

Environmentally Friendly, Energy-saving Air-conditioning System

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Amid the recession, it is said that business operators will tend to outsource more and more so that they can gather their IT resources in one place, improve their efficiency and reduce their costs. Data centers are at the heart of this outsourcing, and they consume a large amount of electricity. They need to use electricity safely and efficiently. Against this social background, a new annex of the Tatebayashi System Center, located in Gunma Prefecture in Japan, has implemented an energy-saving air-conditioning system as a measure to try to reduce its environmental impact. This paper introduces an outline of this measure to optimize air conditioning implemented in the server room, based on the cooling method for greening that has been newly introduced this time. In addition, it introduces the effect of the measure that makes the best use of the advantages of scale at the data center.

1. Introduction

Data centers need to have safety, scalability and energy-saving performance. Constructing and operating data centers that meet these requirements in a balanced way has given rise to center facilities that are the foundation of the outsourcing business, and they can be operated safely.

The continued recession and the sluggish improvement in corporate profitability have accelerated the trend toward business outsourcing. At the same time, they have increased the expectations for efficient data centers that support business infrastructure and lower environmental burdens that can be achieved with the merits of scale resulting from system aggregation. In terms of the global warming issue, activities to further reduce CO₂ emissions are expected to take place on a global scale in the future, as discussed at COP15 (Fifteenth Session of the Conference of Parties to the United Nations Framework Convention on Climate Change) in

December 2009.

With the construction of the new annex at the Tatebayashi System Center, located in Gunma Prefecture in Japan, (hereafter “Tatebayashi new annex”), Fujitsu has not only advanced the features of stable operation and scalability, which have long been developed, but also materialized the following eight facility measures, along with formulating a cooling method for greening. The purpose is to improve energy-saving performance.

- 1) Optimization of airflow in the server room
- 2) Optimization of airflow of air conditioners
- 3) Adoption of high-efficiency equipment
- 4) Introduction of cool outside air
- 5) Free cooling
- 6) Operation using water with a large temperature difference
- 7) Local air-conditioning system
- 8) Energy-saving operation management system

The cooling method for greening is, as shown

in **Figure 1**, aimed at improving the efficiency of air conditioning, which accounts for a large portion of the electric power consumed at data centers, thereby reducing environmental burdens. To be specific, Fujitsu thoroughly studied the method when the new annex was being planned as a way to have continuous high efficiency. This can be done by implementing the PDCA of cooling

facilities based on the eight facility measures listed above, and Fujitsu incorporated this PDCA in the execution design (**Figure 2**).

Appropriately adopting these energy-saving measures has allowed the electric power consumed for cooling to be continually reduced and further improved the power usage effectiveness (PUE) of the center.

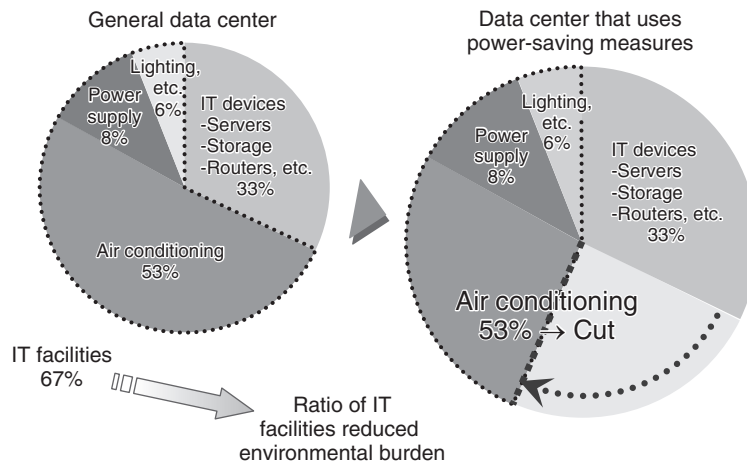


Figure 1
Aim of power saving.

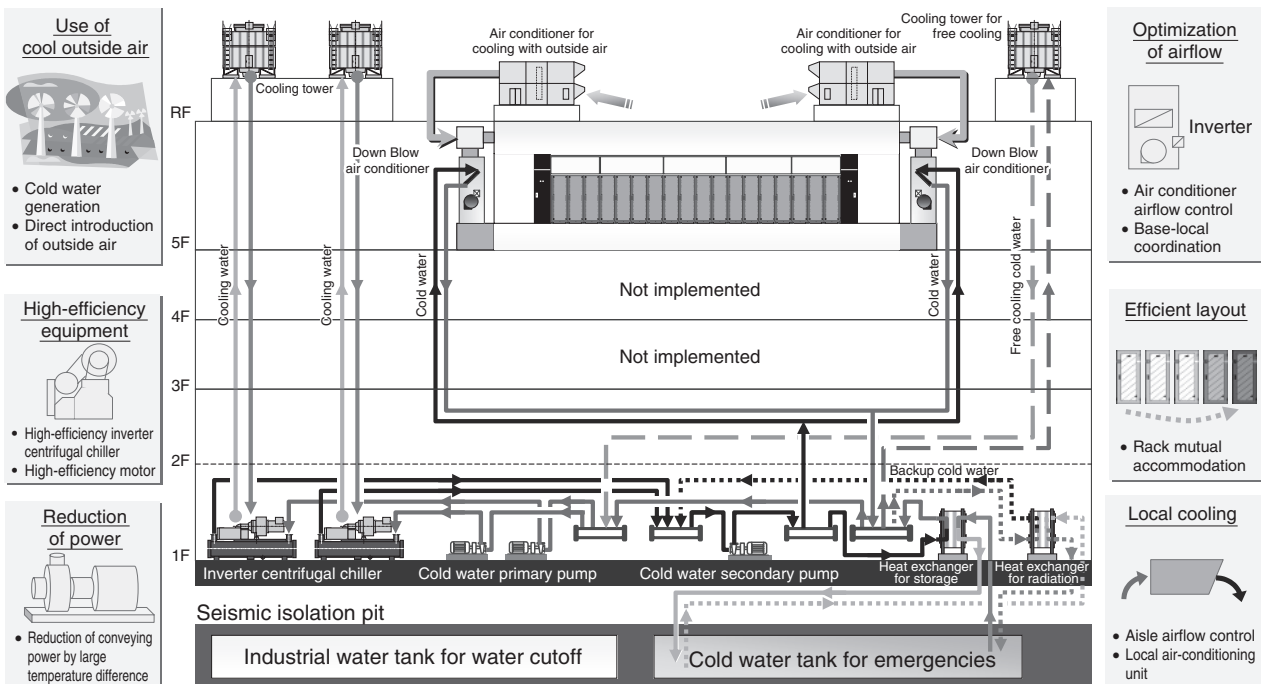


Figure 2
Overall image of cooling method for greening.

This paper outlines the characteristics of the eight measures based on the cooling method for greening from qualitative and quantitative perspectives.

2. Optimization of airflow in the server room

Air-conditioning facilities at conventional data centers were not premised on ventilation for server racks, but planned on the basis of stabilizing the temperature and humidity environment of the surrounding space. This was the basis for achieving stable operation by introducing cool air directly from below the floor for general-purpose machines at EDP centers. In most cases, equipment was laid out facing in the same direction in order to ensure that there was the space required for maintenance work and a reasonable distance between devices. If this basis is applied to current server rack layouts, there tends to be insufficient cool air supply for cooling server racks. The reasons for this include the fact that exhaust from the adjacent server rack is sucked in from the front, which requires floor grills to be opened as a solution. However, with the floor grills opened it is difficult to balance the airflow and there is a repeated cycle in which the open floor grills lead to hot spots because of a

change to the equipment layout.

By contrast, most of the current data centers house rack-mounted servers and most use a system where the required cool air is supplied through the front of racks.

At the Tatebayashi new annex, to achieve efficient cooling and prevent hot spots, the layout configuration has been premised on having an appropriate air intake at server racks and a good server rack layout based on combining hot and cold aisles to optimize the airflow in the server room.

3. Optimization of airflow of air conditioners

In addition to conventional air conditioning that focuses on temperature control, Fujitsu studied a system that could enhance the server cooling effect. It does this by matching the airflow of air conditioners with the server air intake to allow the airflow of air conditioners, which tended to be oversupplied, so that it is optimized. At the Tatebayashi new annex, air conditioners equipped with an airflow adjustment function by means of an inverter have been introduced. This system optimizes the airflow of air conditioners, and has led to a reduction in the power used for the airflow system and provided a way to eliminate overcooling and hot spots (**Figure 3**).

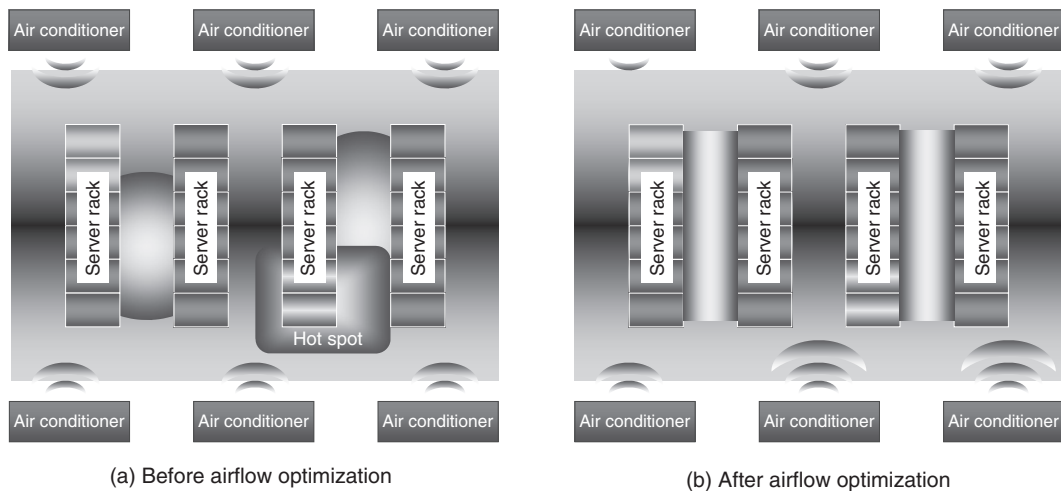


Figure 3
Image of optimizing airflow.

4. Adoption of high-efficiency equipment

Traditionally, absorption chillers that use fossil fuel have often been adopted as refrigeration equipment to make primary energy redundant. However, the adoption of electric chillers with high equipment efficiency is now becoming a popular way to reduce CO₂ emissions as a measure against global warming. The high-efficiency inverter centrifugal chillers that have been adopted have a coefficient of performance (COP), or equipment efficiency (which is equal to output divided by input) of up to 15 or higher, and boast a performance that by far outstrips absorption chillers (with a COP of around 1). In addition, high-efficiency motors are used in pumps for feeding the cold water generated by chillers to air conditioners and conveying equipment, and in air blowers for feeding cool air generated by air conditioners into rooms. With this system, the amount of power consumed at the center can be reduced. Furthermore, fan coil units with heat pumps are used for air conditioning in common areas. Cold water is used for air conditioning and the heat in the cold water is extracted with heat pumps to use for heating, which has led to a reduction in the total amount of power consumed.

5. Introduction of cool outside air

The outside air conditions change throughout the year, and this makes the four seasons of Japan appealing. One way to make use of this appealing climate to reduce energy is to cool devices and areas by introducing cool outside air. That is, cool outside air in autumn, winter and spring can be used to reduce the amount of energy needed for cooling with chillers. As an example that takes only the temperature conditions into account (although operation must also consider the air's humidity), if the server rack takes in air at a temperature of 18°C then introducing outside air when the outside temperature is lower than that allows the area

to be cooled without running any chillers. If this theory can be applied to the climate around Tatebayashi, outside air cooling is supposed to be used under that condition for over 4000 hours annually, which means that outside air cooling can be used for almost half the year.

6. Free cooling

As with using cool outside air, free cooling helps to reduce the number of hours of chiller operation. Free cooling is a method of generating cold water by radiating heat into the atmosphere from a cooling tower, without depending on chillers. At the Tatebayashi new annex, a scheme with an even greater investment effect has been adopted. Ordinary free cooling generates cold water by bypassing chillers during the period when a large effect can be expected. At the Tatebayashi new annex, the cooling towers are installed in an area of the system before the cold water is returned to the chillers. This further increases the number of hours that the cooling towers can be operated each year for free cooling, and extends the period for which the chiller load is reduced. This leads to a reduction in power consumption. As a result, the energy-saving effect has reduced the time before a return on investment is achieved and, based on our plan, we will recoup the investment in the free cooling system in five years according to a trial calculation.

7. Operation using cold water with a large temperature difference

Water is a medium with a constant heat capacity per unit mass. When using it to provide a certain amount of cooling energy, making the temperature difference larger can reduce the amount of cold water required. For example, assume that cold water at the same temperature is supplied in the following two cases.

Case 1 All of the cold thermal energy equivalent to $\Delta t = 5^{\circ}\text{C}$ is used

Case 2 All of the cold thermal energy equivalent to $\Delta t = 10^{\circ}\text{C}$ is used

The amount of water to supply the same cooling thermal energy in case 2 is only half of that in case 1. That is, making the temperature difference larger can reduce the amount of cold water needed, which in turn reduces the conveying power that the pump needs. For the Tatebayashi new annex, the “ $\Delta t = 10^{\circ}\text{C}$ ” plan has been adopted, and this helps to dramatically reduce the conveying power required. In addition, the multiplier effect with the inverter control of the cold water pumps that restrains any wasteful flow by means of accurate cold water flow control allows the annex to conserve even more energy.

8. Local air-conditioning system

The Tatebayashi new annex allows for high integration of servers and a local air-conditioning system. It was designed in this way to accommodate the need for cooling when the assumed cooling heat quantity of the general air conditioner (base air conditioner) of a server room is exceeded. This is commonly called task air conditioning and some commercial products are available to this end. However, there are very few cases in which those products have been adopted in Japan and their reliability cannot be verified. For that reason, we are developing jointly with Fuji Electric Systems a product that is more suitable for data center functions, and we are currently preparing to introduce it (Figure 4).

The following briefly explains the features of the local air-conditioning system.

1) Compact and highly efficient

While similar cooling systems are available from other companies, this system has achieved a COP of 13 or higher.

2) Energy-saving operation according to heat load variation

The local air-conditioning units are optimally controlled by controlling the chiller pump unit and electronic expansion valve, which



Figure 4
Local air-conditioning unit.

has achieved energy-saving operations.

3) Prevention of water damage

The function to prevent dew condensing in the heat exchanger in a local air-conditioning unit has eliminated the need for drain piping. This also prevents server water damage caused by any water leaks that would need to be dealt with when installing local air-conditioning units above the server racks.

4) Optimum control of overall and local air conditioning

The overall air conditioning is controlled in accordance with the server air intake and energy needed for cooling. In addition, when a local air-conditioning unit is installed, the cooling heat quantity and airflow borne respectively by the base and local air conditioning are balanced with each other so that the cold aisles and hot aisles are always isolated from each other. This prevents heat from circulating in the server room and hot spots from being generated, thus achieving the optimum server room environment.

9. Energy-saving operation management system

Along with the optimization of IT represented by improving the energy efficiency of IT devices, facilities can be optimized to achieve greening at

data centers. We have presented so far various elemental technologies and measures to do this. But to optimize energy, it is essential to have a process of making evaluations and judgments to decide how much energy should be supplied to what and how to use the energy. As a measure to that end, a system that allows real-time detection of the load and operating conditions is required. With the Tatebayashi new annex we have achieved a means of visualizing these things and started to make use of the measured data. The environmental conditions correctly understood by actual measurement allow further energy conservation while ensuring safety. This section outlines the measures and their features.

1) Electric power measurement for each server rack

The intelligent distribution board, which was jointly developed with Fuji Electric Systems, integrates plug-in breakers with CTs and power measuring units so that power consumption can be monitored in detail.

2) Monitoring of temperature and airflow for each server rack

The newly-developed small power-saving temperature and wind velocity sensors and the environment monitoring network makes it easier to have an accurate understanding of the conditions at server racks and the environment surrounding the racks.

3) Visualization of energy usage and air-conditioning conditions

The conditions are visualized by linking with the air conditioning control and building management systems to offer an intuitive, easy-to-understand view of conditions with an integrated view screen to use for day-to-day monitoring and management.

For information on the specific measures and means for the energy-saving management system, see “Optimization of IT Load and Facility Energy in Data Centers” contained in this issue.

10. Conclusion

This paper has introduced the energy-saving measures that have been employed in the Tatebayashi new annex from the perspective of its air-conditioning system. We believe that PDCA activities on a daily basis and a system that allows operators to gain an understanding of them can serve as a springboard to a next-generation data center cooling system.

Lastly, we would like to add that it would not have been possible to build the energy-saving air-conditioning system at the new annex of the Tatebayashi System Center without the enthusiasm of the construction companies and professionals who took part in the construction including Fuji Electric Systems.



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