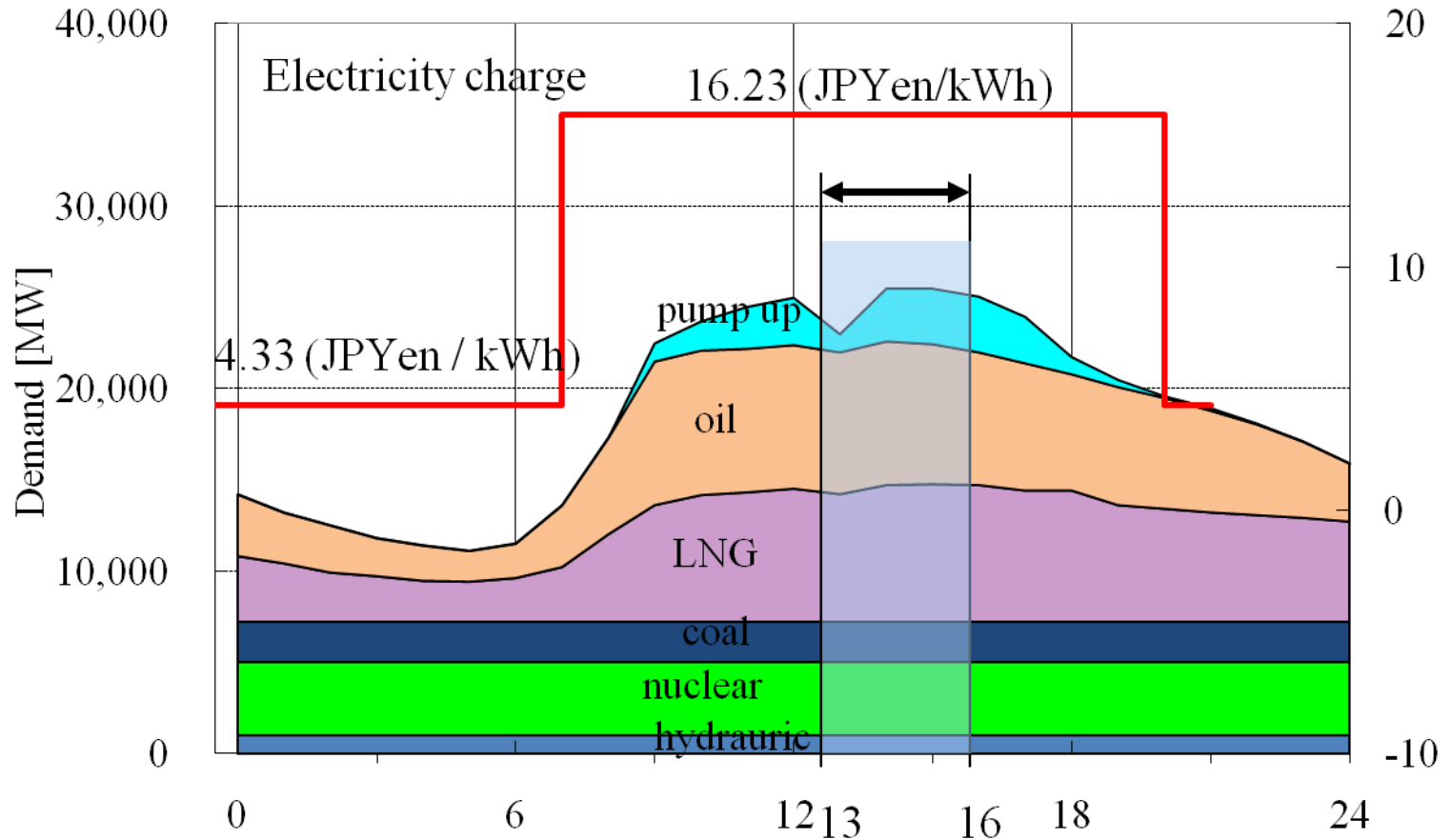


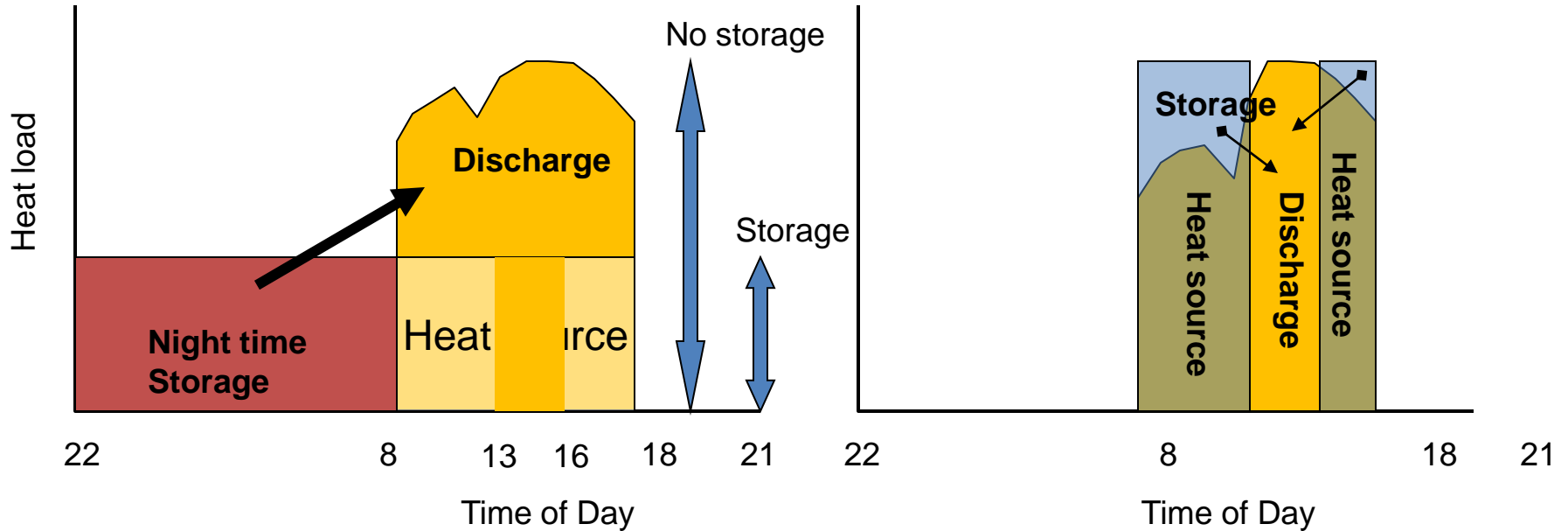
# A THERMAL STORAGE SYSTEM USING PHASE CHANGE MATERIALS IN AIR DISTRIBUTION SYSTEMS FOR PEAK SHAVING

Motoi Yamaha  
Chubu University

# Electric situation in Japan

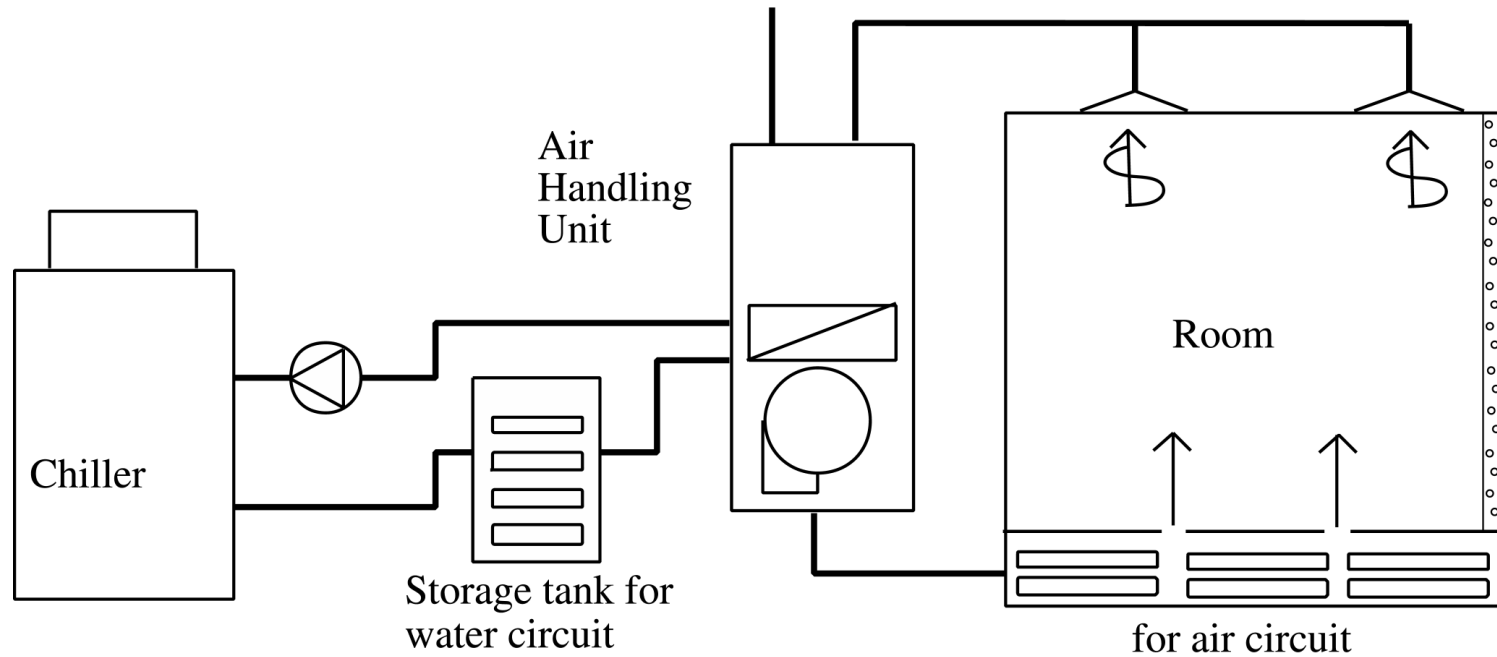


# Operational patten of TES



# PCM storage system

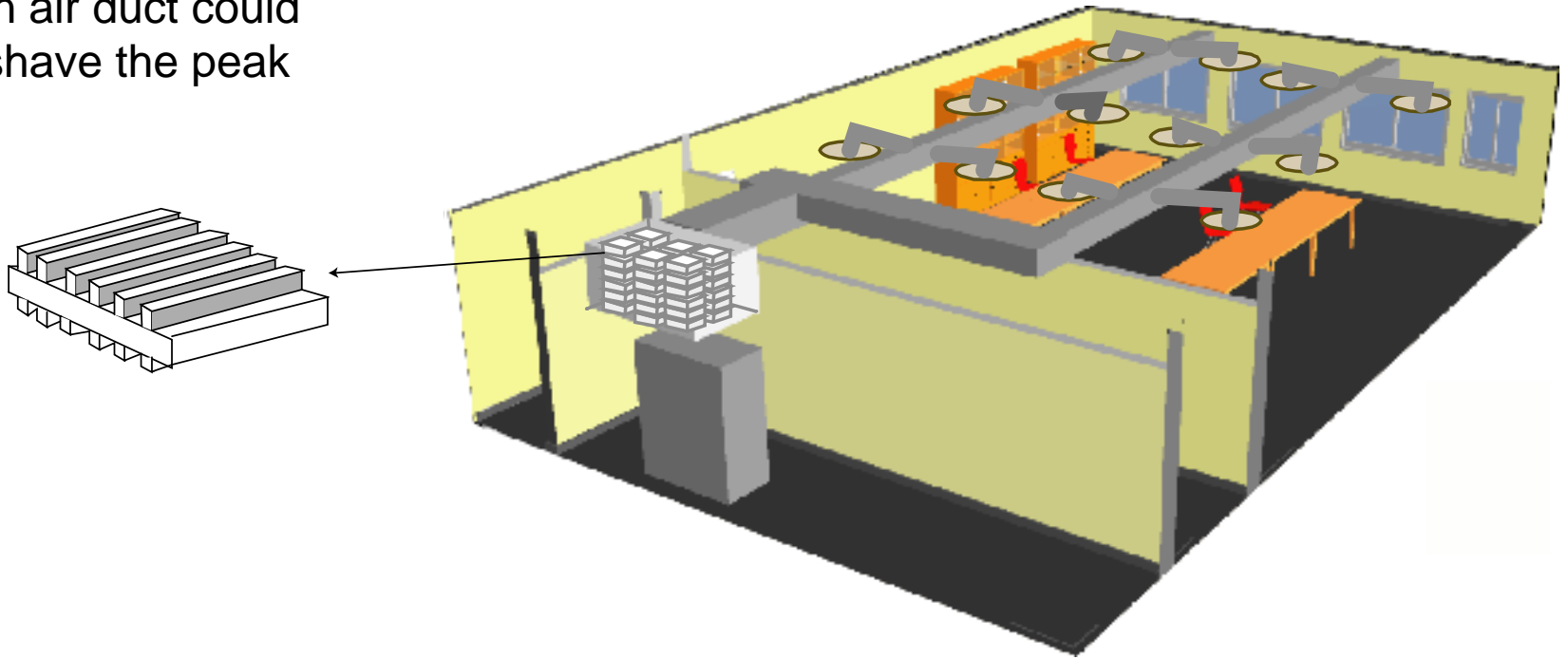
To enlarge storage capacity,  
PCM can be installed in Air circuit



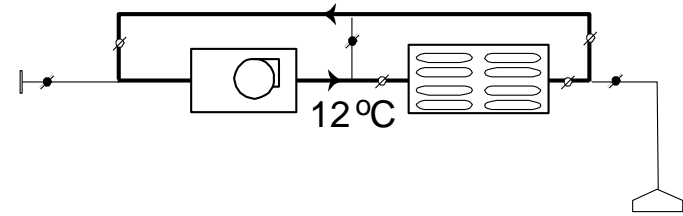
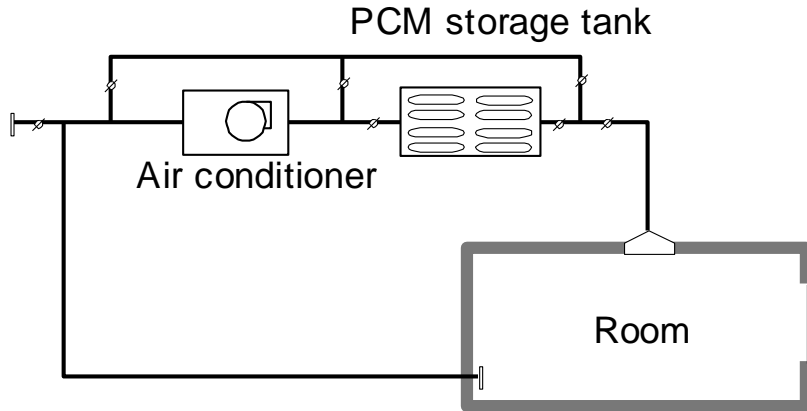
Ice or water storage

# A system analyzed in this study

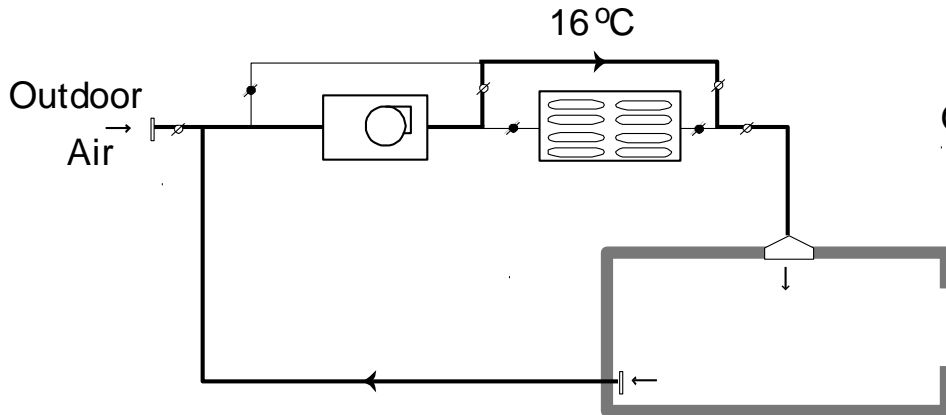
PCM storage  
containers installed  
in air duct could  
shave the peak



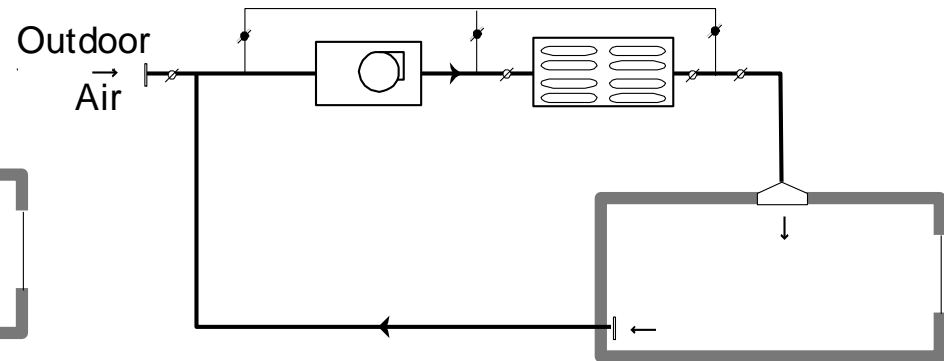
# Operation of the system



(1) Charging operation (5:00 - 8:00)



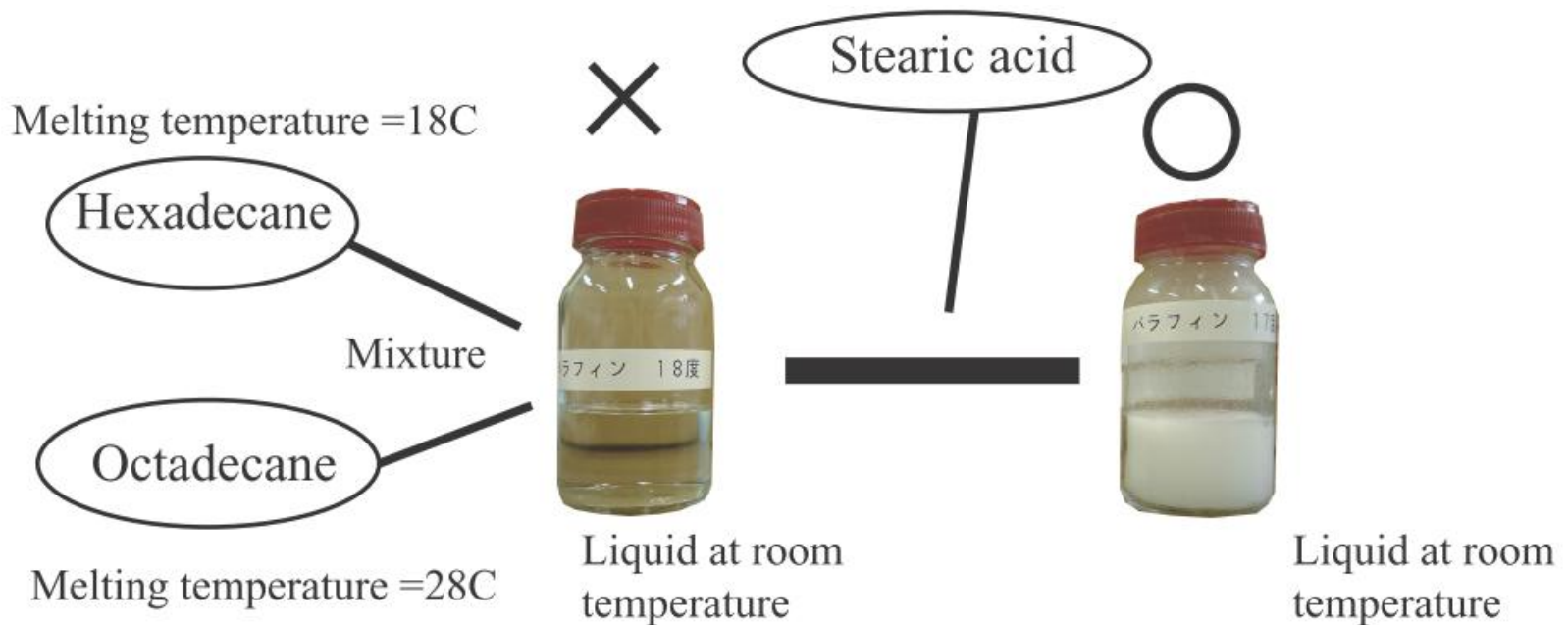
(2) Ordinary air conditioning  
(9:00 - 13:00 and 16:00 - 18:00)



(3) Discharge operation ( 13:00 - 16:00)

# Mixture of paraffin waxes

- According to Japanese Building code, no flammable liquid at 20 C is not allowed to use.



# Mixtures used

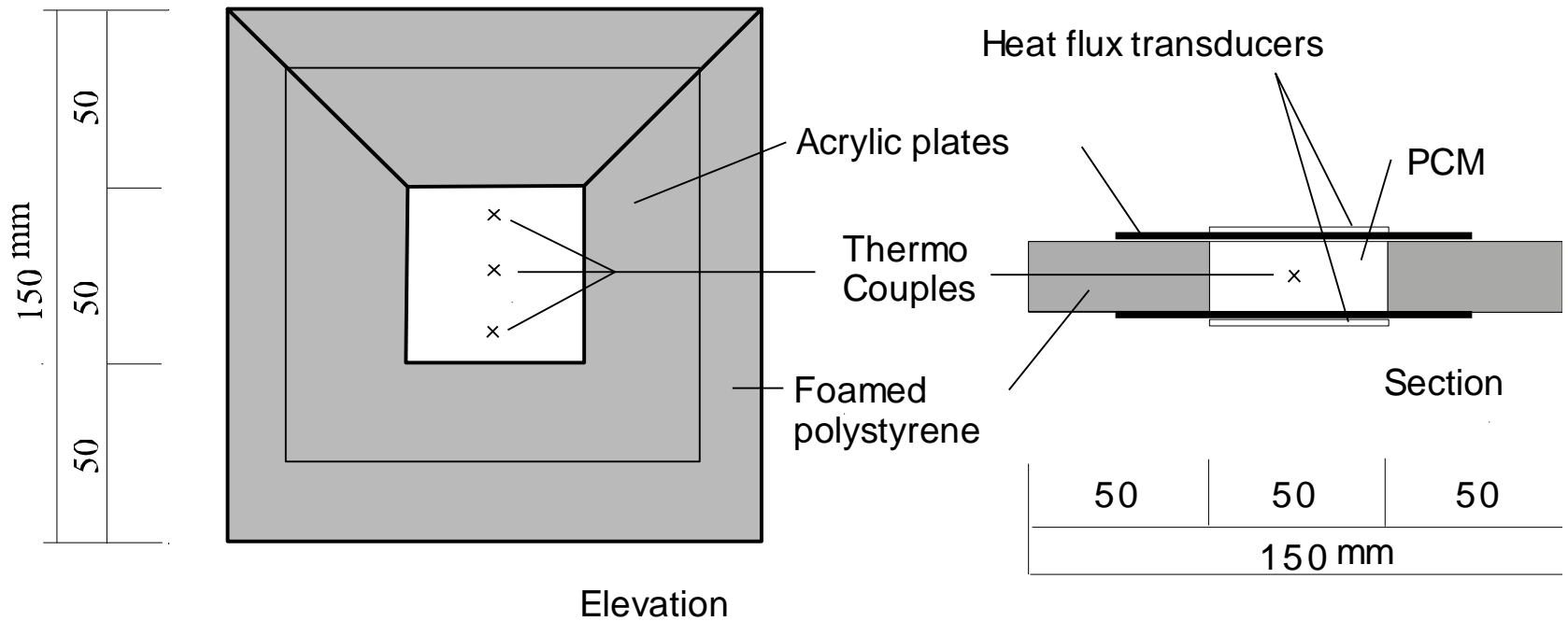
*Table 1. The concentration of Paraffin waxes and fatty acid used in this study*

	Estimated Melting Temp.	Concentration of Paraffin ( $t_m; 18^\circ \text{C}$ )	Concentration of Paraffin ( $t_m; 28^\circ \text{C}$ )	Concentration of Stearic acid	Mass of PCM (g)
MT 17	$17^\circ \text{C}$	40 %	40 %	20 %	39.1
MT 19	$19^\circ \text{C}$	28 %	52 %	20 %	40.4
MT 21	$21^\circ \text{C}$	24 %	56 %	20 %	40.0
MT 23	$23^\circ \text{C}$	16 %	64 %	20 %	38.5

$t_m$ ; The melting temperature



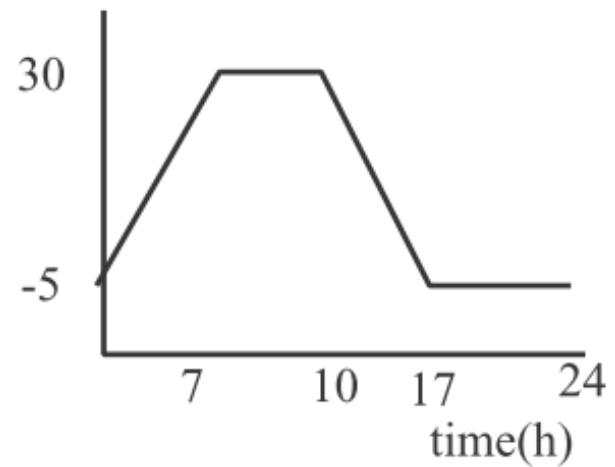
# Measurement of thermal properties



# An apparatus for measurement

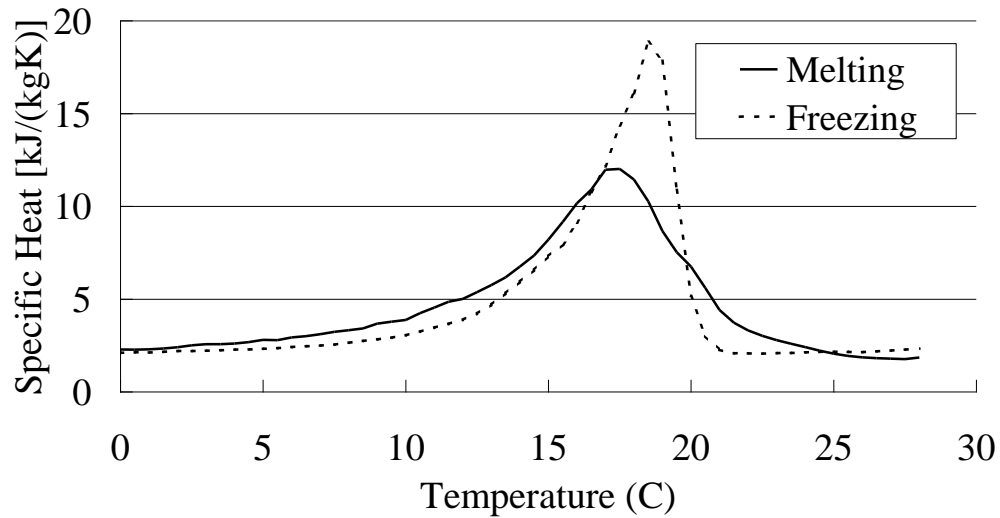
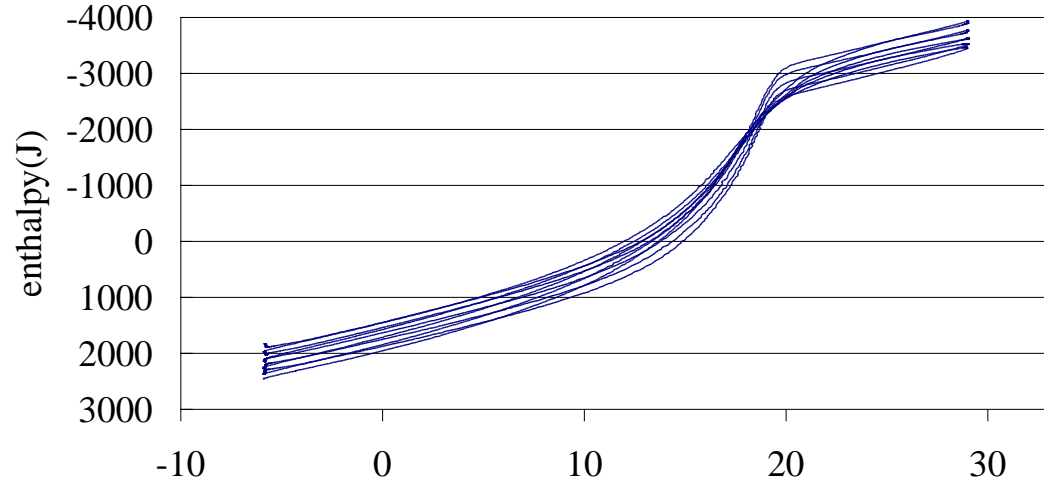


temp.



# Results of MT 17

Temp.(°C )

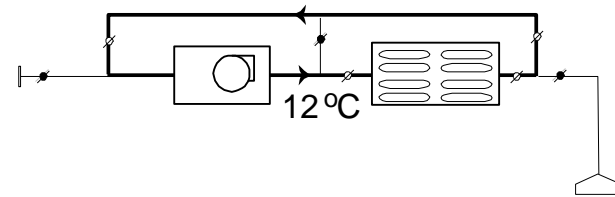
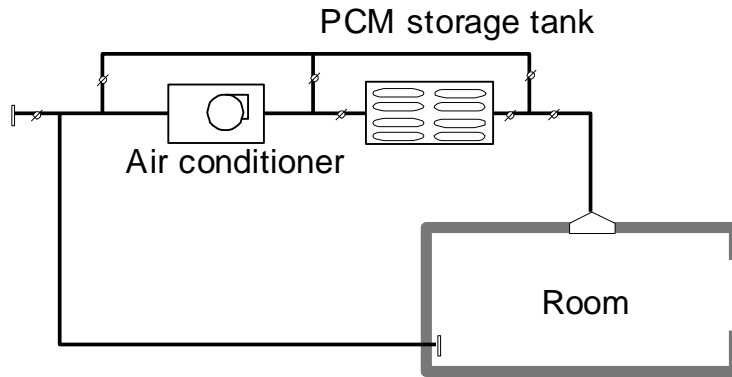


# Results of all mixtures

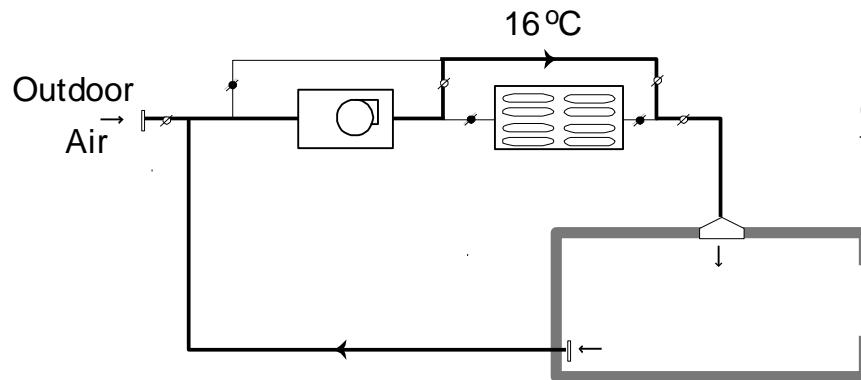
*Table 2. Thermal properties of materials*

Materials	Operations	Peak temperature [° C]	Amount of latent heat [kJ/kg]
MT 17	Freezing	18.5	86.1
	Melting	17.5	77.0
MT 19	Freezing	21.5	87.1
	Melting	20.5	85.9
MT 21	Freezing	21.5	84.6
	Melting	20.5	86.6
MT 23	Freezing	21.5	75.8
	Melting	22.0	83.4

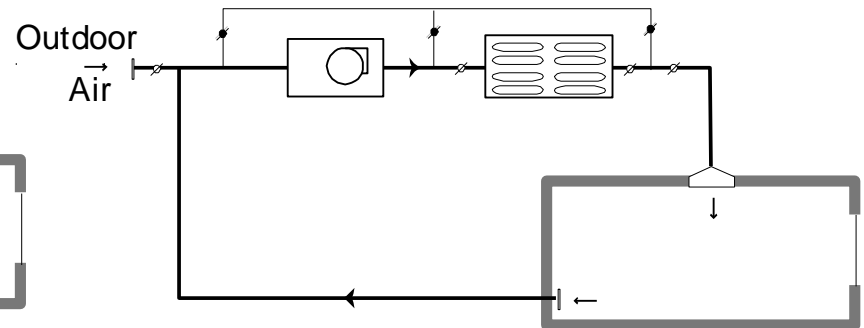
# System simulation



(1) Charging operation (5:00 - 8:00)



(2) Ordinary air conditioning  
(9:00 - 13:00 and 16:00 - 18:00)

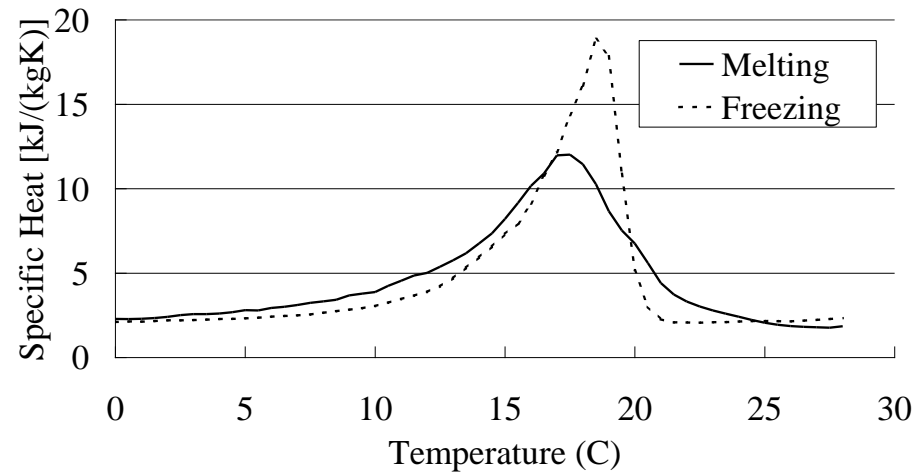
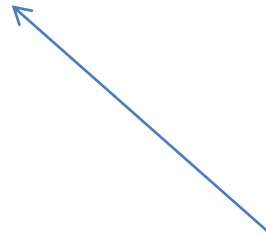


(3) Discharge operation (13:00 - 16:00)



# Enthalpy method

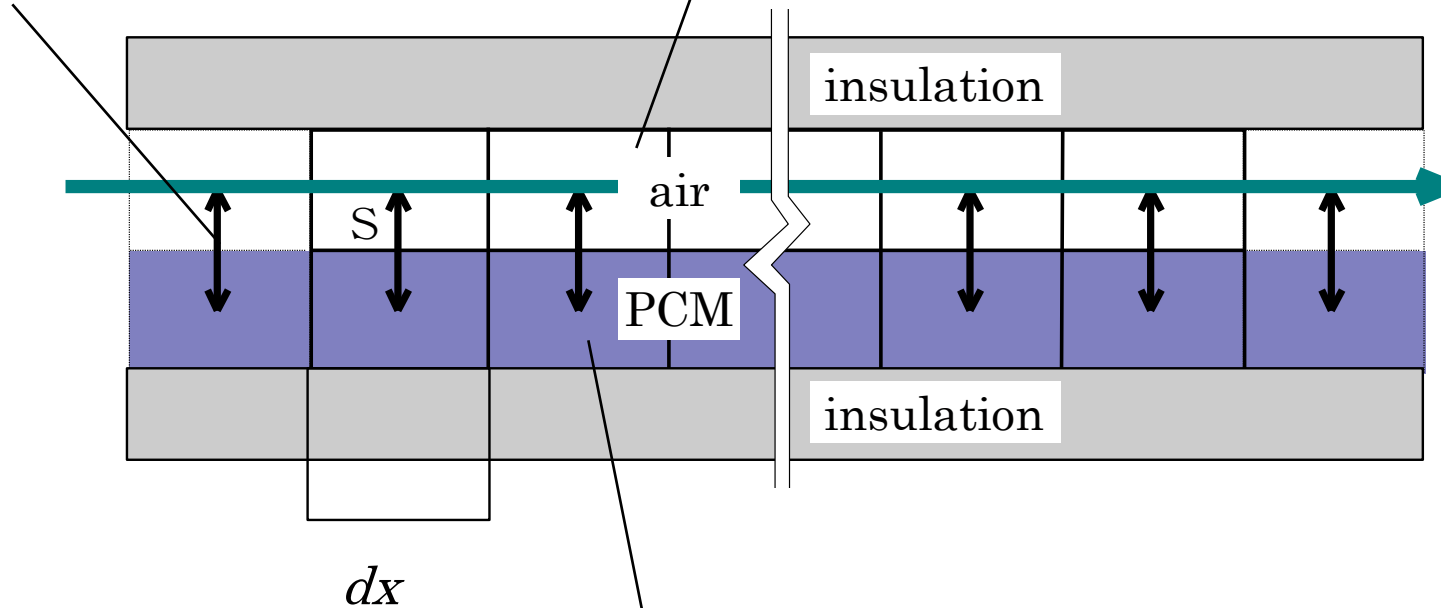
$$\frac{\partial}{\partial t} \{ \rho C_p^*(\theta) \theta_p \} = \frac{\partial}{\partial x} \left( \lambda_p \frac{\partial \theta_p}{\partial x} \right) + \frac{S}{dz_p}$$



# Calculation model

$$S = k A (\theta_a - \theta_p)$$

$$\frac{\partial \theta_a}{\partial t} = \frac{\lambda}{\rho_a C_a} \frac{\partial^2 \theta_a}{\partial x^2} - u \frac{\partial \theta_a}{\partial x} - \frac{S}{\rho_a C_a A dz_a}$$

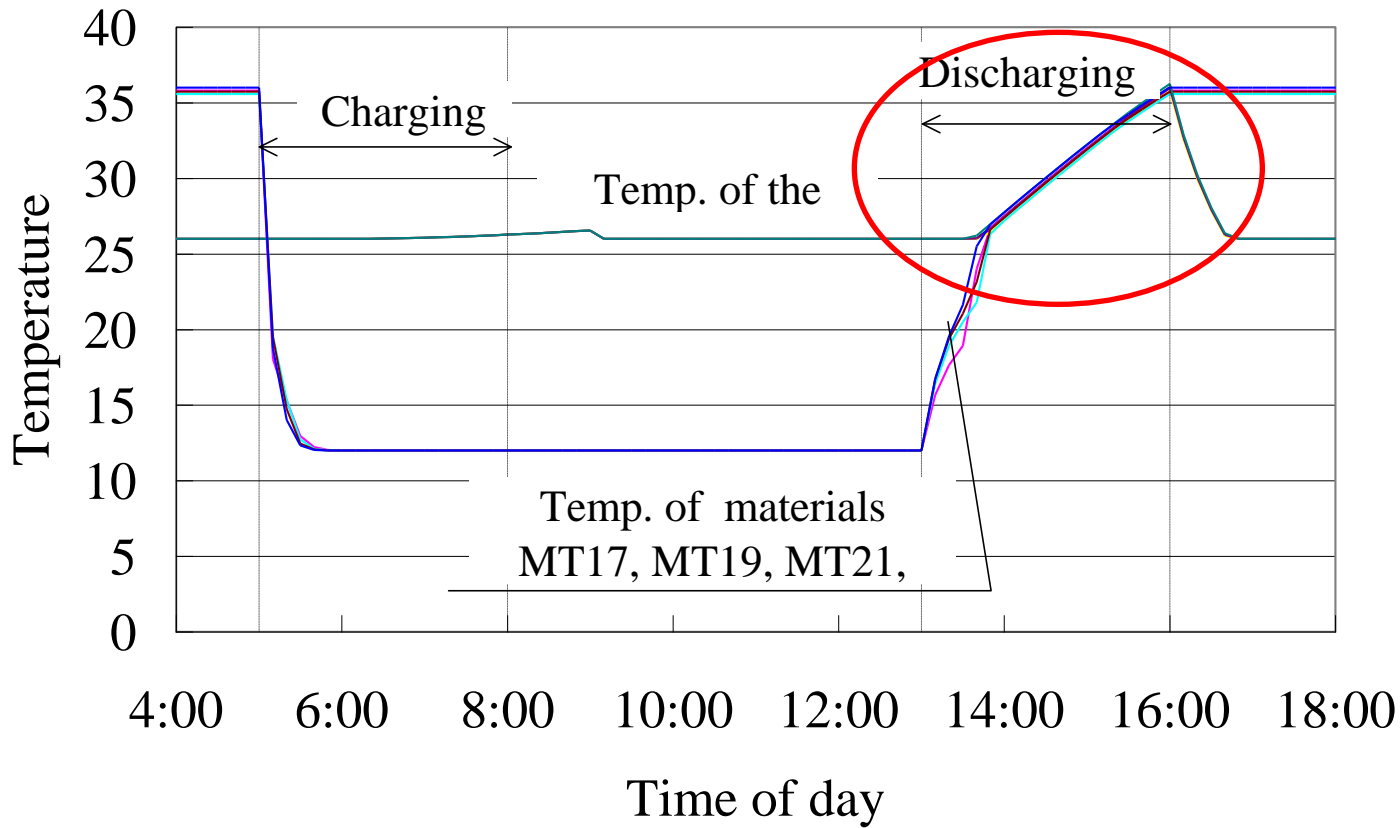


$$\frac{\partial \theta_p}{\partial t} = \frac{\lambda}{\rho C_{pcm} A} \frac{\partial^2 \theta_p}{\partial x^2} + \frac{S}{\rho C_{pcm} A dz_p}$$



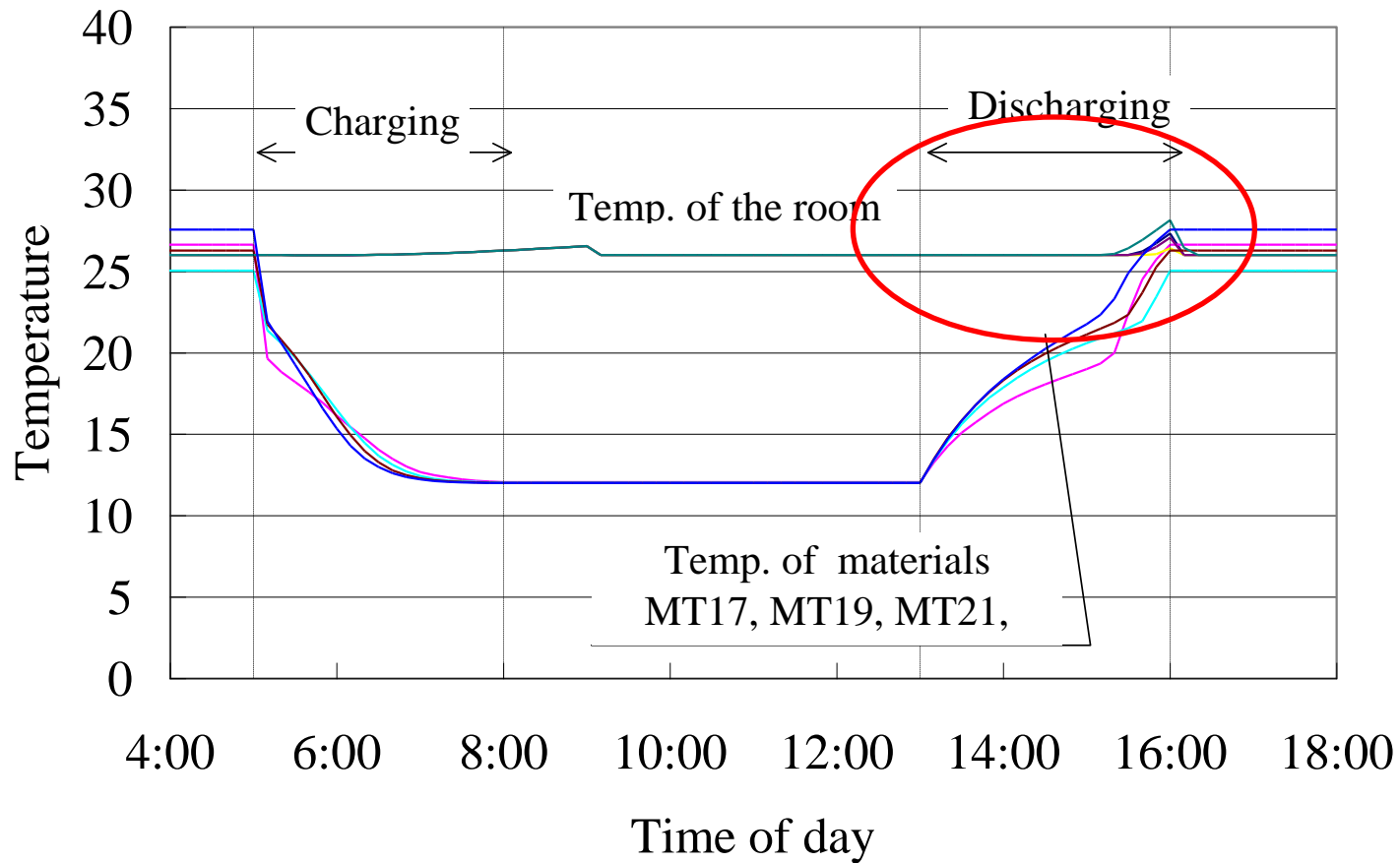
# 100 kg

Room temperature rose.  
Quantity of PCM is not enough

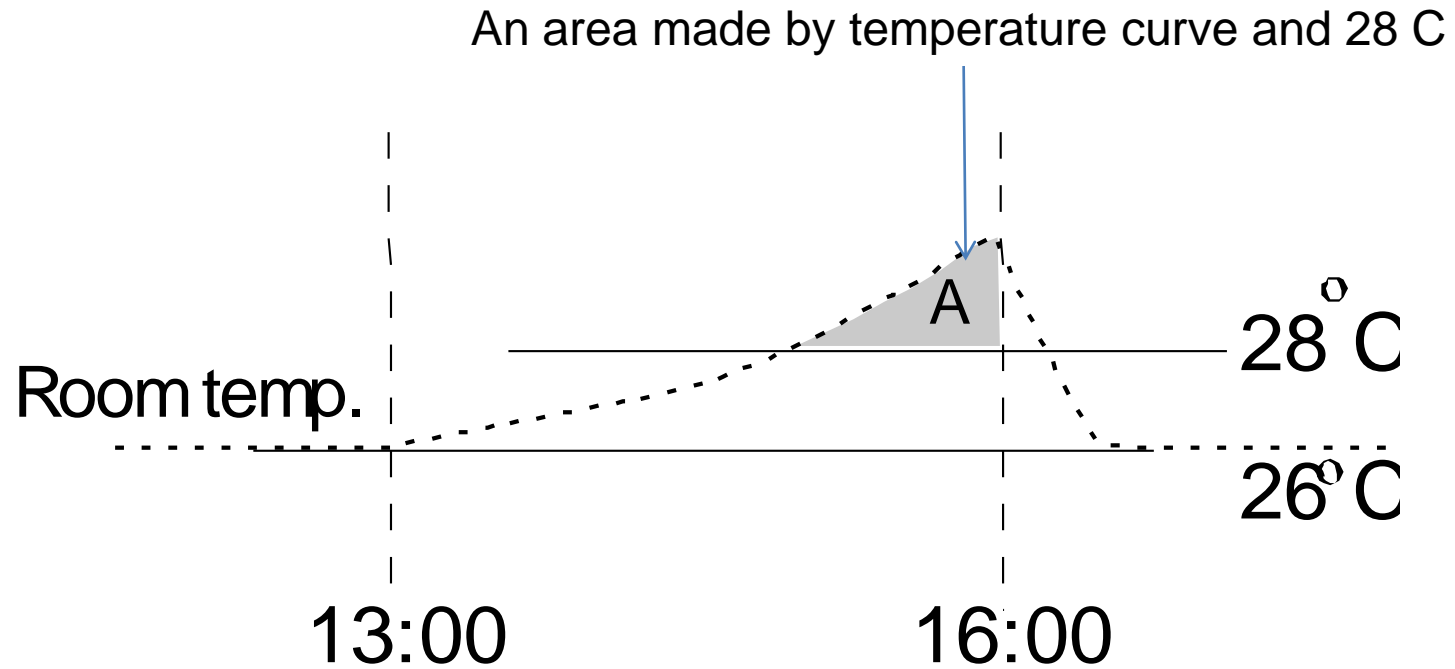


# 400 kg

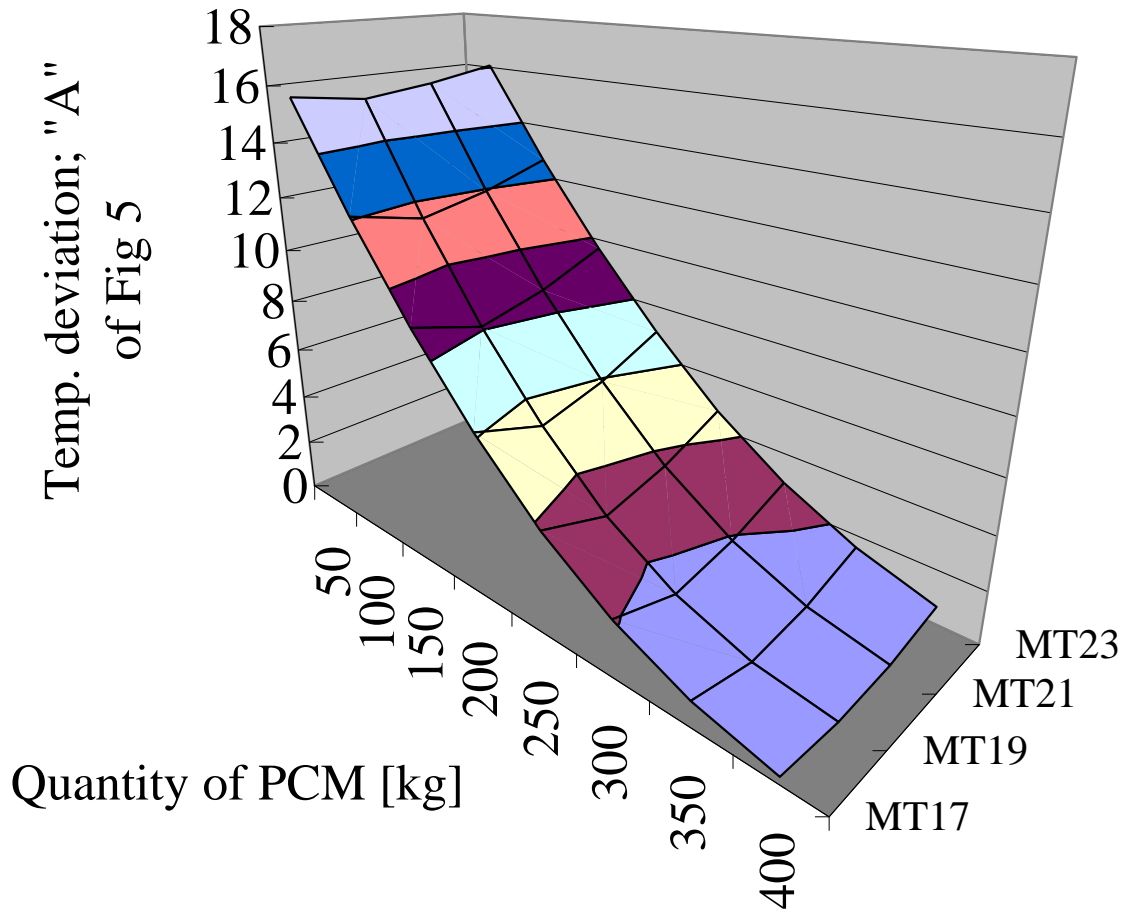
Room temperature was constant.



# An index for evaluation



# Effects of mass and melting temperature on room condition



MT 19 with 400 kg  
Is most effective

# Summary

- The air distribution system with PCM in air ducts was proposed.
- Mixtures of paraffin waxes were tested for thermal properties.
- From simulation results, 400kg for 73.8m<sup>2</sup>, or 5.4 kg /m<sup>2</sup>, of MT19 could maintain room temperature within comfort zone.