Data center of Singapore
Green Survey Report

Feb. 23, 2010

NTT DATA Intellilink CORPORATION

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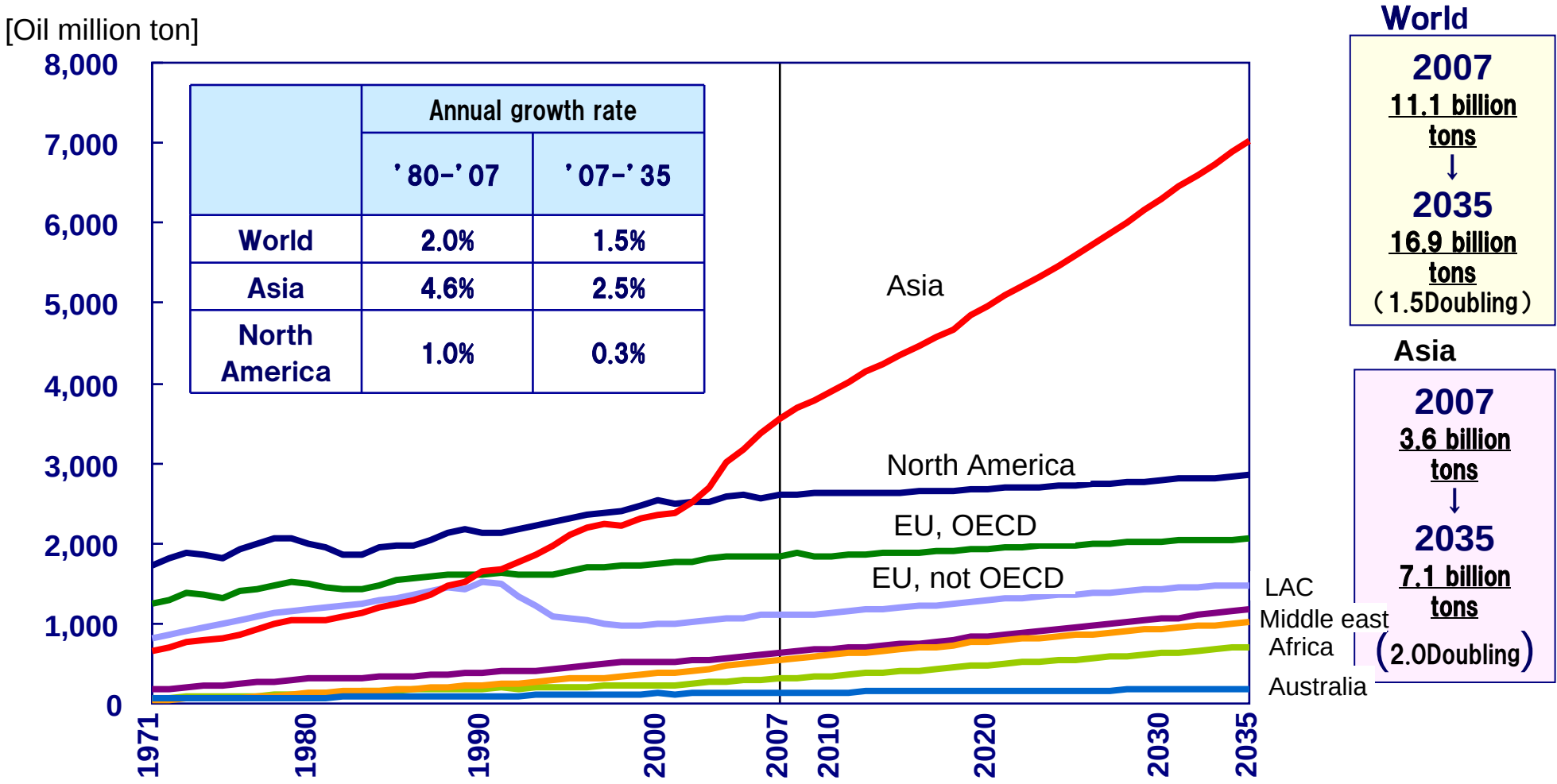
1-(1) Background

The primary energy consumption in the world

The energy consumed of Asia in 2035 expands to about double, compared from present under the steady economic growth.
(3.6 billion tons in 2007→7.1 billion tons in 2035)
About 90% of the increase in an energy consumption results from Developing country



(出展)日本エネルギー経済研究所「アジア/世界エネルギーアウトルック2009」

1-(2) Purpose

Energy issues in ASEAN countries are critical factors to disturb our economic growth. That is why interest of energy-saving is getting increase.

Under such situation, “Green IT” expects to be one of the solutions to save energy consumption.

This survey aims to introduce Japanese advanced energy saving technologies and to contribute to support economic growth in ASEAN countries, based on the survey results in Singapore data center.

2. Abstract

2-(1) Survey Items

Before introduction of advanced energy-saving technologies, current situation and problems shall be recognized. So the following surveys were implemented.

1. Power Usage Effectiveness (PUE) Survey

This survey implemented to estimate PUE value. PUE was developed by the Green Grid and is an indicator which evaluates energy consumption load of IT facilities in data center. Merits of PUE usage are mentioned below.

- **PUE can evaluate energy efficiency level in your DC.**
- **PUE can find location of power loss in your DC.**
- **PUE can utilize as renewable indicator that replace A/C, power facilities etc.**

2. Thermal Environment Survey

This survey implemented to analysis thermal environment in DC, such as A/C conditions, issues etc.

- **Assessment of thermal environment (thermal picture by thermo camera, temperature logger, air volume measurement at blower point etc.)**
- **Recognition of PAC operation**

3. Computational Fluid Dynamics (CFD) Analysis:

As for server rack environment in data center, optimizing air conditioning was considered by three dimension analysis (temperature and flow volume).

2-(2) Company Surveyed and its System

- Company Surveyed

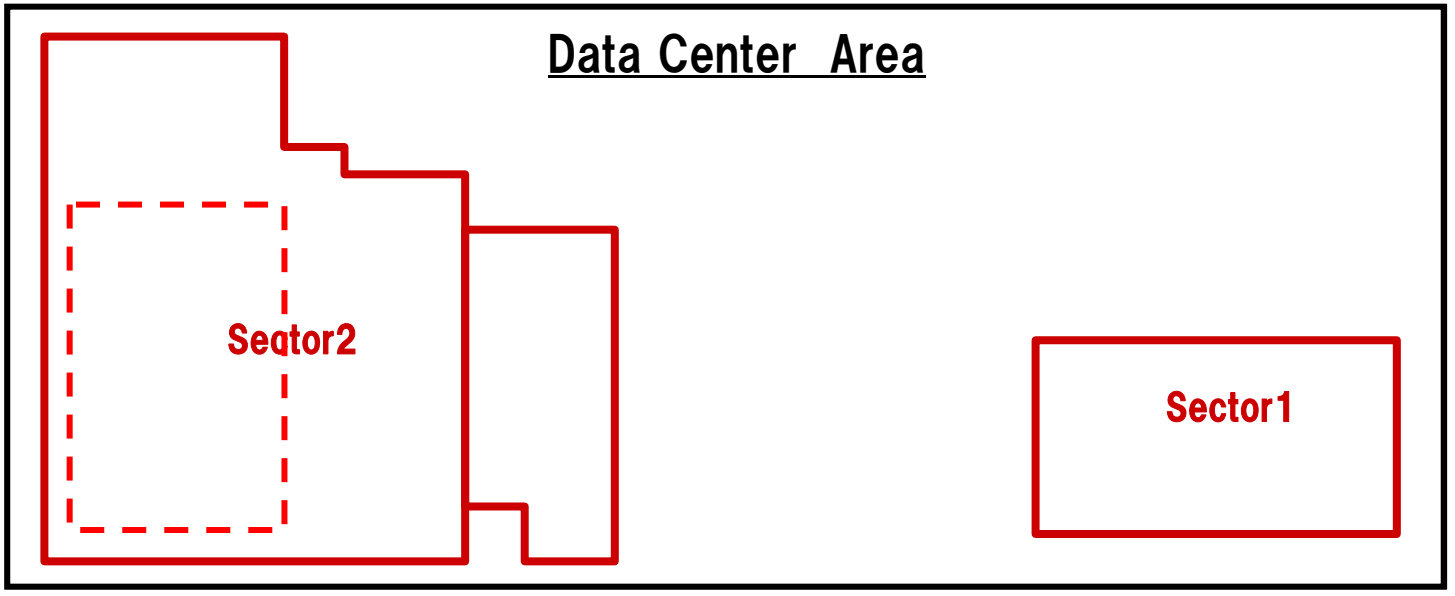
  Data center of Singapore

- Surveyed System

  ◆PUE Survey : Sector2 , Sector1

  ◆Thermal Environment Survey : Sector2 , Sector1

  ◆CFD Analysis : Sector2



2-(3) Schedule and Implementation Structure

1. Schedule

From October 15, 2009 to January 7, 2010.

2. Executed content

Oct. 15	Sealing NDA
Oct. 3 to 30	Preliminary survey and preparation of survey schedule
Nov. 3 to 10	Energy-saving survey
Nov. 12 to 28	Confirmation of unknown information and data collection
Dec. 7 to 28	Preparation of survey report
Jan. 7	Closing workshop on survey results and submission of survey report

3. Implementation Structure

・NTT DATA INTELLILINK CORORATION　　Green Consulting Business Division

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・Takasago Thermal Engineering Co., Ltd.　Head Office FS Gr.・R&D Center

Masahiro Ikeda、Naoki Aizawa、Kentaro Kimura、Atsushi Takahashi

・Takasago Singapore Pte. Ltd.

Yusuke Toda、Desmond Liu Ing Ming、WONG Wai Kitt Leroy

3. Results of PUE Survey

3-(1) Measurement Level of PUE Survey

According to white paper of the Green Grid, data center level is categorized based on the PUE values.

Level 1 (basic) : Data is measured at least once in month. Measurement points are UPS facilities, cooling system, mechanical facilities in A/C room etc.

Level 2 (medium) : Data is measured at least once in day. Measurement points are PDU, distribution system of electric power etc.

Level 3 (advanced) : Data is measured continuously. Measurement points are all IT facilities.

	Level 1 (Basic)	Level 2 (Intermediate)	Level 3 (Advanced)
IT Equipment Power Total Facility Power Where	UPS Data Center input power	PDU Data Center input power less shared HVAC	Server,... Data Center input power less shared HVAC plus building lighting, security
Minimum Measurement Interval	1month / 1Week	Daily	Continuous (XX min)

Source : Green Grid White Paper ＃14

As for this survey, PUE level was decided as follows:

PUE L2、WD ＝ The reading point is PDU. The data of every a day is totaled for one week.

3-(2) Definition of PUE (1/2)

Definition of PUE

$$PUE = \frac{\text{Value A : Total facility power in DC}}{\text{Value B : IT equipment power in DC}}$$

PUE was defined officially by the Green Grid, however it is not clear in its definition. So some factors in this survey were defined as follows:

1. Total facility power in DC (Value A)

Following items were surveyed as IT facilities.

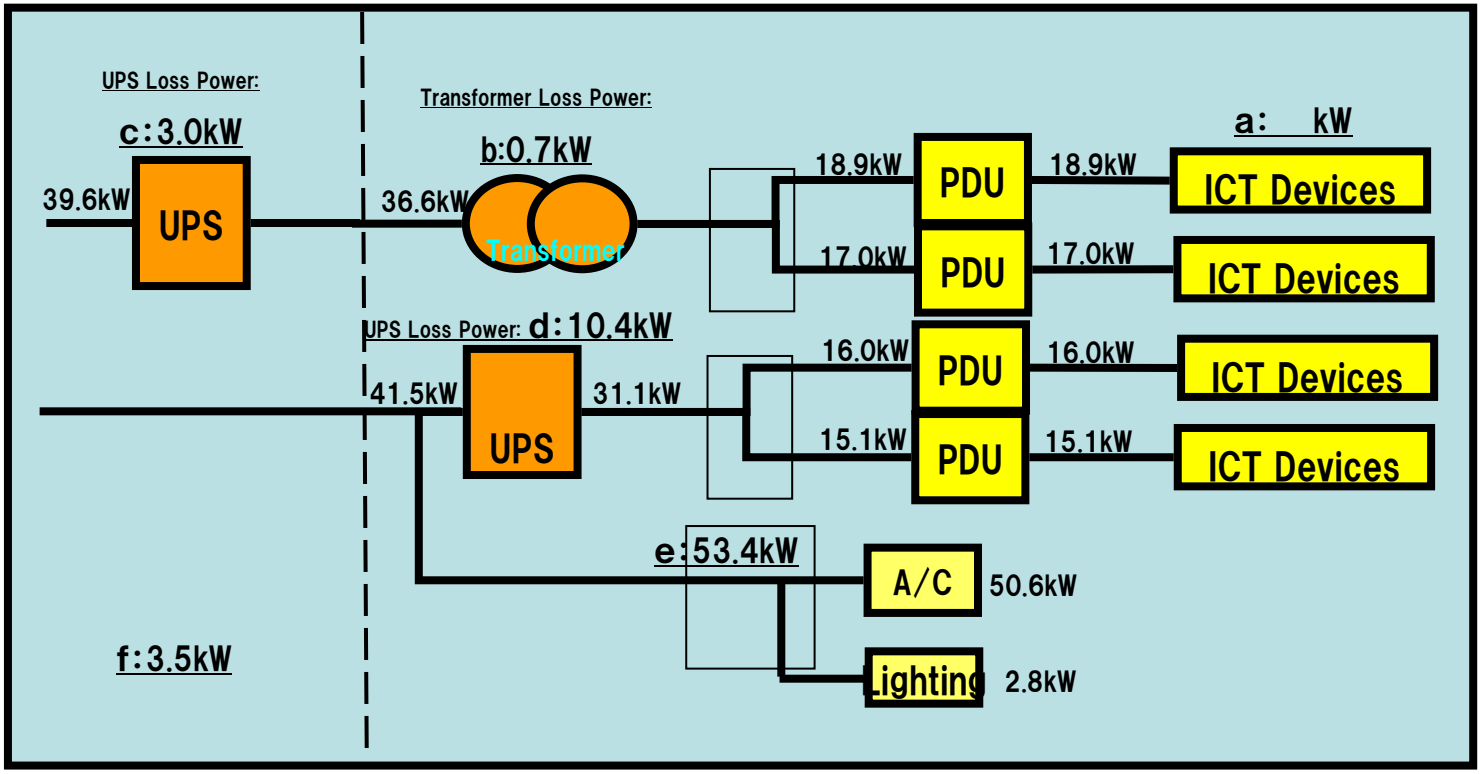
- Power supply components (UPS、switches、generator、PDU、battery etc.) and power losses of outside IT equipment
- Chiller, A/C units in computer room (CRAC, DX, units)
- Calculation, Network, etc.
- Lighting of data center, other component loads etc.

2. IT equipment power in DC (Value B)

In this survey, IT equipment power in DC regards as output power in PDU. Because PDU in your DC does not have transformer.

3-(3) Results of PUE Survey (Sector1)

◆Rough sketch of SLD and composition of power consumption



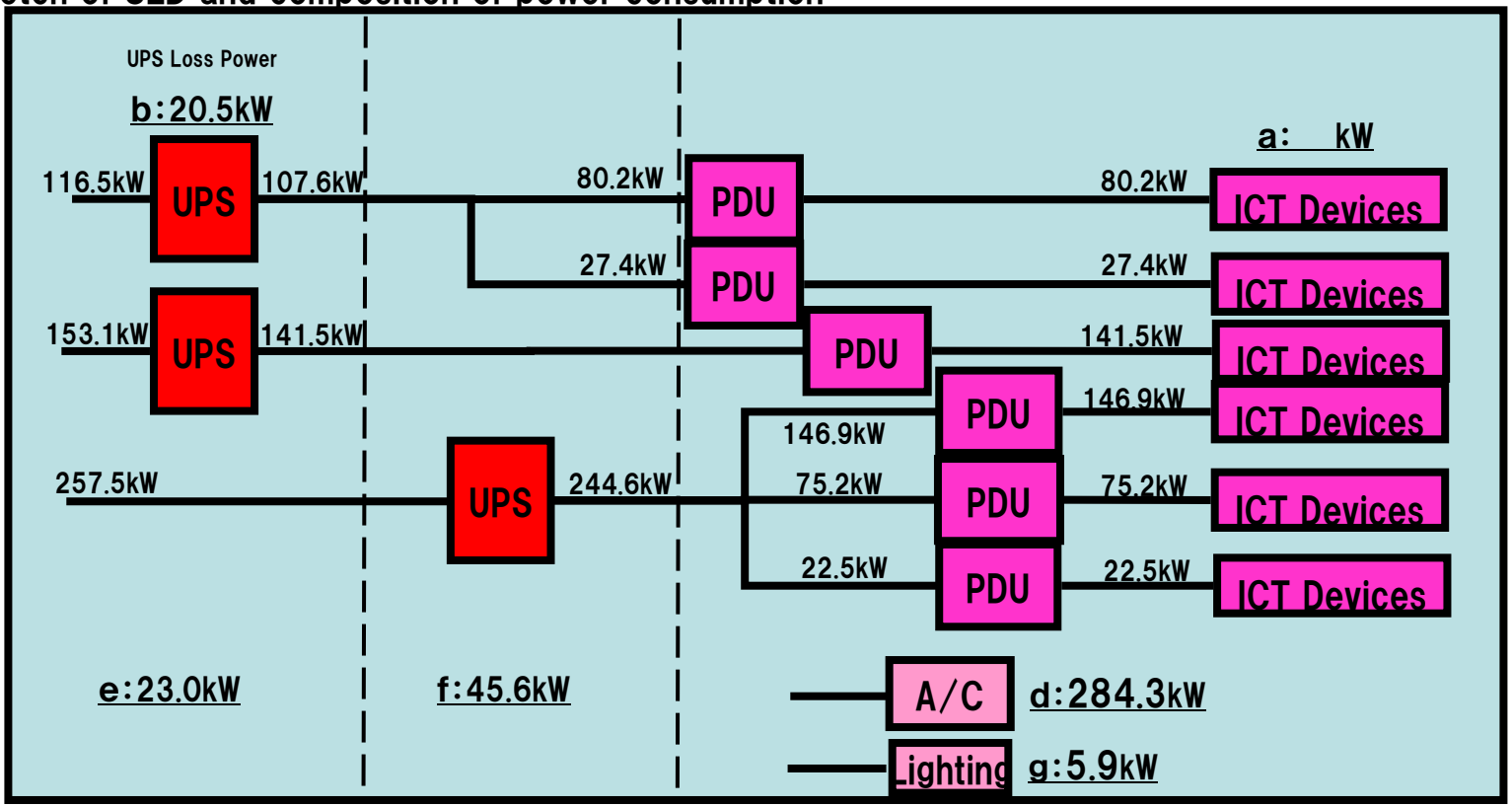
•PUE of Sector1site

$$PUE = \frac{\text{Value A : Total facility power in DC}}{\text{Value B : IT equipment power in DC}}$$

$$PUE_{L2,WD} = \frac{a+b+c+d+e+f}{a} = \frac{(67+0.7+3.0+10.4+53.4+3.5)}{a}$$

3-(4) Results of PUE Survey (Sector2)

◆Rough sketch of SLD and composition of power consumption



•PUE of Sector 2

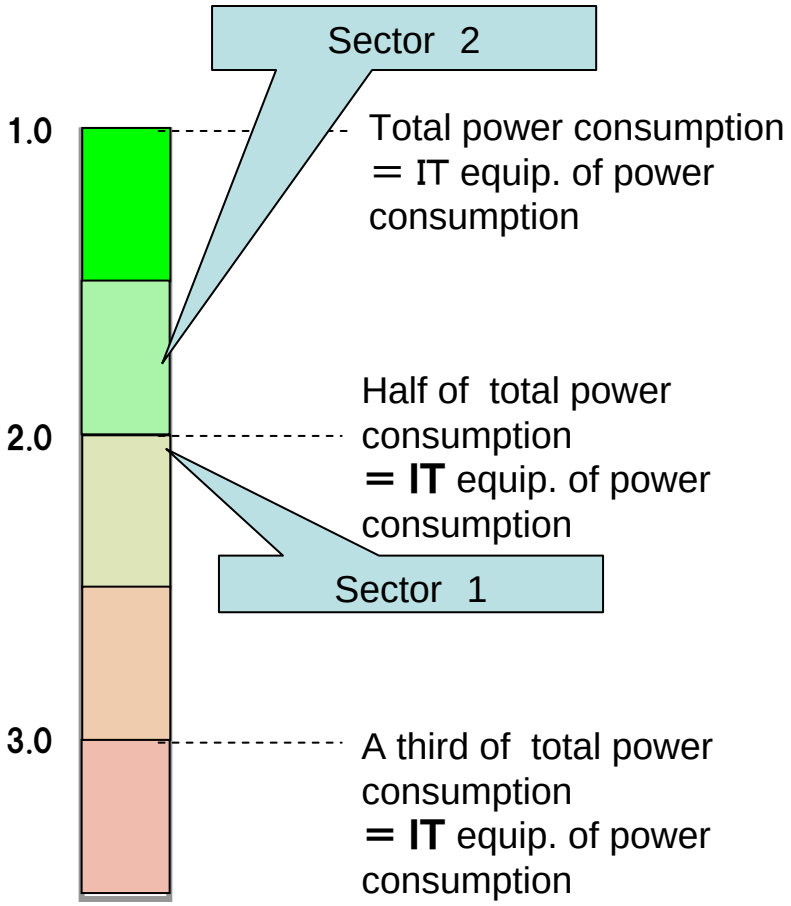
$$PUE = \frac{\text{Value A : Total facility power in DC}}{\text{Value B : IT equipment power in DC}}$$

$$PUE_{L2,WD} = \frac{a+b+c+d+e+f+g}{a} = \frac{(493.6+20.5+12.9+284.3+23.0+45.6+5.9)}{a}$$

3- (5) Issues and Countermeasures

Results of PUE study on data center are as follows:

<PUE levels>



＜Source : Nikkei BP＞

・ Target value of PUE :

a) IBM : 1.8

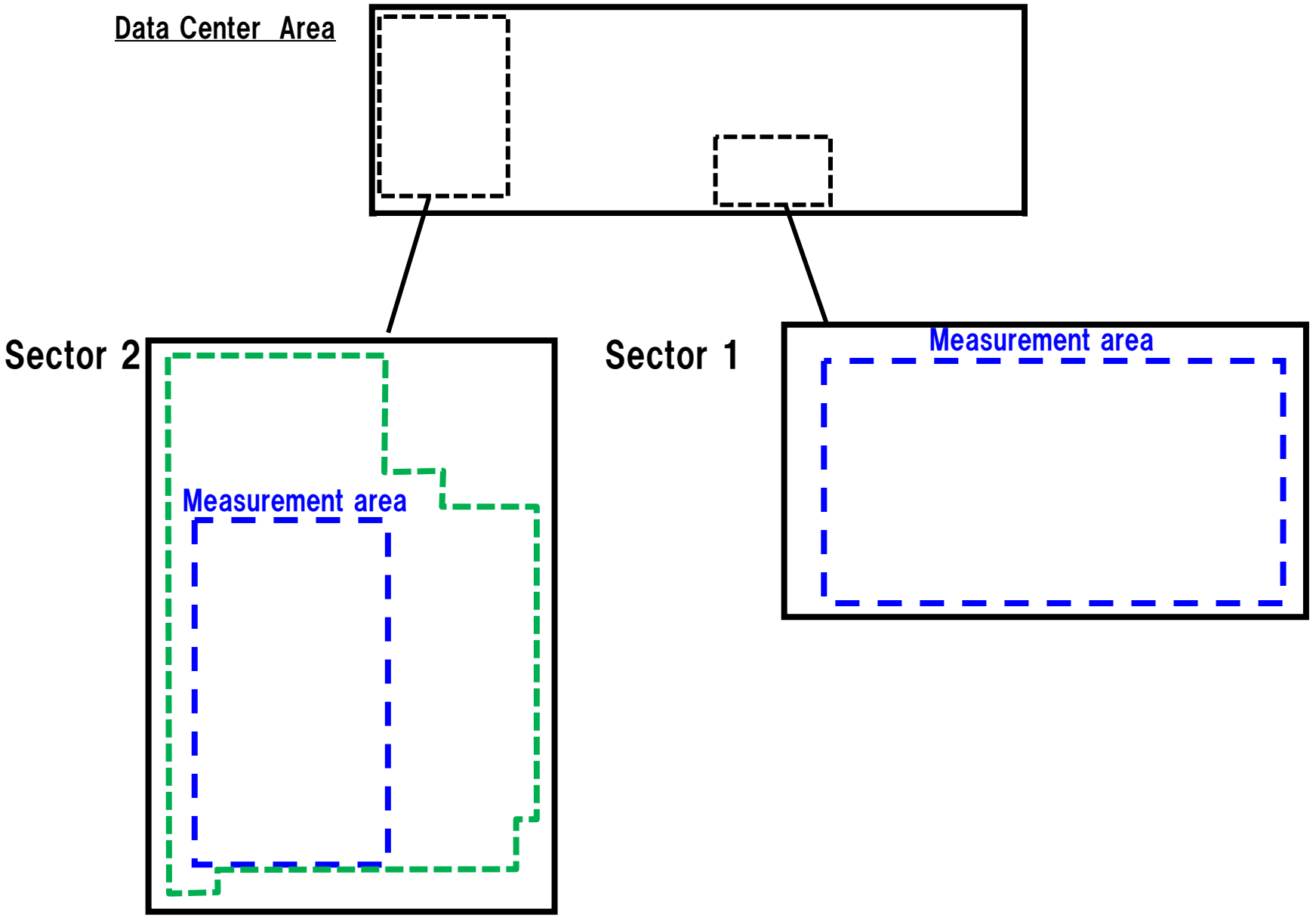
b) Hitachi : less than 1.6 in year2009

・PUE value of different status are as follows:

- Poor power efficiency : more than 3.0.
- Normal power efficient : 2.3 to 2.5
- Excellent power efficiency : less than 2.0.

4. Thermal Environment Survey

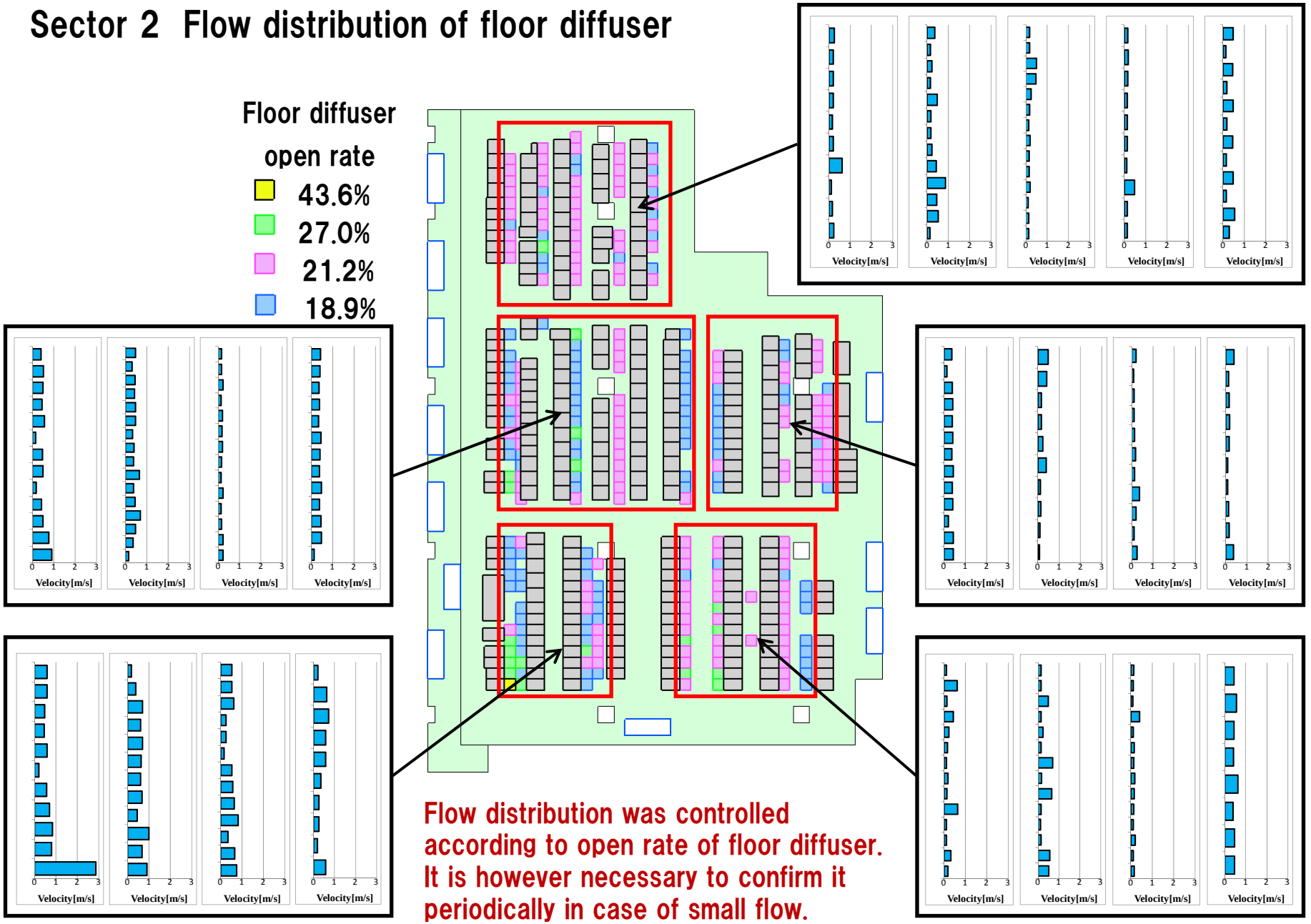
Areas of thermal environment survey



Sector 2 Flow distribution of floor diffuser

Floor diffuser open rate

- 43.6%
- 27.0%
- 21.2%
- 18.9%



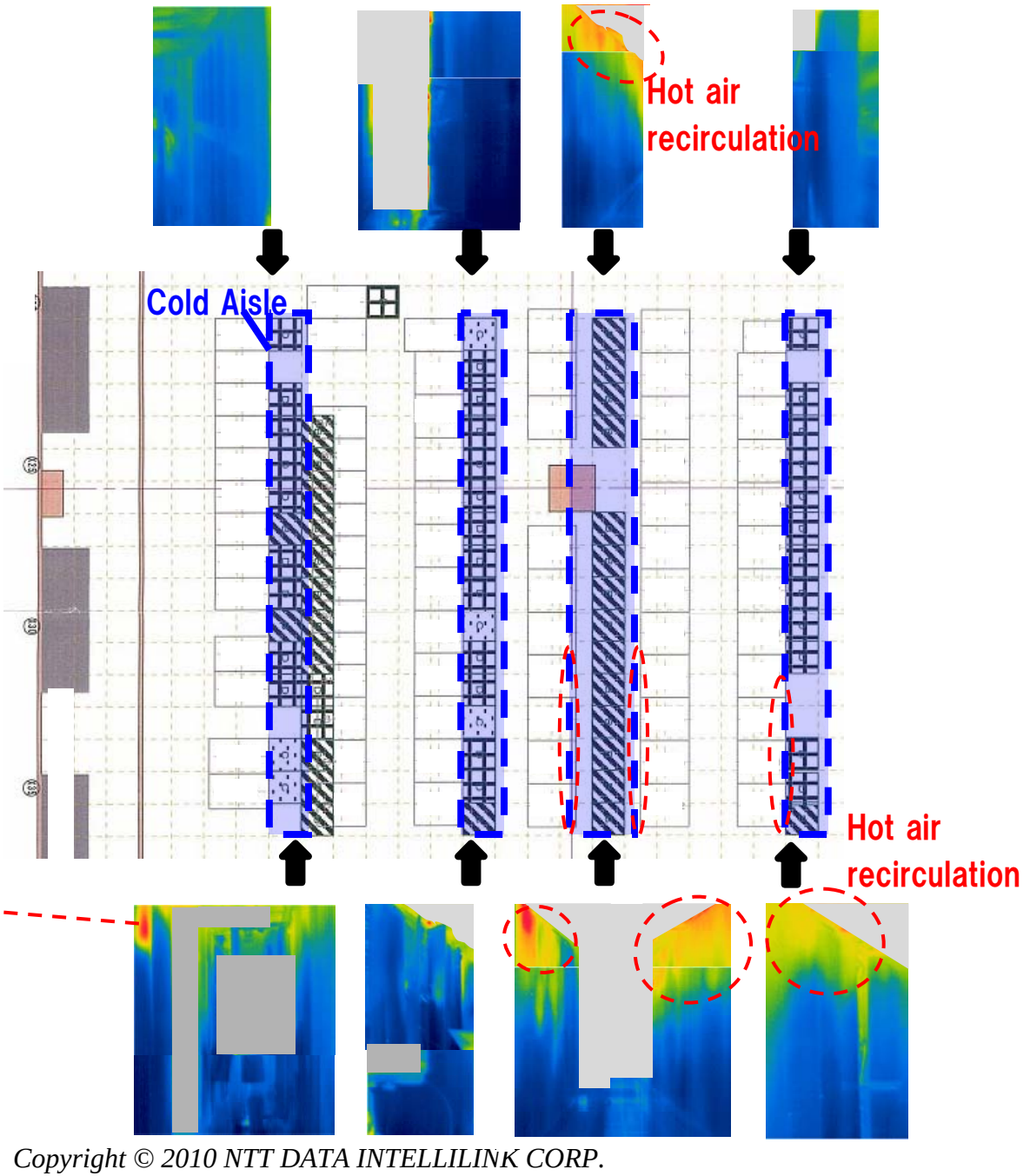
Flow distribution was controlled according to open rate of floor diffuser. It is however necessary to confirm it periodically in case of small flow.

4-(3) Thermal Environment Survey

Thermography in server room

Sector 2

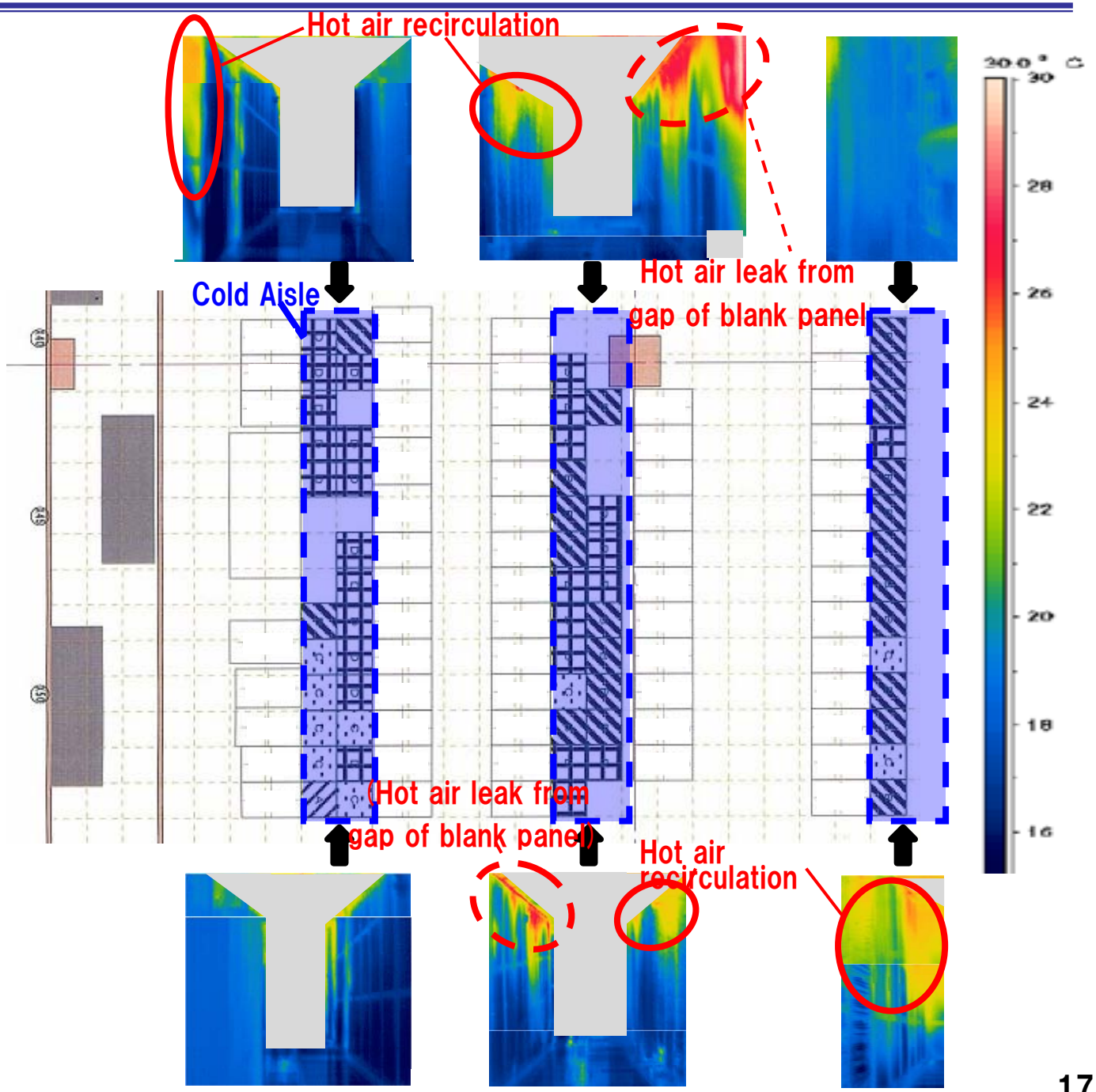
Survey area



4-(4) Thermal Environment Survey

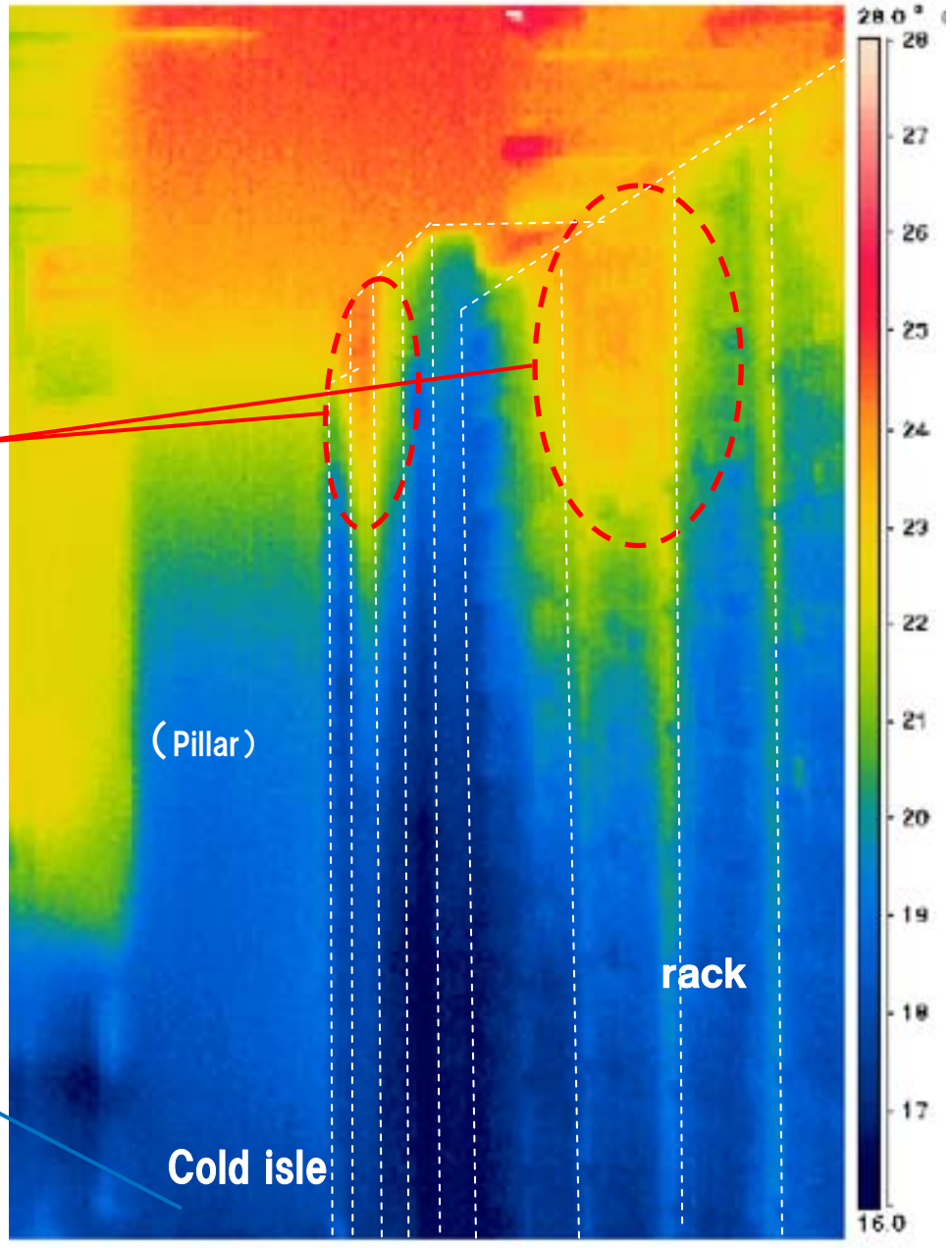
Thermography in Server room

Sector 2



4-(5) Thermal Environment Survey

Thermography of the rack surface



High temperature area by hot air recirculation 23 to 25℃

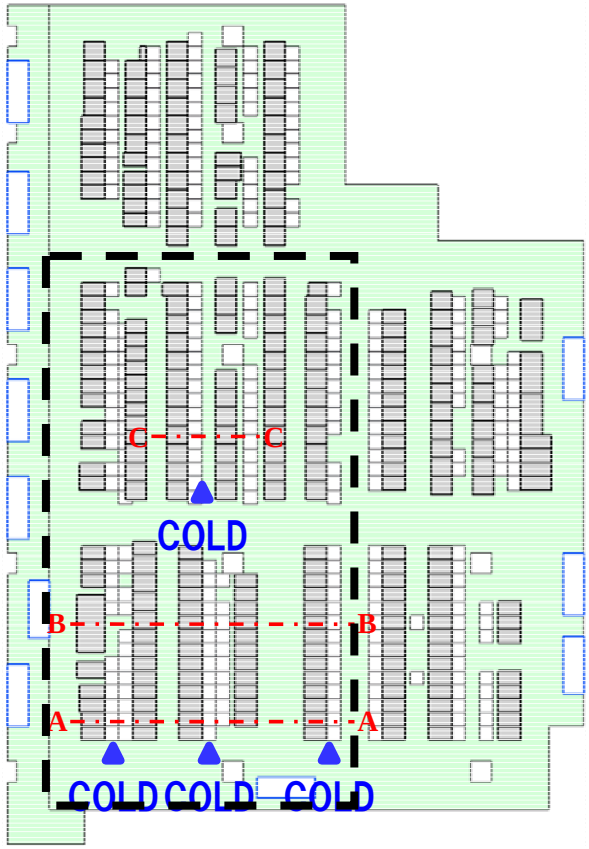
The machine room spec. of temperature
:20℃±5℃

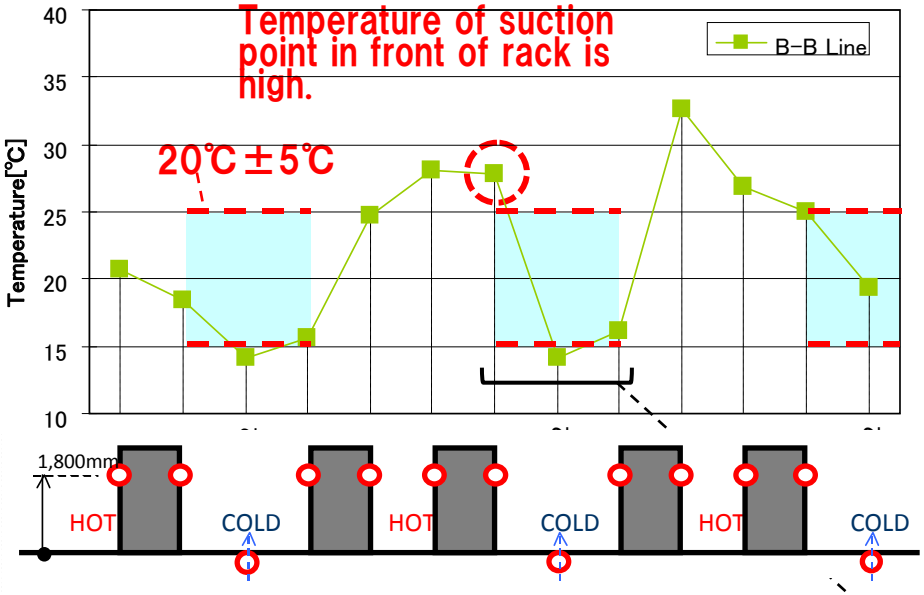
Air temperature of floor diffuser SA
14～15℃

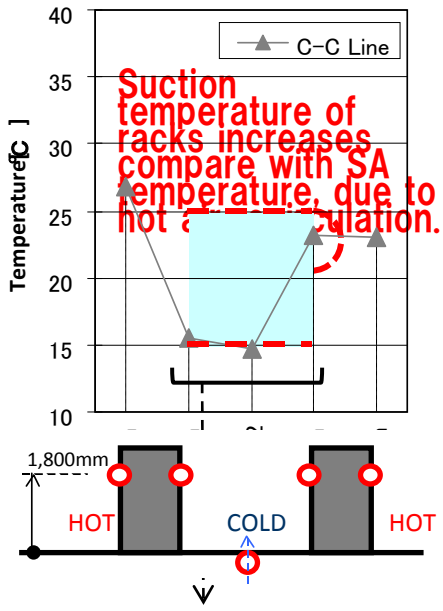
Hot air recirculation was confirmed in the part of upper rack area.

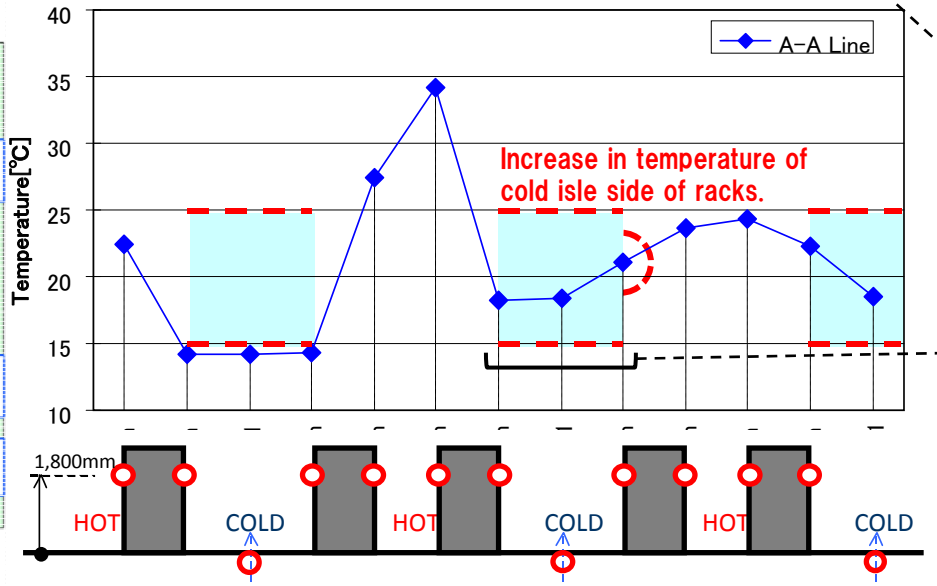
4-(6) Thermal Environment Survey

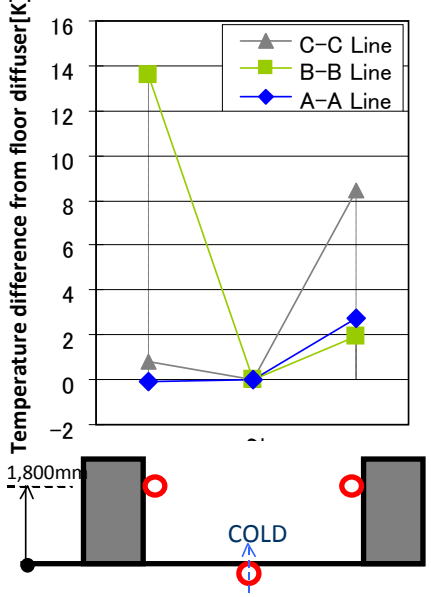
Sector 2 Temperature









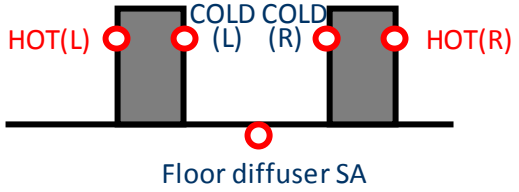


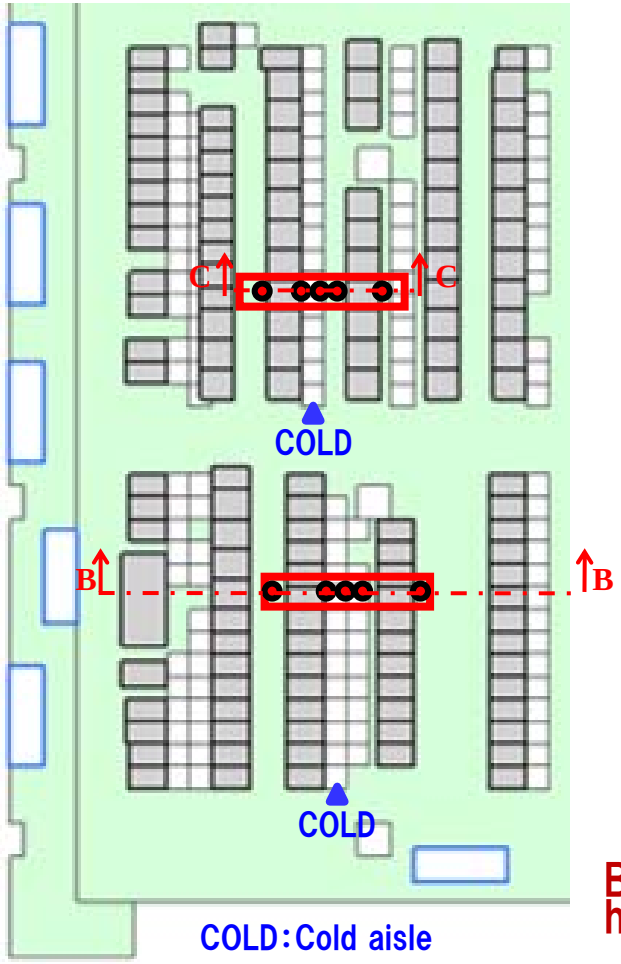
A part of suction temperature is high, and hot air recirculation was confirmed.

ΔT :measure temp.-diffuser temp.
ΔT →0 means non-hot air recirculation

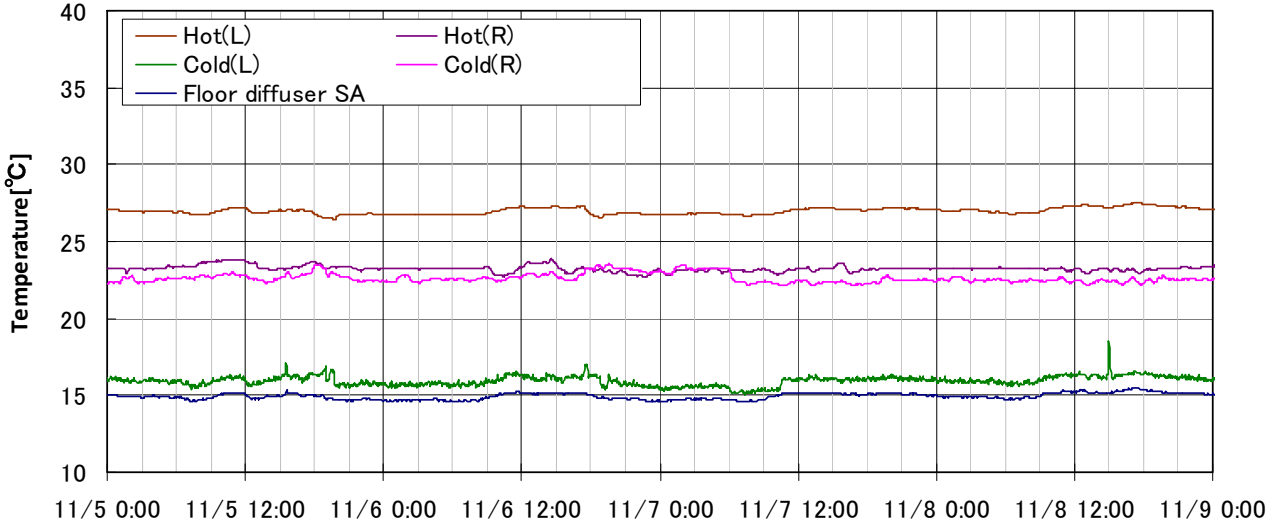
4-(7) Thermal Environment Survey

Sector 2 Temperature

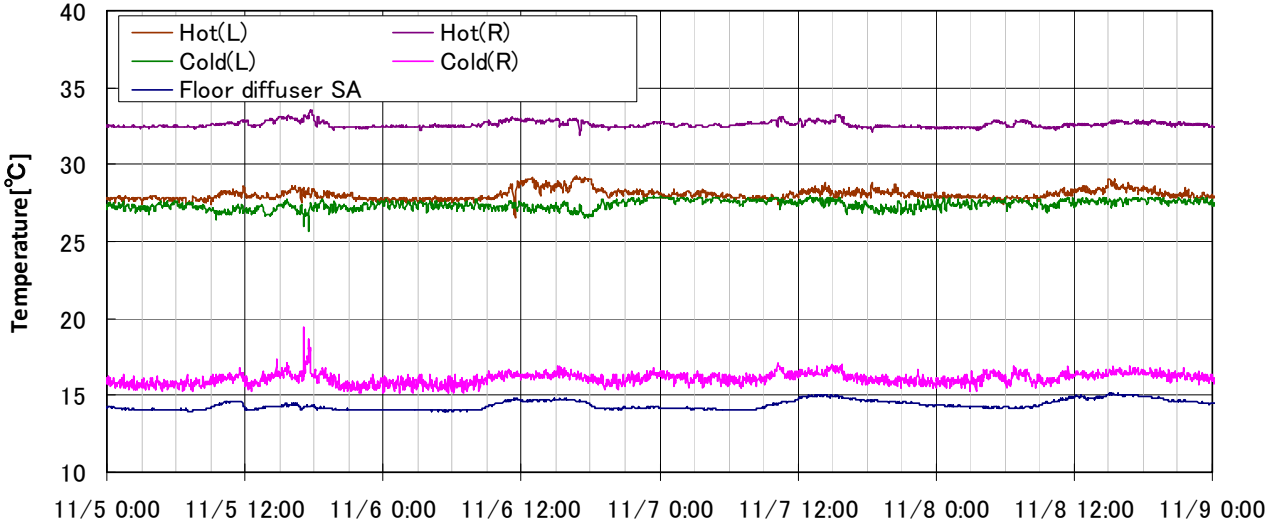




C-C line



B-B line

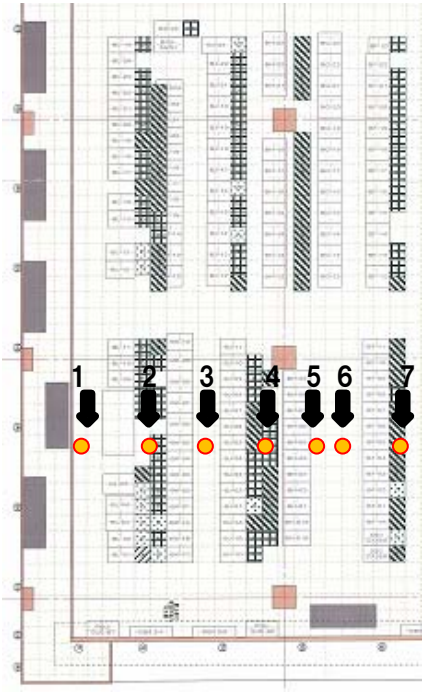


Because fluctuation temperature between cold and hot aisles is stable, heat load of racks also recognizes as stable.

4-(8) Thermal Environment Survey

Sector 2

Temperature in the room by thermography



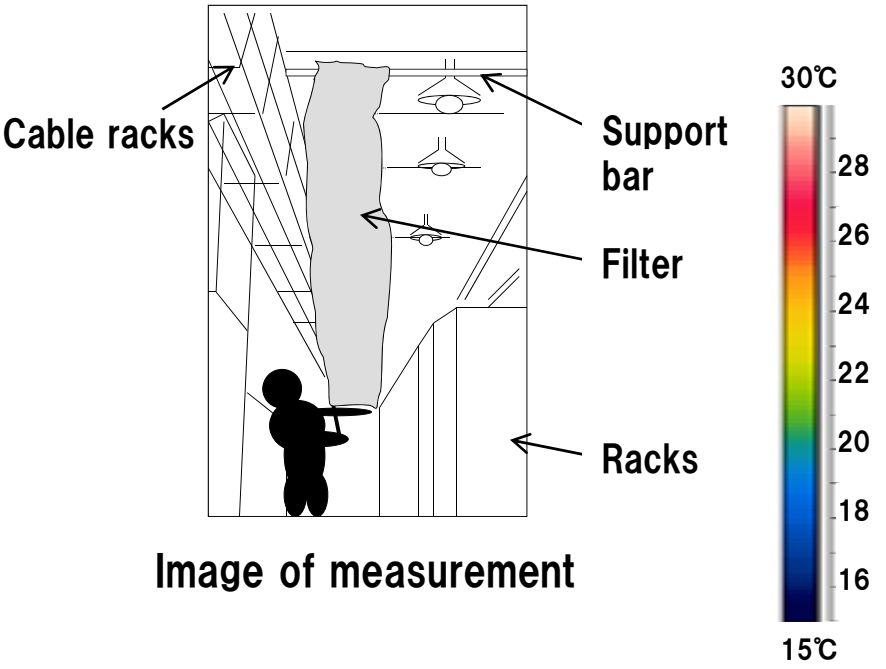
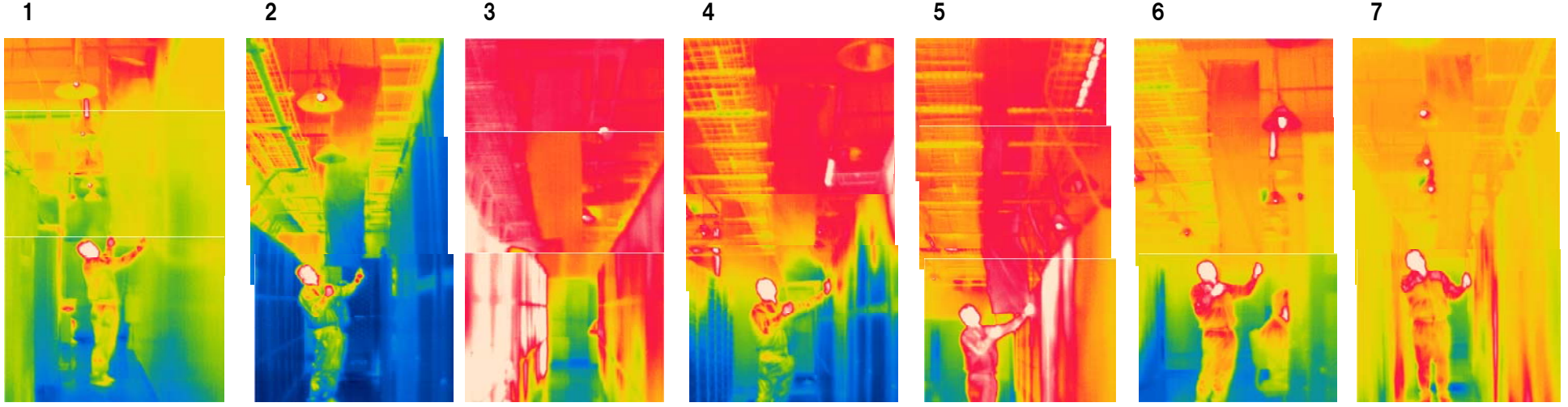


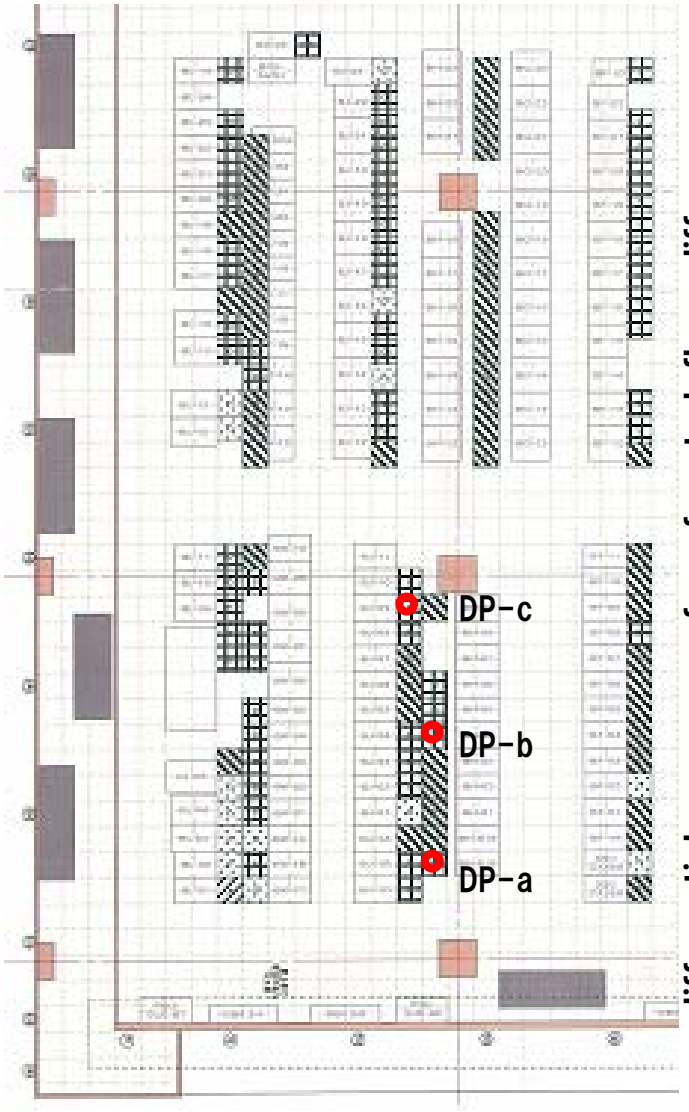
Image of measurement

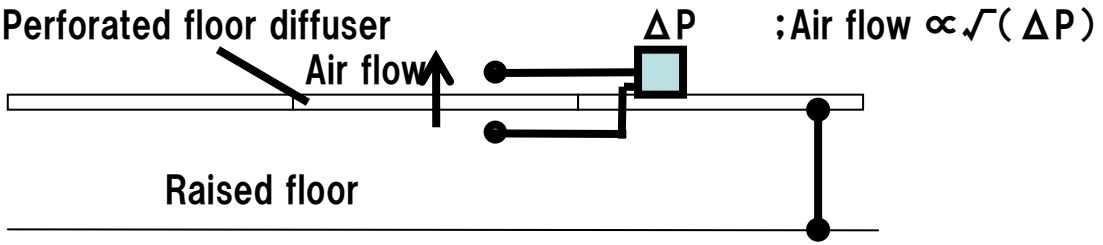


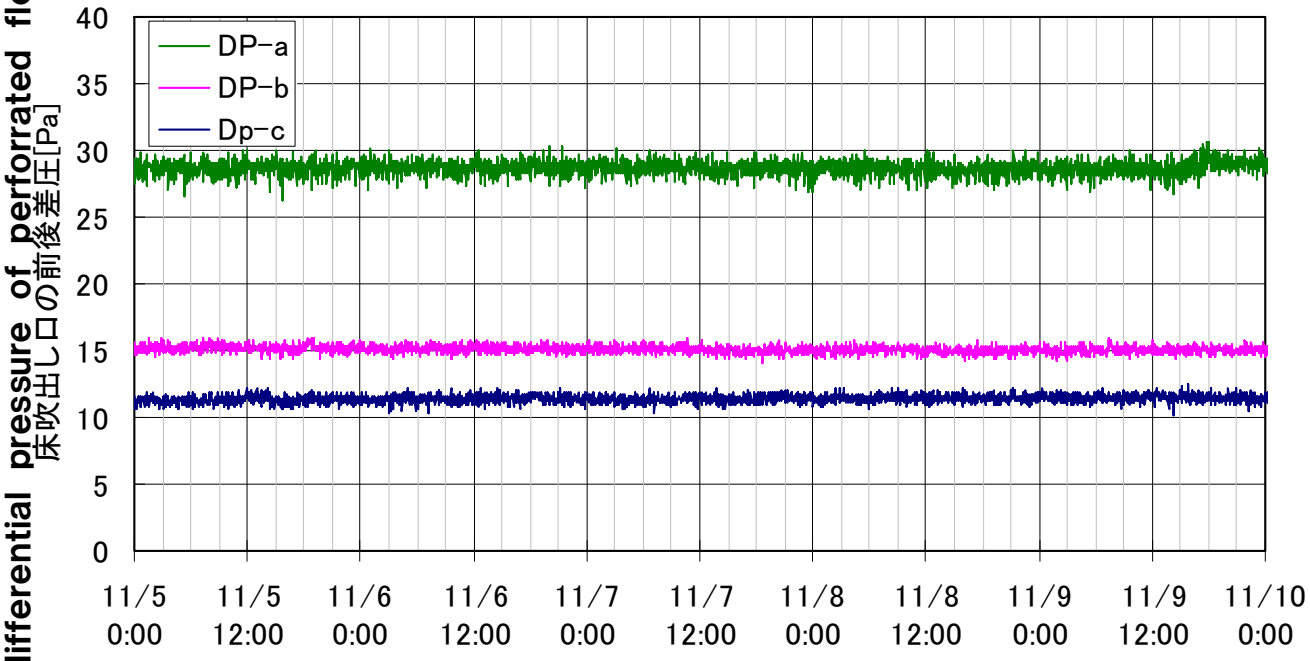
Temperature distribution along vertical direction of the room was confirmed. Center and upper part of machine room has high temperature than others.

4-(9) Thermal Environment Survey

Sector 2 : Air flow from floor diffuser

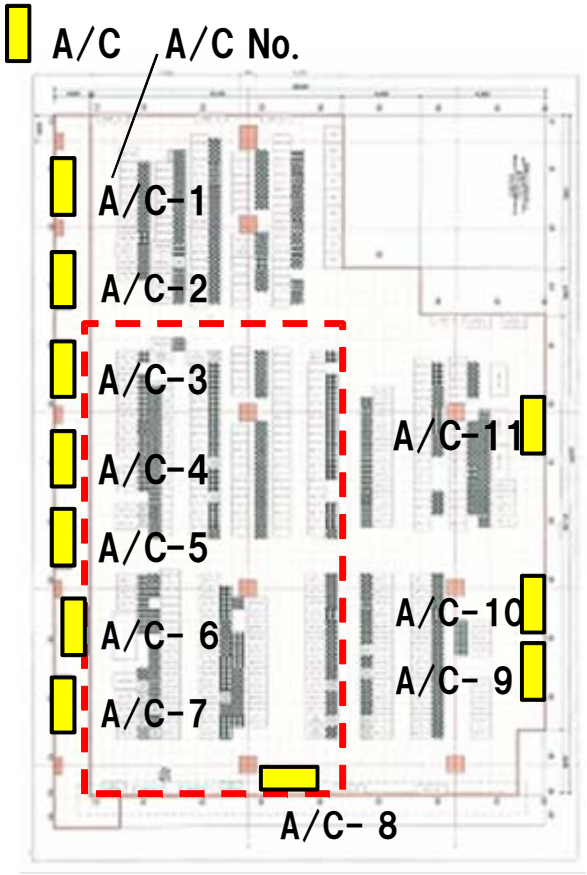




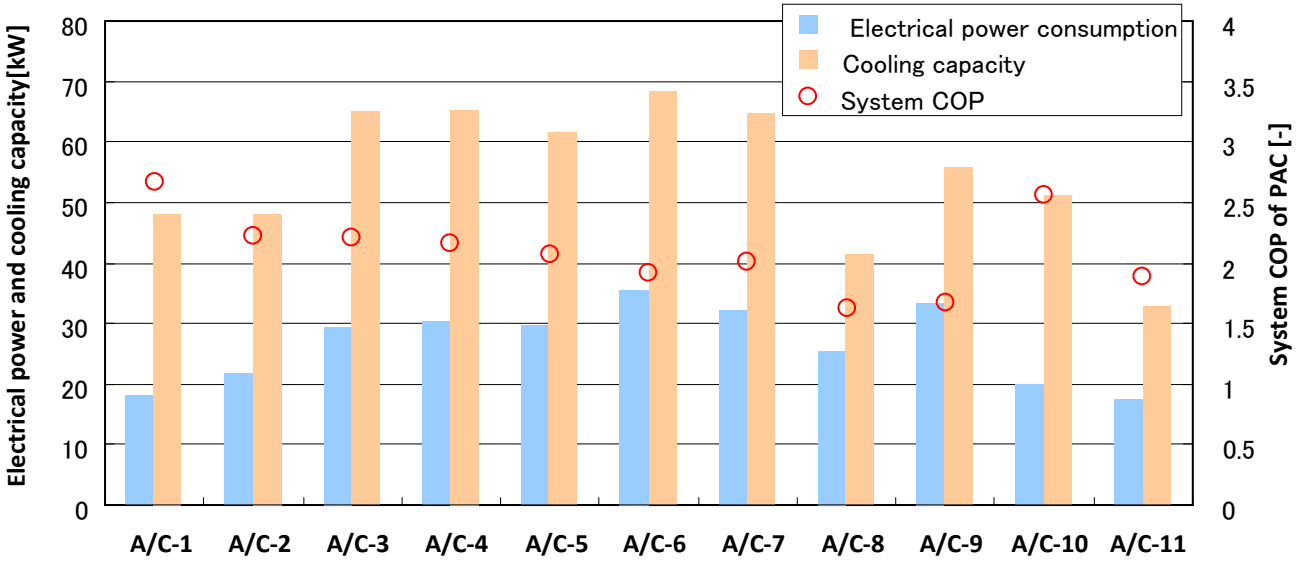


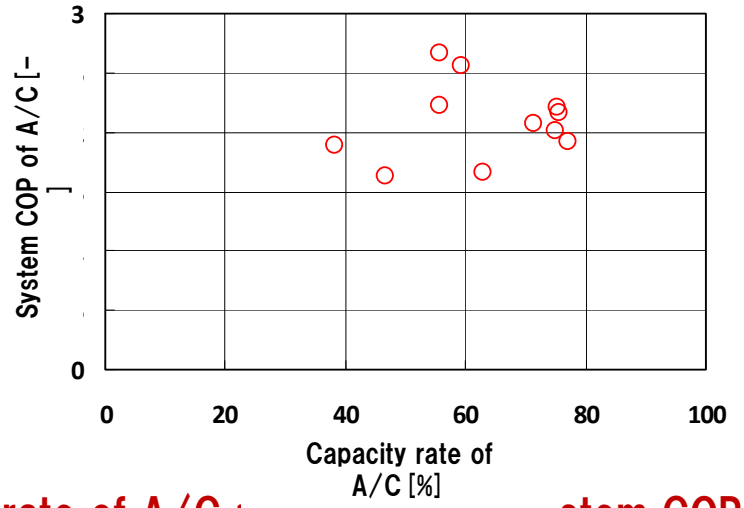
Flow fluctuation was recognized as small according to differential pressure from floor diffuser.

Sector 2 Cooling capacity and COP of A/Cs, Average value from 0:00 to 3:00 on Nov. 7



Survey area of thermal environment





*Electrical power consumption were calculated by current of A/C-1～7,10,11 and mesured kWh meters of A/C-9～6.

*Cooling capacity were calculated by SA,RA temperature and measured air flow volume of each PAC.

COP is lower than CRAC of the latest specification. Improvement is needed according to the renewal.

Performance rate of A/C : 40 to 80%, System COP : 1.5 to 2.7

4-(11) Result of the Thermal Environment Survey

<Result of Sector 2 >

- Overall air volume in DC can be controlled, however, air volume in machine room is not controlled partly.
- Hot air recirculation was partly confirmed around suction area.
- In the CFD analysis, hot air recirculation was also partly confirmed.
- Fluctuation of temperature is not so big during survey, and heat load of racks was stable.
- Rate of A/C is 40 to 80%, and system COP is 1.5 to 2.7.

5. Issues and Countermeasure

5- (1) Issues and Countermeasures

"In order to improve PUE value, it is recommend that the followings shall be plemented."

1. Hot air recirculation was happened from hot aisle area to cold aisle area in server racks.

2. Air supply temperature in A/C was increased partially.

3. Over-cooling was confirmed.

4. The ability of the A/C is lower than that of the latest equipment.

1. Installation of cold aisle capping upper/side areas of server racks.

2. Changes of return temperature control into air supply temperature control in each A/C.

3. Implementation of optimizing cooling by A/C blower control.

4. Renewal to highly effective A/C

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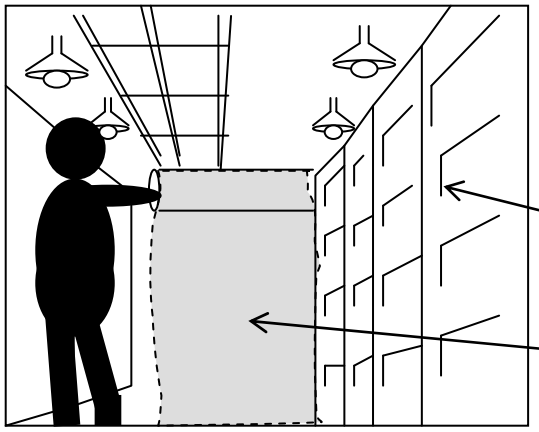
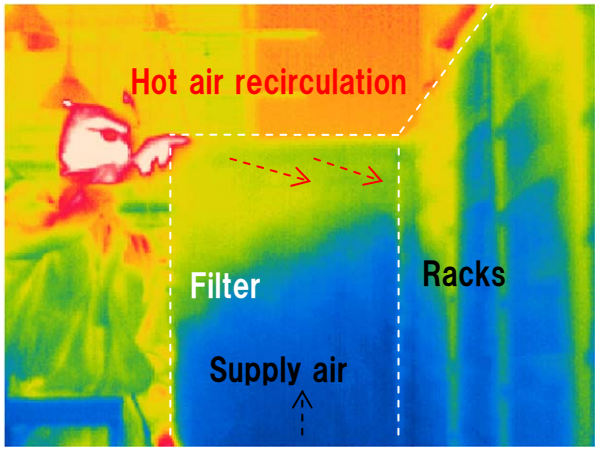
Effect of temporary cold isle capping
Cold aisle capping test (1)





Cold Aisle

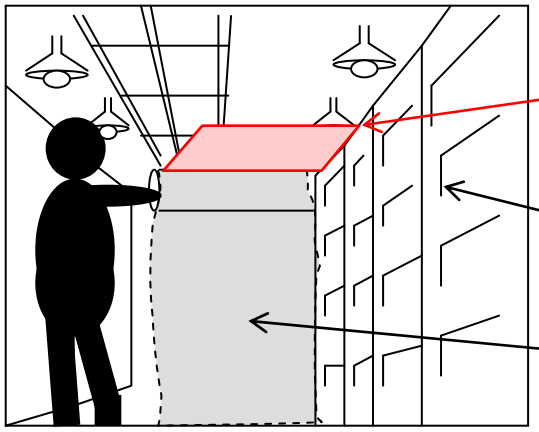
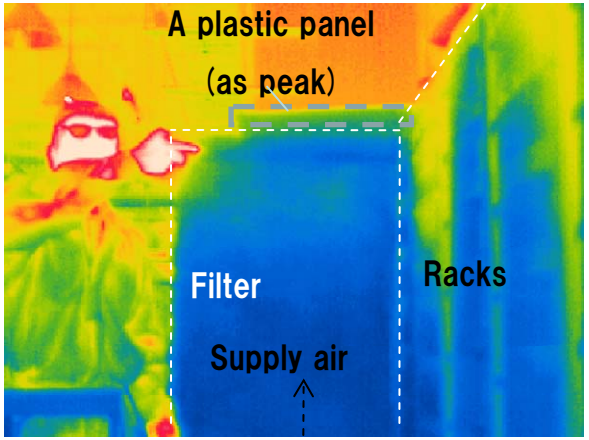
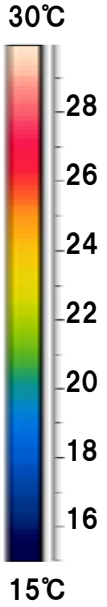


Image of measurement

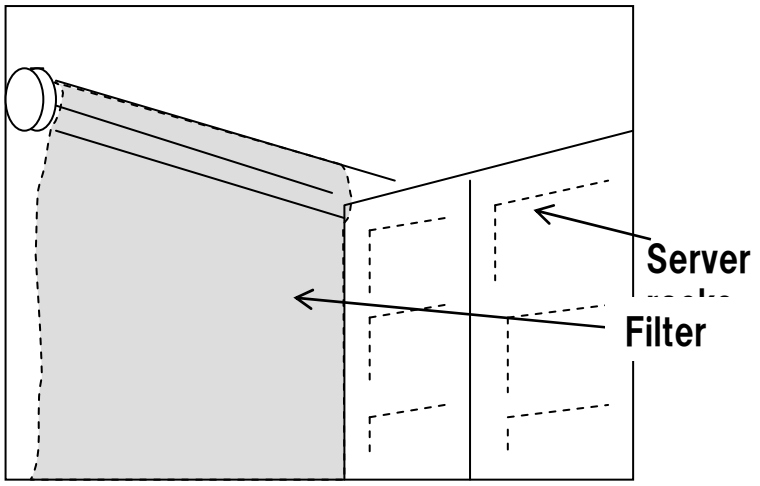


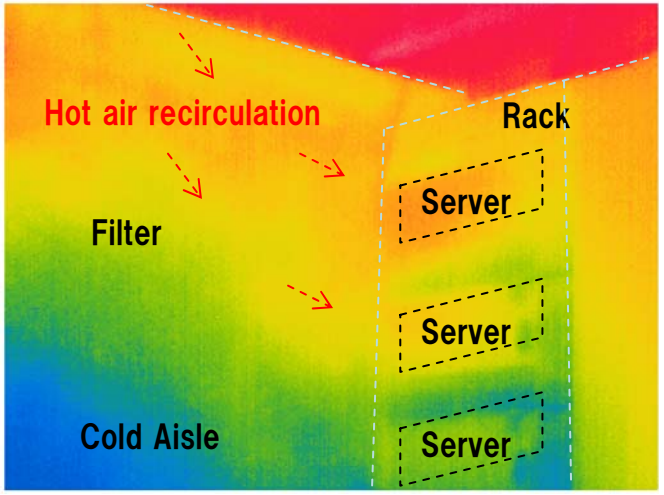
Cold Aisle

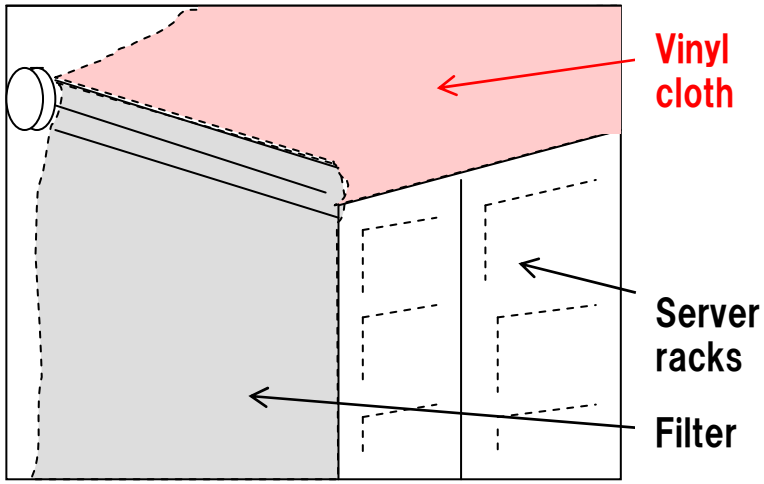


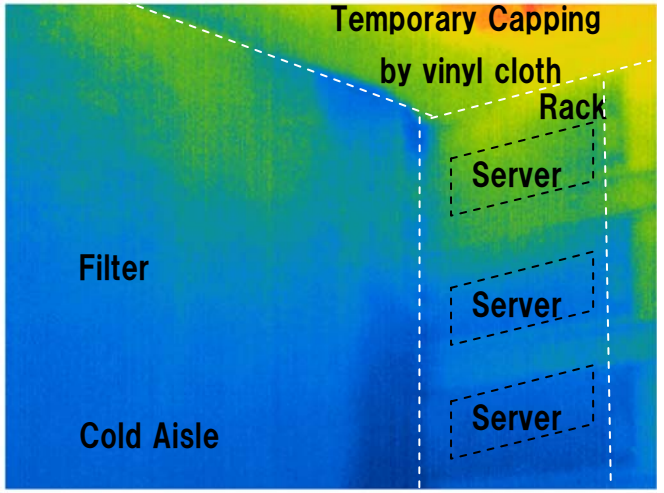
By capping the cold isle, volume of hot air recirculation was eliminated.

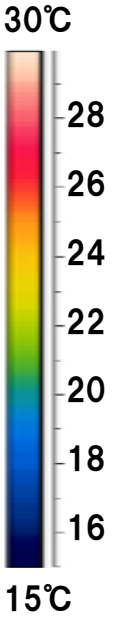
Effect of temporary cold isle capping
Cold aisle capping test (2)





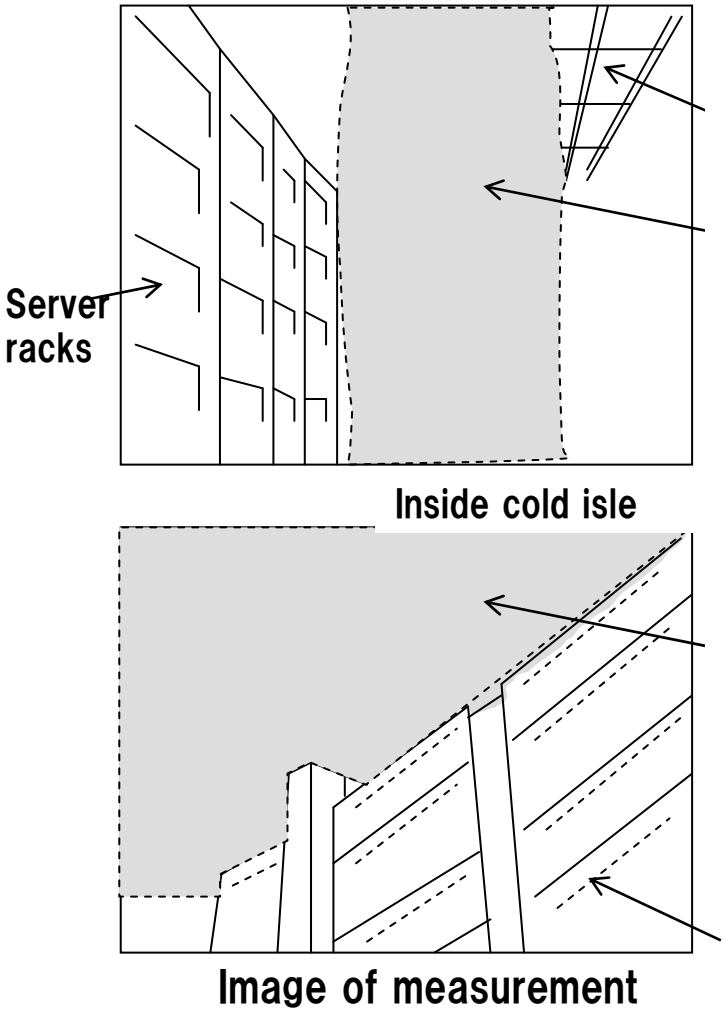




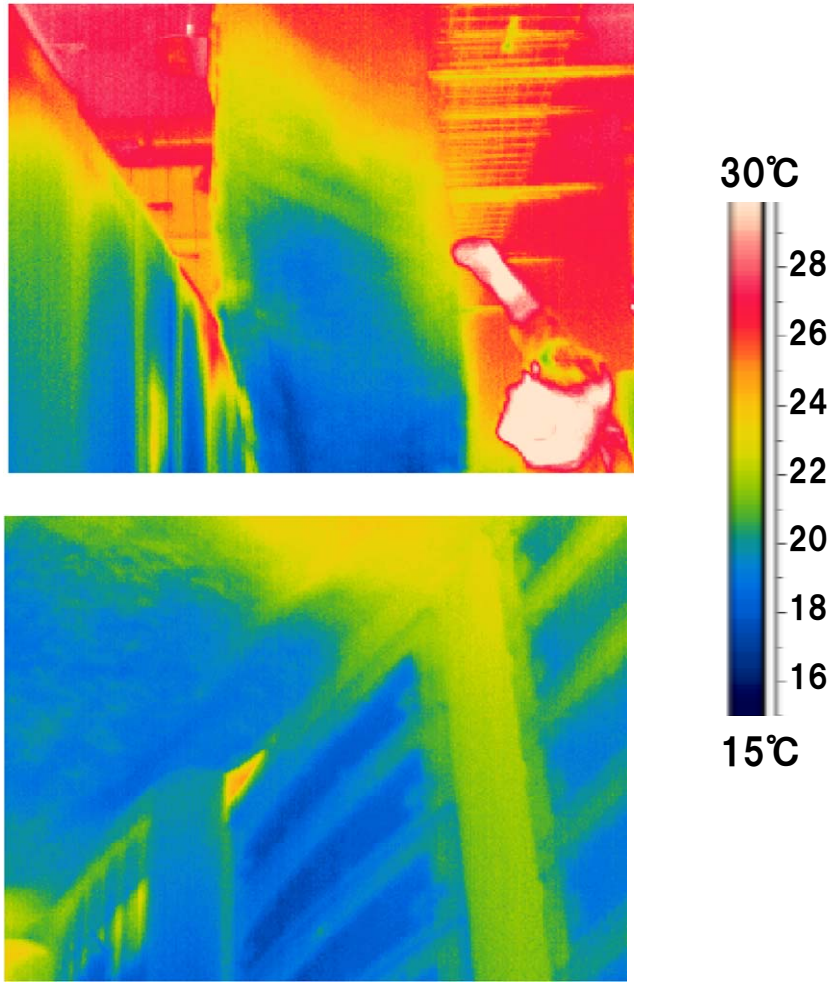


Cold aisle capping can be effective for elimination of hot air recirculation and energy saving.

Effect of temporary cold isle capping
Cold aisle capping test (3)



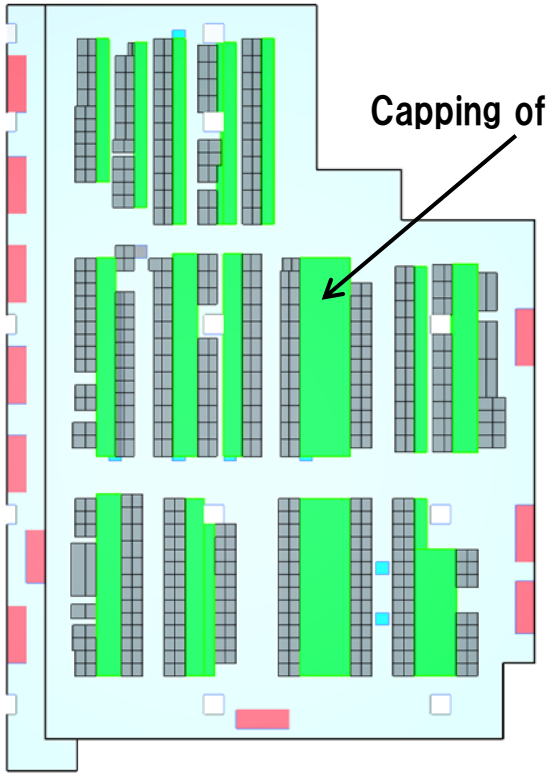
There is some excess as A/C air volume.

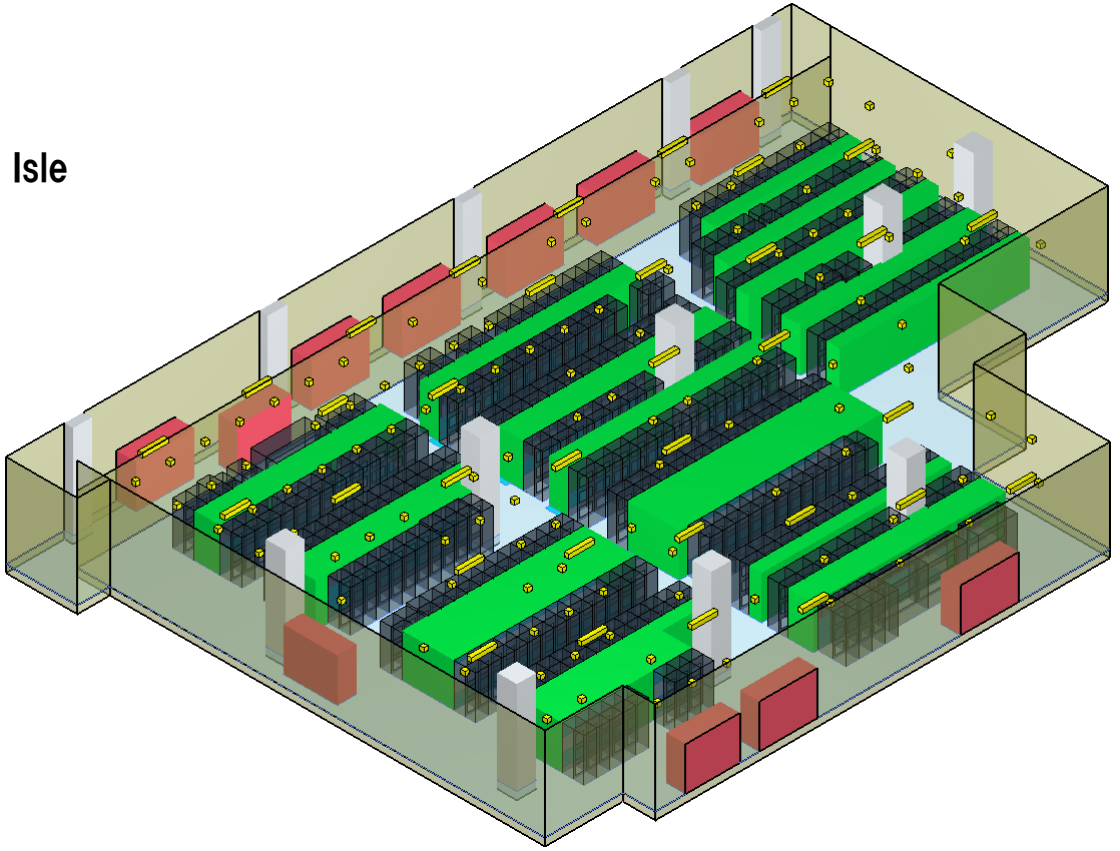


There is some excess in the floor blow area.

By cold aisle capping, air can be supplied efficiently in the ceiling area with satisfied air supply.

Countermeasure ① Cold Isle Capping





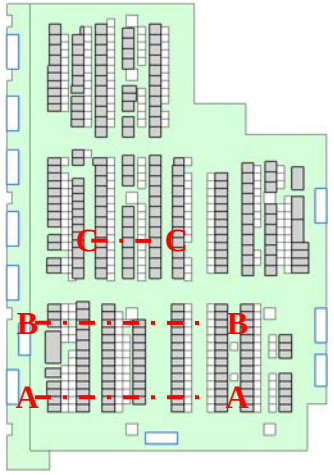
Except cold isle capping, other conditions are same as current CFD model.

Countermeasure ① Cold isle capping

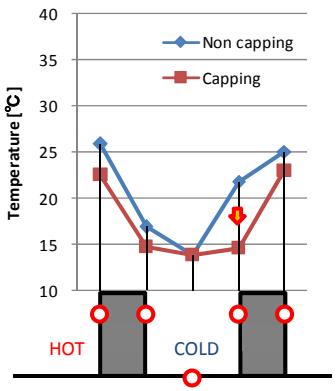
With cold isle capping, suction temperature of racks is decreased considerably.

↓

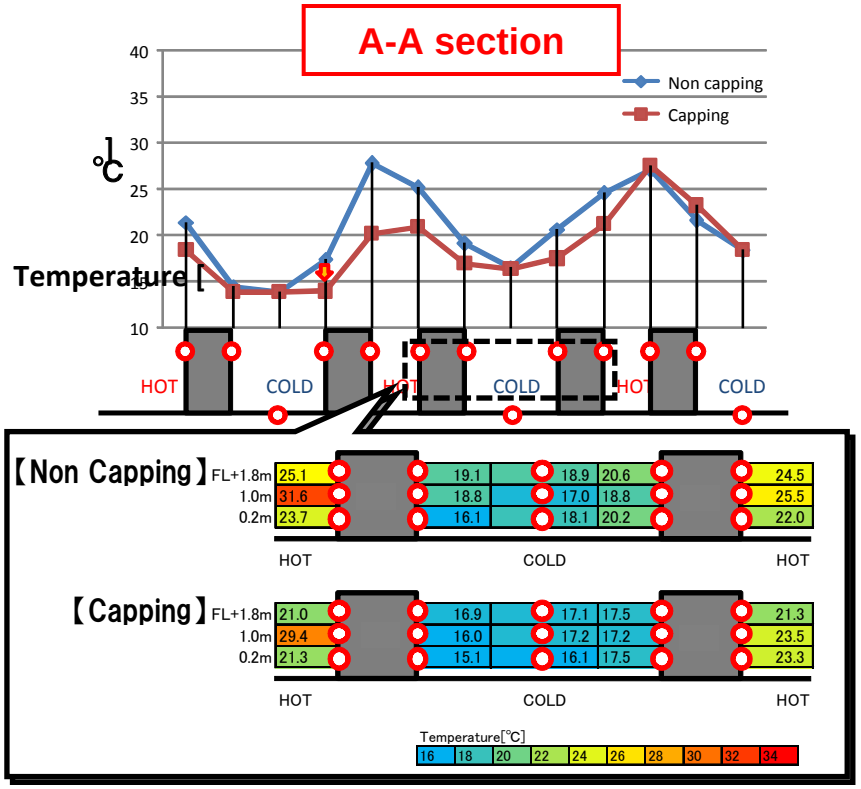
It is expected to execute energy-saving operation.



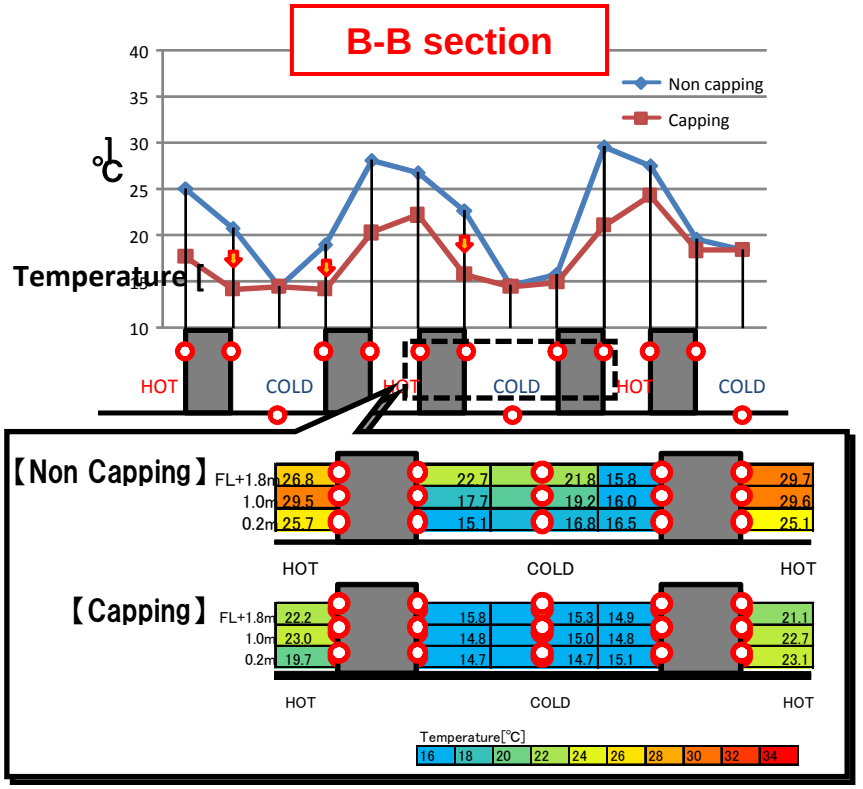
C-C section



A-A section



B-B section



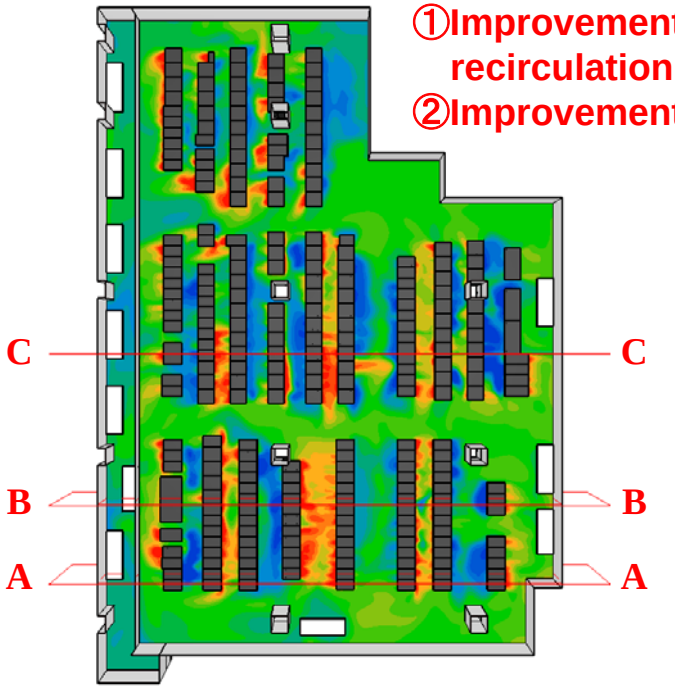
Countermeasure ① Cold Isle Capping

Temperature [℃]
15 20 25 30

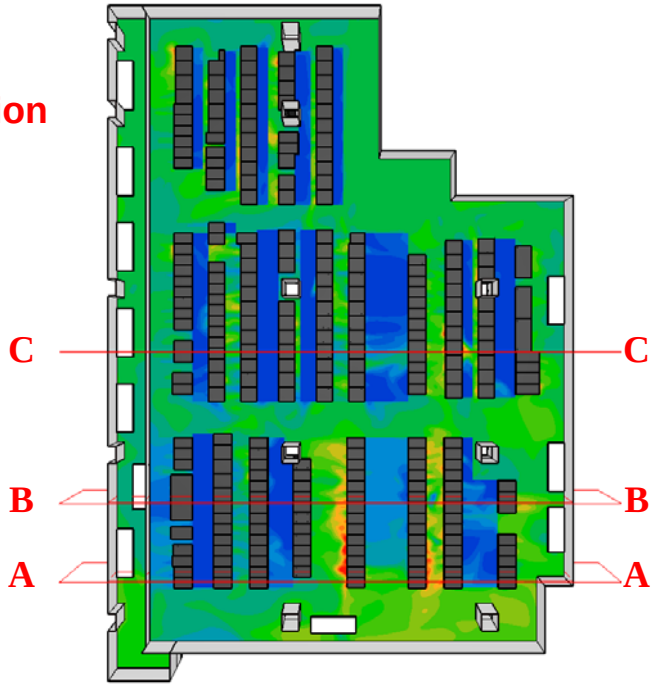
Horizontal

FL+1.8m

①Improvement hot air recirculation
②Improvement of over suction

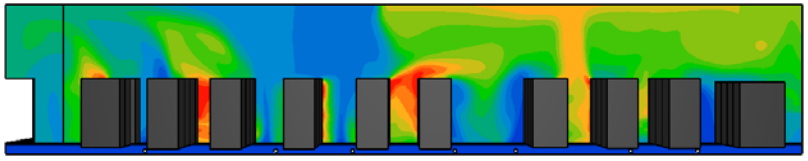


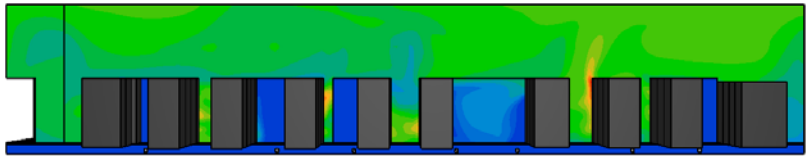
【Capping】



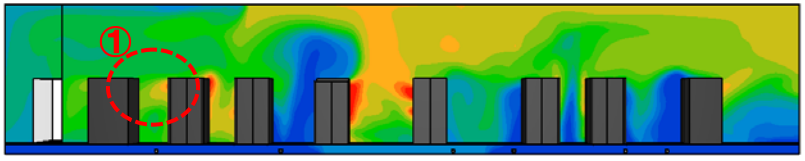
Vertical

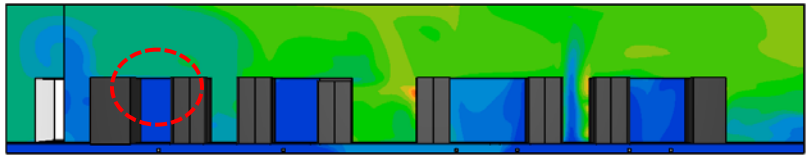
C-C



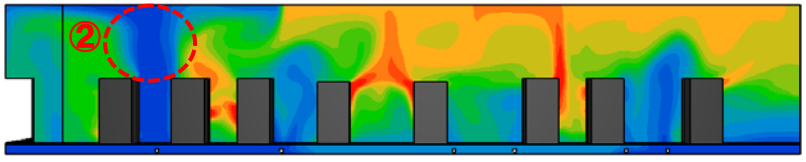


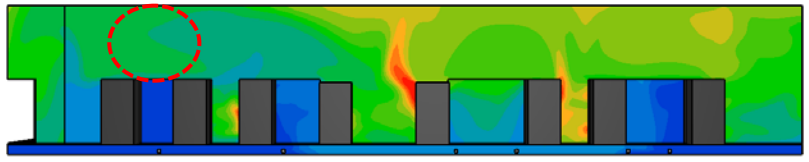
B-B





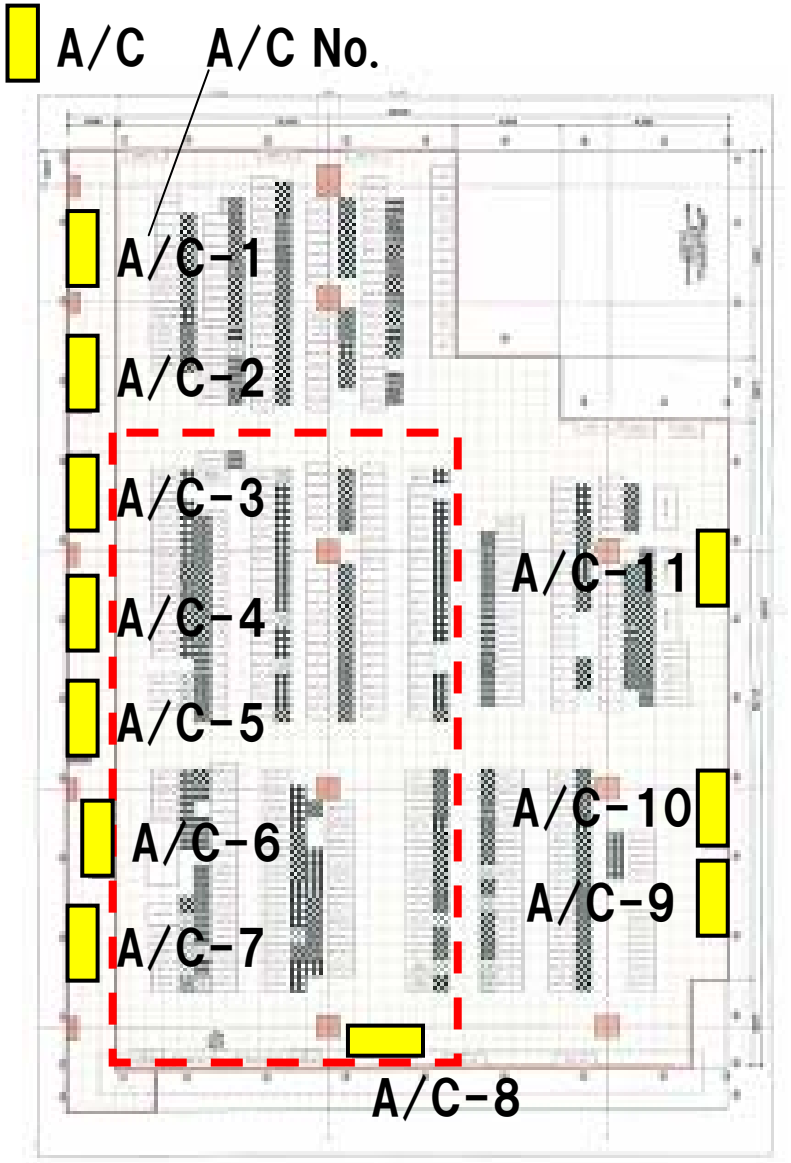
A-A



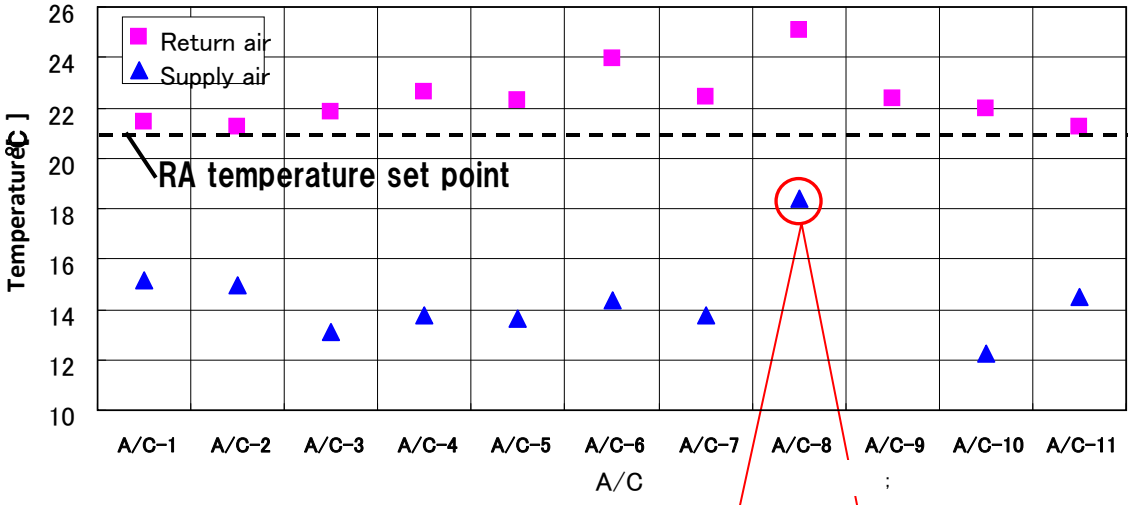


Sector 2 : A/C operation status

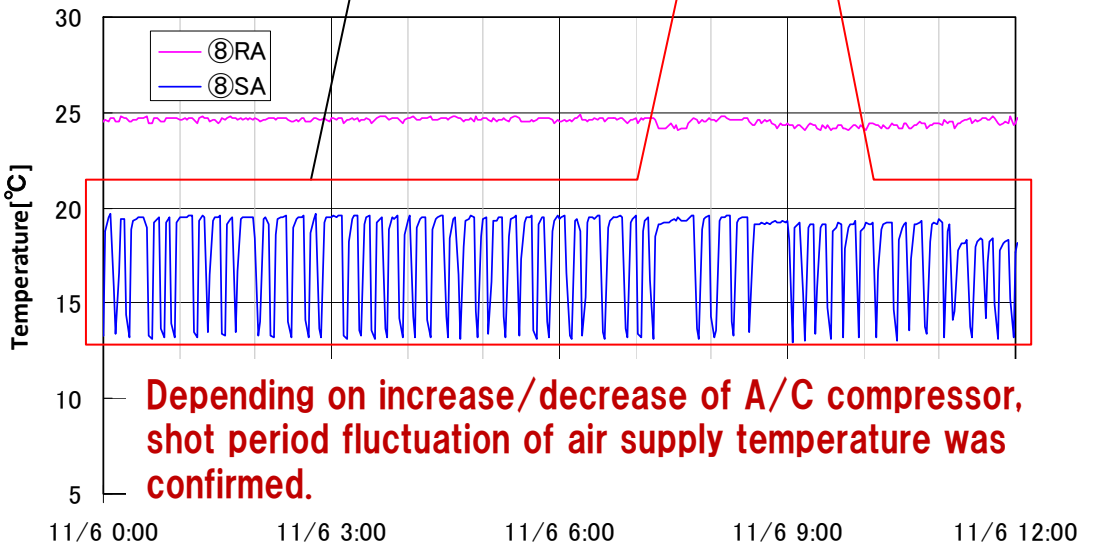
A/C supply air temperature and return air temperature



Survey area of thermal environment



A/C-8 Alteration of supply air temperature



Depending on increase/decrease of A/C compressor, shot period fluctuation of air supply temperature was confirmed.

5-(3) Issues and Countermeasures, <Shift to temperature control by air supply>

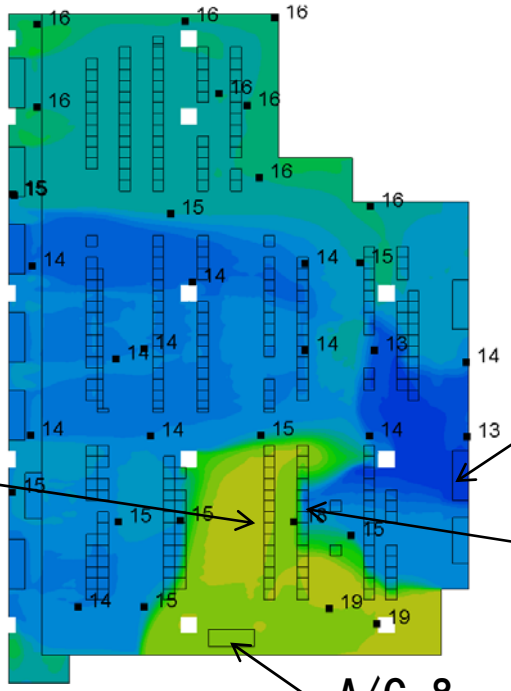
Suction air temperature control

⇩

Difference of air supply in each CRAC

Horizontal

FL-0.1m



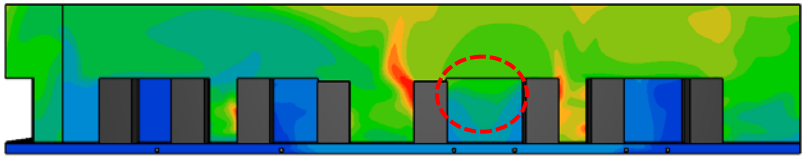
A/C-10
Low temperature air supply

Increase of air blow temperature

Mixing loss

A/C-8
High temperature air supply

A-A



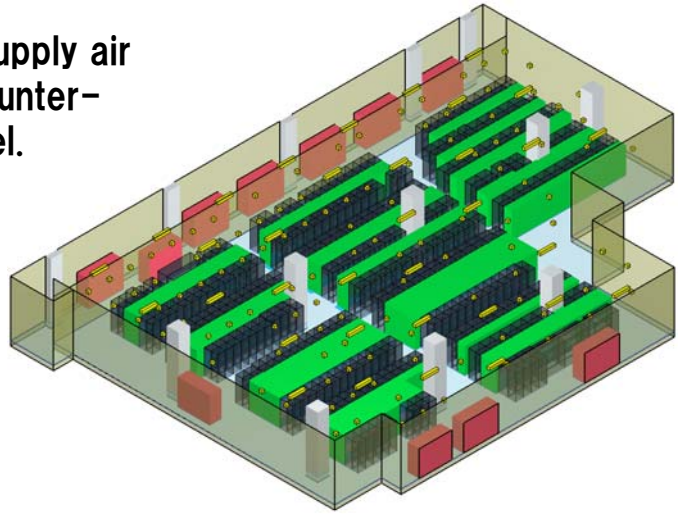
Suction temperature around racks is high at the high temperature point,

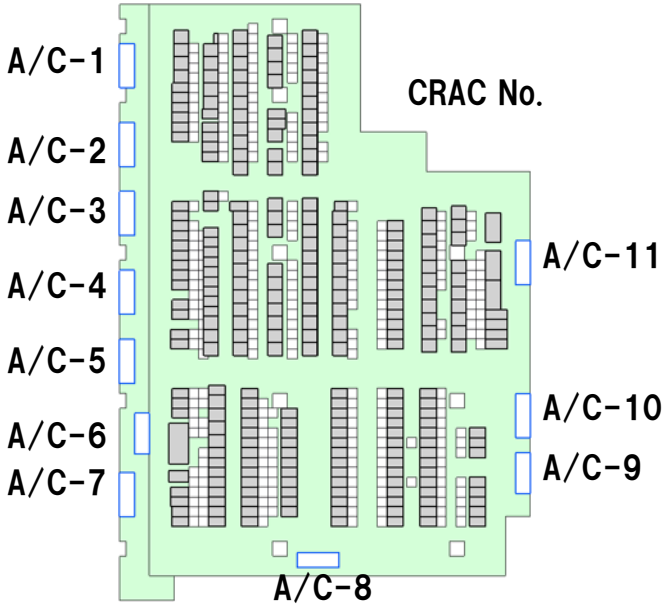
To solve above issues, fixing air supply control is effective.

5-(3) Issues and Countermeasures, <Shift to temperature control by air supply>

Countermeasure ② Fixing Air Flow Temperature

All conditions except supply air volume are same as counter-measure ① : CFD model.





Fixing Air Flow Temperature

Countermeasure ①

	Volume flow [m3/h]	Temperature [℃]
A/C-1	22,700	15.1
A/C-2	22,900	15.0
A/C-3	22,200	13.1
A/C-4	22,000	13.8
A/C-5	21,200	13.7
A/C-6	21,100	14.4
A/C-7	22,300	13.8
A/C-8	13,300	18.4
A/C-9	10,000	14.0
A/C-10	7,800	12.2
A/C-11	7,300	14.5

Countermeasure ②

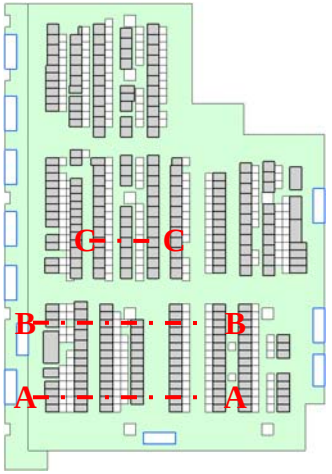
	Volume flow [m3/h]	Temperature [℃]
A/C-1	22,700	14.5
A/C-2	22,900	14.5
A/C-3	22,200	14.5
A/C-4	22,000	14.5
A/C-5	21,200	14.5
A/C-6	21,100	14.5
A/C-7	22,300	14.5
A/C-8	18,300	14.5
A/C-9	10,000	14.5
A/C-10	7,800	14.5
A/C-11	7,300	14.5

Countermeasure ② Fixing Air Flow Temperature

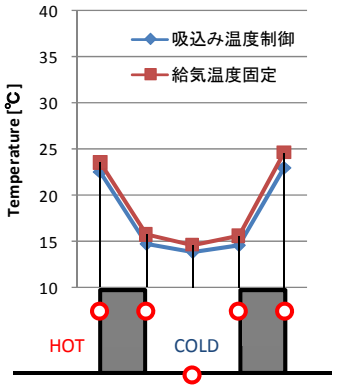
By fixing temperature air supply, suction temperature in each rack can be homogenization

↓

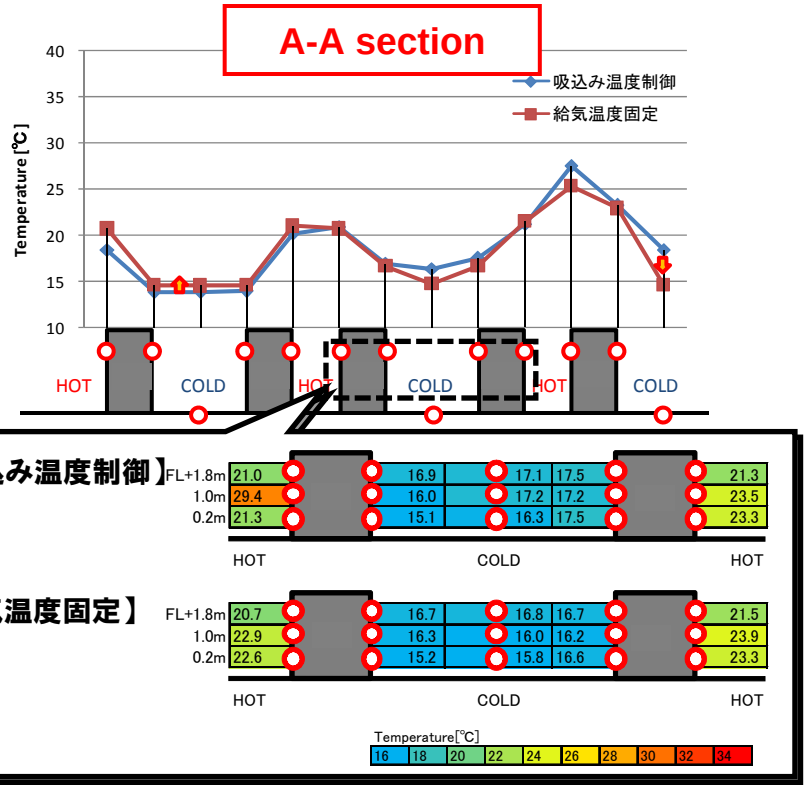
It is expected energy-saving operation such as increasing temperature of air supply, reduction of air volume etc.



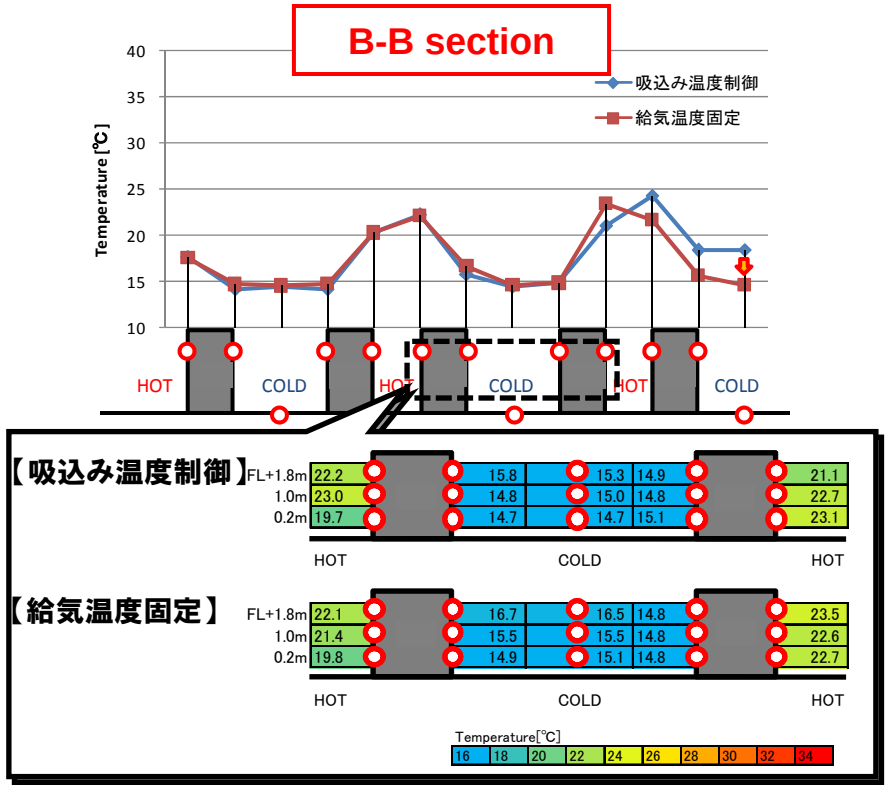
C-C section



A-A section



B-B section



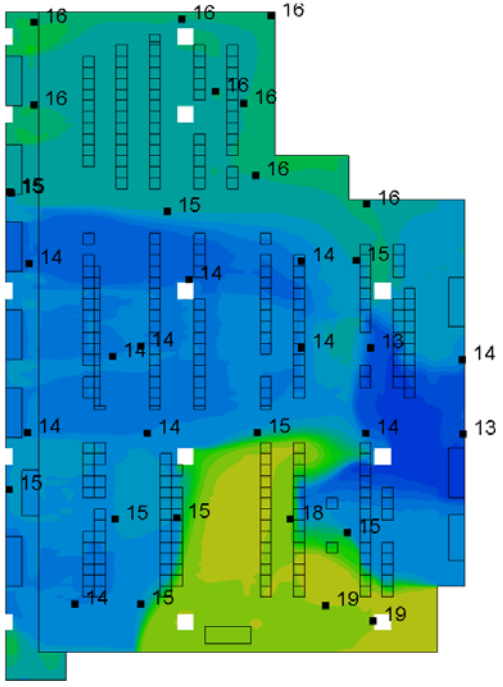
Countermeasure ② Fixing Air Flow Temperature

Temperature [℃]
15 20 25 30

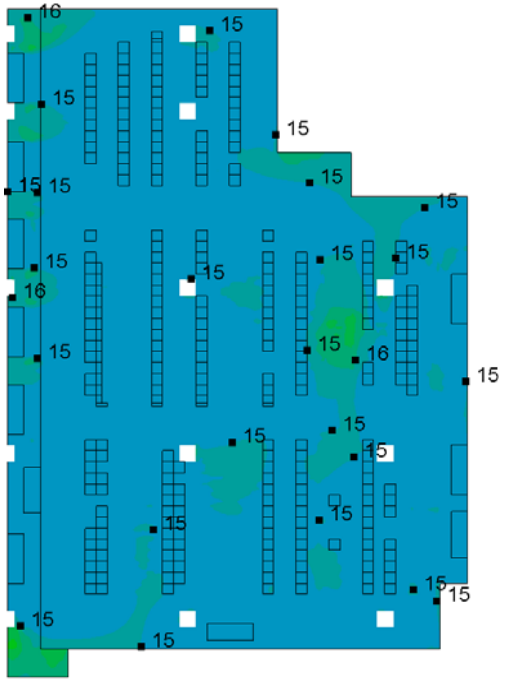
Horizontal

FL-0.2m

【Suction temperature control】



【Fixing air supply control】



Temperature under floor chamber is uniformized.

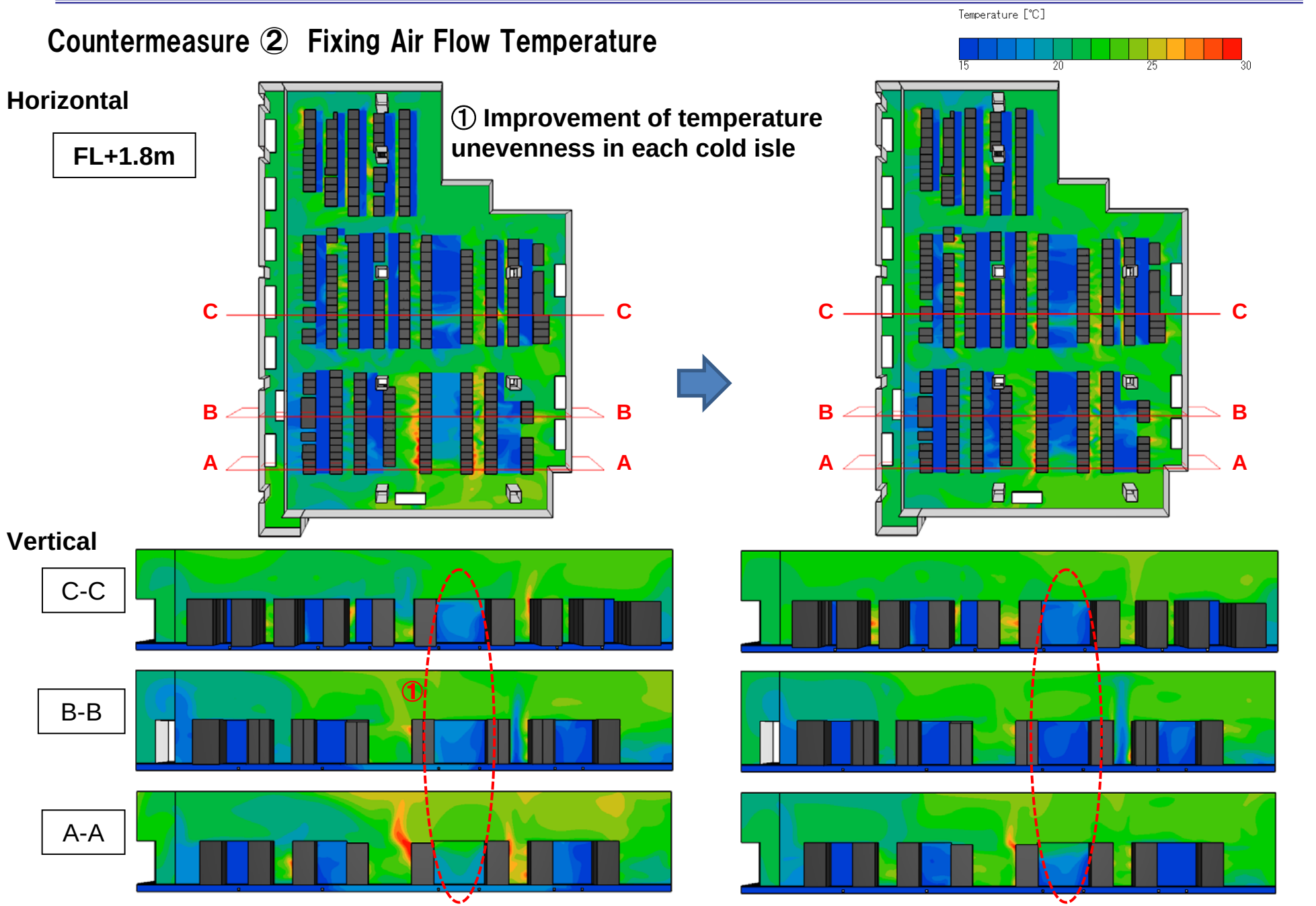
↓

・Decreasing mixing-cross

・Decreasing possibility of hot spot emersion

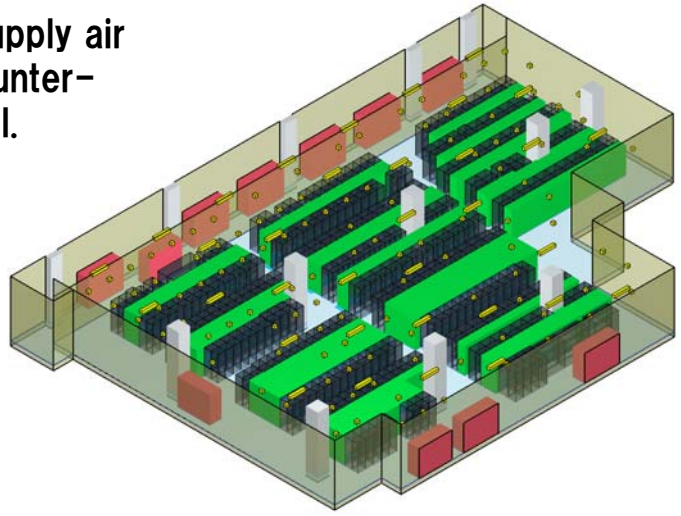
5-(3) Issues and Countermeasures, <Shift to temperature control by air supply>

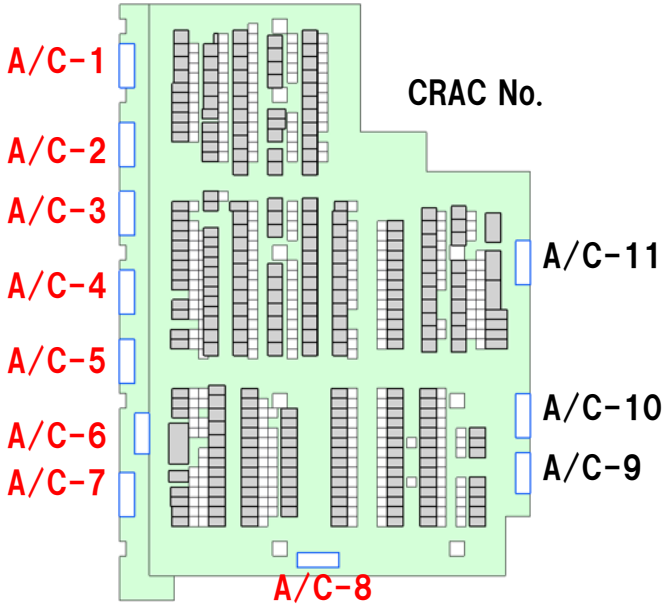
Countermeasure ② Fixing Air Flow Temperature



Countermeasure ③ Number/air flow control of A/C

All conditions except supply air volume are same as counter-measure ② : CFD model.





Countermeasure ②

	Volume flow [m3/h]	Temperature [℃]
A/C-1	22,700	15.1
A/C-2	22,900	15.0
A/C-3	22,200	13.1
A/C-4	22,000	13.8
A/C-5	21,200	13.7
A/C-6	21,100	14.4
A/C-7	22,300	13.8
A/C-8	13,300	18.4
A/C-9	10,000	14.0
A/C-10	7,800	12.2
A/C-11	7,300	14.5

Countermeasure ③

Decrease 80% CRAC air supply

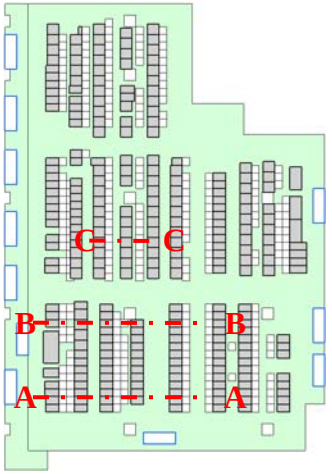
	Volume flow [m3/h]	Temperature [℃]
A/C-1	18,100	14.5
A/C-2	18,400	14.5
A/C-3	17,800	14.5
A/C-4	17,500	14.5
A/C-5	17,000	14.5
A/C-6	16,900	14.5
A/C-7	14,700	14.5
A/C-8	14,700	14.5
A/C-9	10,000	14.5
A/C-10	7,800	14.5
A/C-11	7,300	14.5

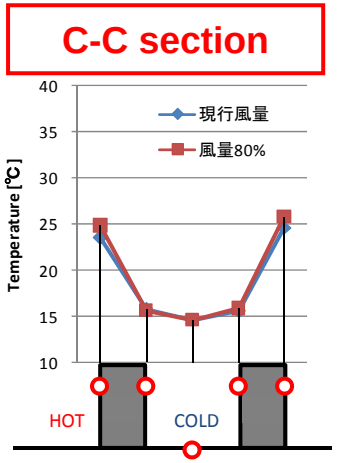
Countermeasure ③ Number/air flow control of A/C

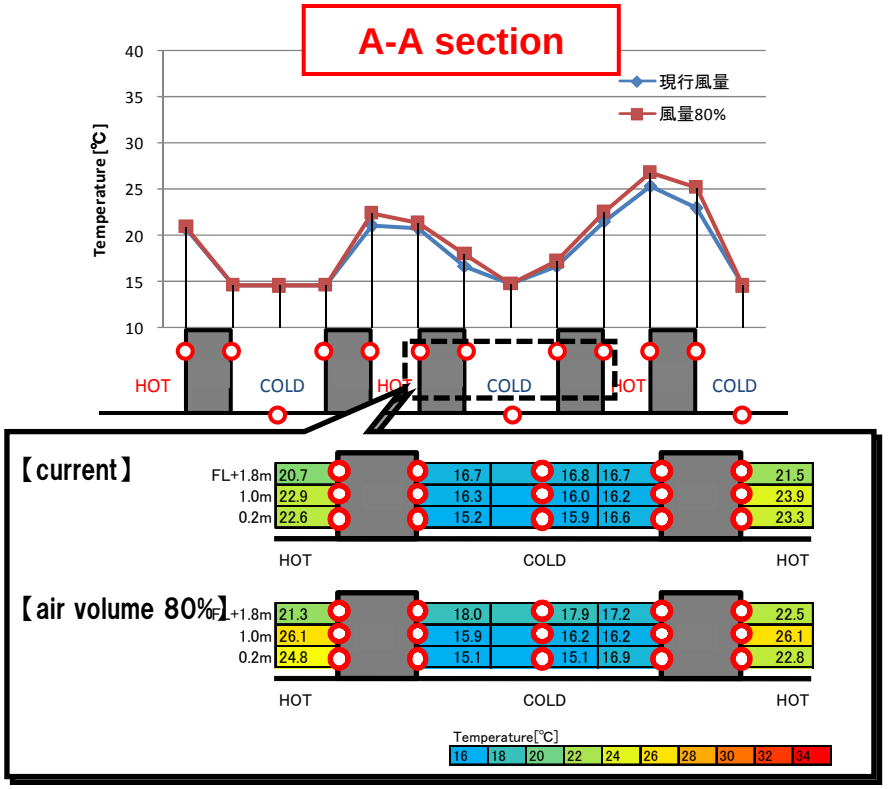
Due to reducing 20% air volume, overall temperature becomes high, however temperature in cold aisle is satisfied with less than 25℃.

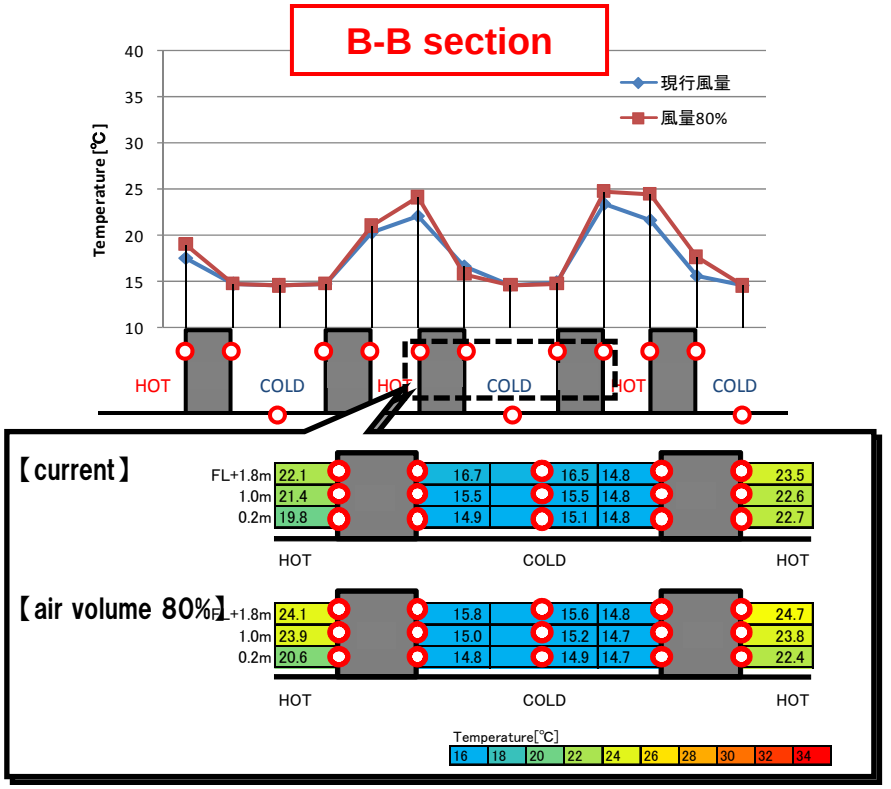
↓

It is expected further reduction of air volume.







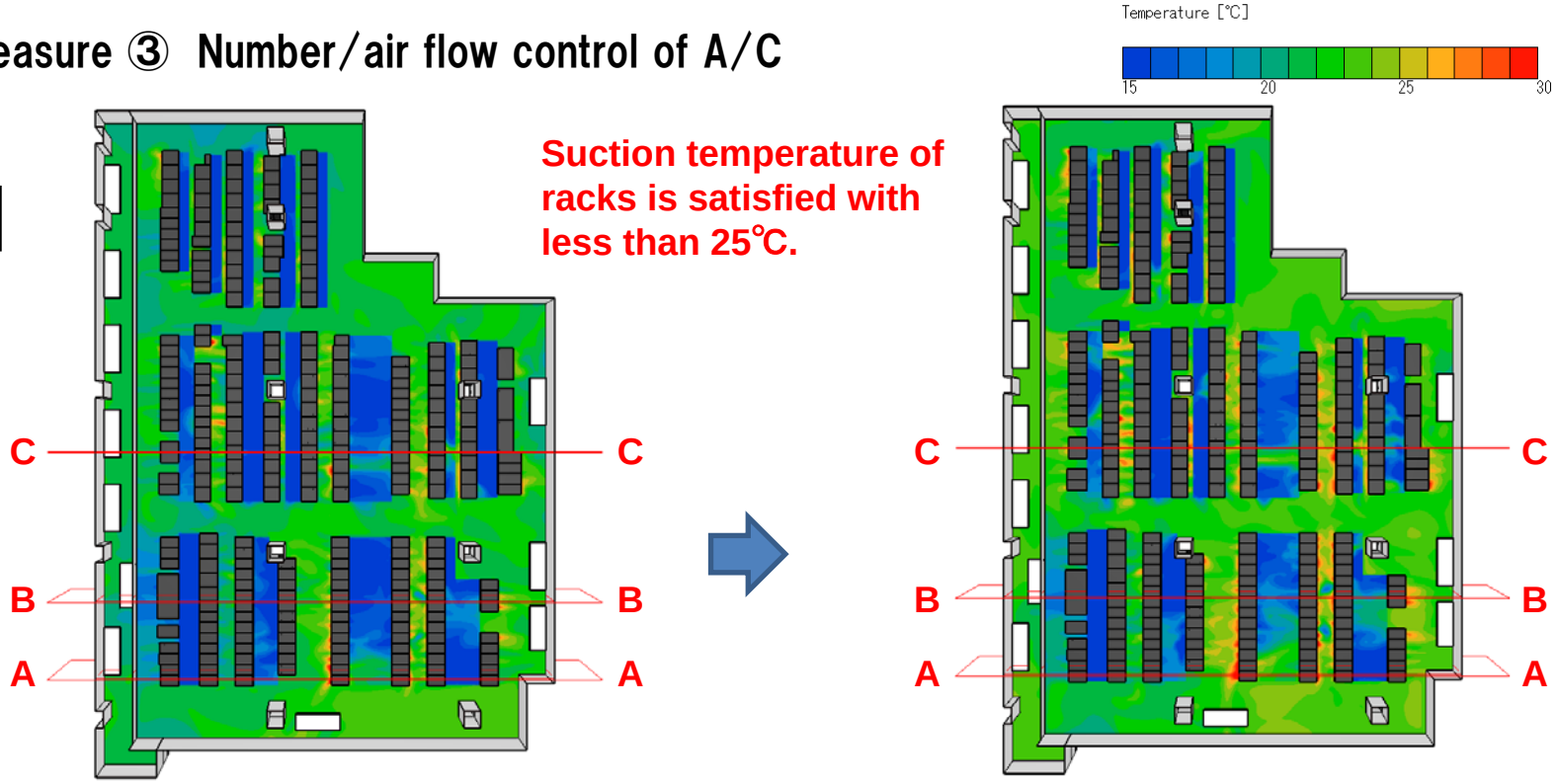


5-(4) Issues and Countermeasures,<Optimization of Air Blower Control>

Countermeasure ③ Number/air flow control of A/C

Horizontal

FL+1.8m



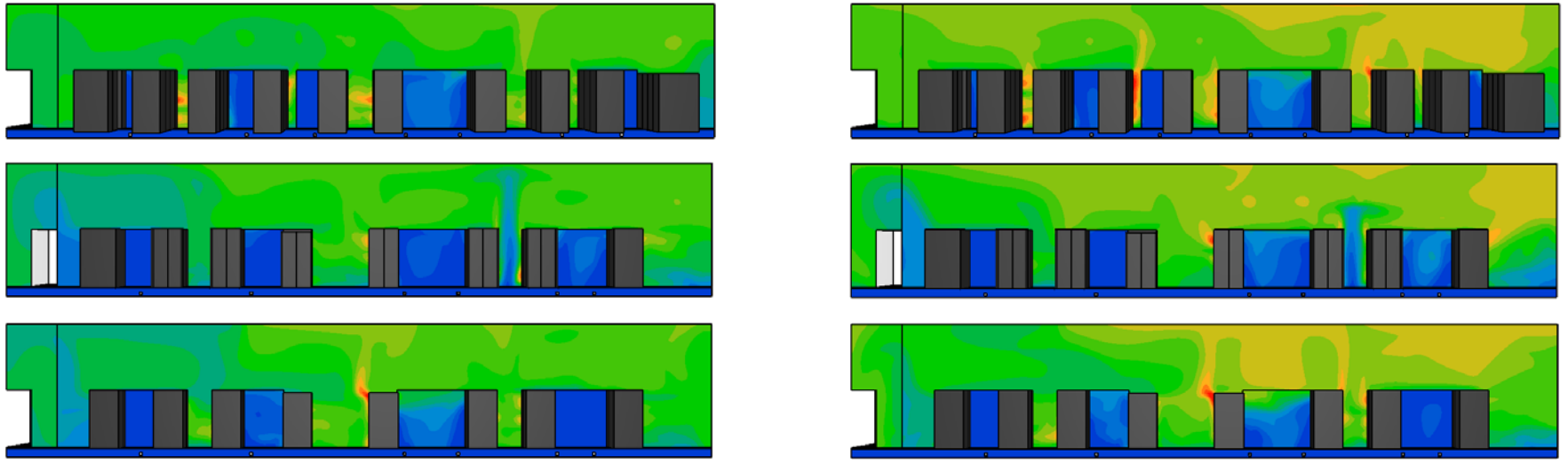
Suction temperature of racks is satisfied with less than 25℃.

Vertical

C-C

B-B

A-A



<Sector 2>

Estimated Effect of Air Blow Control

Electrical power consumption by all A/Cs (estimated) : 295 kW

Electrical power consumption by A/C indoor unit fan (estimated) :

295×28%/11=7.5 kW/A/C

7.5 kW/A/C ×8 A/Cs =60 kW

Estimated reduction of Electrical power consumption

A/C Air flow volume decreasing(80%) by capping ⇒ 30 kW

⇒ 263,000 kWh/year (8760h))

With the above implementation, PUE value can be improved as follows:

(Electrical power by all A/Cs :

295 kW ⇒ 265 kW (10%DN))

<Sector 2>

COP of present CRAC (Coefficient Of Performance)2.9→ The latest specification about 3.73

When CRAC is renewal, it leads to energy saving when a highly effective type is selected .

Trial calculation of effect

Present CRAC power consumption 295KW

COP2.9→ When renewal to the CRAC of COP3.73

578, 000KWh ⇒ 106, 700 SGD/Year

6-(1) Improvement on other equipment and operation

Visualization

- Automatic measurement of PUE by addition of current and watthour meter.
- Temperature measurement of server rack and temperature survey with periodic thermostat camera by periodic air volume control and airflow control.

Effective use for energy

- Lighting control with human sensor in machine room. (security synchronization)
- Reduction in volume of fresh air with CO2 sensor.

Operation

- Installation of panel of blank in saver rack.
- Improvement of UPS load factor (thinning out of the number of UPS).

It would be greatly appreciated if it could contribute to the reduction of the use energy in the data centers of your own country about the result of the survey and measures that were going to be introduced in this seminar.

Thank you.

NTT DATA INTELLILINK CORPORATION

TAKASAGO THERMAL ENGINEERING Co. Ltd