

Envisioning Future Building Occupants and Their Energy-Related Behaviors

Panel Discussion at Annex 66 Expert Meeting on March 30, 2015

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1. Personal Characteristics (Hui Zhang, UC Berkeley)

1.1. Discussion Question

- What internal characteristics of future building occupants will be most relevant to their behavioral interactions with the built environment?
 - Past 100 Years Example: Changing personal sensibilities about “comfort” encouraging the use of air-conditioning in homes and offices.

1.2. Presentation highlights

- Thermal alliesthesia - the “pleasure” principle:
 - Traditional design buildings for static conditions in spite of a dynamic human perception of the thermal environment
 - Thermally “neutral” environment cannot achieve “very comfortable” occupant responses.
 - “Transient” and “spatial” alliesthesia:
 - Transient can be short, while spatial is longer.
 - Laboratory testing is challenge due to possible long time duration of effect.
- Comfort is a “zone”, not a single point:
 - Zone of thermal preference, but body has extreme capabilities beyond this zone.
 - Body adapts to wide range before requiring modification of immediate environment.
 - HVAC design can accommodate wider comfort zones with more efficient personalized controls and better knowledge of sources of discomfort in warm/cool conditions.

1.3. Discussions and Implications for Future Buildings

- Future building designs must consider huge adaptation range of the human body, designing not for a single optimized point but for a range that is generally free of discomfort.
 - Future buildings are unlikely to achieve 100% satisfaction with the thermal environment if only relying on centralized systems – the designs must turn to more personalized thermal comfort provision through portable/wearable devices (e.g. vision aids for elders, clothes providing extra heat) that reduce the need for energy consumption.
- Given consistency in human thermal perception across 100 years, what works physiologically today in terms of comfort provision will likely work 100 years from now.
- Future environments can leverage shifting expectations from occupants about comfort provision:
 - Occupants 100 years ago did not expect a tightly controlled environment
 - Expectations of occupants 100 years from now can be influenced by the types of environments they are accustomed to encountering – building designers can shift expectations by the types of building environments they develop for occupants.
 - Expectations may go beyond thermal comfort, to the provision of services towards work/family balance (i.e. babysitting, food services).

2. Social and Economic Context (Clinton Andrews, Rutgers University)

2.1. Discussion Question

- What external aspects of future occupants' built environment will most influence and/or constrain their behavioral interactions with the built environment?
 - Past 100 Years Example (Social): Development of open/semi-enclosed office furniture, exemplified by the Steelcase Corp. "Modern Efficiency Desk" and Herman Miller "Action Office", respectively.
 - Past 100 Years Example (Environmental): Unchecked growth of energy consumption and associated environmental degradation due to abundant, cheap energy and mass production of consumer goods.

2.2. Presentation highlights

- Future demographic trends:
 - Population growth: More people means more buildings.
 - Median age: people are living longer, working longer.
 - Dependents/working-age population: old-age dependency ratio going up, child dependency ratio going down.
 - Average hours worked per week have dropped dramatically.
 - Increasing urbanization (Urbanization includes the sprawled suburban areas).
 - Increasing income inequality vs. urban propinquity, segregation, and high interurban mobility. Cities need to accommodate both rich and poor residents.
- How to design the workplace for these trends:
 - Trans-humanism emerges (office in buildings, then in pocket, then implant).
 - Security issues persist (due to core-periphery tensions, local economic inequality).
 - Persistently need diverse workspaces for both collaboration and contemplation.
 - Increasingly need to fit workspaces into richer life in which boundaries blur (e.g. bike racks at work).
 - Building structures should be designed for long time scales; their functional systems should be more replaceable over time.

2.3. Discussions and Implications for Future Buildings

- Future buildings need to accommodate the needs of an aging population (at work and home).
- The new work/life balance (increased leisure time) will affect building design:
 - We will likely see a reduction in the amount of work done in a workspace and an increase in the work that is done from home.
 - Gathering points will still be needed to meet the social and collaboration needs.
- Work spaces will become more diverse to accommodate different natures of work (large open space is not always the appropriate setting).
- Work spaces will be denser and configurations will vary in space and time
 - Challenge is enabling these flexible reconfigurations.

3. Enabling Technologies & Approaches (Steve Selkowitz, LBNL)

3.1. Discussion Question:

- What technologies will enable future occupants to meet personal comfort needs and preferences?
 - Past 100 Years Example: Central space conditioning and room thermostats; personally-controllable mechanical fans and heaters.
- What technologies/approaches will improve our ability to quantify and evaluate occupant behavior and its effects in buildings?
 - Past 100 Years Example: Development of wired/wireless environmental sensing equipment; development of occupant-focused modeling approaches (i.e. comfort, productivity models) and computing resources.

3.2. Presentation highlights

- We cannot motivate many needed behaviors on the basis of energy efficiency alone, but perhaps on the basis of thermal and visual comfort.
- We need better integrated, responsive, intelligent systems in the future.
 - Three system design approaches:
 - Foolproof (passive) systems built into the infrastructure;
 - Hybrid systems with some level of active human control;
 - Super intelligent and automated systems.
- My working Hypothesis: Occupants cannot be expected to reliably figure out and manage building system-level impacts of their behaviors:
 - Optimizing comfort/preference can in some cases increase energy use/peak
 - Suite of variables too complex (i.e. weather dynamics, internal dynamics, comfort, productivity, etc.) for occupant to consider all at once
 - Automated systems (i.e. smart shades) can deliver both better energy savings and comfort
- “Internet Of Things” is coming (with privacy issues).
 - Buildings will have cheaper sensors and wireless links to all devices.
 - Buildings will have more responsive, adaptive building controls and granular service supply and matching controls (for example, individual task oriented LED light fixtures with occupancy and daylight sensors and link to utility price signal).

3.3. Discussions and Implications for Future Buildings

- Buildings will be sensor-rich but Occupants will use more wearable electronics and apps, possibly including implanted devices:
 - Wearable devices will provide more flexibility for granular control of personal spaces
- Wearable/personal devices will have embedded sensors to automate overall system operation and optimization given local-level data:
 - Occupants should have some control over the optimization goals but the majority of the operational information collection, synthesis, and optimization can be automated and invisible to the user.
 - Information must be distilled down in complexity before interfacing with occupants for feedback.
- Future buildings will be produced more as manufactured systems, with integrated functionality more like cars today:
 - Technology integrates inputs from dozens of sensors to optimize real time performance, i.e. like a driverless car.
 - Goals, settings and amount of control is up to the user.

4. New Building Paradigms (Cary Chan, Swire Properties)

4.1. Discussion Question:

- Given the imagined future development of occupants and their social, environmental, and technological context, what new building paradigms might emerge?
 - Past 100 Years Example: Modern office buildings with deep floor plates, enabled through electric lighting and air-conditioning.

4.2. Presentation highlights

- “Eco profits” vs. financial profits must drive development
 - Requires change in culture and education.
- Living places in future:
 - Integration of living, working, leisure, net-zero, renewables penetration, passive design, flexible

4.3. Discussions and Implications for Future Buildings

- New building typologies are not driven by technology alone; policy/economics are overlooked drivers
 - Future zoning and public policy must be integrated with sustainability

Working Document