

### **Background: Low Energy Buildings**

- How to achieve low energy building?
  - **1. Appropriate indoor thermal environment**
  - 2. Reasonable architecture design
  - 3. Low energy thermal environment control facilities





Hoyt *et al.* (2009) "Energy savings from extended air temperature serpoints and reductions in mixing." <u>International Conference on Environmental Ergonomics</u>, Boston.













5

### What thermal comfort model should be used for mixed-mode building?

- Mixed-mode building=Free running + Air-conditioning
- In many Asia countries, most buildings are mixedmode buildings
- We found that thermal adaptation is also present in mixed-mode buildings
- Adaptive opportunities:
  - Natural ventilation, shading, solar radiation, change cloth, drink cold/hot drinks.....
  - Electric fan, air-conditioner, personal comfort system(PCS)

# 2. Reasonable architecture design

12

#### A Mixed-mode office building, Shenzhen, China Subtropical area, humid and warm climate Strategy: open spaces, natural ventilation, local controlled AC, 60% energy consumption







#### Office building in Guian, China Free-running building, Moderate climate zone









Office building, mixed-mode, Ahmedabad, India. Hot climate Adaptive opportunities: Personal fans, window openings, clothing Electrcity: 56.99 kWh/m<sup>2</sup>a, with equipment load 37.87 kWh/m<sup>2</sup>a, without equipment load



20





### The heated/cooled chair



Mesh PCS chair UC Berkeley Ed. Arens & Hui Zhang



- battery-powered
  seat and back separately controlled
- four levels of heating or cooling
- total maximum power is 14 W for heating and 3.6 W for cooling



Semiconductor refrigeration Contacted cooling chair Tsinghua University









## Thanks for your attention!

#### **Operating Agents:**

Yingxin Zhu Tsinghua University China Richard de Dear The University of Sydney Australia Secretary:

Bin Cao Tsinghua University China