most common method of reducing energy for cooling is not to cool more than necessary. For that purpose, visualization must be used to take detailed measurements of the status of air conditioning in the server room and adjust the operation of the individual air conditioners. Because IT devices generate varying amounts of heat depending on the model, at common commercial data centers housing various customer IT environments, heat generation varies for each rack. This means that a uniform general air conditioning method may cause a local build up of heat (hot spots). Measuring the temperature of each rack to reliably deliver the appropriate amount of cooling air is the biggest theme.

In constructing data centers recently, a cooling method that makes use of the cool outside air has come to be always considered. In theory, cooling with outside air is possible all year round at data centers in areas with an annual maximum temperature of up to 18°C. On top of this method of directly taking in outside air, free cooling technology that uses outside air to generate cold water without using a refrigerator has already been established.

4) Clean energy

Use of natural energy such as photovoltaic and wind power generation is symbolic of the measures for environmental contribution. Photovoltaic power generation is currently spreading rapidly around the world and the technology is evolving on a daily basis. Some of the data centers of the Fujitsu Group have introduced this technology and we plan to continue to increase the number of centers with such power generation facilities. In consideration of the current power generation efficiency and cost, however, it is still difficult to provide all the energy required in large data centers with

photovoltaic power generation alone. We hope to develop technology to store electricity for improved power generation efficiency, reduced costs and a stable supply of power.

5) Contrivance in buildings

We will take energy-conserving measures when designing and constructing a new data center. We will always take into consideration measures such as greening the roof and outer walls containing heat-insulating materials at the time of designing new buildings. In the future, it will also be necessary to fundamentally change the concept of a building, as shown by the concept of container-type data centers.

6) IT platform

Energy-conserving models of IT platforms including servers, storage and network devices have been spreading through the efforts of vendors and customers, who have come to intentionally choose energy-conserving models. We expect energy reduction technology for IT devices to advance further in the future.

In addition, the expansion of Cloud computing centered on virtualization technology will standardize IT devices installed at data centers, allowing the design of a more efficient cooling method.

Furthermore, if there are computers that do not require cooling, the need for facility energy for cooling will be eliminated. Smaller IT devices will allow installation space to be saved as well. In this way, IT devices can be put to use in various situations to reduce the total energy consumption of data centers. Striving to meet the requirements of IT devices assuming they are to be used at data centers ultimately leads to IT platforms used exclusively for data centers. The Fujitsu Group is also working on such special servers for data centers.

7) Optimized energy linking between facilities

On top of the possible energy-conserving measures within data centers, there are methods of energy linking with other facilities in the neighborhood. Examples include the construction of a data center near a hydraulic power plant and combination of fuel cells and renewable gas at a neighboring biofactory.

Concerning this category, the measures will not be applicable to all cases because they can be considered only when the conditions of location permit it and collaboration with other companies is required as well. However, this is worth considering in terms of contributions to the global environment as a whole.

To construct environmentally friendly data centers, Fujitsu's policy is as follows:

- First, measures in categories 1) to 3) must be considered. That is, visualize, make full use of energy without making a loss, and cool with the minimum possible energy.
- Then, if the cost allows, introduce clean energy. For the construction of a new center, implement contrivances in the building. For the IT platform, choose the latest energy-conserving models as of the introduction phase. If there are a number of options regarding the site location itself, consider energy linking between facilities.

## 5. Actual implementation in new annex of Tatebayashi System Center

Fujitsu opened a new annex in the Tatebayashi System Center (hereafter "Tatebayashi new annex"), located in Gunma Prefecture in Japan, in November 2009 (**Figure 2**). Various energy-conserving measures have been taken in the Tatebayashi new annex to make it the industry's No.1 environmentally friendly data center. This section introduces the major measures implemented in the Tatebayashi new annex.

### 5.1 Visualization

As described in the previous section, visualization is the basis of all measures. In the Tatebayashi new annex, we have worked on visualization on a full scale and realized it

Figure 2
New annex in the Tatebayashi System Center.

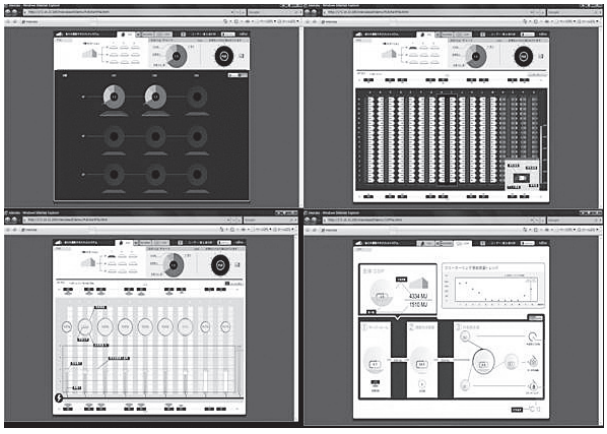

Figure 3
Energy-conserving operation management system.

as an energy-conserving operation management system (**Figure 3**). The system incorporates a variety of new technologies developed, which are described below.

1) Visualization of electric power

This has been achieved in joint technological development with Fuji Electric Systems. A multipoint power measurement unit integrated in an intelligent distribution board is used for measuring the power usage of individual breakers and the data is accumulated. Together with the information acquired by linking with the building management system, the power usage at each point between the special high voltage power receiving unit and server racks is visualized.

2) Visualization of temperature

This has been made possible by a wired sensor network system that makes use of the new, small, power-saving temperature and wind velocity sensor developed by Fujitsu Laboratories and Fujitsu's proprietary ad hoc communication technology. Use of wired ad hoc communication nodes that autonomously form and restore a network without the need for configuration allows sensing in a large-scale and high-density environment using tens of thousands of sensors, while significantly reducing the introduction and operation costs at the same time.

With this measure, the temperature and airflow for each server rack can be measured in detail, which facilitates optimized air conditioning control.

## 5.2 Optimized energy utilization

1) High-efficiency facilities

In the Tatebayashi new annex, high-efficiency devices including top-runner transformers have been adopted.

2) Optimized power distribution

An energy-conserving management system is used to select the optimum breaker at the time of adding server racks. This makes the most of the capacity of UPSs and distribution board.

## 5.3 Optimized air conditioning

1) Thermal fluid simulation

The optimum layout has been achieved by repeated thermal fluid simulation in the design stage. For simulation, many different cases have been assumed such as a local arrangement of high-density racks and we have taken care to ensure that the required amount of cooling air is supplied in any case.

2) Free cooling

In the Tatebayashi new annex, cold outside air in winter can be directly taken in to use for cooling the server room. Free cooling by the rooftop cooling tower (**Figure 4**) has also been

Figure 4
Cooling tower for free cooling.

Figure 5
Local air-conditioning system.

Figure 6
Photovoltaic power generation panel (vertically installed portion).

adopted.

3) Local air conditioning system

The Tatebayashi new annex allows IT devices of up to 20 kW per rack to be installed. If high-density racks like this are concentrated in a certain area, general air conditioning from under the floor alone cannot supply the required amount of cooling air. To address this issue, we have adopted the method of combining general and local air conditioning for local high-heat-generating areas. **Figure 5** shows the local air-conditioning system jointly developed with Fuji Electric Systems.

### 5.4 Clean energy

To ensure stable power generation throughout the year, photovoltaic power generation combined with horizontal and vertical installation has been adopted (**Figure 6**).

## 6. Conclusion

Based on the overall framework that we have developed, we at Fujitsu plan to apply the know-how to our other centers and group companies. Energy conservation technologies are advancing on a daily basis and we intend to use the latest technologies when constructing a new center or renewing an existing center to make a continuous environmental contribution as the entire Group.

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Mr. Nagazono is currently engaged in research and development of energy-saving technologies for use in data centers.