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Experimental Study in Energy Performance of Temperature and Humidity Independent Control System with Multiple Split Air-Conditioning System

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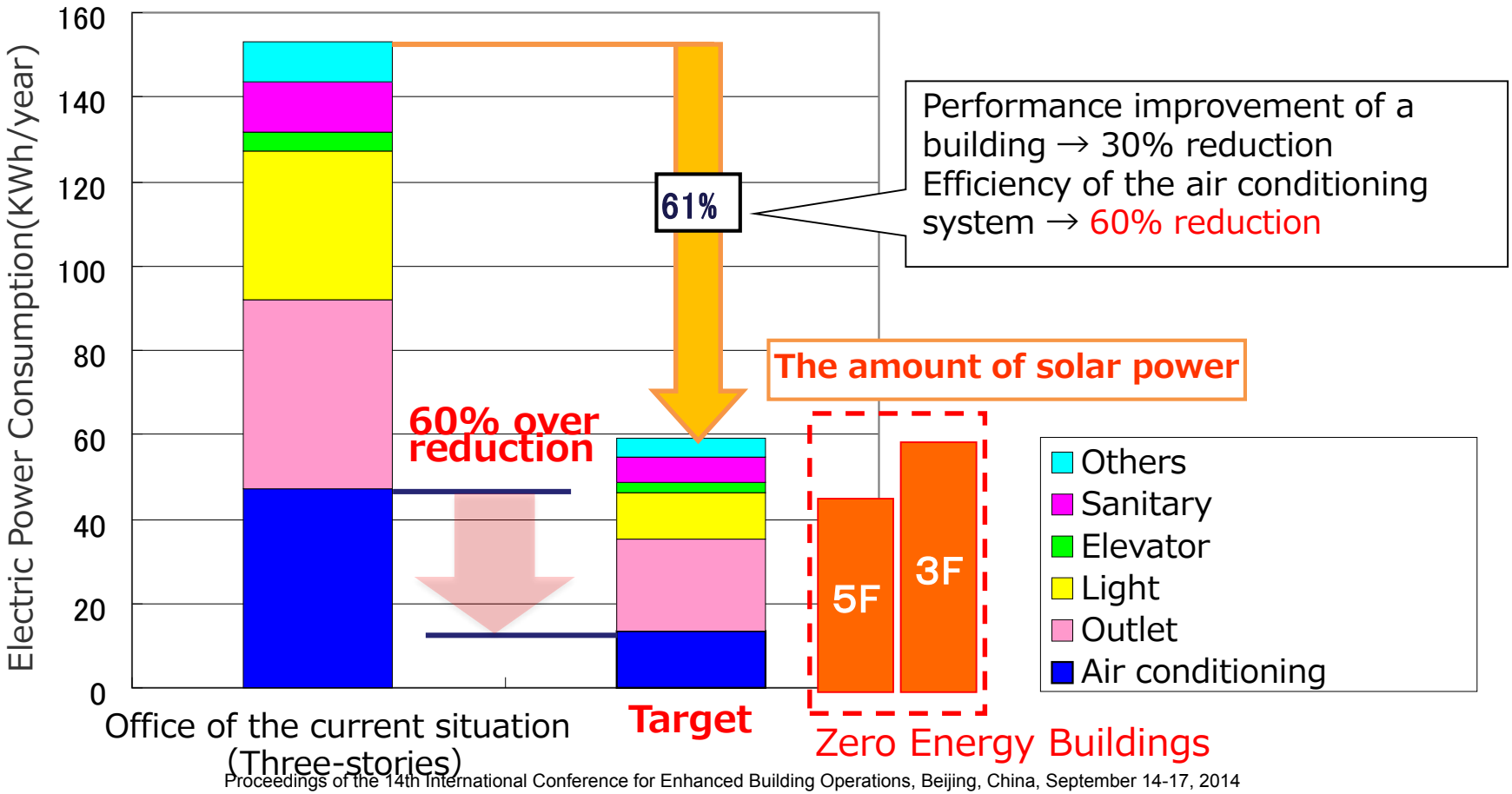
1. Overview of the developed system
2. Demonstration test
3. Development of a simulation model
4. Evaluation for application to a design tool
5. Conclusions

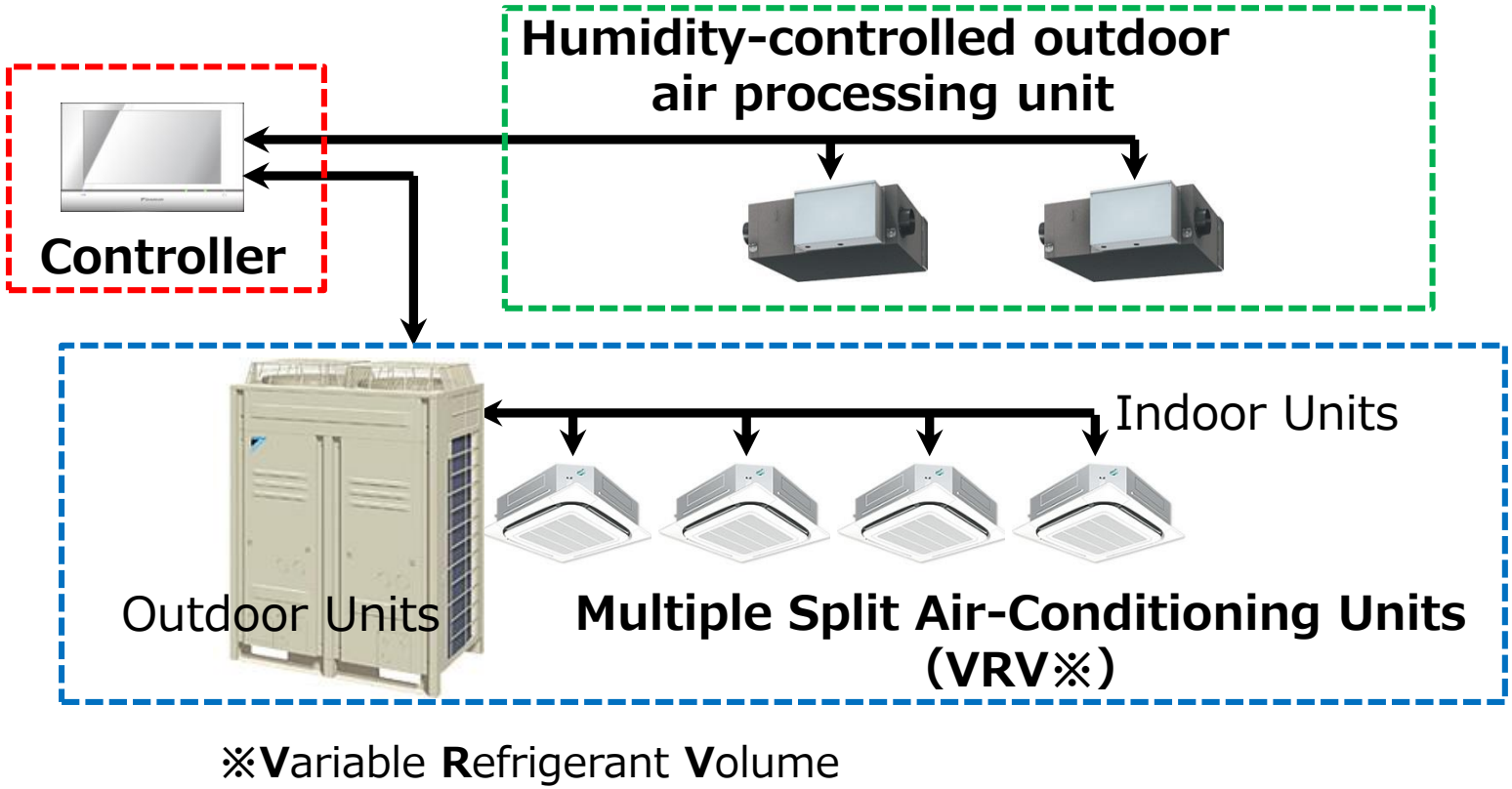
1.Overview of the developed system

The multiple split air-conditioning system that we have developed is designed to reduce year-round power consumption by more than 60% over conventional systems and to contribute to realizing Zero Energy Buildings (ZEB).



1.Overview of the developed system

Developed system which consists of a combination of the following.

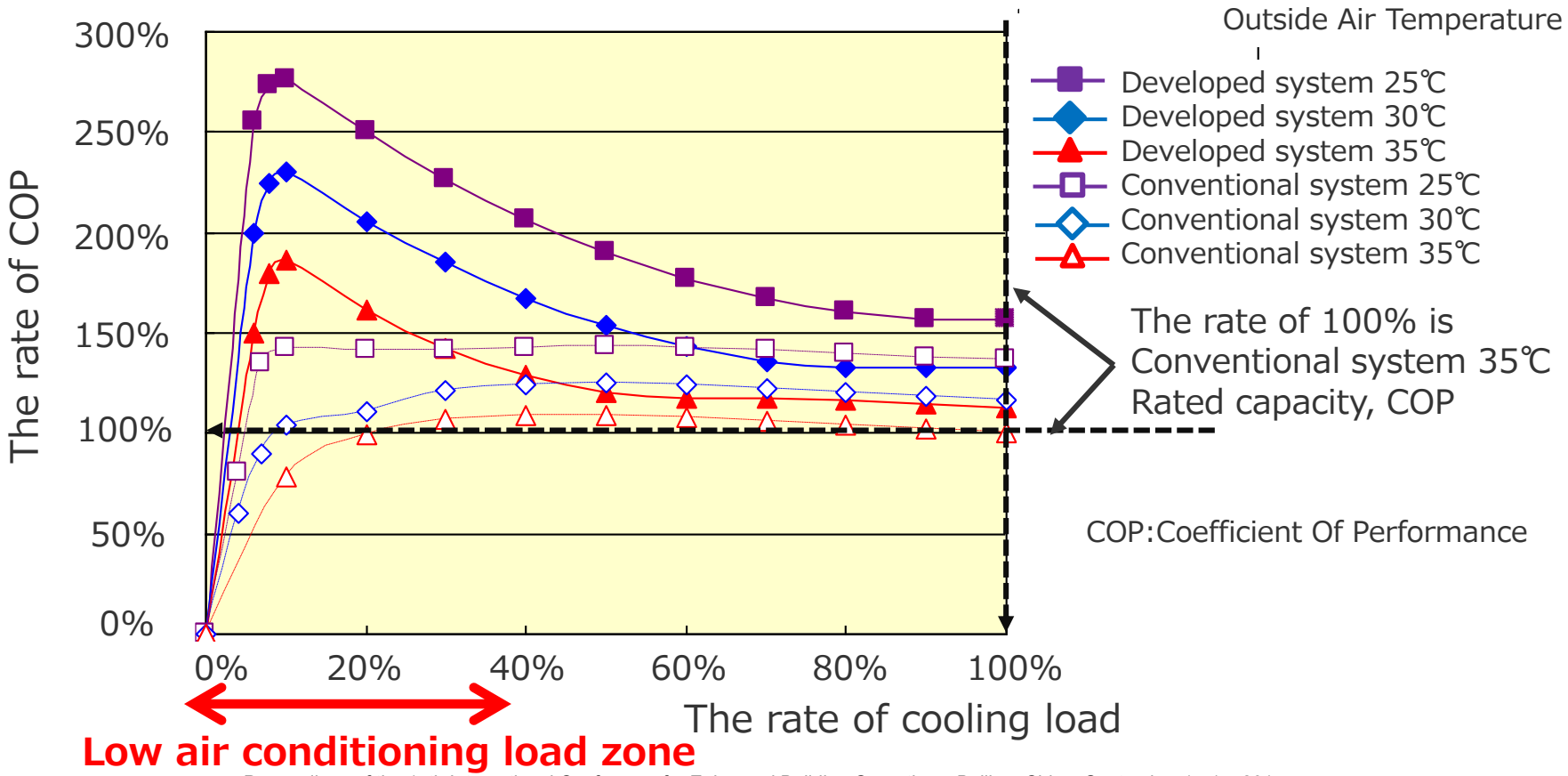


※**V**ariable **R**efrigerant **V**olume

1.Overview of the developed system

Multiple Split Air-Conditioning Units

Optimizing this unit focuses on a low air conditioning load zone with a load factor of less than 50%



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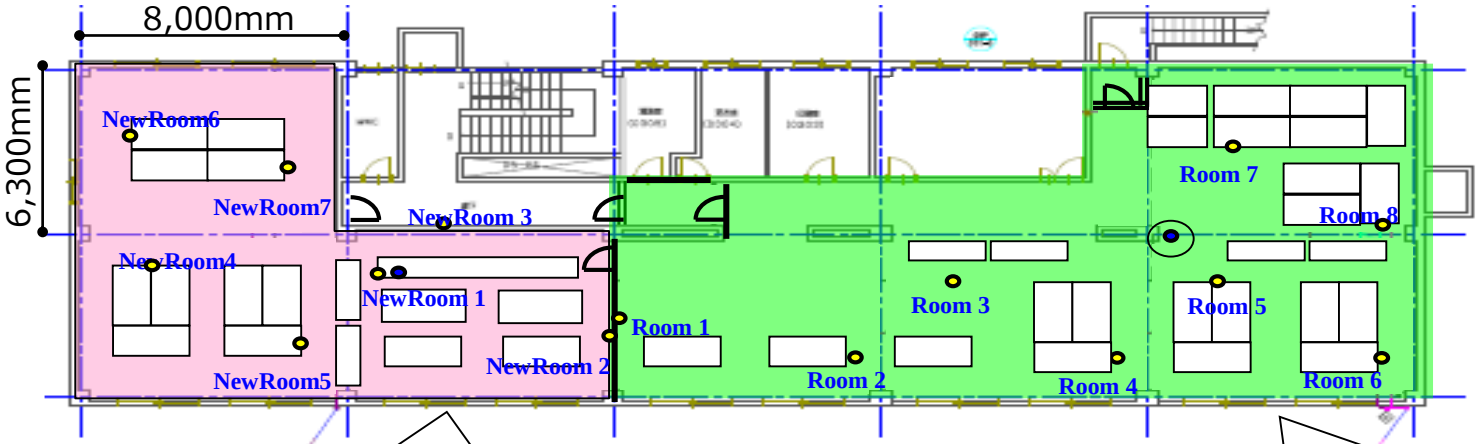
2. Demonstration test

- A demonstration test to evaluate the performance of this system, was performed in the administrative office building.

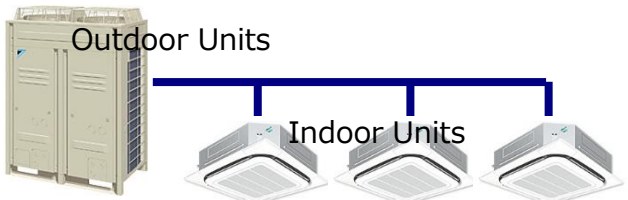


151.2m² 12persons

The floor plan

226.9m² 22persons

Developed system

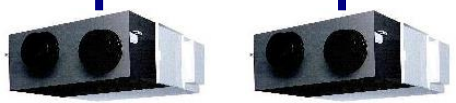


Multiple Split Air-Conditioning Units (VRV)

Humidity-controlled outdoor air processing unit

Conventional system

Multiple Split Air-Conditioning Units (VRV)

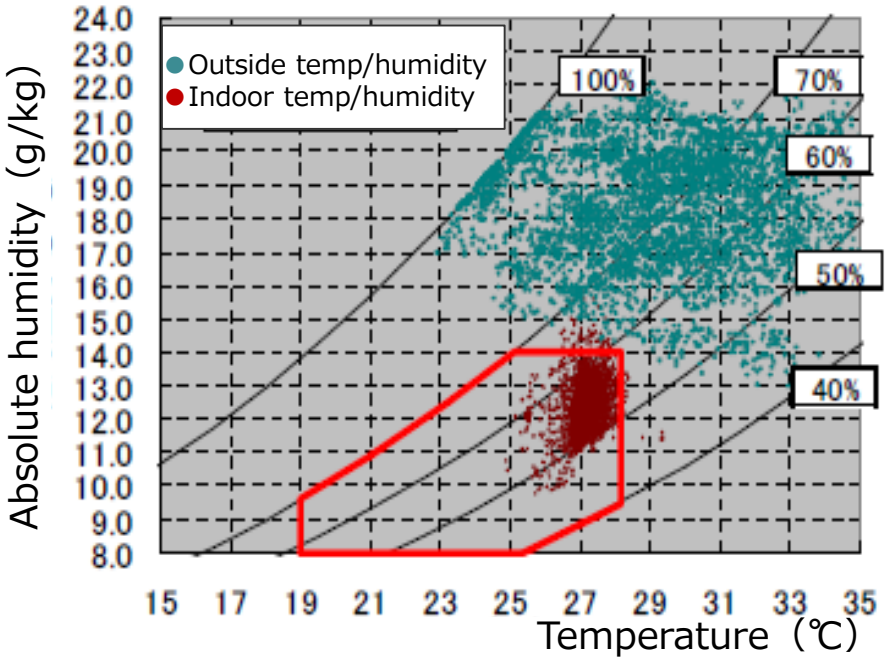


Outdoor air conditioning unit

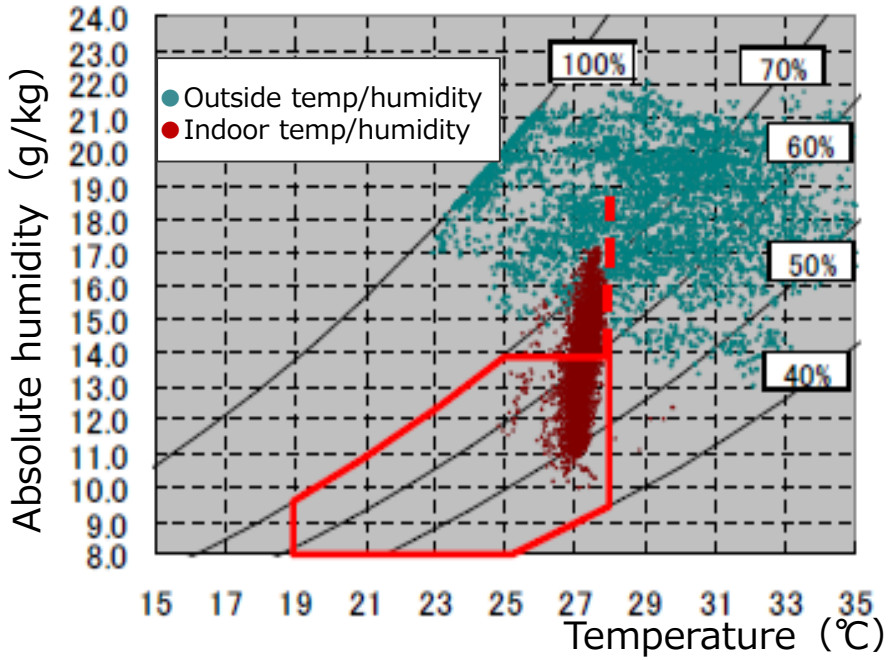
(1) Environmental measurements of room temperature and humidity

Measurement results in SUMMER

- In the developed system, the room temperature and humidity were controlled to the target room temperature and humidity environment to control latent heat and sensible heat independently.
- In the conventional system, the air was not sufficiently dehumidified.



Developed system



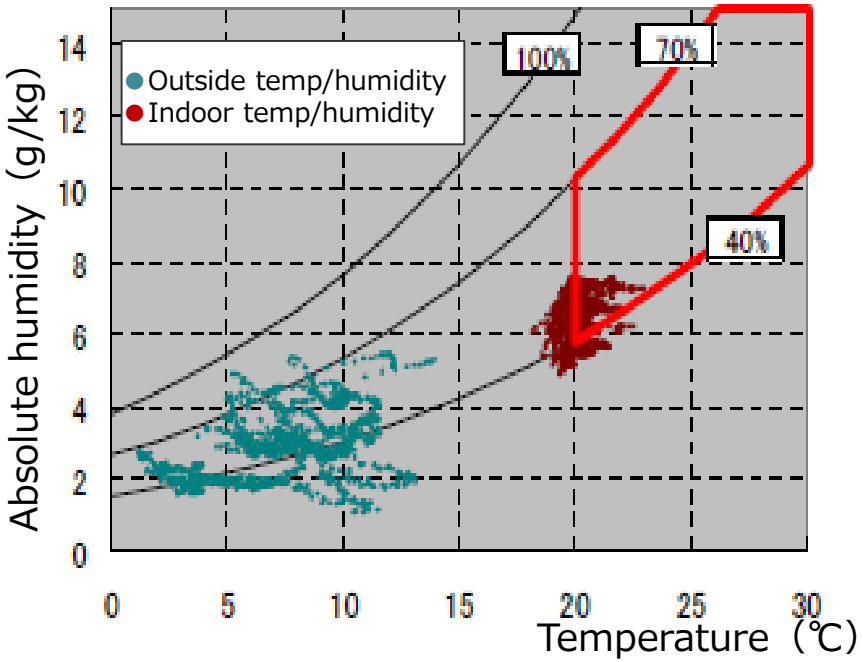
Conventional system

Measurement results in summer

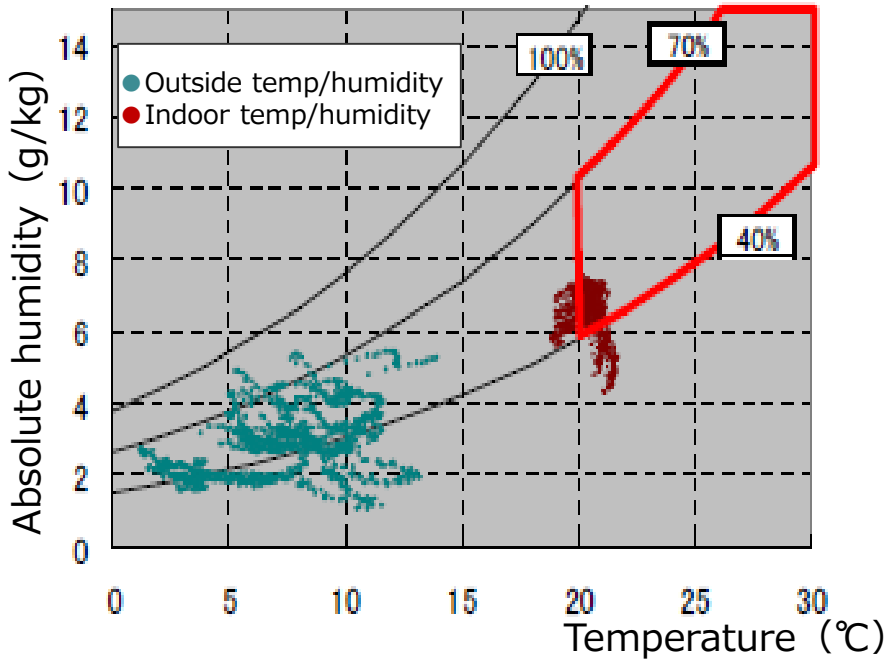
(1) Environmental measurements of room temperature and humidity

Measurement results in WINTER

- In both systems, the target room temperature and humidity conditions were generally met.



Developed system



Conventional system

Measurement results in winter

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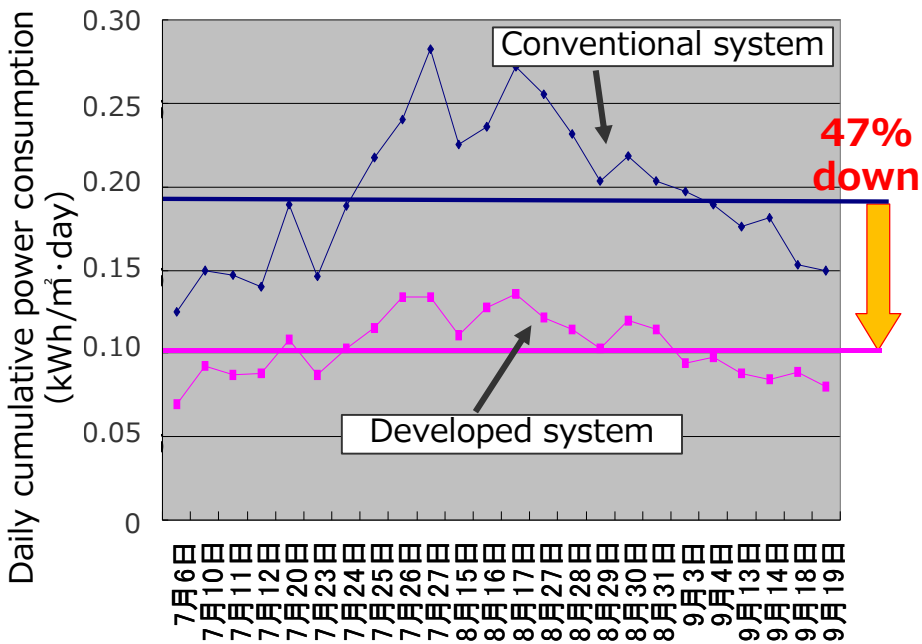
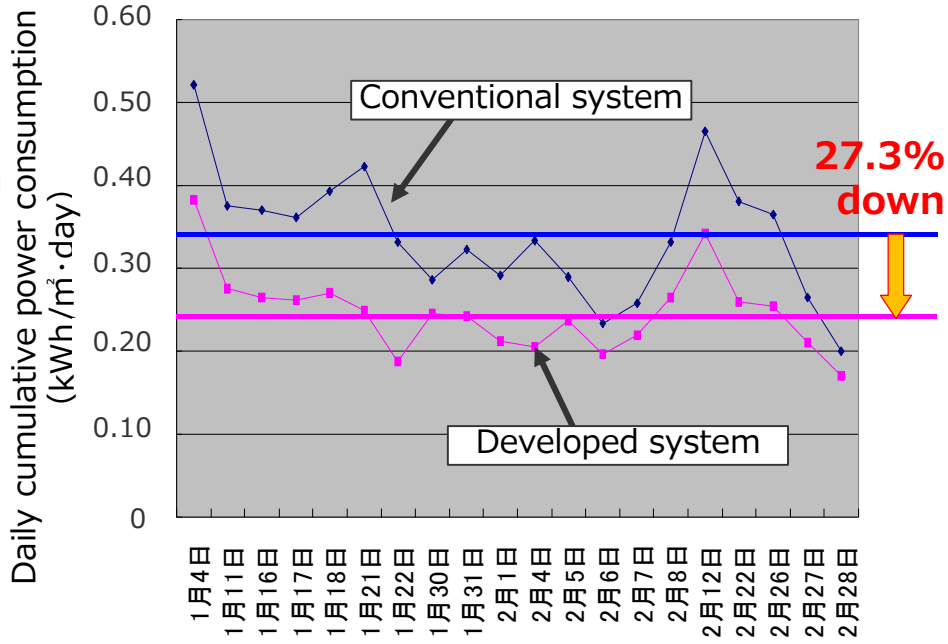
(2) Measurements of equipment efficiency and power consumption

- The power consumption of the developed system decreased to nearly half due to its significantly high operational efficiency.
- The developed system showed only a small improvement in operational efficiency due to the larger indoor-outdoor temperature difference in the winter than in the summer, but showed an approx. 30% reduction in power consumption.



SUMMER



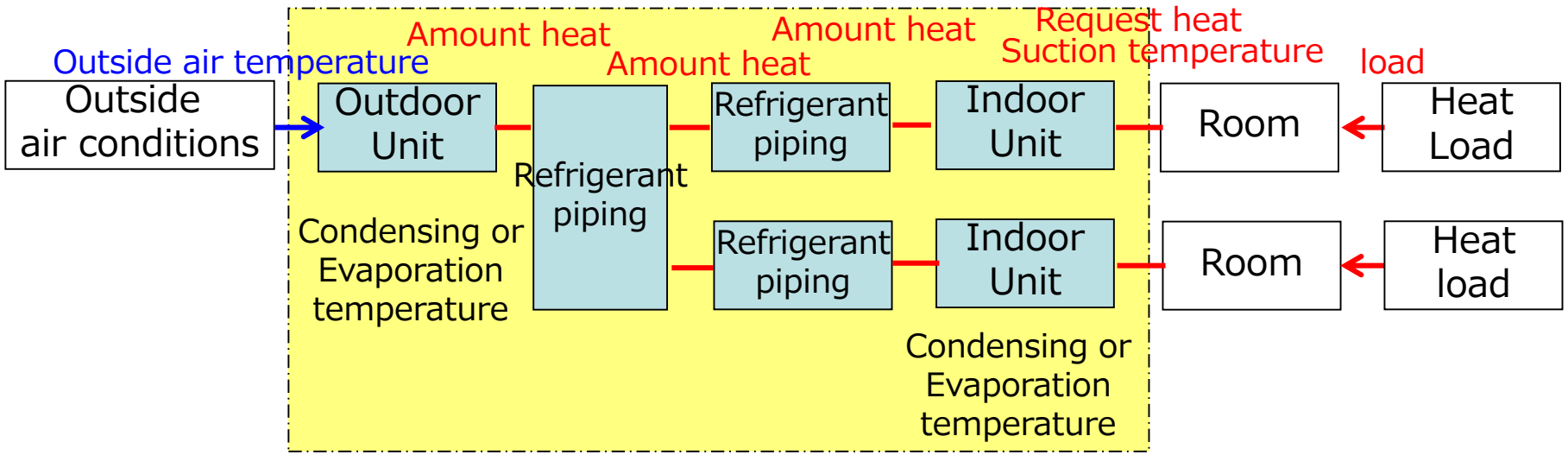
WINTER

Measurement results

3. Development of a simulation model

- We developed an Excel-based LCEM(life cycle energy management) simulation model as an application of the design tool for the developed system.
- Taking into account the issues that were identified in the process of developing the system, we have developed a model, with a built-in theoretical formula for the refrigeration cycle, that converts information communicated between the computation models for the indoor and outdoor units to the temperature, pressure, and flow rate of the refrigerant.

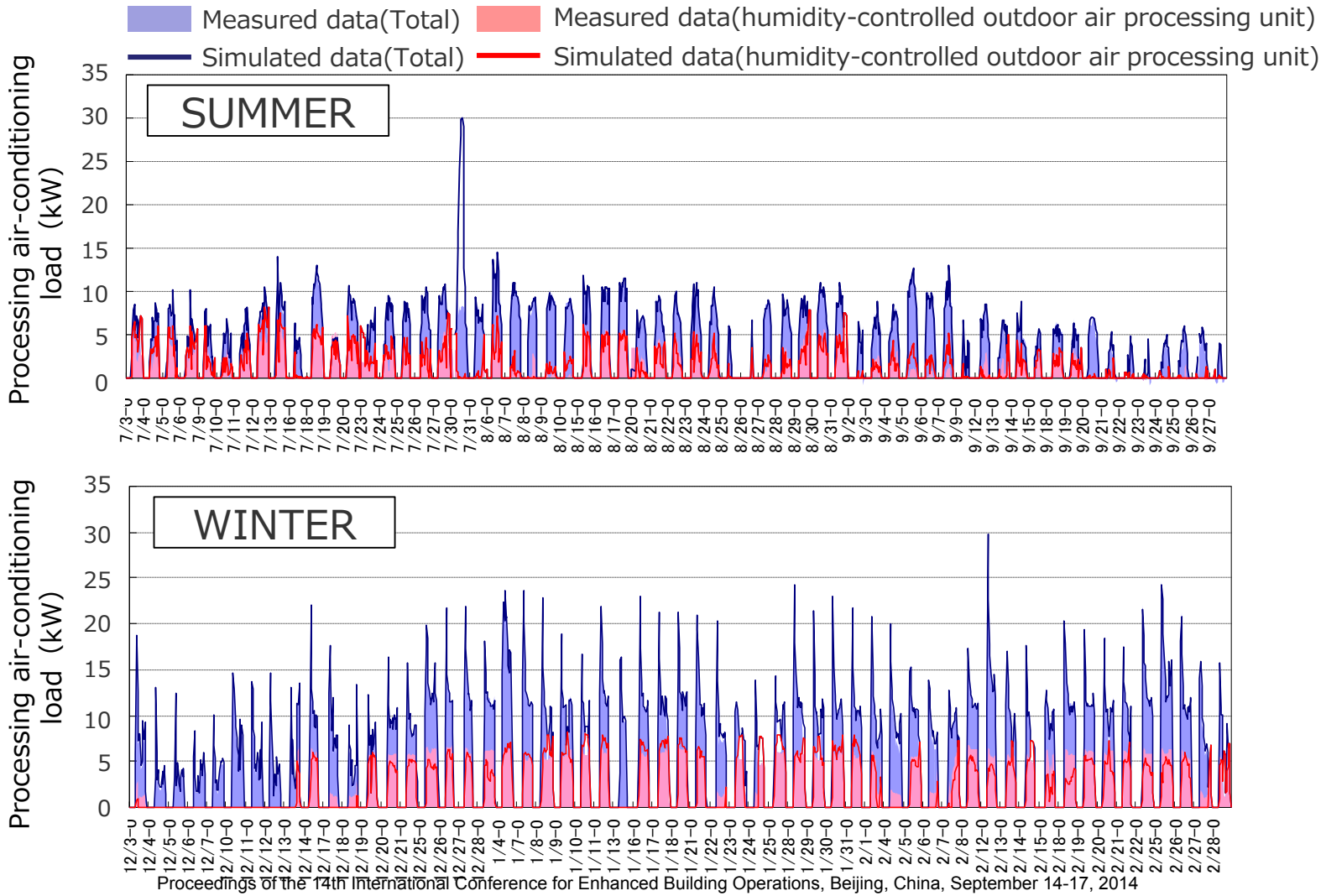
Simulation model



The convergence calculation of the amount of heat exchange

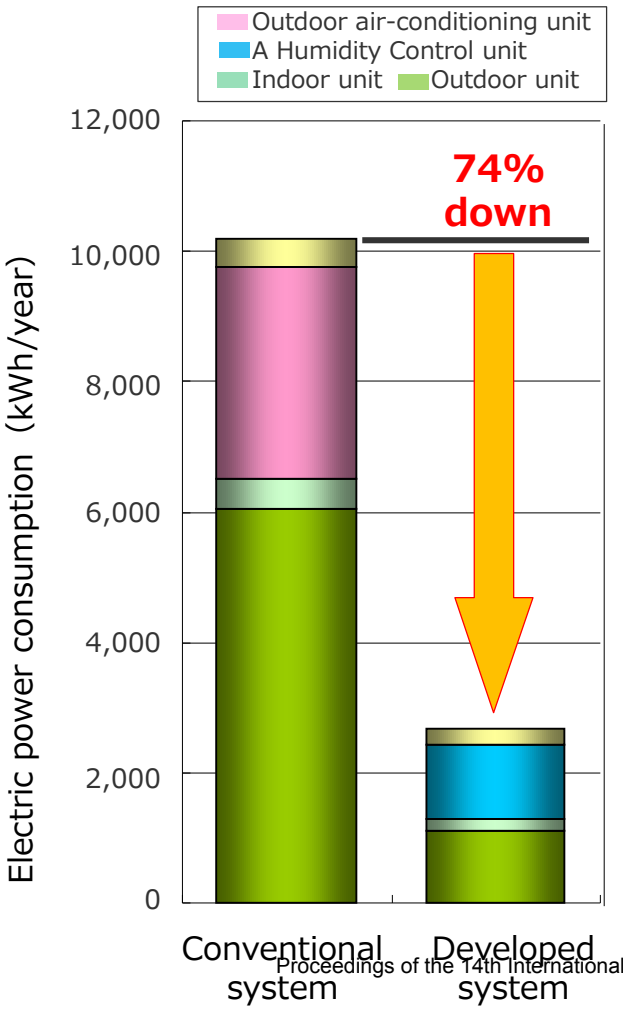
(1) Evaluation of the accuracy of the simulation model

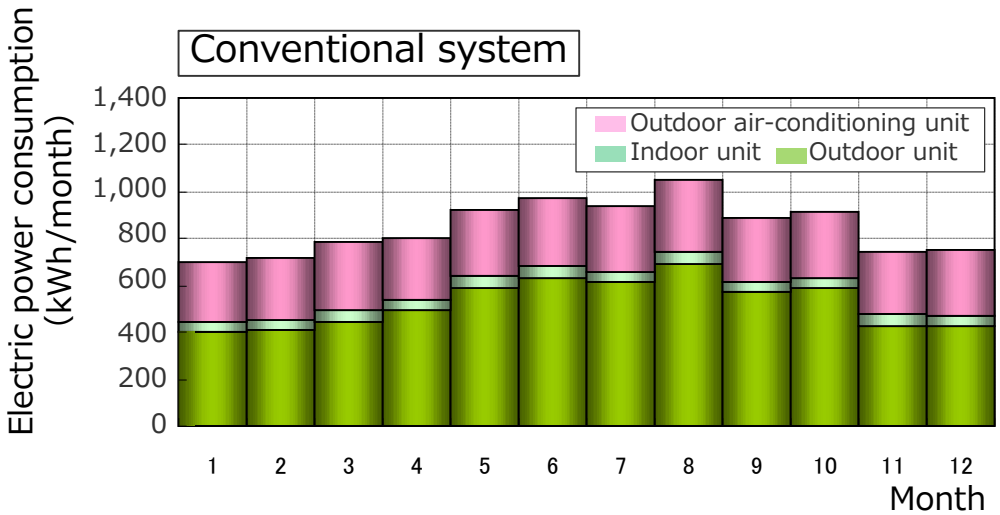
- The measurement results both for summer and winter were well reproduced by the simulation.

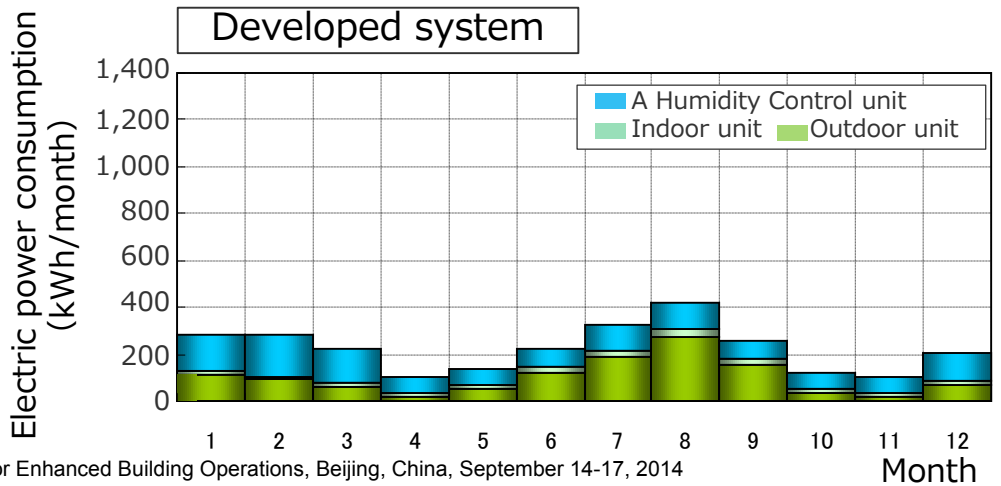


(2) Results of simulation of annual performance

- The annual power consumption of the developed system is 74% less than that of the conventional system.
- The reduction in the power consumption of outdoor unit is mainly due to the improvement in the annual efficiency of the developed system.

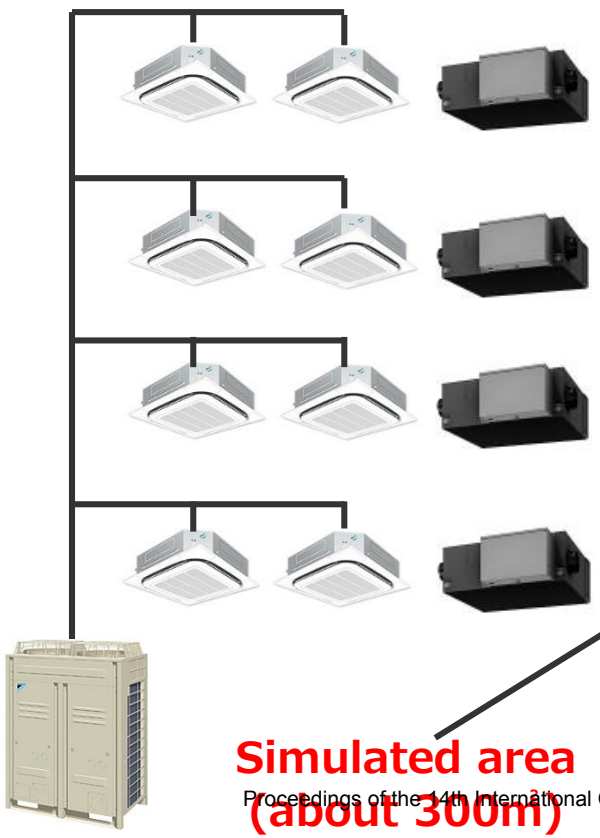


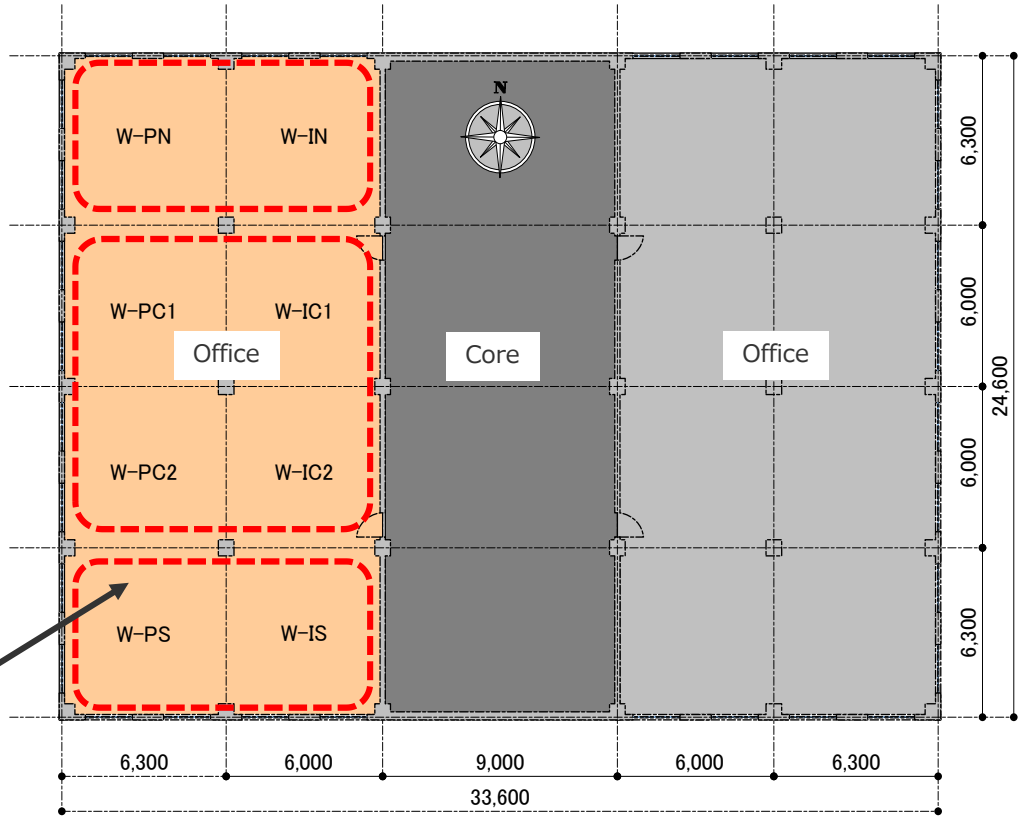




4. Evaluation for application to a design tool

- The calculation was performed based on the west side of the reference floor of the modeled building.
- Modeled air conditioning System
  - Four humidity-controlled outdoor air processing units (about 75 ㎡/zone)
  - Eight multi-package indoor air conditioning units (about 40 ㎡/zone)
  - One VRV outdoor air conditioning unit





Simulated area (about 300m²)

(2) Calculation results for Cooling and Heating cases

- The efficiency of the multiple split air conditioning system varies due to the indoor-outdoor differences in temperature and humidity conditions, load factor, and temperature settings.
- The aim of using this simulation model as a design tool, several parameters were defined and used in the calculation.

【Cooling】 Outside temperature 35℃

CASE1 **The indoor temperature setting** was varied
CASE2 **The indoor humidity setting** was varied
CASE3 **The internal equipment heat generation** was varied
CASE4 **The load factor** was varied

【Heating】 Outside temperature 7℃

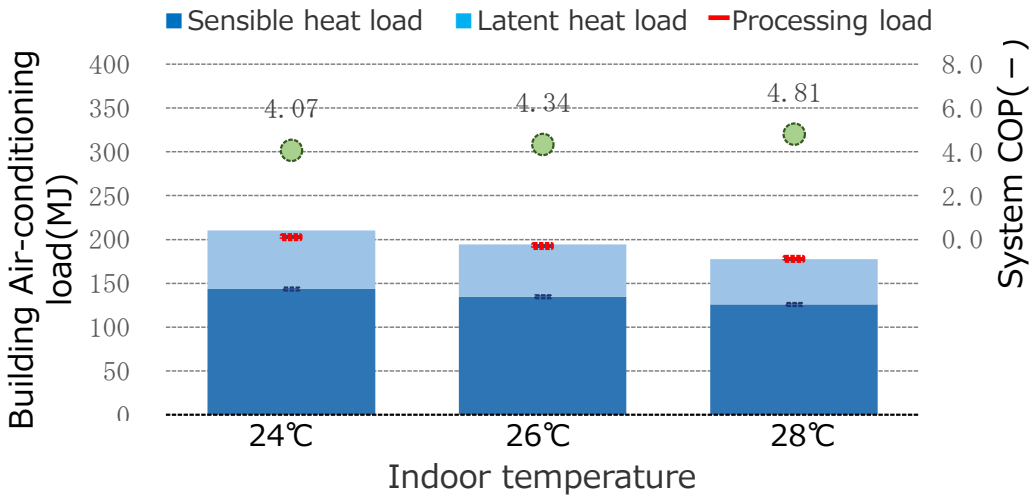
CASE5 **The indoor temperature setting** was varied
CASE6 **The indoor humidity setting** was varied

(2) Calculation results

CASE1

The indoor temperature setting was varied.
24℃,26℃,28℃
Indoor humidity setting was 50% fixed.

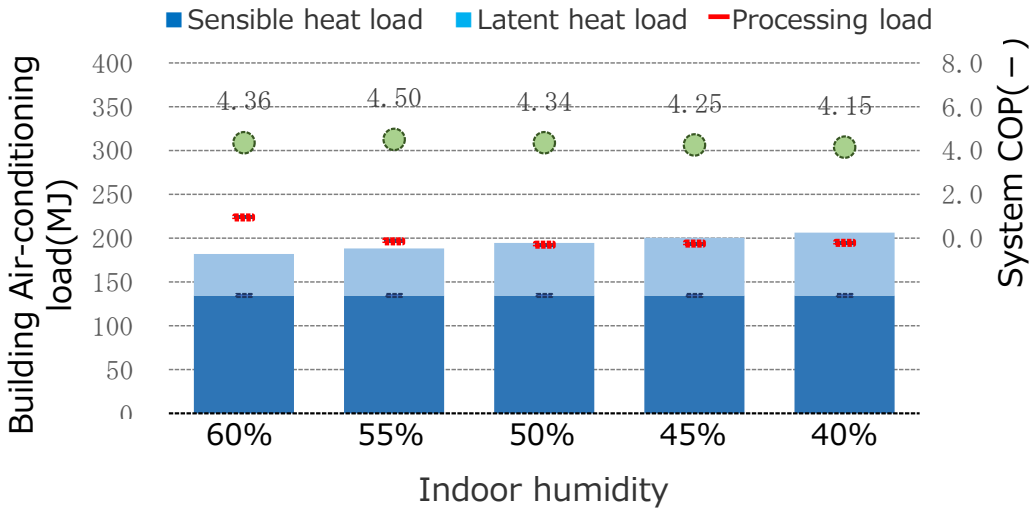
System COP improves with higher temperature settings.



CASE2

The indoor humidity setting was varied.
60%,55%,50%,45%,40%
Indoor temperature setting was 26℃ fixed.

The processed cooling load had only a small effect on the indoor humidity setting and system COP.



(2) Calculation results

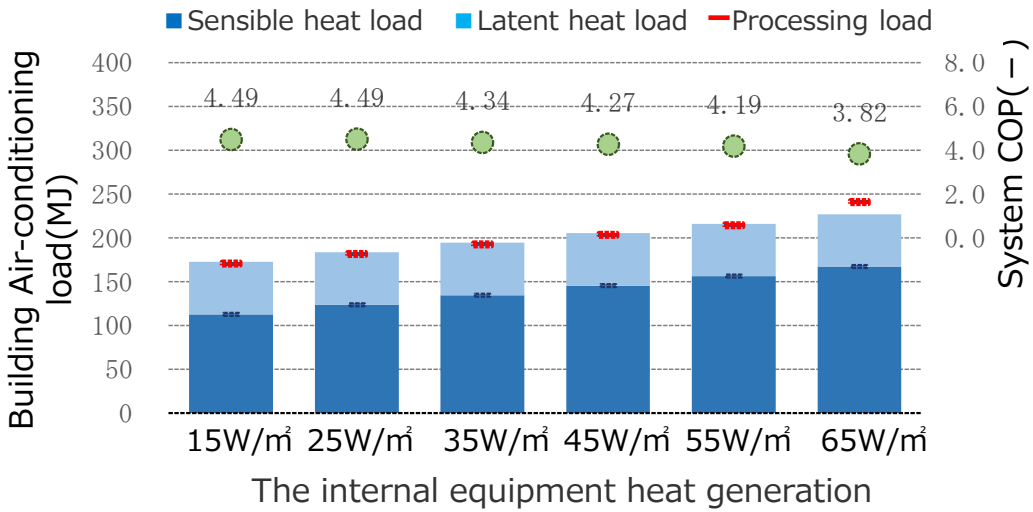
CASE3

The internal equipment heat generation was varied.

15,25,35,45,55,65W/㎡

Indoor temperature setting was 26℃ fixed and indoor humidity setting was 50% fixed.

System COP improves with decreasing internal equipment heat generation.



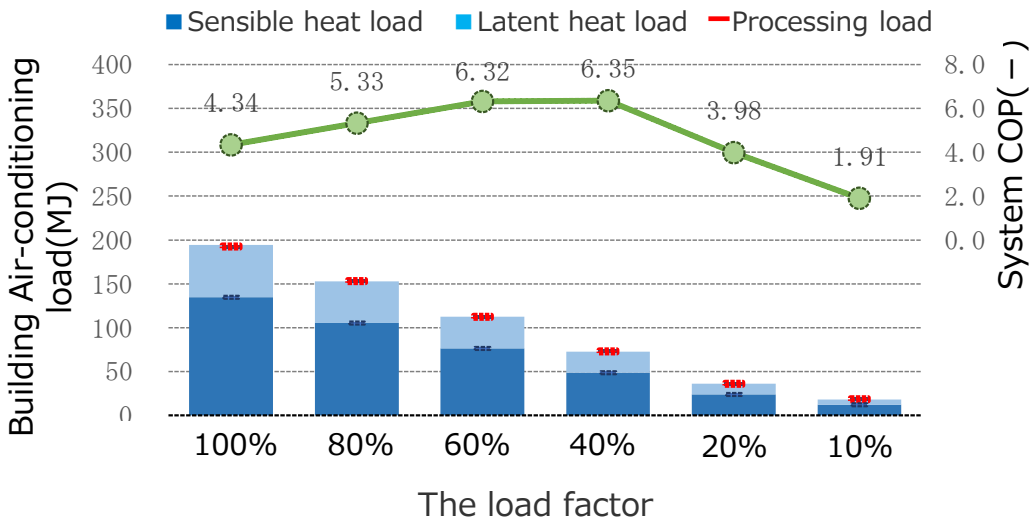
CASE 4

The load factor was varied.

100%,80%,60%,40%,20%,10%

Indoor temperature setting was 26℃ fixed and indoor humidity setting was 50% fixed.

System COP improves for a load factors from 100% to 40% and decreases after that.

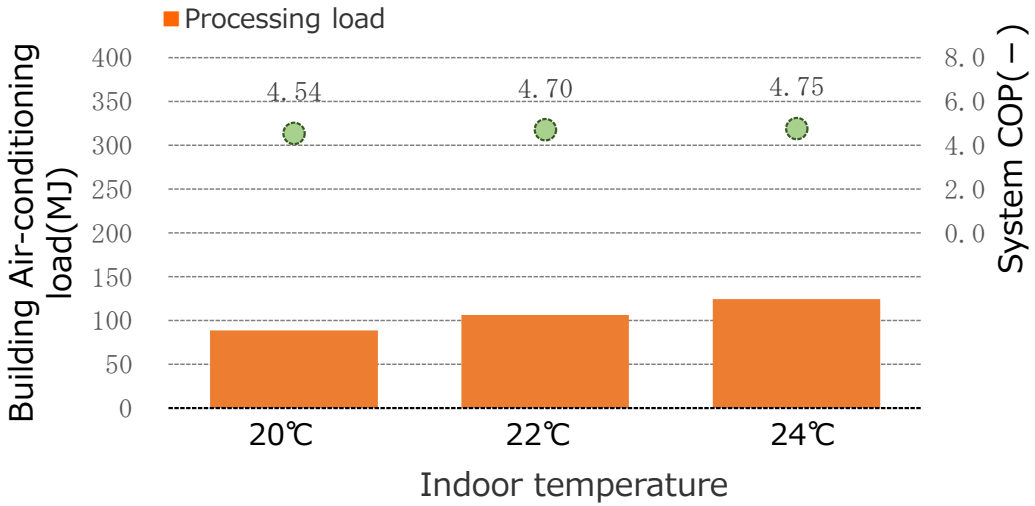


(2) Calculation results

CASE5

The indoor temperature setting was varied.
20℃,22℃,24℃
Indoor humidity setting was 50% fixed.

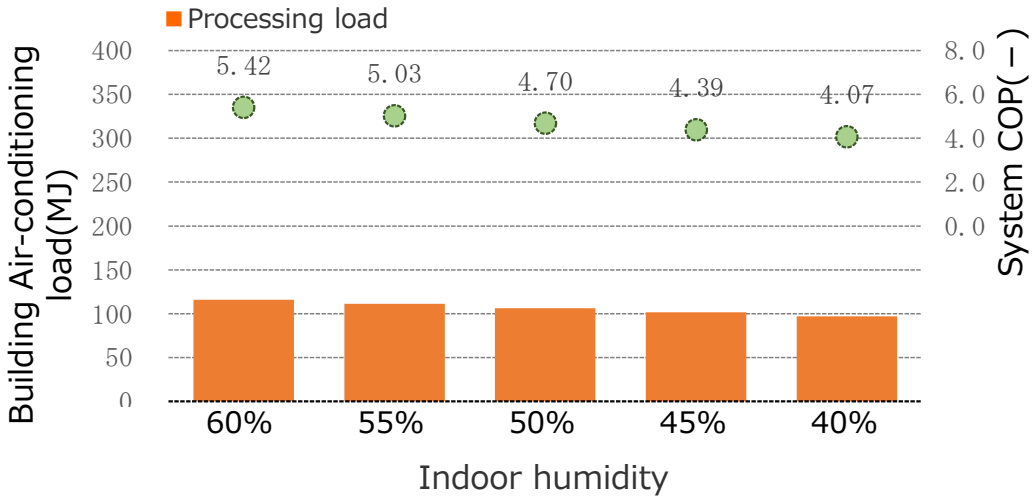
System COP improves with higher temperature settings.



CASE6

The indoor humidity setting was varied.
60%,55%,50%,45%,40%
Indoor temperature setting was 22℃ fixed.

System COP improves with higher humidity settings.



5.Conclusions

In conclusion,

- To further increase the efficiency of multiple split air conditioning systems, which are commonly used in Japan, we have developed equipment for this type of system.
- We also took data to evaluate system performance and developed a simulation model, and conducted a number of case studies.
- In the next step, we will develop design guidelines for this type of system to properly reflect the results obtained in the simulations of future designs.

Thank you for your time