

# Research on setting temperature of air conditioner in offices and thermal comfortability for office workers in Phnom Penh, Cambodia

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## Introduction

### Background

Recently, in urban area of Cambodia, high-rise buildings are being constructed rapidly in association with economic growth.

However, many low efficient buildings that have no insulation materials and turbulent air-conditioning plan are still remaining.

And also, the people of hot-humid area are resistant to intense heat but, they prefer to cool environment. These two fact have gap of thermal sensation.

To reduce the energy consumption of AC, it is necessary to reveal the actual indoor thermal environment in the office and the thermal preference of office workers in hot-humid area.

### Object

To clarify the relationship between the thermal sensation and the AC usage and to propose a guideline for energy saving in software part.

## Method

### Survey overview

- Measurement of thermal environment 18 office rooms
- Questionnaire Survey 107 office workers

By showing each other, it is possible to reveal the comfort thermal environment which the people living in hot-humid area prefer to and the factor influencing thermal comfortability.

Table 1. Survey Overview

Research Place	Phnom Penh, Cambodia
Research Period	2018/8/30~2018/9/6
Research Object	• RC structure • Air-conditioner Installed
Number of Samples	• 18 office rooms • 107 office workers
Required time	• About 1 hour per office room (between 9:00 to 17:00)

Table 2. Type of office building in Cambodia



These 4 types of buildings are popular in Phnom Penh. In this research, targets of survey are low efficient buildings, such as high-rise building, medium-rise building and town-house.

### Questionnaire survey

Questionnaire survey is conducted for Cambodian office worker.

Table 3. Question Items

Question item
Sex
Age
Clothes
Frequency of changing AC setting temperature
Preference of AC setting temperature (PST)
Thermal sensation vote (TSV)
Comfort sensation vote (TCV)
Thermal preference (TP)

Table 4. Scale of thermal sensation indicators

Scale	Thermal sensation vote (TSV)	Thermal comfort vote (TCV)	Thermal preference (TP)
+3	Hot	Very uncomfortable	-
+2	Warm	Uncomfortable	-
+1	Slightly warm	Slightly uncomfortable	Warmer
0	Neutral	Neutral	As it is
-1	Slightly cool	Slightly comfortable	Cooler
-2	Cool	Comfortable	-
-3	Cold	Very Comfortable	-

In addition to these indicators, preference of setting temperature (PST) is used as thermal sensation indicators in this research.

### Measurement survey

Table 5. Measurement Items

Measurement Item	Measurement position
Temperature [°C]	Indoor (interior, Perimeter), Outdoor
Humidity [%]	Indoor (interior, Perimeter), Outdoor
Radiation temperature [°C]	Floor, Wall, Ceiling, Window

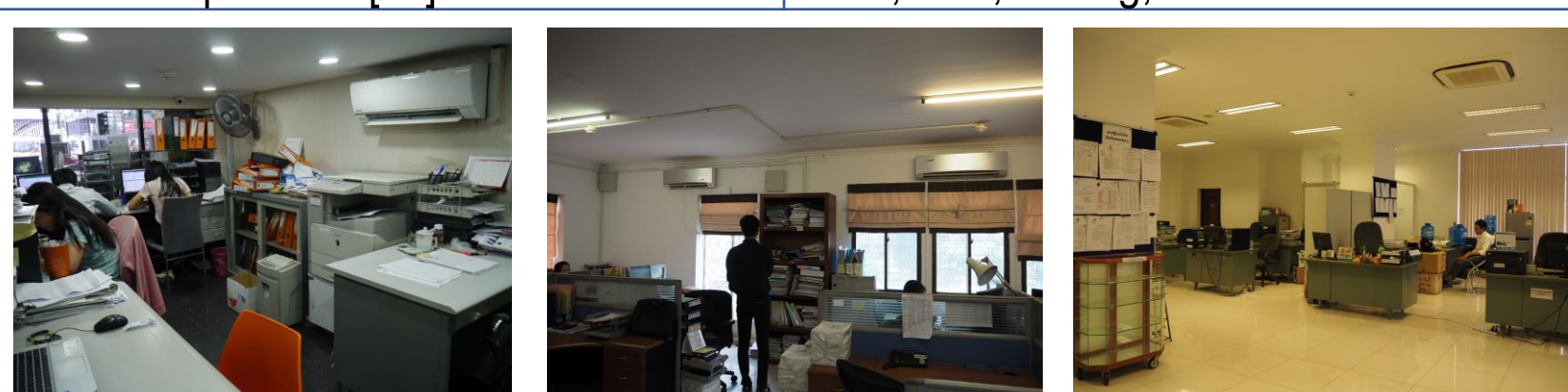


Figure 1. Interior of office

Not only measuring indoor thermal environment of working place But also, checking the difference from AC setting temperature.

## Result < Thermal measurement >

### Indoor thermal environment

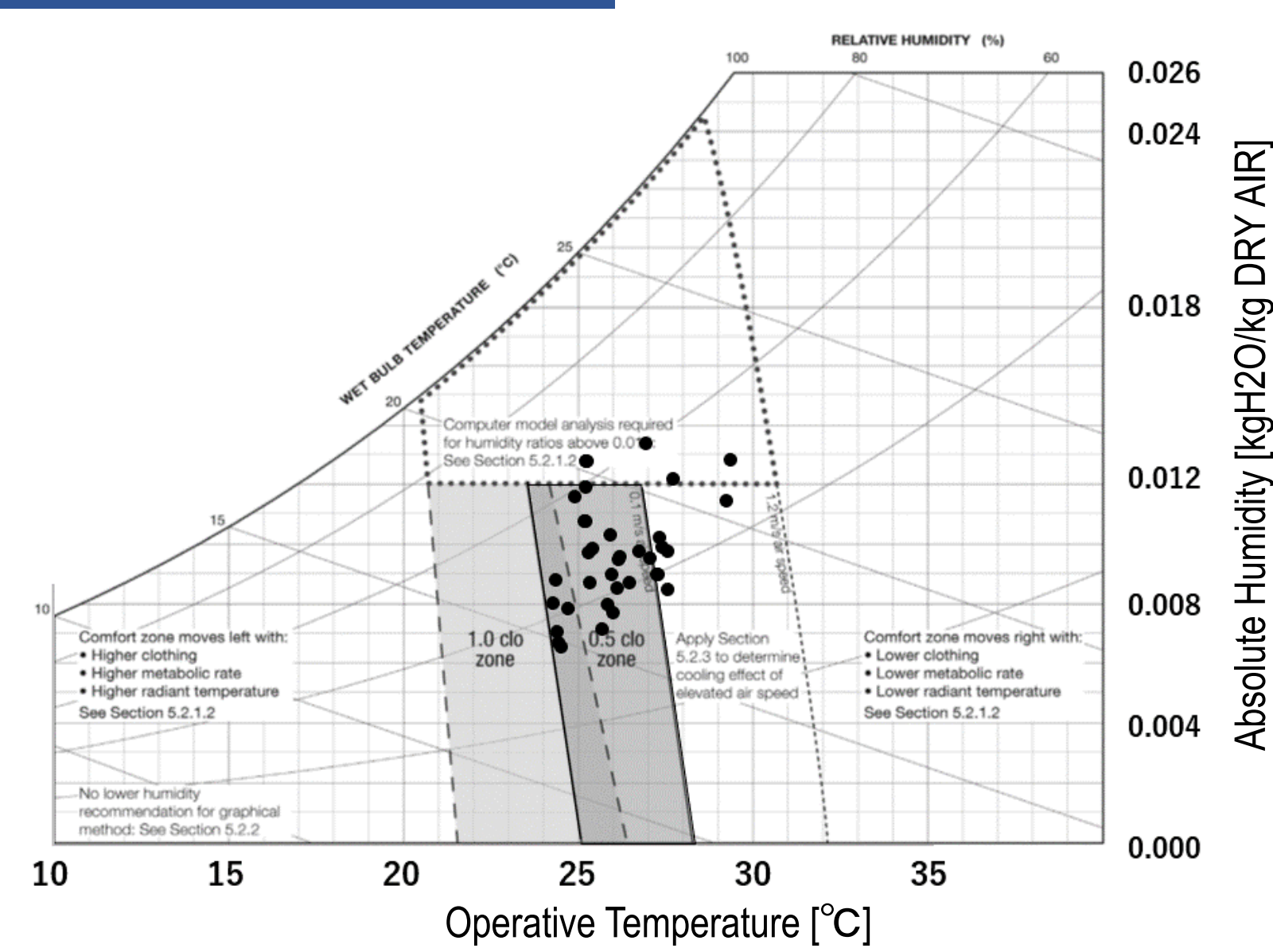


Figure 2. Validation by Operative Temperature (ASHRAE Standard 55)

67% measuring points are regarded as comfortable environment by assessment for 0.5clo zone.

### AC Setting Temperature – Room Temperature

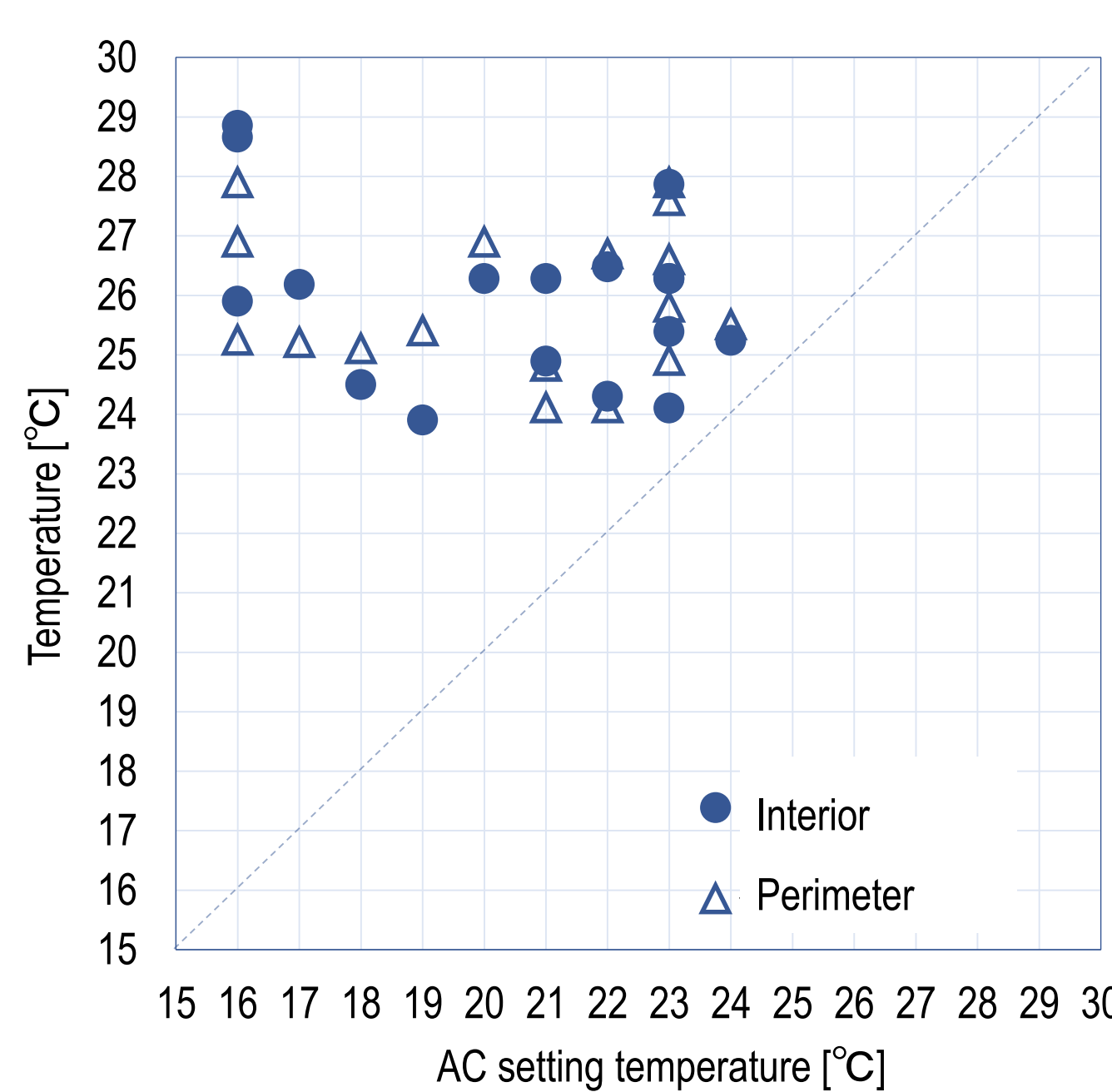


Figure 3. The difference between actual temperature and AC setting temperature

It is revealed that the actual temperature of the room is high compared to AC setting temperature. So, cooling capacity or thermal insulation may have problem.

## Result < Questionnaire survey >

### Subjects overview

Table 6. Questionnaire survey result (average)

	Age	clo	TSV	TCV	TP	PST[°C]
Male [N=55]	32.4	0.54	-0.79	-1.28	-0.26	22.4
Female [N=48]	29.1	0.55	-0.34	-1.14	-0.14	21.8
Whole [N=103]	30.8	0.54	-0.58	-1.21	-0.21	22.1

### Thermal sensation

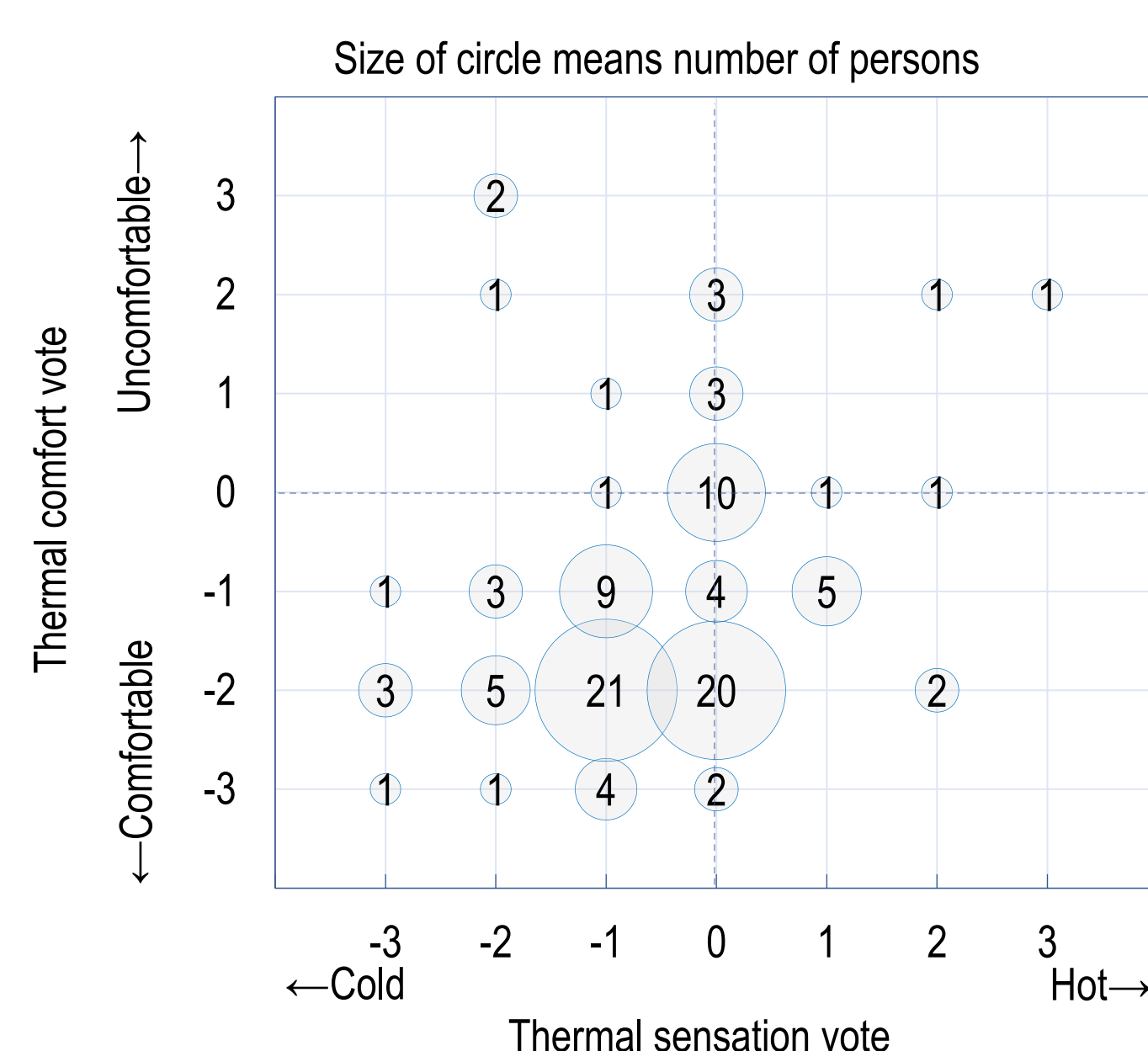


Figure 4. The difference between actual temperature and AC setting temperature

47% workers feel both cool and comfortable in office and the correlation coefficient is 0.27. That means environment become cooler, workers feel more comfortable.

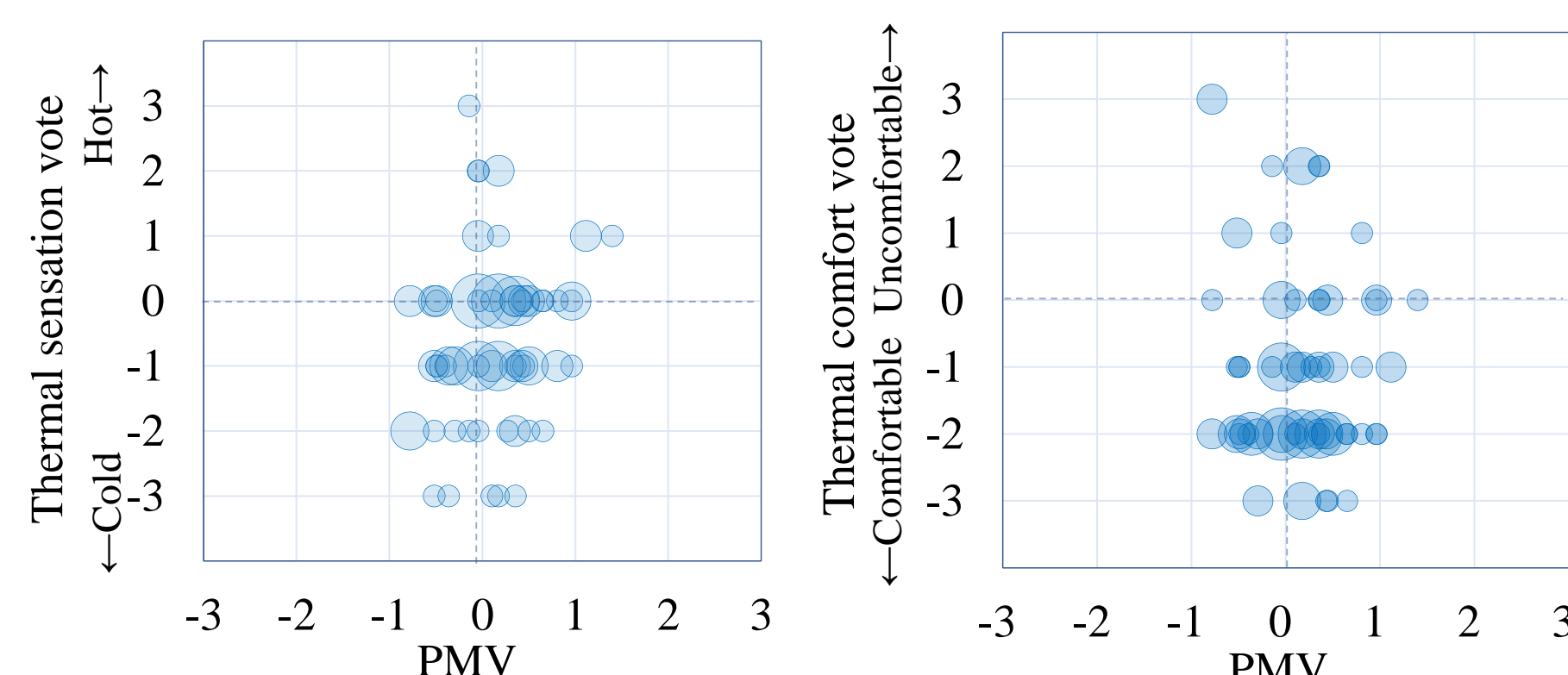


Figure 5. PMV-TSV

Figure 6. PMV-TCV

90% workers in the warm environment assessed by PMV answer that feeling cool. So, people in hot-humid area have tolerance of hot environment.

## Analysis

### Factor thermal sensation decision

Table 7. Thermal factor influencing thermal sensation. (correlation)

Factor	TSV	TCV	TP
Sex [M=1, F=2]	0.24	0.073	0.13
Outdoor - Indoor	-0.24	-0.29	-0.013
Indoor temperature	0.29	0.11	0.032
Humidity	-0.12	0.02	0.032
MRT	0.12	0.31	-0.053
OT	0.22	0.28	-0.023
PMV	0.23	-0.016	0.060

Table 8. Thermal factor influencing AC setting temperature. (correlation)

Factor	PST	ACST
Internal factor	Sex	-0.02
	TSV	-0.24
	TCV	-0.06
	TP	0.29
External factor	Temperature	-0.21
	Outdoor - Indoor Temp.	0.12
	Indoor-ACST	-0.15

The difference of temperature between indoor and outdoor influence the thermal sensation of workers.

Preference of setting temperature is influenced by internal factors, actual setting temperature is influenced by external factors.

### Thermally neutral position

To calculate the thermally neutral position, Griffith method is used.

$$T_c = T + \frac{(0 - C)}{a} \quad (T = \text{temperature } C = \text{TSV } a = \text{sensitivity})$$

0.5 is adopted for sensitivity.

By using this method, it is revealed that the thermally neutral position for Cambodian office workers is 27.0°C.

The rate of the people who feel discomfort is only % in the environment below 27°C, based on the questionnaire survey. So, if air conditioning is operated at 27°C, comfortability can be kept and energy can be saved.

## Conclusion

### Summary

The main findings of this research may be organized as follows.

67% of the measuring points were included in comfort zone by AHRAE 0.5clo. But, Cambodian office workers require the cooler environment.

In every office rooms, the temperature is high compared to AC setting temperature. Cooling capacity or thermal insulation may have a problem.

Cambodian office workers' thermally neutral position is 27.0°C.

Preference of setting temperature is influenced by internal factors such as thermal sensation vote, actual setting temperature is influenced by external factors such as the difference of temperature between indoor and outdoor.

### Conclusion

Guideline for energy saving :

When occupants start feeling warm, the rate of discomfort will rise sharply, so to save energy without sacrificing comfort, it is needed to keep the room temperature below the neutral temperature of 27°C.

Because the amount of change in the environmental temperature affects the feeling of comfort and thermal sensation, set the air conditioner temperature higher on days when the outside temperature is high.

## Acknowledgements

I am grateful to T. Shimizu and R. Funaki for collaboration on the early stages of this work. I would like to thank the members of Institute of Technology of Cambodia for their hospitality during my visit, when the main results of this paper were obtained. I would also like to take this opportunity to thank the office owners and office workers for cooperate with us.

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