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**Commissioning test for existing large
scale building using simulation modeling**

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Introduction

Before an upcoming renovation of the existing building, various energy-saving effect items were examined and assessed on the 24th of the building office.

Since the result of the assessment was greater than expected, the analysis of the assessment result was conducted by using simulation to clarify the mechanism of the energy saving.

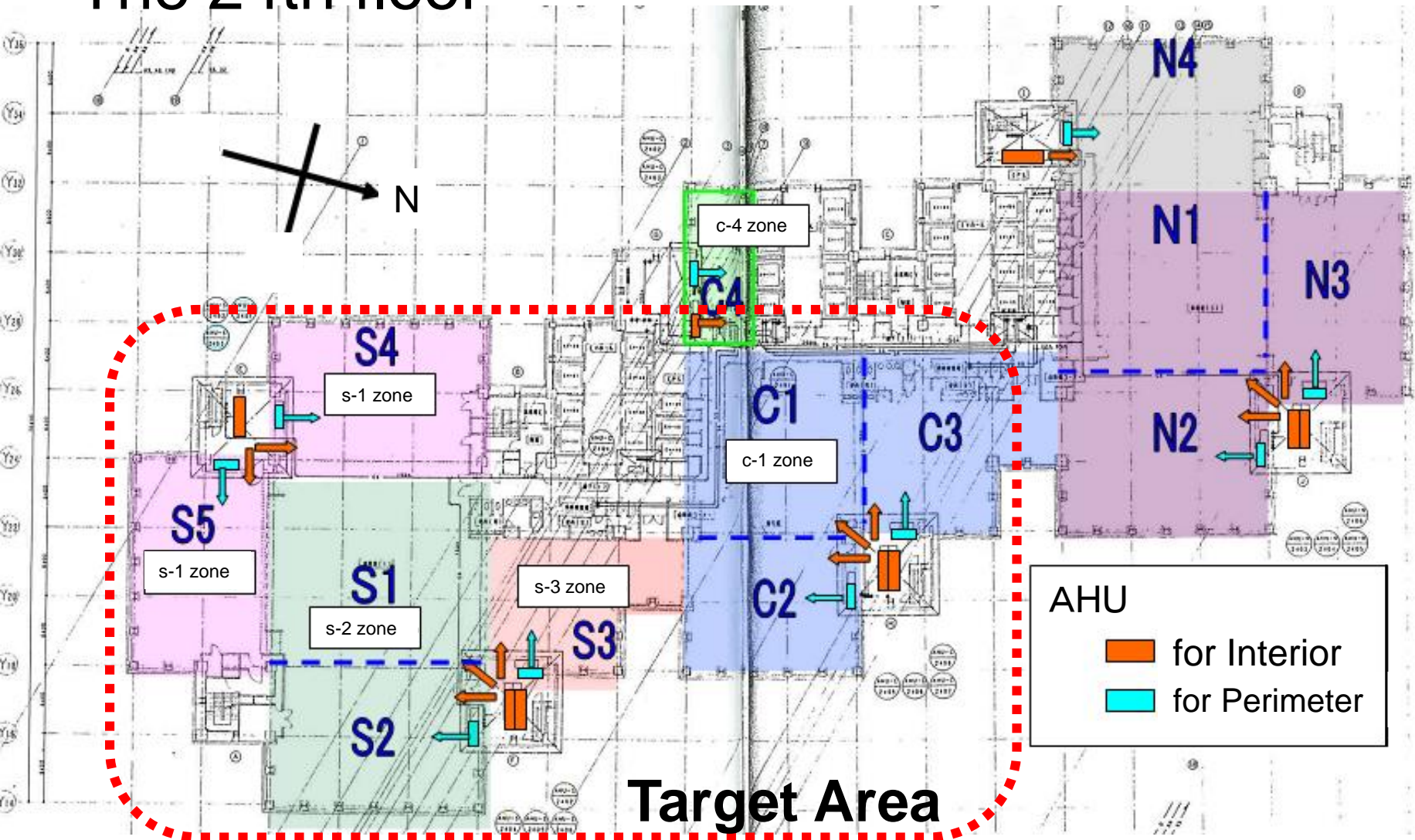
This presentation presents the energy-saving method and evaluation by BEMS data, and analytical method by using simulation and the calculation result.

Profile of the Building

Location	Shinjuku-ku, Tokyo
Scale	The fifth floor under the ground The 52nd floor above the ground 235m in height
Total floor area	About 264,000m²
Completion	Constructed in 1994
Use	Office : from 8th to 37th floor Hotel : from 39th to 52th floor Shop : from B1th to 7th floor

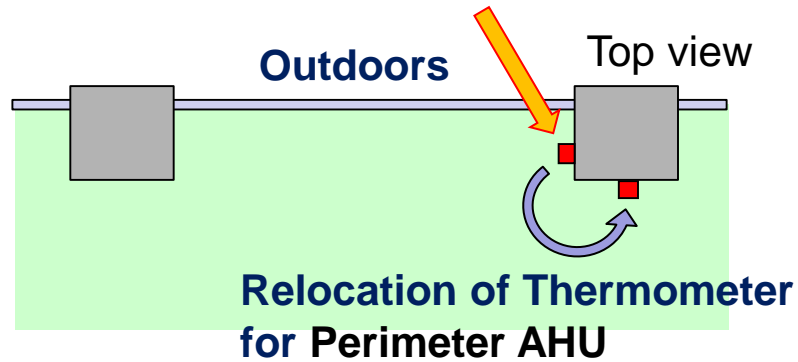
The Target Area

The 24th floor



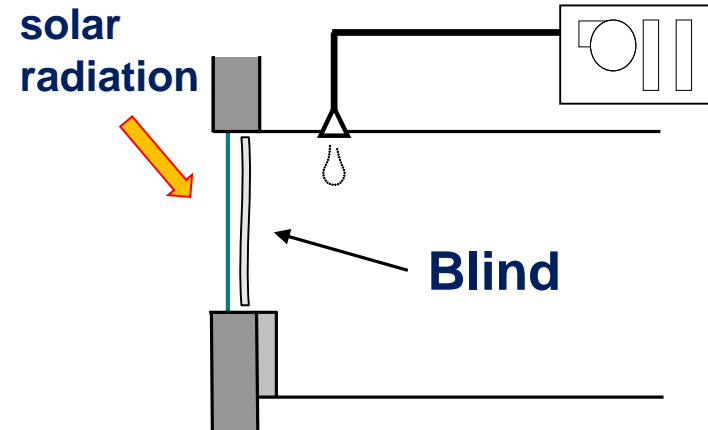
Improvement Item for Energy Saving -1

(1) Relocation of the Thermometer



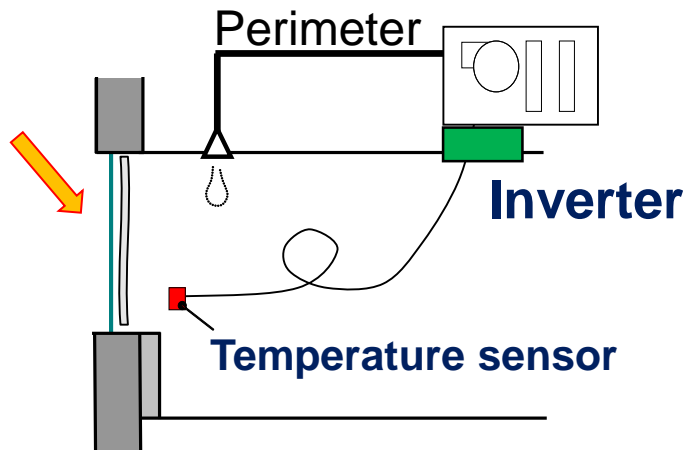
Remove Effect of the Solar Radiation

(2) High-performance Blind



Reduction of the Air Conditioning Load

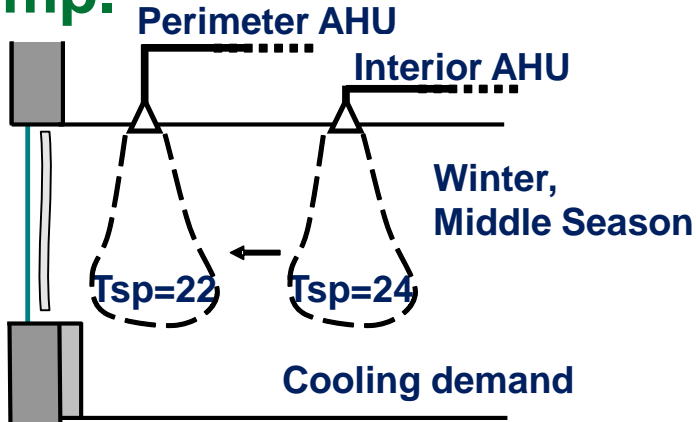
(3) Inverter Control of the Fan



Reduction of the Fan Electricity

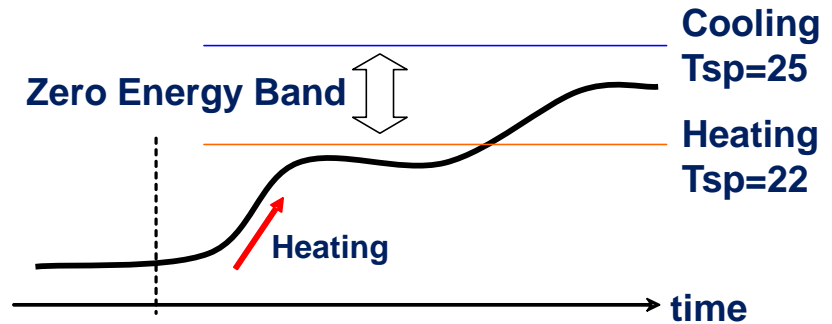
Improvement Item for Energy Saving -2

(4) Adjustment of the Setting Temp.



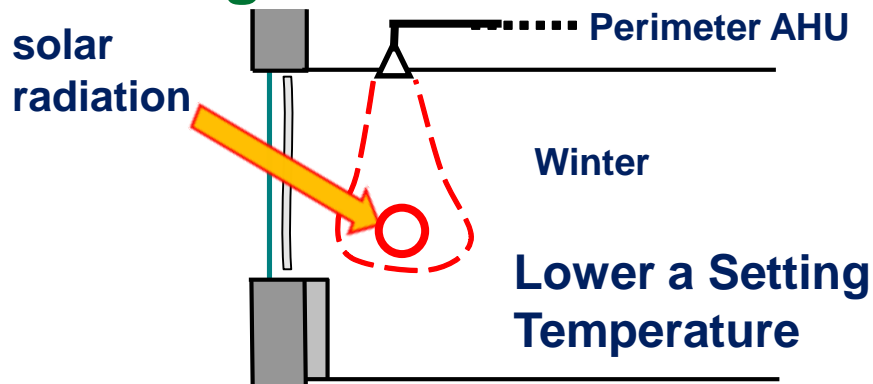
Reduction of the Mixing Loss

(5) Zero Energy Band for Perimeter AHU



Prevention of the Excessive Operation

(6) Temperature setting Using of Radiation heat



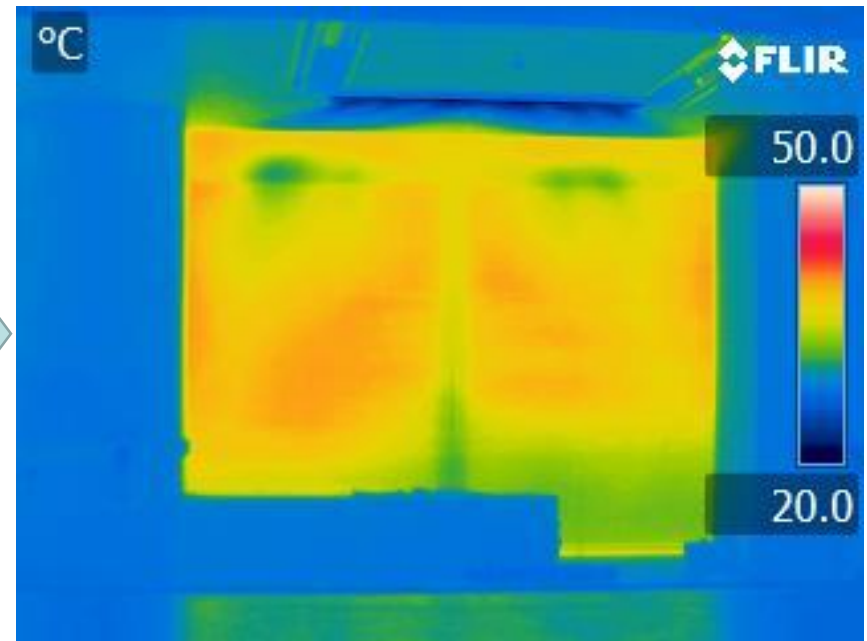
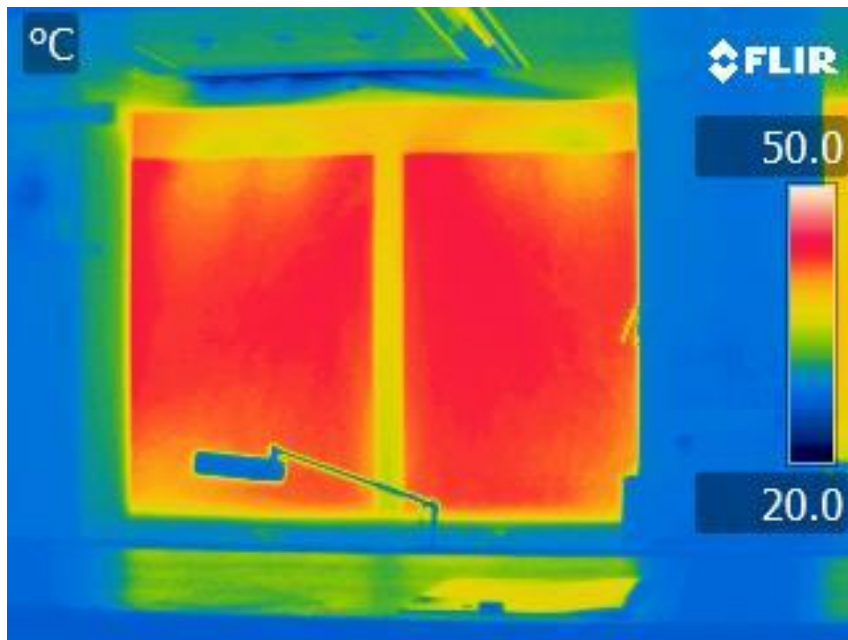
Reduction of the Air Conditioning Load

Verification of the Improvement - 1

The effect of each improvement item were verified

Thermal Performance of the Blind

2013 August



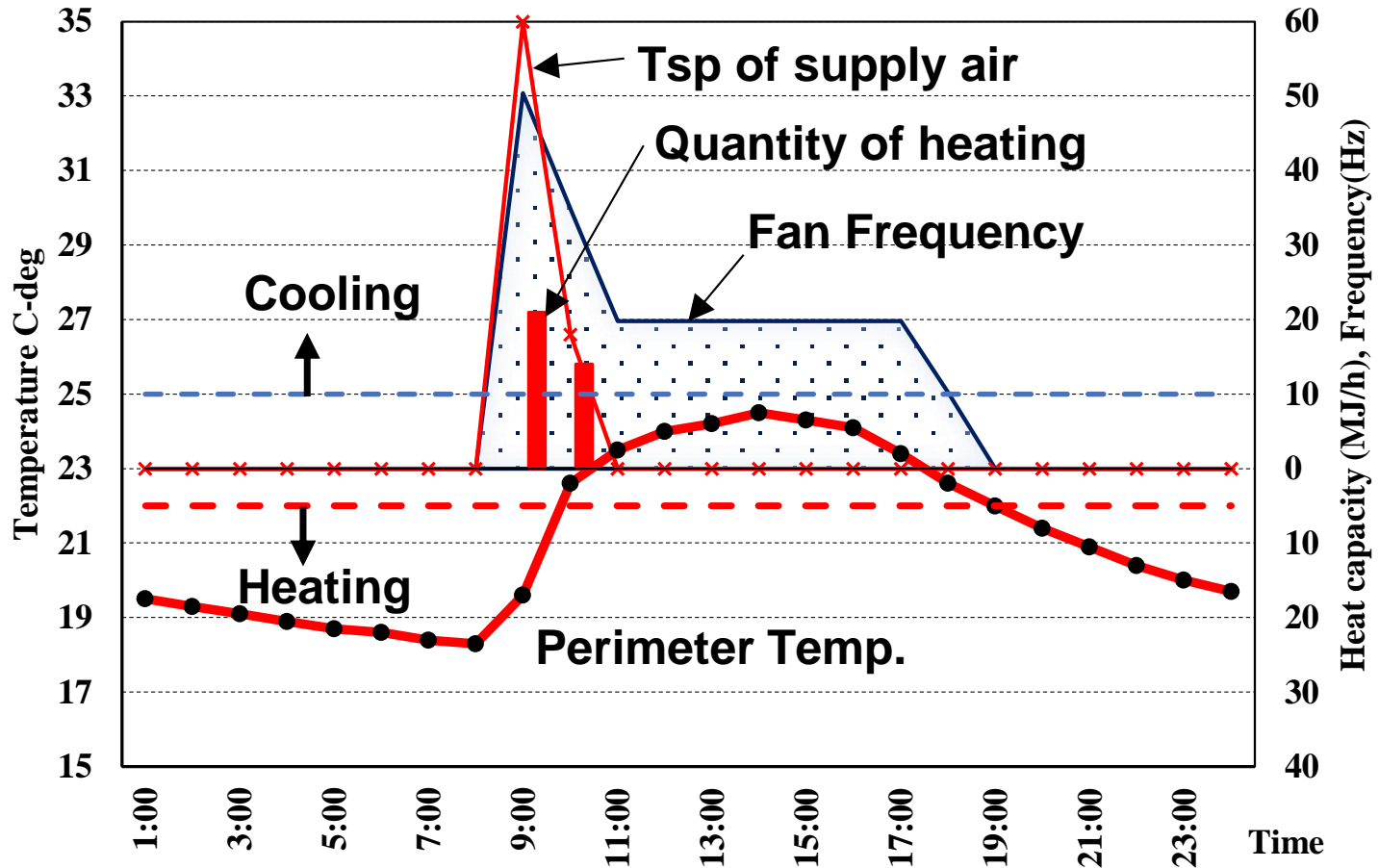
Existing Rolling Screen

High-Performance Blind

Confirm the heat load reduction of the window

Verification of the Improvement - 2

Inverter Control of the Fan



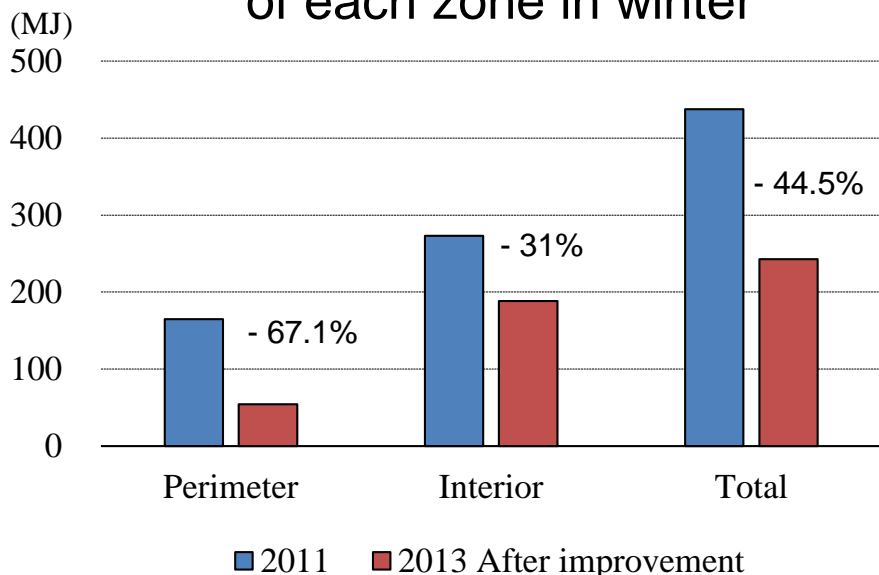
Operation check of fan control, zero energy band

2011 : Before improvement

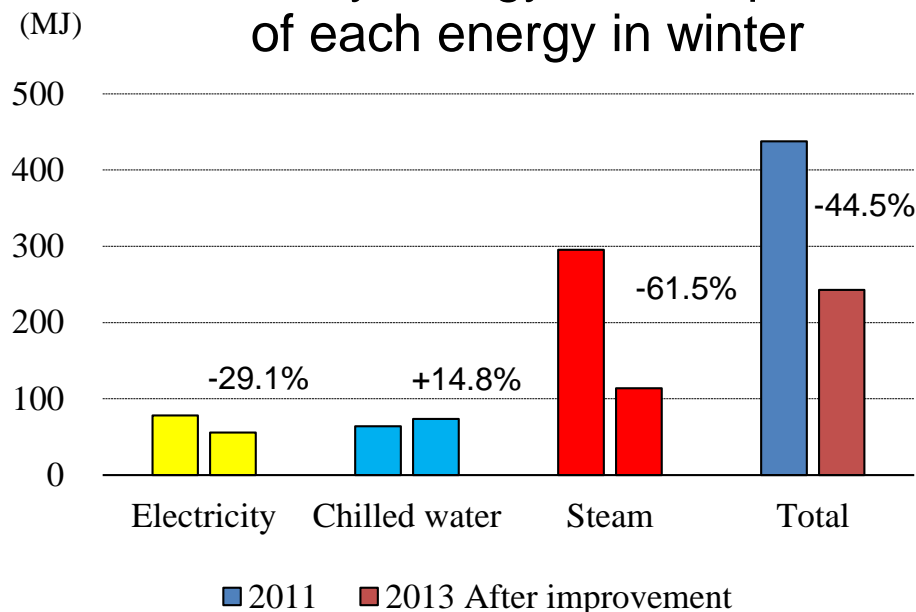
2013 : After improvement

Operational state is about the same

Primary energy consumption of each zone in winter



Primary energy consumption of each energy in winter

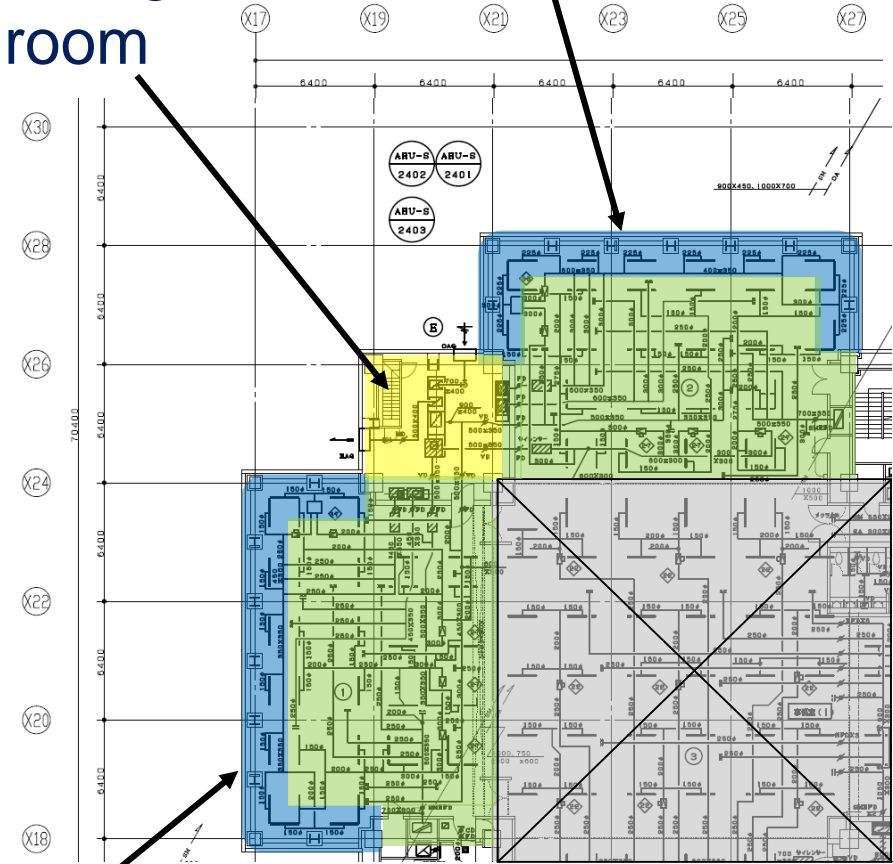
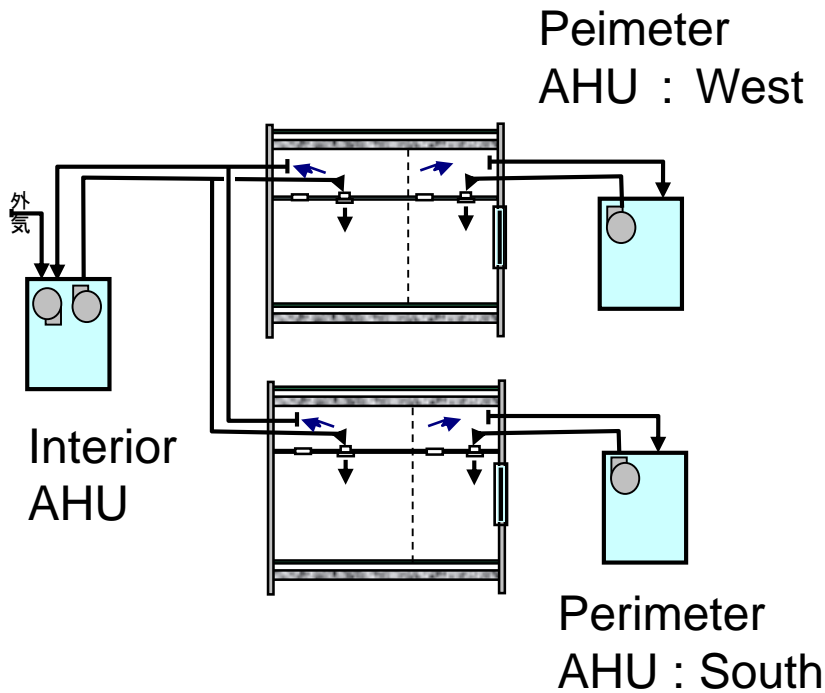


Explanation is impossible by big effect more than expected >>> Analyze it by simulation

Analytic Target by the Simulation

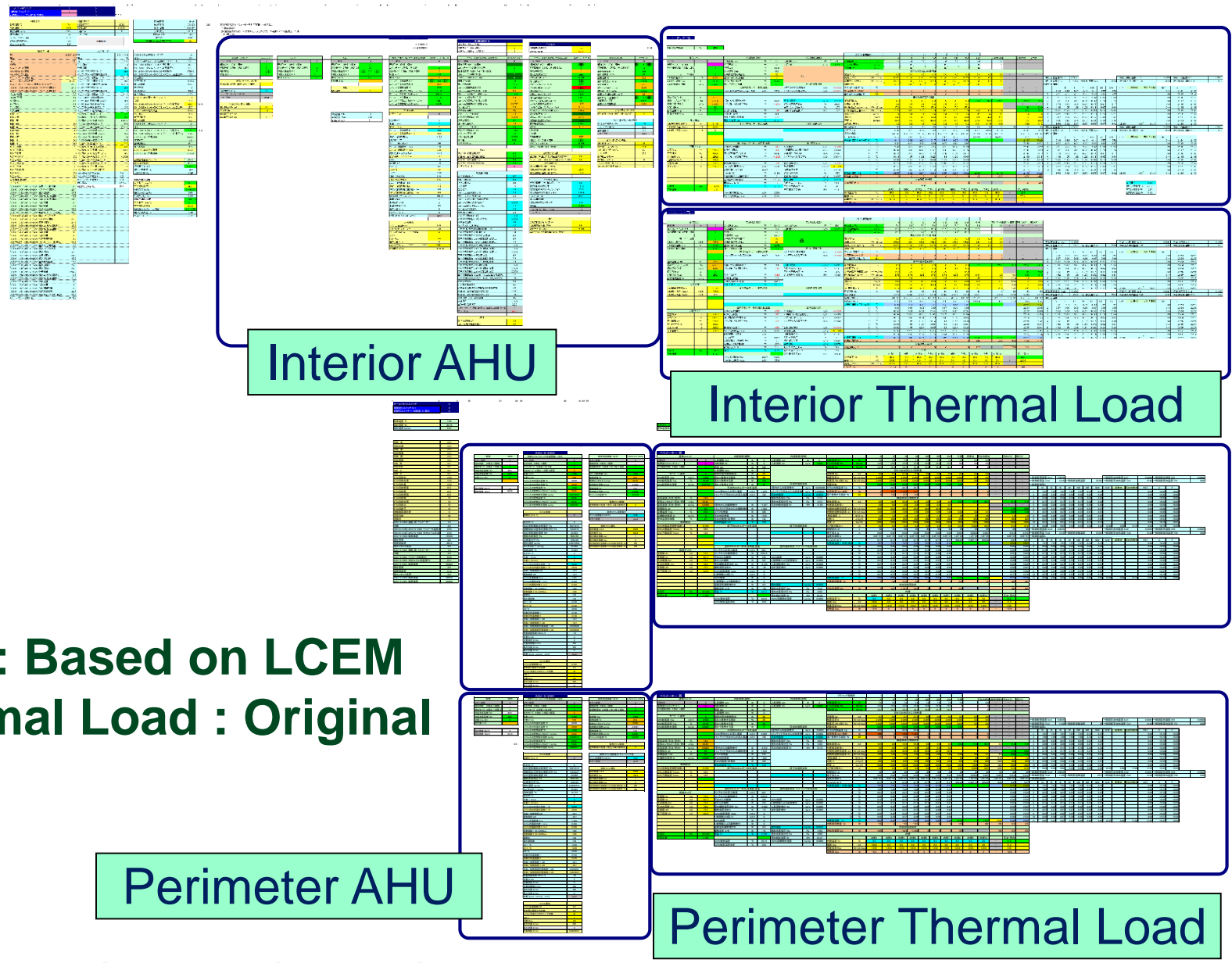
air conditioning
machine room

West Perimeter



South Perimeter

Simulation Tool of LCEM and Indoor Thermal Load



AHU : Based on LCEM
Thermal Load : Original

Perimeter AHU

Perimeter Thermal Load

Thermal Load Program on the Spreadsheet

Ceiling chamber

Indoor air

Heat Flow from Window

N E S W

Heat flow from Wall

通信ユニット				内部発熱(顕熱)				内部発熱(潜熱)			
ERROR	-	0	人員顕熱 qms	W	0	人員潜熱 qml	W	0	人員潜熱 Xml	kg/h	0.000
時間送りスイッチ 0:1	-	0	内部発熱 Qr	W	0	人員潜熱 Xm	kg/h	0.000			
ACU-3運転状態 U:停止 1:運転	-	0	照明 Qlg	W	0						
			人員顕熱 Qms	W	0						
モード 1:通常		2	照明の室内発熱割合	W	0						
AHU給気量 Vsa	m3/h	0	直ちに発熱する割合	%	80						
AHU給気温度 Tsa	°C	32.00	直ちに発熱する量	W	0						
AHU給気絶対湿度	kg/kg	0.0000	遅れて発熱する量	W	0						

ブラインド閉鎖率		1	1	1	1	1	1	1	1
外気温度 To	°C	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ガラス日射量 Ra	W/m2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
日射量 Ra	W/m2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

天井内エネルギー収支温度

IAHU2402室内からの流入風量 m3/h 0

1室内からの顕熱増分 W 0

1ベリ南からの顕熱増分 W -158

スラブ伝熱量 W 1.126

天井材伝熱量 W -1.441

天井内発熱+床骨材 W 431

天井内温度 Tcel °C 22.8

湿度収支

IAHU給気風量 Vade m3/h 0

IAHU給気風量 Vade m3/h 0

IAHU給気風量 Vade m3/h 0

IAHU給気風量 Vade m3/h 0

制御設定

AHU風量調整係数 k - 0.010

AHU最大風量 Vamax m3/h 4.500

AHU最小風量 Vamin m3/h 0

部屋サイズ

室面積 Ar m2 226.6

室容積 Vr m3 609.6

天井面積 Acl m2 226.6

天井内容積 Vcl m3 339.9

床面積 Afl m2 226.6

床下容積 Vfl m3 226.6

部屋サイズ

室面積 Ar m2 226.6

室容積 Vr m3 609.6

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床下容積 Vfl m3 226.6

湿度収支

IAHU給気風量 Vade m3/h 0

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湿度収支

IAHU給気風量 Vade m3/h 0

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IAHU給気風量 Vade m3/h 0

Calculate Crank Nicholson by finite volume method

$$\rho c \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} \left(\lambda \frac{\partial T}{\partial x} \right)$$

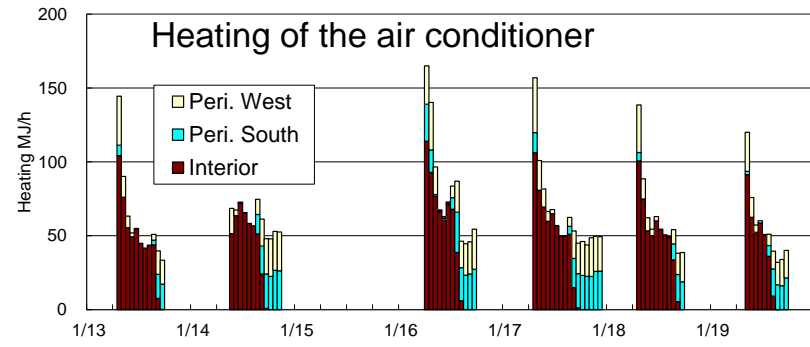
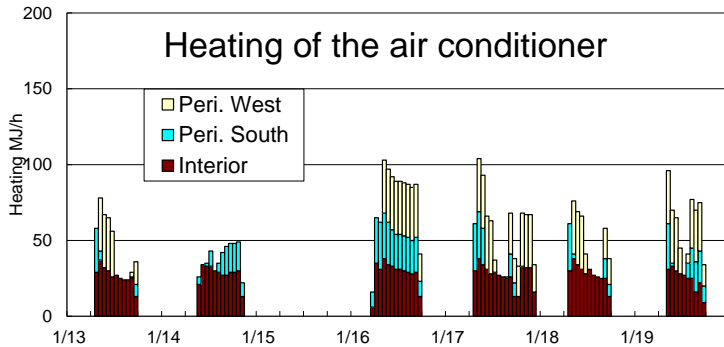
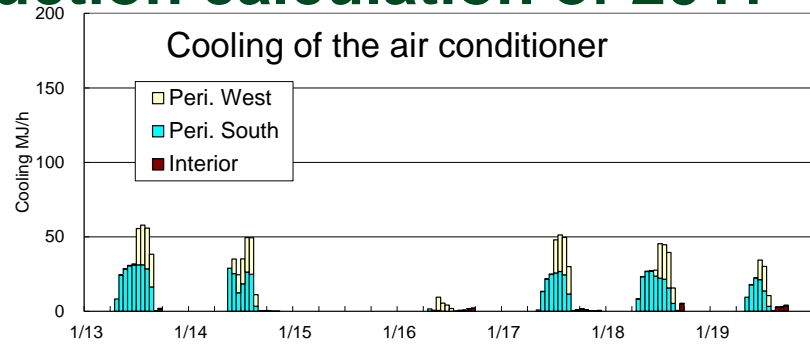
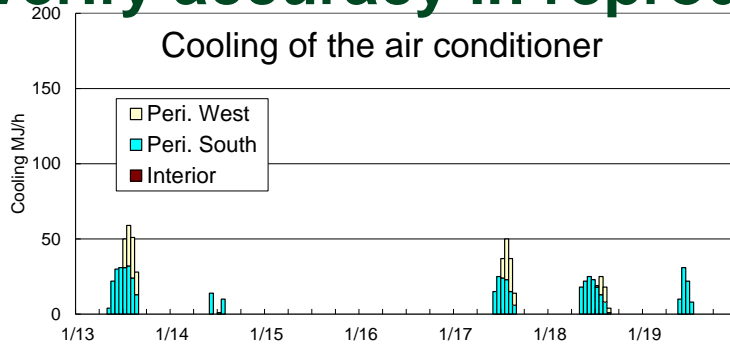
Proportional control of air volume

$$V \rho c \frac{\partial T}{\partial t} = \Sigma Q + \rho c v (T_s - T_r)$$

Time step = 80 seconds

Verification of the calculation accuracy

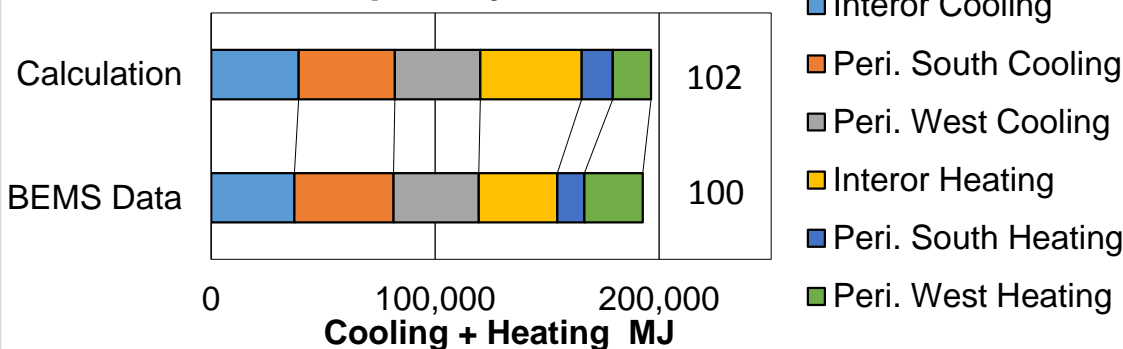
Verify accuracy in reproduction calculation of 2011



BEMS Data

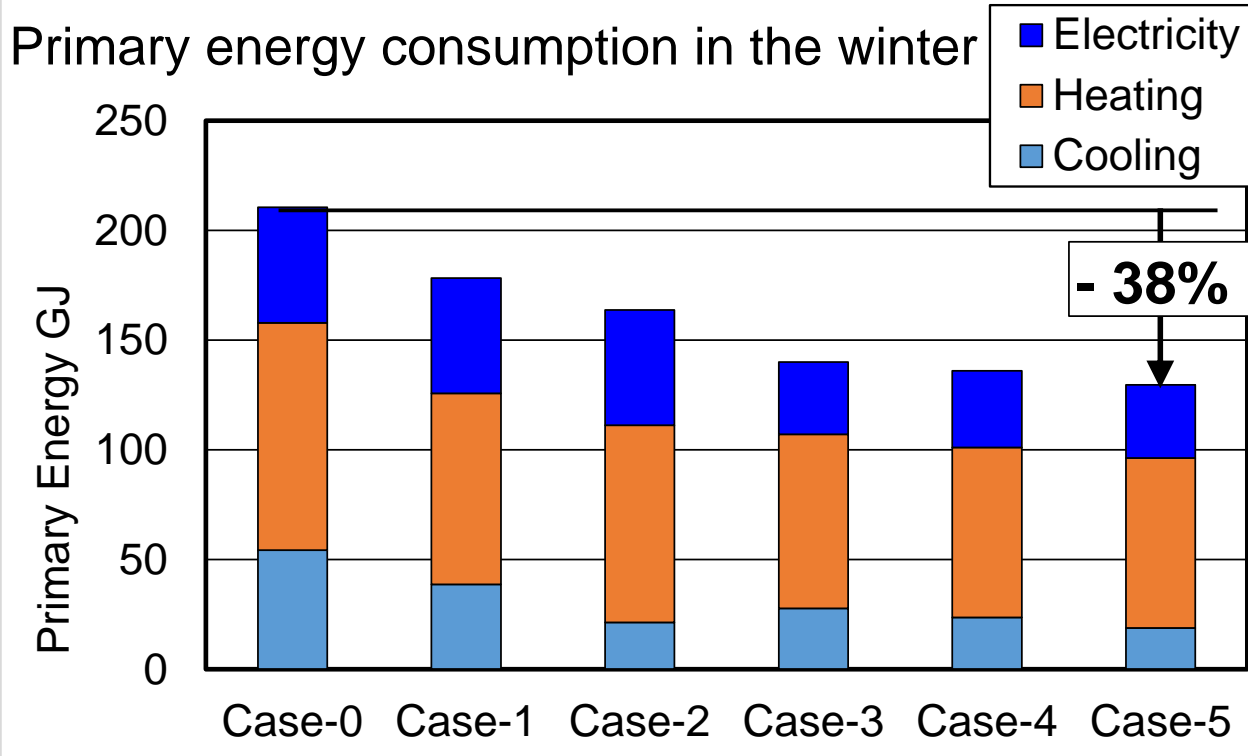
Calculated Value

Annual heat quantity of the AHU



The annual consumption accorded, but further improvement is necessary

Analysis of the improvement effect by the simulation



No.	Item	%
C-0	Before improvement	100
C-1	Relocation of the Thermometer	85
C-2	High-performance Blind	78
C-3	Inverter Control of the Fan	67
C-4	Adjustment of the Setting Temp.	65
C-5	Zero Energy Band for Perimeter AHU	62
C-6	Temp. setting Using of Radiation	Not ready

Mixing loss disappeared by C-1

The thermostat of perimeter is heated in solar radiation, and cool too much it. To disappear cool too much, the interior is heated too much.

Comparison between of 2011 and 2013 BEMS data

>>>> **43.5% Reduction**

Calculation by case study



>>>> **38% Reduction**

Conclusion

The mechanism of the energy saving effect was clarified through simulation; a major contributing factor to energy saving was relocation of the temperature sensor which was conducted at lower cost.

In the process of the analysis and the evaluation of the operation phase, this simulation method was shown to be valid.

This assessment is continuing this summer to confirm the last year's results and conduct the energy saving effect evaluation in the summer.

Furthermore, the thermal load calculation including the spatial distribution is under development to improve accuracy of the simulation.