Space, Time, Energy: Learning from Interlocking a House with the Sun

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Space, Time, Energy...
....learning from
Interlocking a house with the sun

Photo credit: Jim Tetro, D.O.E.
‘...a passageway, which leads from the exact sciences to the arts and humanities. While both seek to explain the world with their own methods, they are turning their backs to each other.’

The shipping passage in the North of Canada connecting the Atlantic and the Pacific serves as a metaphor for the complex thought space linking, connecting and dividing these two explanations of the world. This metaphor is dealing with the connection of places, which seemingly are separate: rigidness and fantasy, myths and exactness, quantitative and qualitative knowledge. As the passage through the eternal ice, this path exist, but is constantly changing in time and space, its boundaries are volatile due to changing border conditions.

Low energy building 2000

Passe Kaelber Architects, Berlin
SPACE and AIR AIR AIR AIR !
Interdisciplinary research into the fluid dynamics of natural ventilation and spatial composition

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SUMMARY
The paper presents collaborative research between architecture and mechanical engineering on natural ventilation, a key concept for healthy, energy efficient buildings. The technical focus is on the relationship between interior spatial layout and energy consumption of buildings by using a coupled approach between architecture and computational fluid dynamics (CFD). Preliminary results will be presented on the effects of spatial composition on natural ventilation airflow and energy use. We hypothesize that energy requirements of standard heating and cooling systems can be reduced by effectively shaping complex architectural spaces.
Building related energy consumption

Figure 1-1 U.S. Primary Energy Consumption, 2005²

- 22% Residential
- 32% Industry
- 40% Buildings
- 28% Transportation
- 18% Commercial

- Heating 31%
- Water Heat 12%
- Lights 11%
- Cooling 12%
- Refrigeration 8%
- Wet Clean 5%
- Electronics 7%
- Cooking 5%
- Computers 1%

- Lights 26%
- Heating 14%
- Cooling 13%
- Water Heat 7%
- Office Equipment 6%
- Ventilation 6%
- Refrigeration 4%
- Computers 3%
- Cooking 2%
Building related energy consumption

Figure 1-1 U.S. Primary Energy Consumption, 2005

- Buildings: 40%
  - Residential: 22%
  - Commercial: 18%
- Industry: 32%
- Transportation: 28%

Heating: 31%
Cooling: 13%
Lights: 26%
Other: 13%
Building related energy consumption

Figure 1-1 U.S. Primary Energy Consumption, 2005

- Industry: 32%
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- Computers 3%
- Refrigeration 4%
- Office Equipment 6%
- Ventilation 6%
- Water Heat 7%
- Cooling 13%
- Heating 14%
- Lights 26%

54% Design
53% Design
Achieving Net-zero: reducing demand

Figure 3. Approach for Achieving Net-Zero Energy Buildings
\[ H_{L/G} = U \times A \times (T_i - T_o) \]
Human perception and thermal comfort

- Aino and Alvar Aalto’s own house in Helsinki 1935
- 1928 the Weather maker
For full credit of all Co-Pi’s team members, collaborators and sponsors please see: http://www.solard.iastate.edu
Iowa
SPACE - TIME (LAG) - ENERGY

Interlock with the outdoors
Interlock with the outdoors
SPACE - TIME (LAG) - ENERGY

Interlock with the outdoors
Convective air loop
Cross / Stack ventilation
Cross ventilation
Heat recovery
Architecture + Engineering Design

Photo credit: Jim Tetro, D.O.E.

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Natural Ventilation
Sunspace + Thermal Mass
Daylight and Natural Ventilation

Photo credit: Jim Tetro, D.O.E.

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Electric and thermal systems
Research & Design challenges

- Utilize daily (or seasonal) thermal energy storage for solar energy in the building materials.
- Short term thermal energy storage through thermal mass (concrete, brick, stone) very common in Europe.
- Light weight phase change materials (PCM) could be an alternative for light weight construction.
- Long term durability of the phase change melting and freezing cycles?
- New PCM’s?
- Interaction between air flow and material properties of thermal mass needs to be studied to utilize the natural flow of air (convection, stratification etc) and material properties on multiple scales.
THANK YOU AND TODA!

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THANK YOU AND TODA!