

# Exergy Thinking and Thermal Comfort

-For a better understanding of Low-Exergy Systems-

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Well-**BE**<sup>4</sup>ing

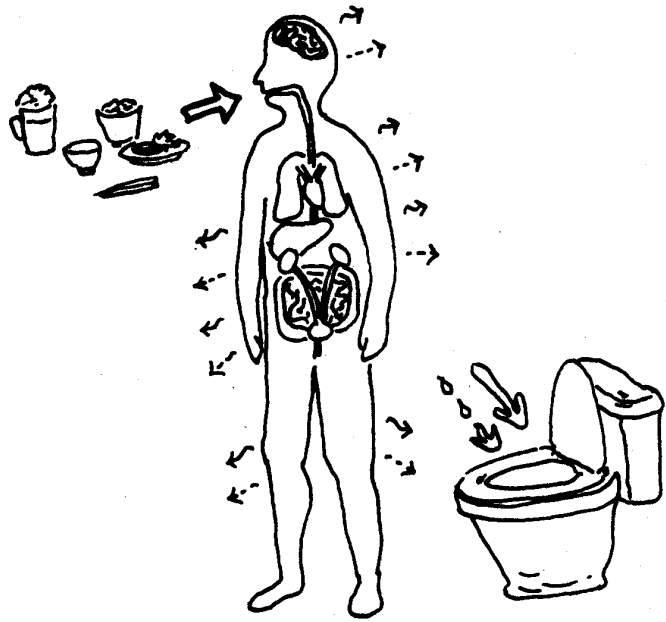


**Shukuya lab.**

by Hiroki Esawira, 2002

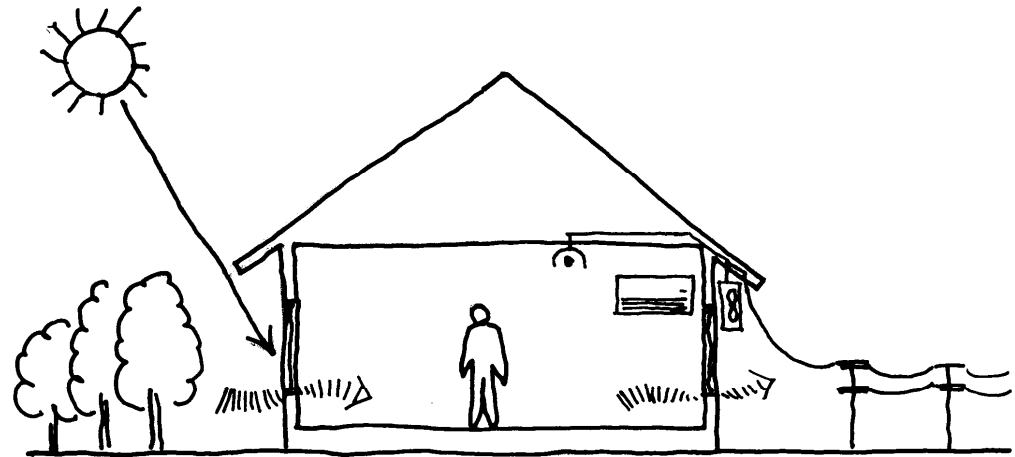


Oskar von Miller Forum, Munich

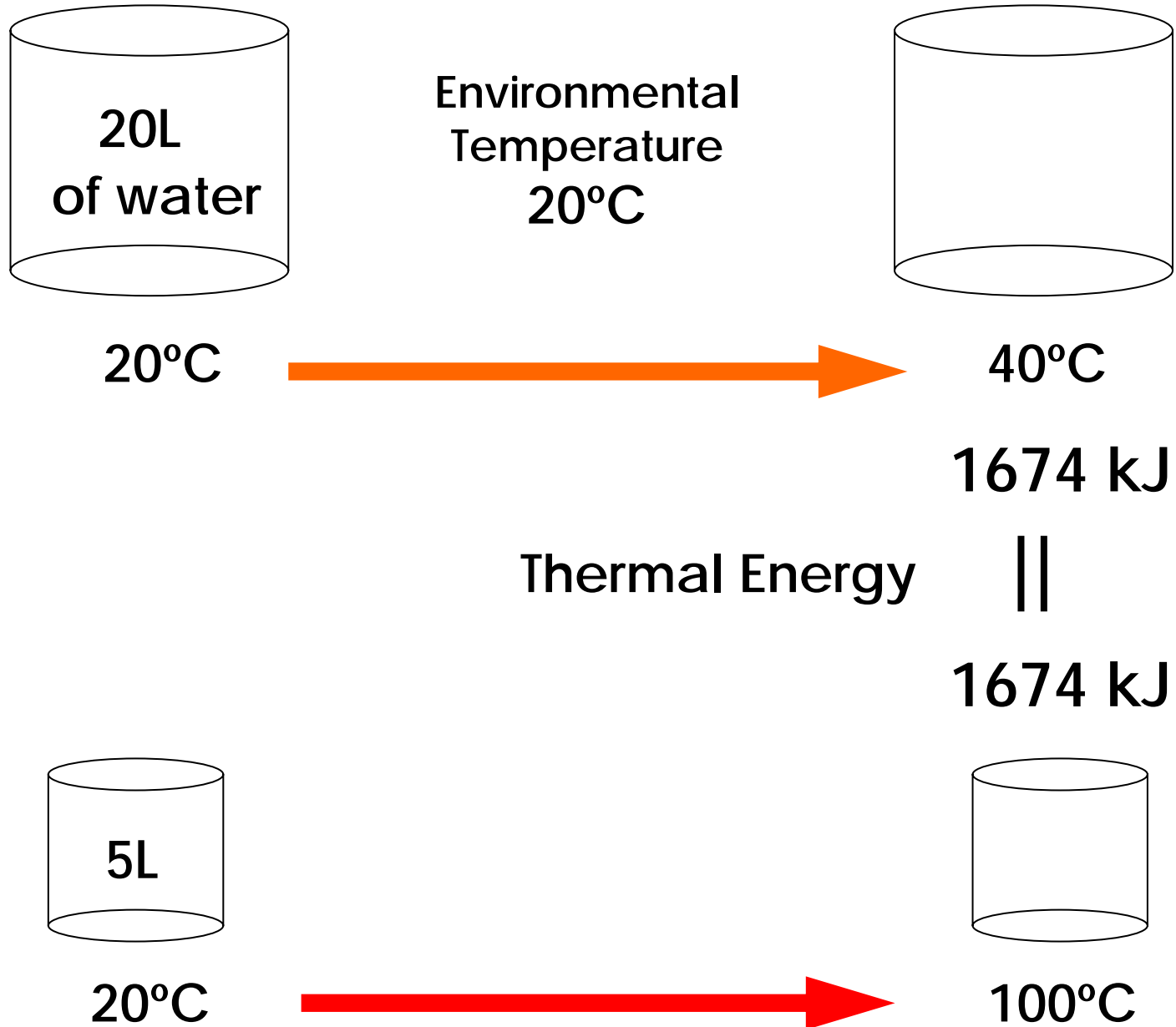


# Human Being and Built Environment

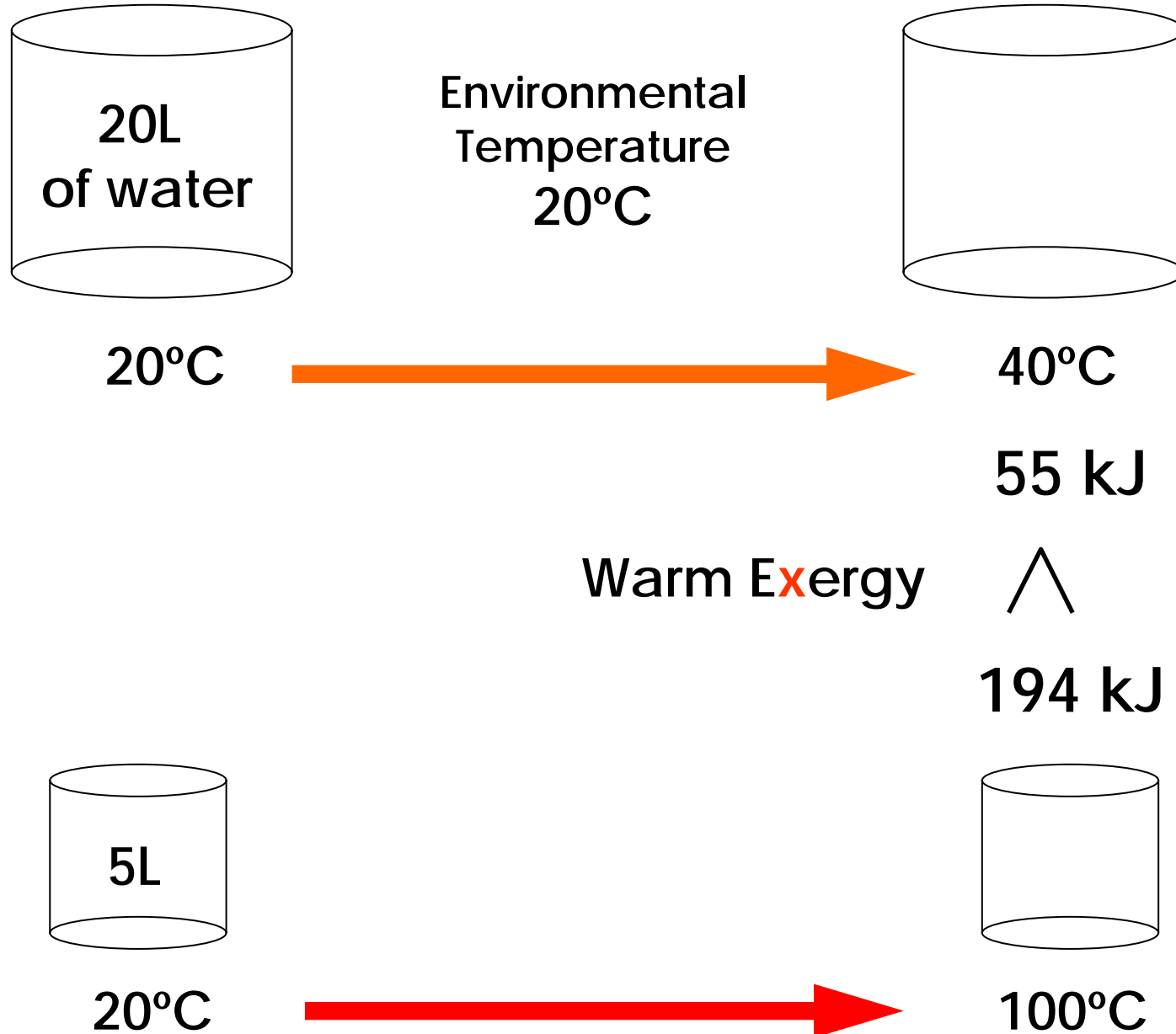
## Thermodynamic Systems



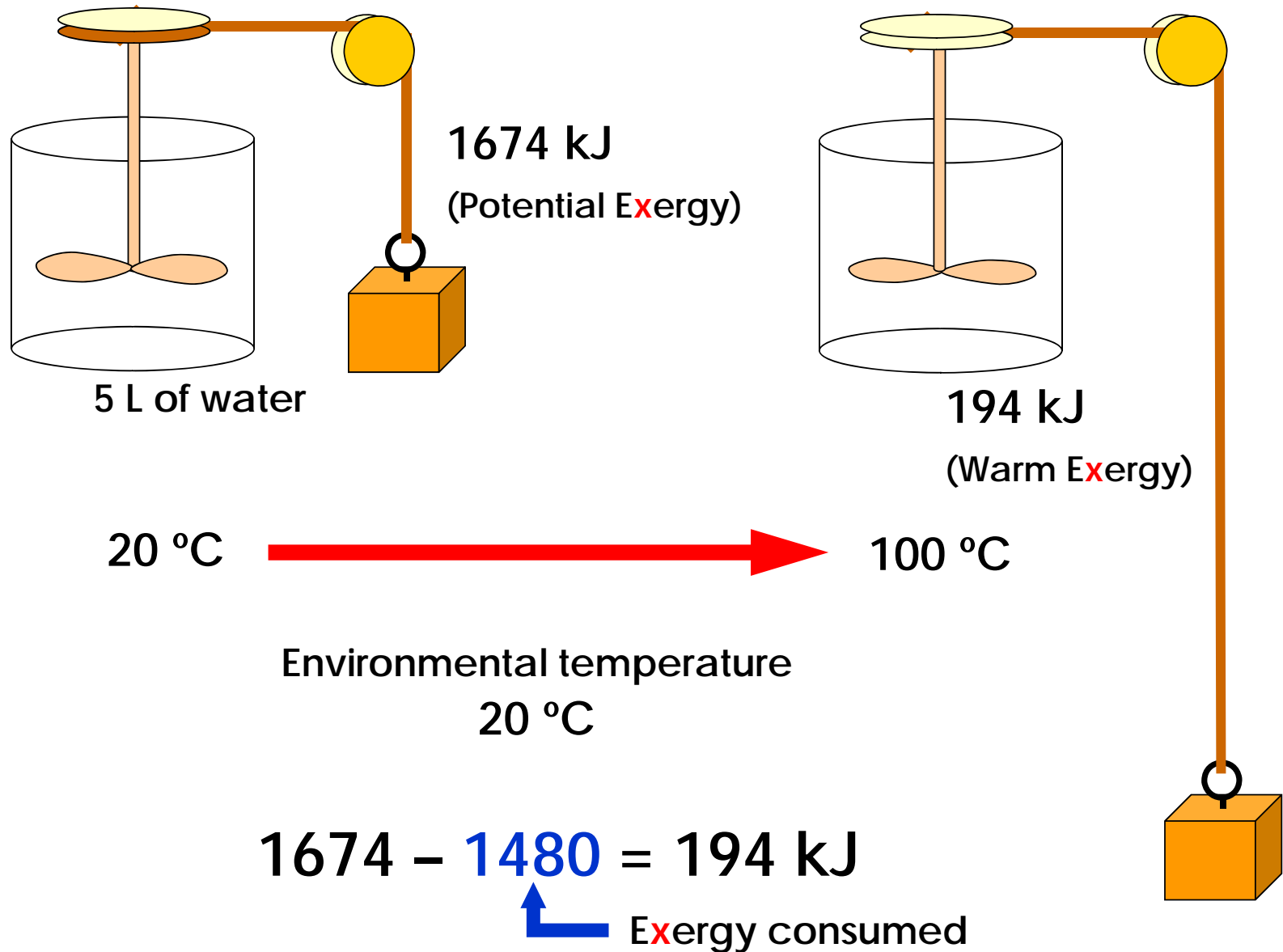
# Why is "Exergy" necessary?



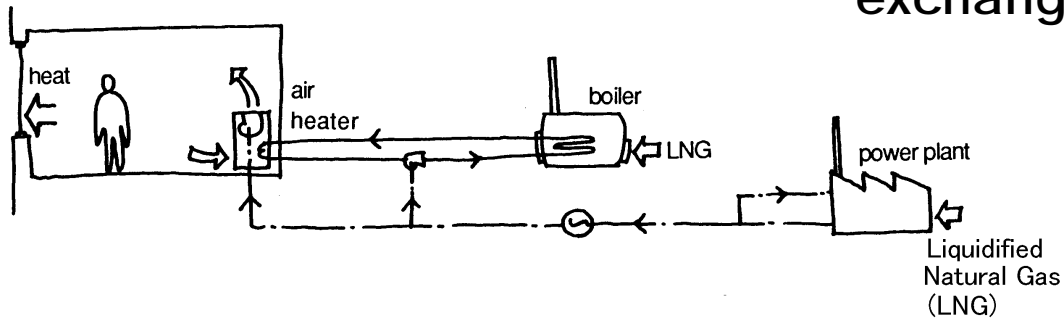
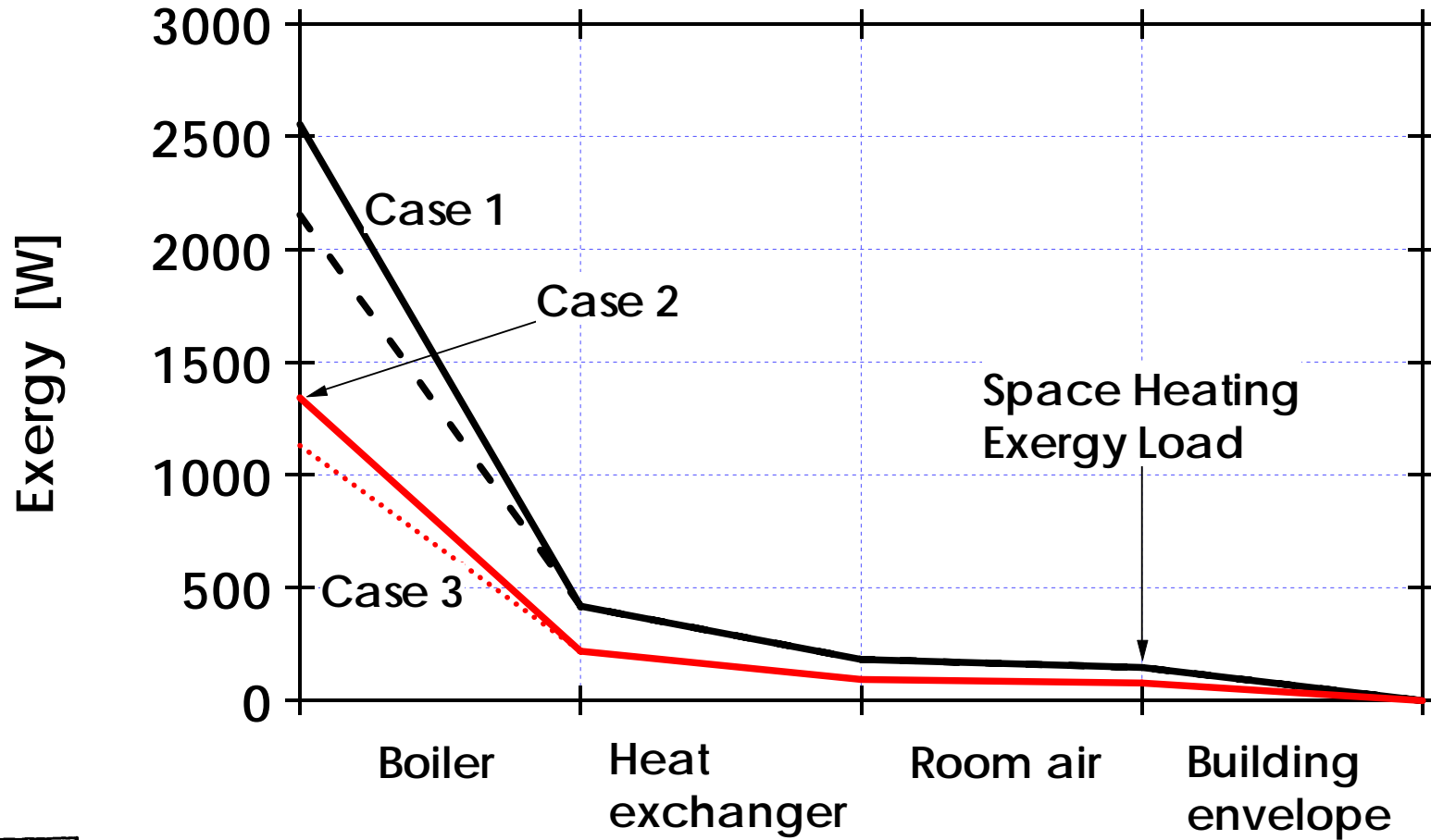
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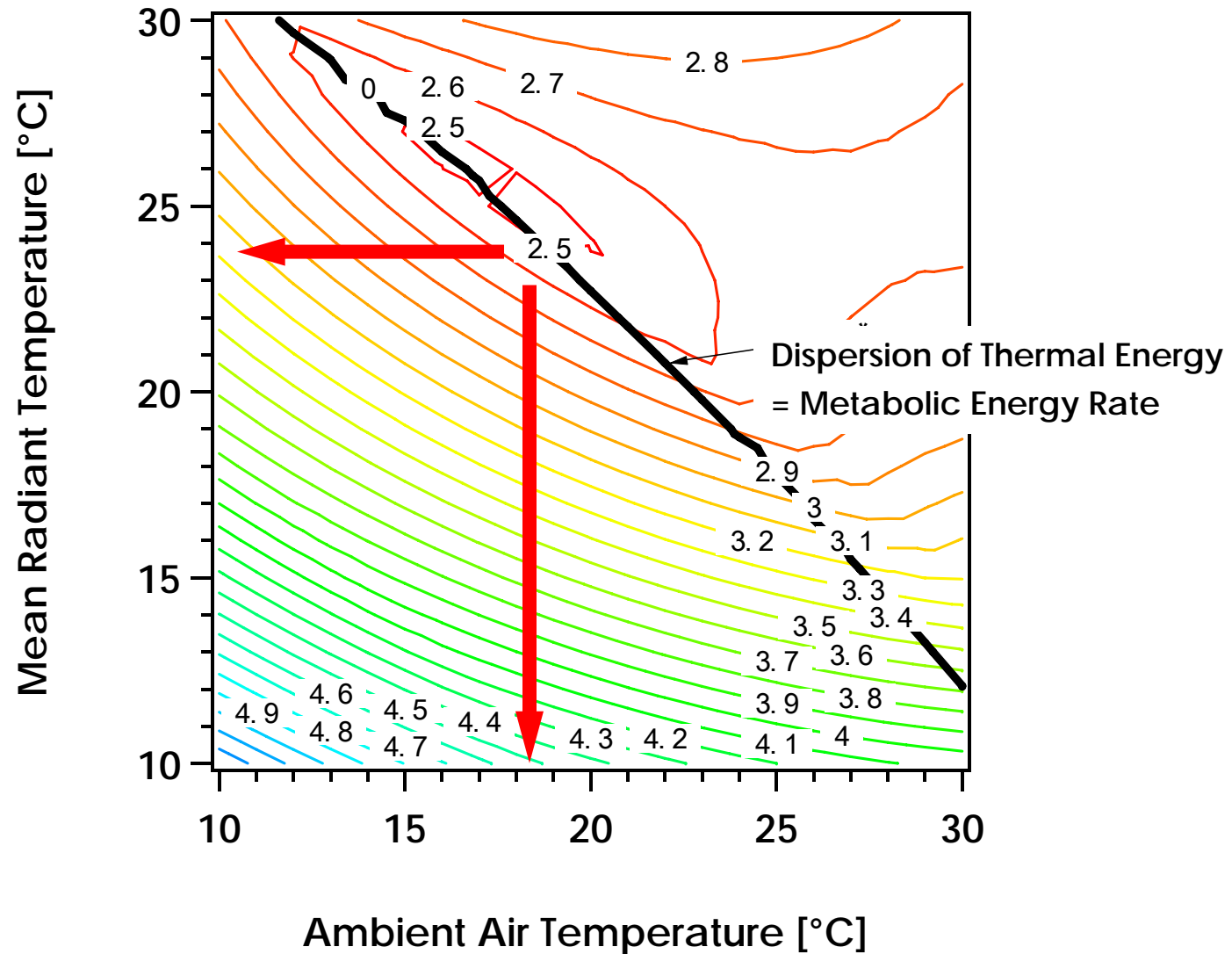
# Why is "Exergy" necessary?



# An Example of Heating Exergy Calculation

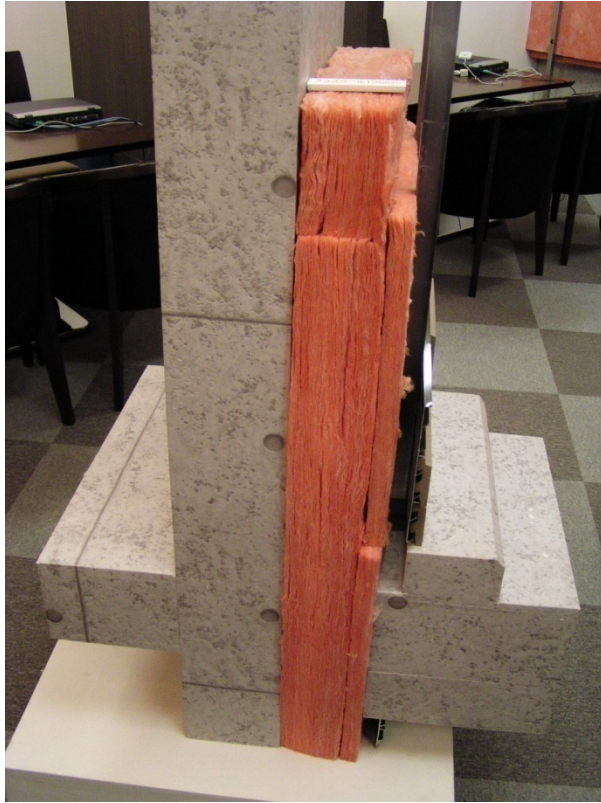


# Human-Body Energy-Consumption Rate and Surrounding Temperatures (Winter)



Outdoor Environmental Condition: 0 °C; 40 %rh

(Isawa & Shukuya, 2002)



Appropriate thermal insulation together with appropriate heat capacity to make use of “warm” and “cool” exergies

**Solar** exergy, which is very rich, to be consumed effectively for space and water heating

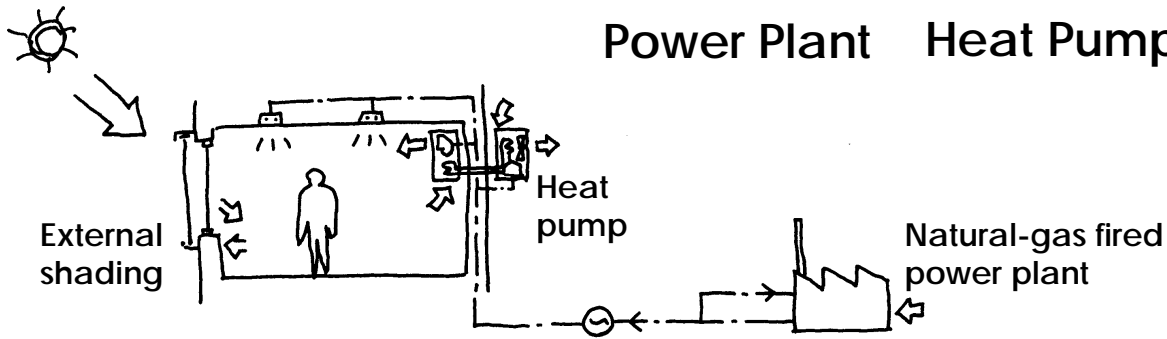
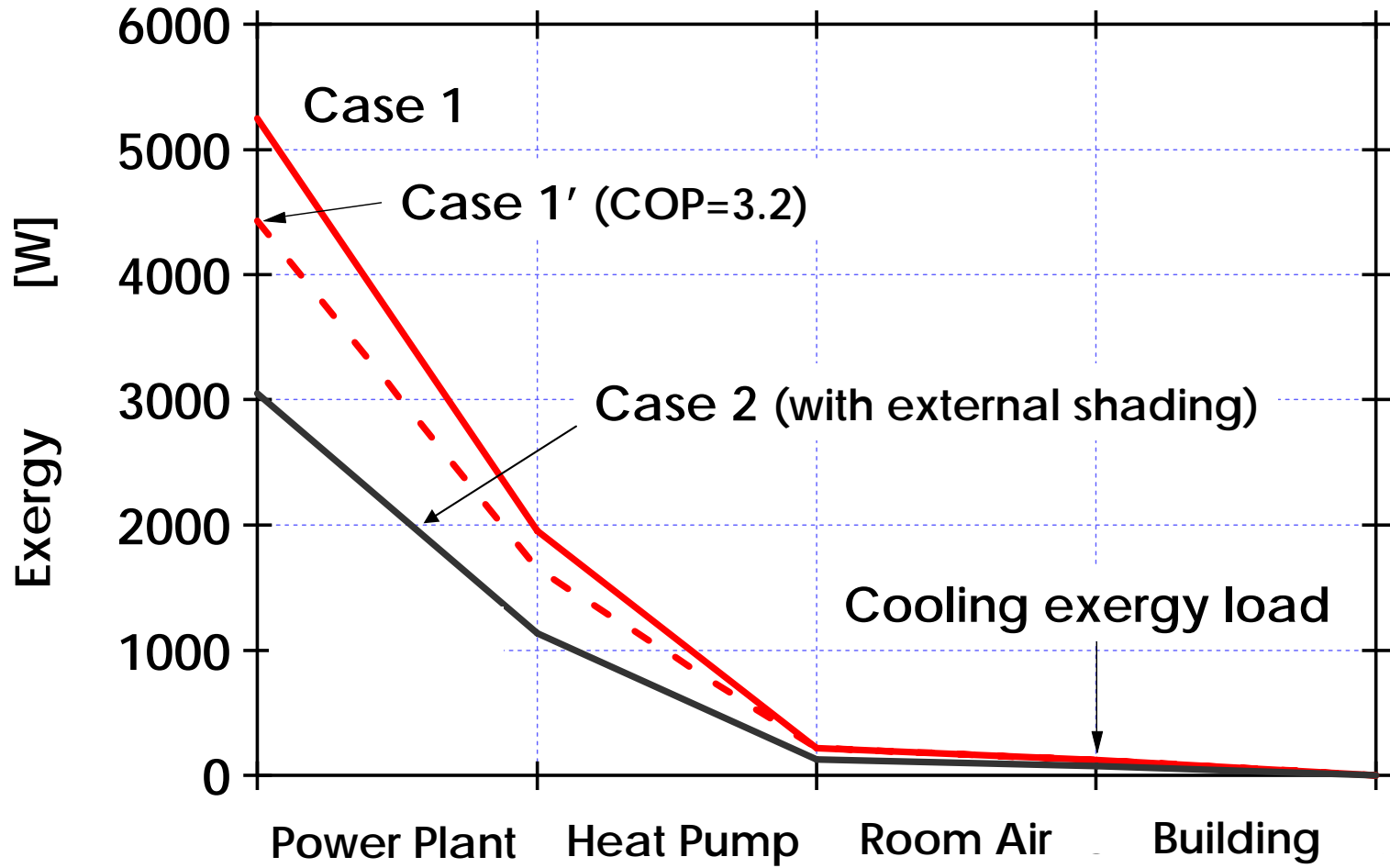


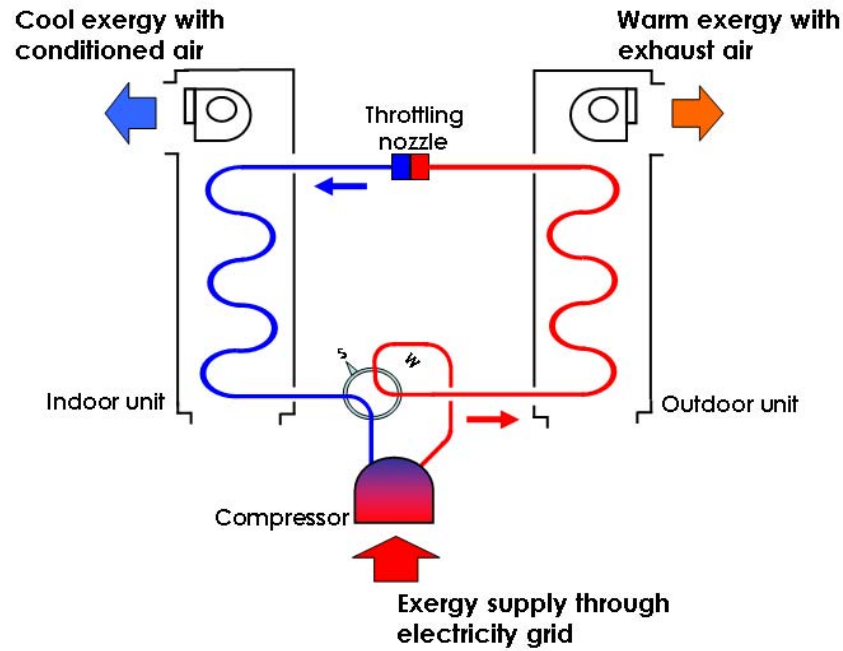


An old Japanese school in Iyo,  
Matsuyama

A classical example of pleasant  
indoor environment with higher  
radiant temperature and lower air  
temperature

# An Example of Cooling Exergy Calculation





$$\begin{aligned}
 & [\text{Exergy Input}] \\
 & - [\text{Exergy Consumed}] \\
 & = [\text{Cool Exergy}] \\
 & + [\text{Warm Exergy}]
 \end{aligned}$$

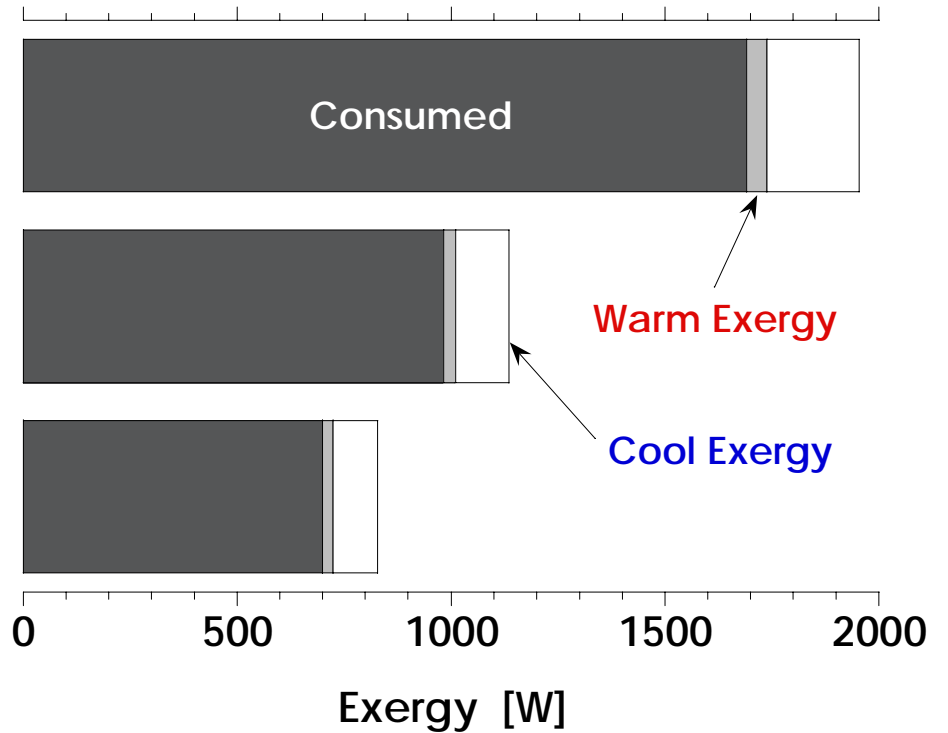
Base Case

↓

With External Shading

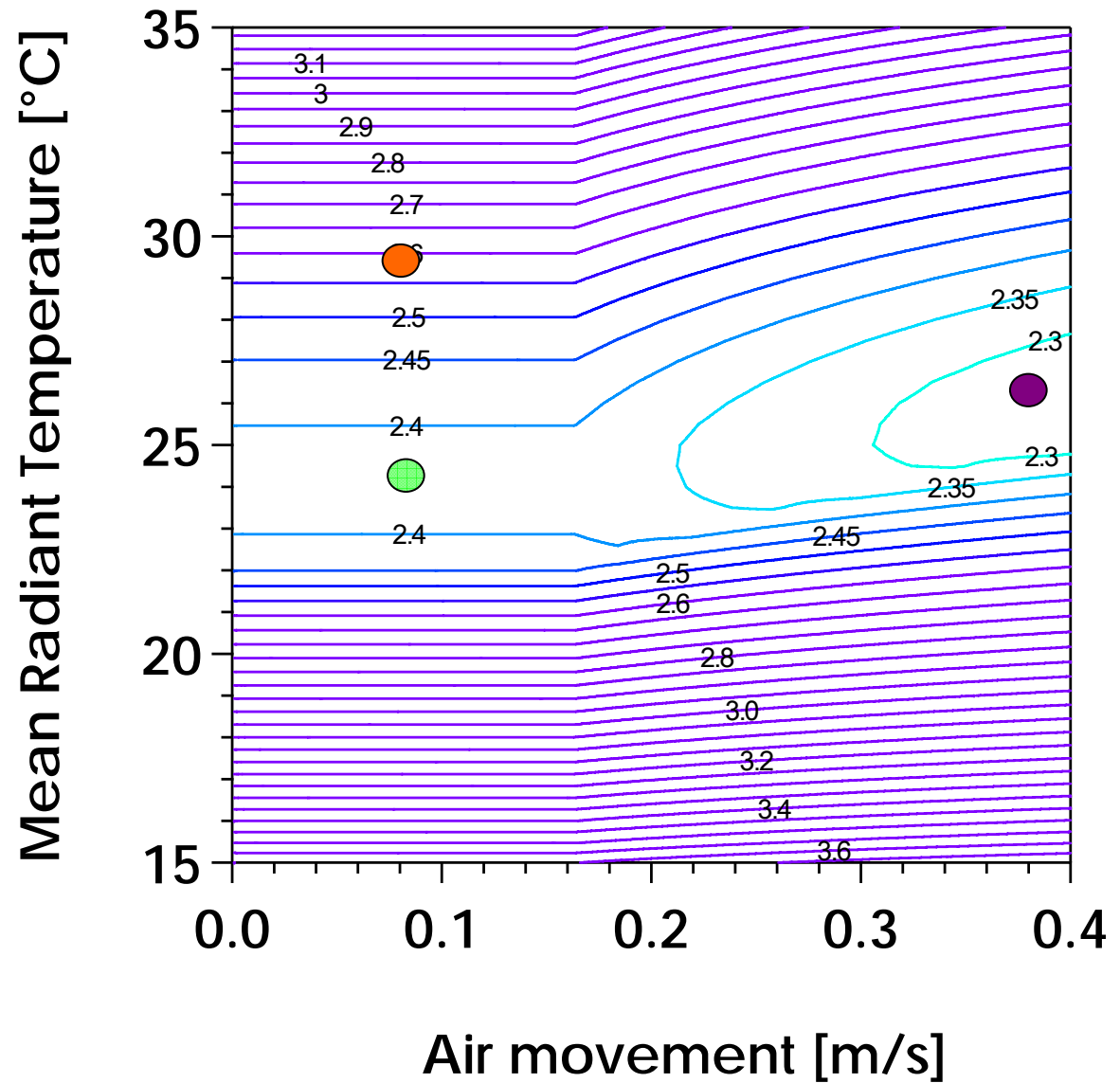
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With Daylighting



# Human-body Exergy Consumption Rate [W/m<sup>2</sup>]

convective cooling

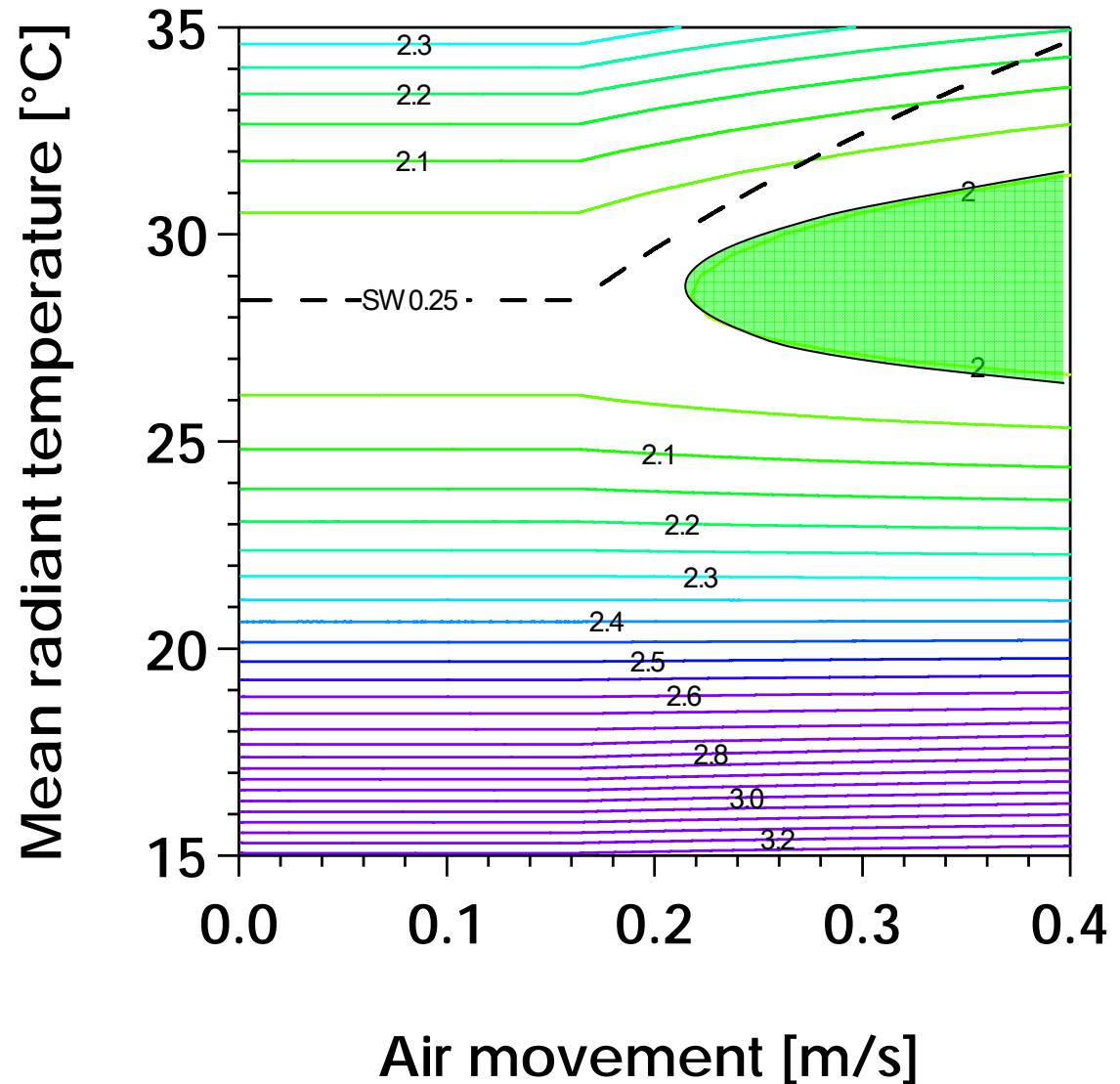


Room air: 26 °C; 50%rh

Outdoor Environmental Condition: 33 °C; 60 %rh

(Iwamatsu & Shukuya, 2008)

# Human-body Exergy Consumption Rate [W/m<sup>2</sup>] natural ventilation + radiant cooling



Room air: 30 °C; 65%rh

Outdoor Environmental Condition: 33 °C; 60 %rh

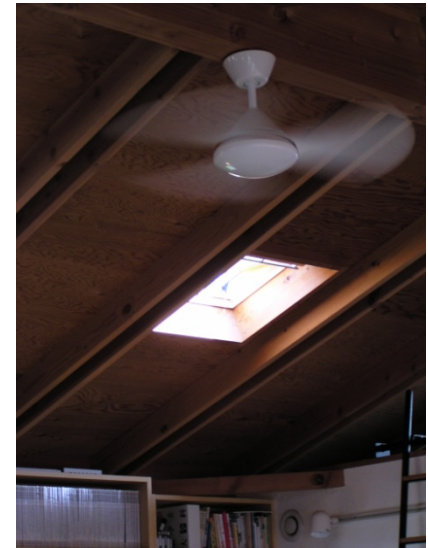
(Iwamatsu & Shukya, 2008)



**A classical example of pleasant outdoor environment with lower radiant temperature and rather high air temperature**



Effective external shading



Enhancement of air movement

Open space for natural ventilation

