



**announcements 5/13/08**

**Final Exam Alternate Time:**

**Wednesday, 6/11**

**4:30 - 6:20**

**SMI 304**

**Final Exam Assigned Time:**

**Friday, 6/13**

**4:30 - 6:20**

**Gowan 201**

**announcements 5/13/08**

**Assignment 4: Shading Model Studies**

**EXTENSION - DUE NEXT WEEK**

*Available on the Course Website (due in sections next week)*

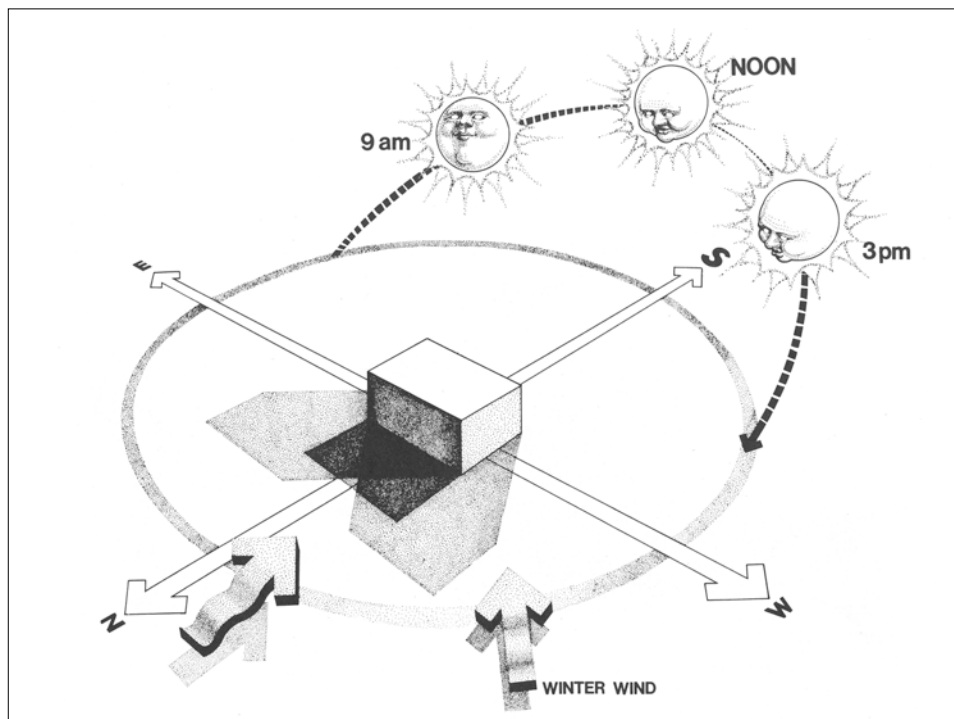
**Wednesday, May 14 • 6:30 in Architecture 147**

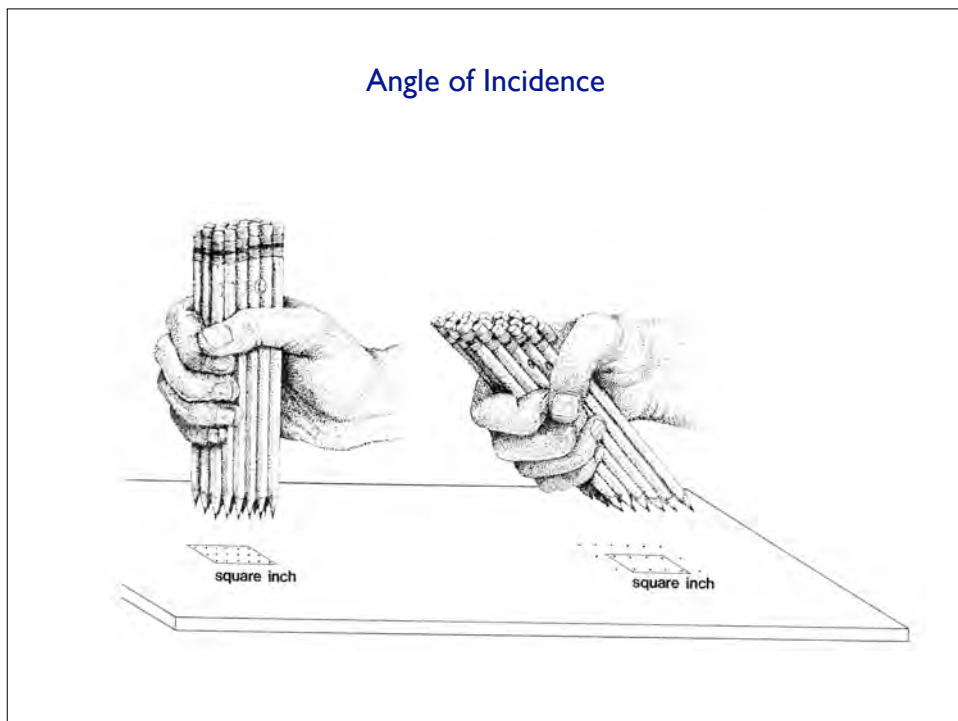
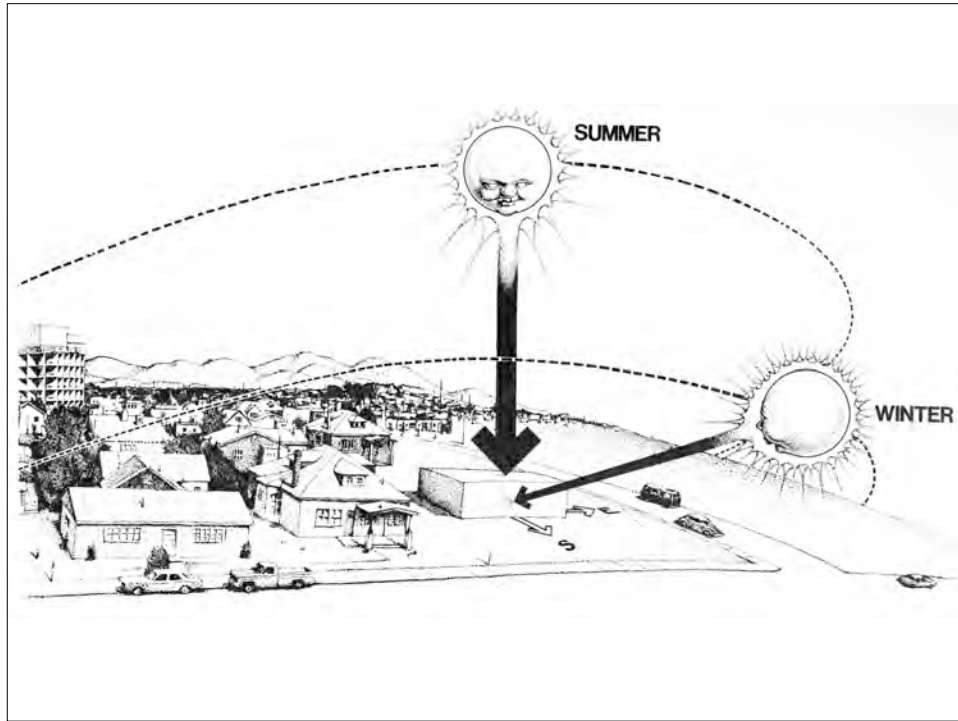
**Glen Murcutt**

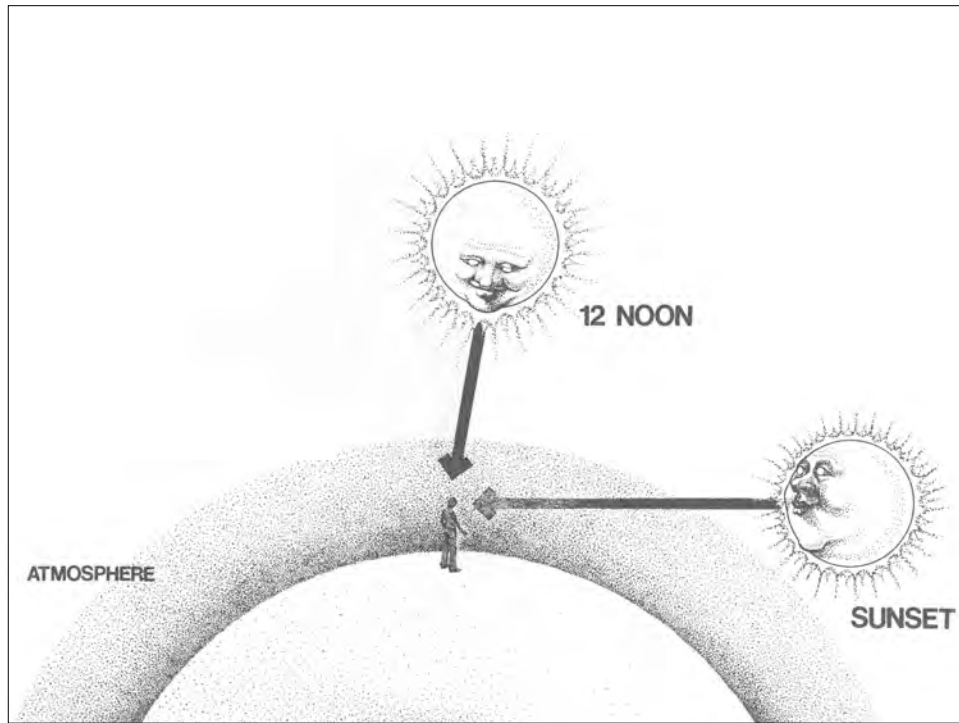
*Materiality and Continuity*

**Sun Angle Calculators**

<http://www.sbse.org/resources/sac/index.htm>







Solar Radiation: Horizontal and Vertical Surfaces

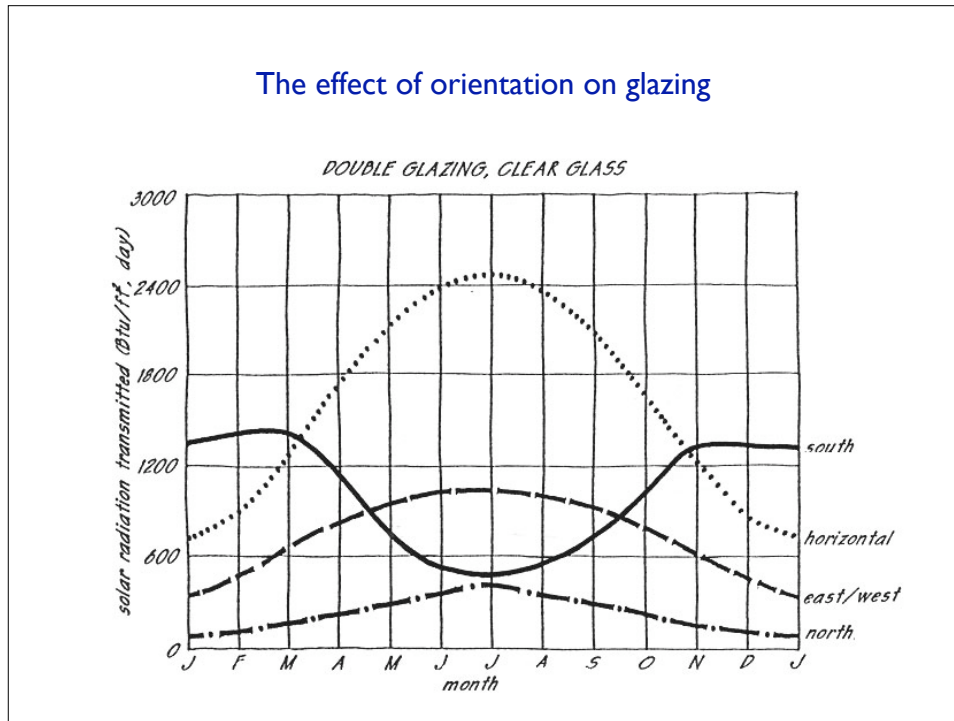
Solar radiation

thermal energy measured in

**Btu/h sf**  
or  
**Watts/m<sup>2</sup>**

*both direct + diffuse sunlight*





Solar Radiation: Horizontal and Vertical Surfaces

MEEB 10th Appendix C: Solar Data

**TABLE C.15**

			Seattle	Phoenix	Denver
Heating Degree Days			4684	1552	6016
January	Solar Insolation BTU/day ft²	HS	262	1021	840
		VS	378	1462	1465
July		HS	2248	2486	2273
		VS	1299	964	1053
Year (avg.)		HS	1056	1371	1570
		VS	857	1326	1334

HS = Horizontal Surface

VS = Vertical South

### Palmetto House

Florida Keyes

Jersey Devil

Architectural Solutions to Environmental Adaptation

- LOCATION
- FORM
- METABOLISM



### Casa Mariposa

Baja California, Mexico

Jersey Devil



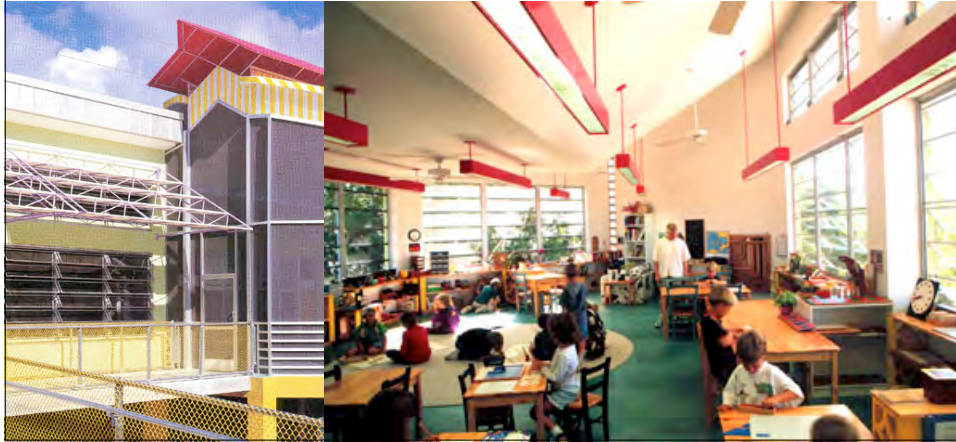
ECS Objectives - Towards Sustainability

- RESOURCE CONSERVATION
- HUMAN HEALTH, COMFORT AND SAFETY
- HUMAN DELIGHT

Montessori Island School

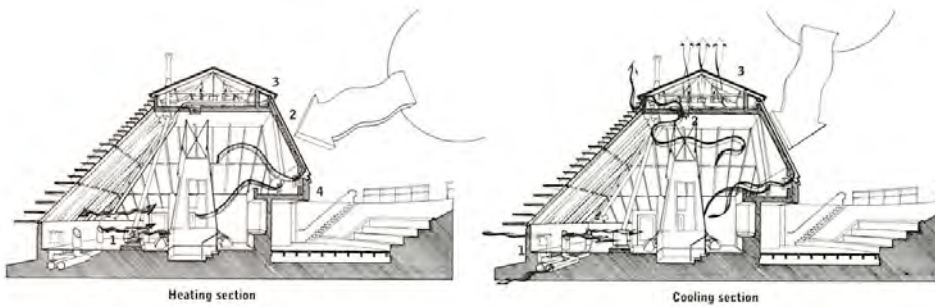
Tavernier, Florida

Jersey Devil



Energy and Form Sustainability

**Architectural Means of Environmental Adaptation**



Spring Lake Visitor Center • Obie Bowman • Santa Rosa, CA

## Thermal Building Types

### Envelope Dominated

- typically small buildings
- low internal heat gains
- space heating determined by heat loss through the envelope.
- relatively high balance point temperature



### Internal Load Dominated

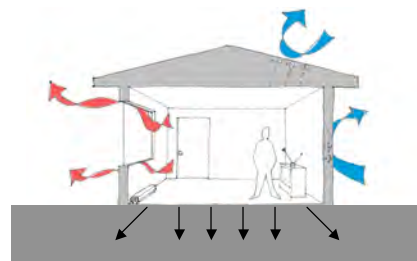
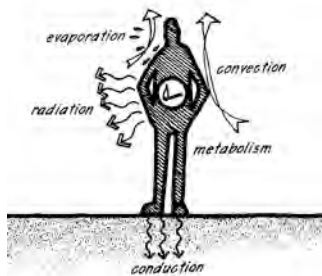
- typically large buildings
- high internal heat gains
- space cooling requirements determined by heat gains from people, lights and equipment within the building
- relatively low balance point temperature



## Balance Point Temperature

*Thermal Equilibrium between Inside and Outside*

$$Q_{\text{losses}} = Q_{\text{gains}} \quad \text{or} \quad Q_{\text{out}} = Q_{\text{in}}$$



Envelope ("skin") losses  
 Infiltration ("lung") losses  
 Perimeter ("feet") losses

### Balance Point Temperature

*Thermal Equilibrium between Inside and Outside*

$$Q_{in} = Q_{out}$$

$$Q_{gains} = Q_{losses}$$

$$Q_{gains} = Q_{free} + Q_{purchased}$$

$Q_{free}$  = people + lights + equipment  
 $Q_{purchased}$  = purchased heat (boiler, furnace, etc.)

$$Q_{losses} = UA \times (T_{in} - T_{outside}) = UA \times \Delta T$$

balance point temperature
thermostat setting
a building's "thermal fingerprint"



**Balance Point Temperature:  $T_{balance\ point} = T_{in} - Q_{gains} / UA$**

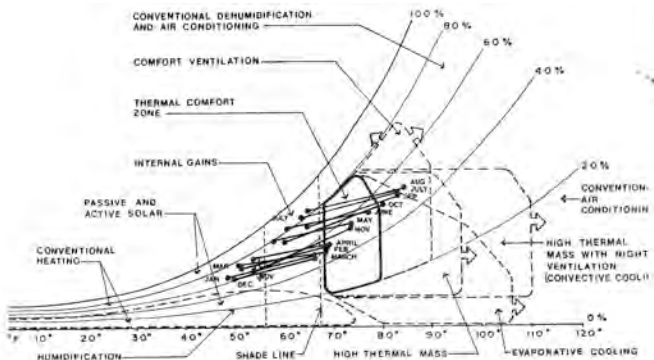
Internal heat gains

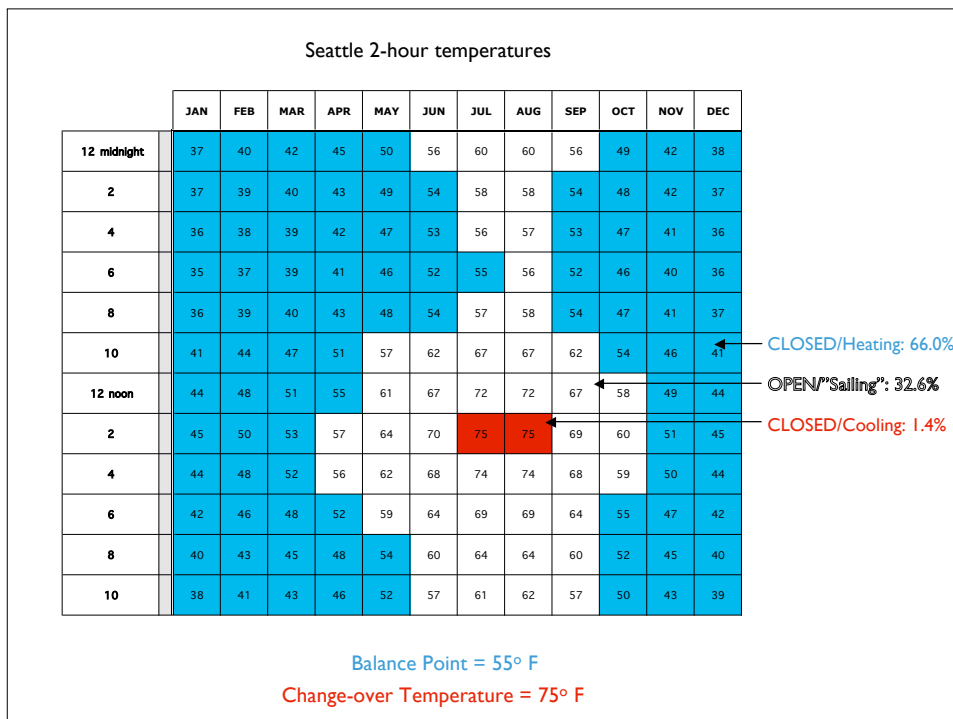
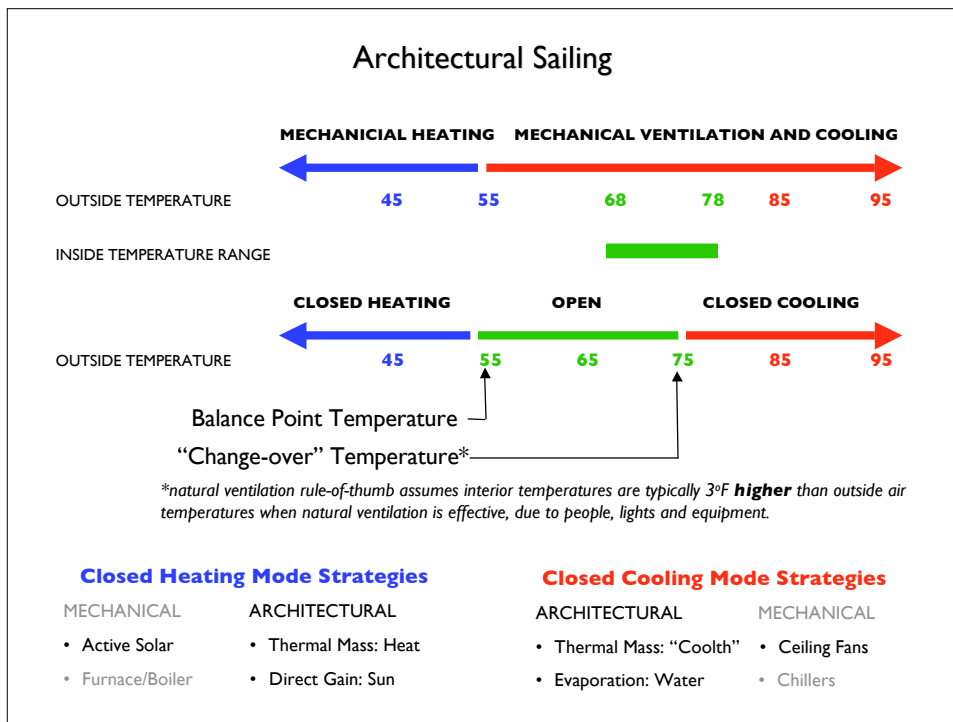
### Climate Design Priorities (5)

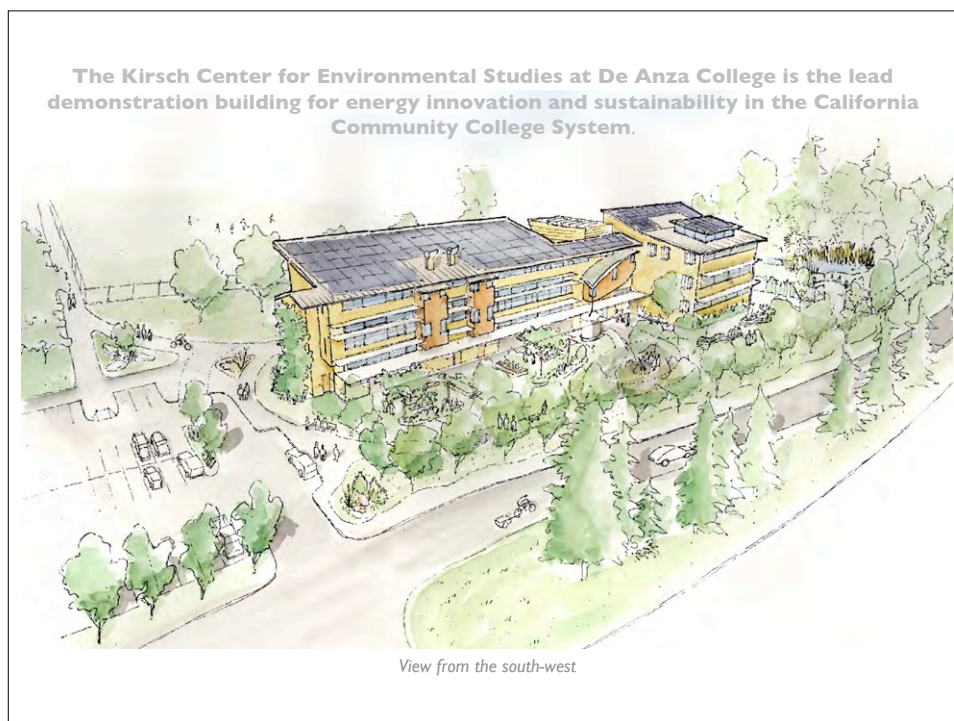
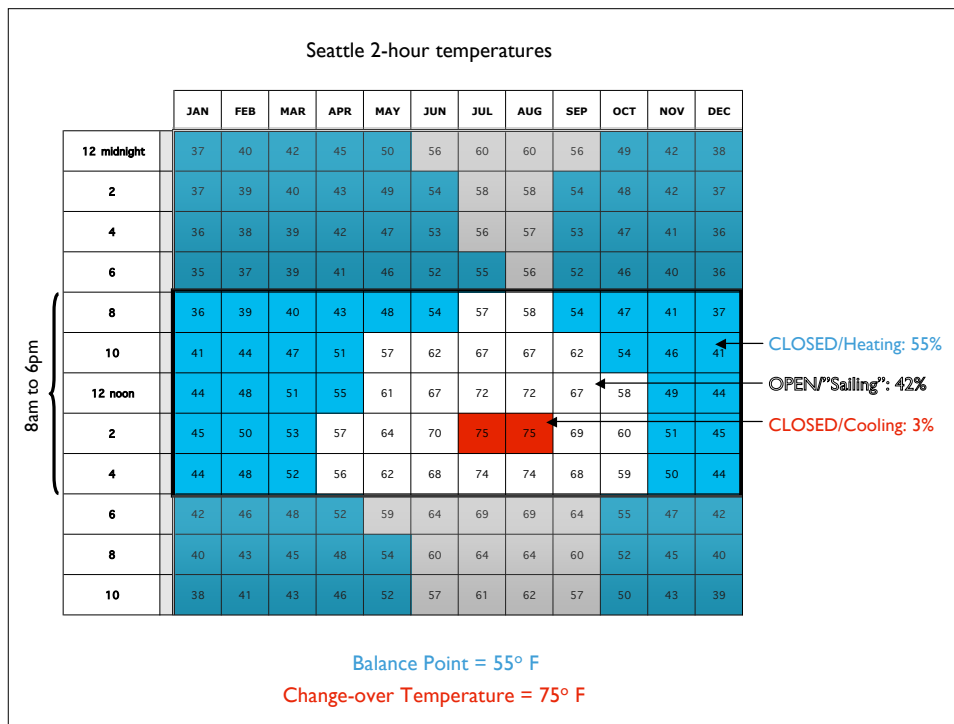
- Open the building to the outdoors since temperatures are comfortable most of the year.
- Protect from the summer sun.
- Keep the heat in and cold out in the winter.
- Use natural ventilation for summer cooling.
- Let the winter sun in.
- Use thermal mass to flatten day-to-night temperature swings in the summer.

#### Southern Coastal California

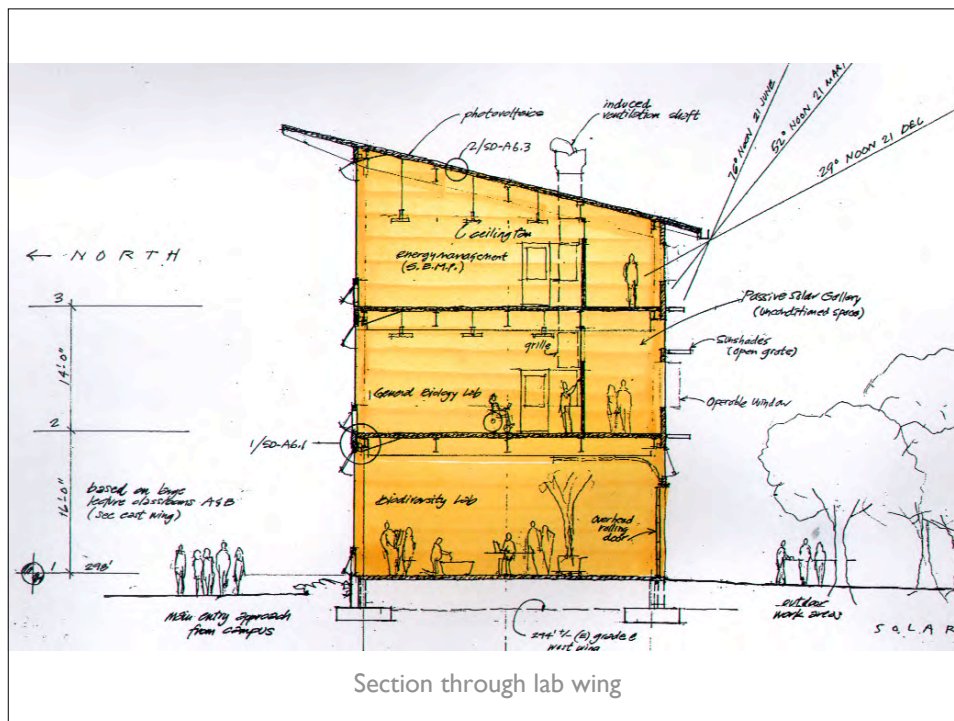
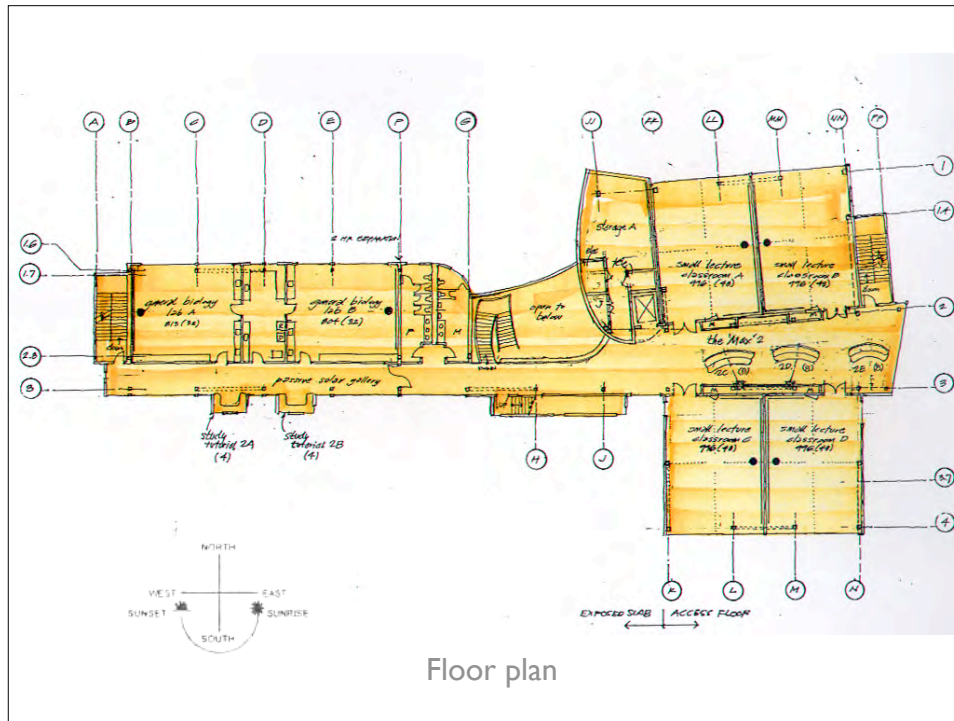





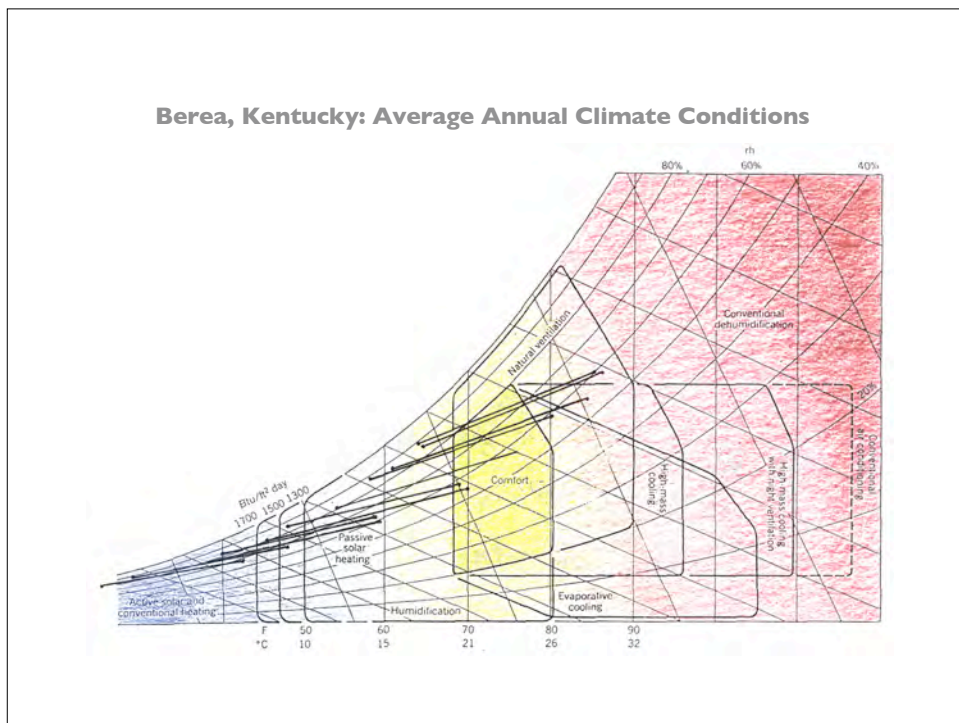


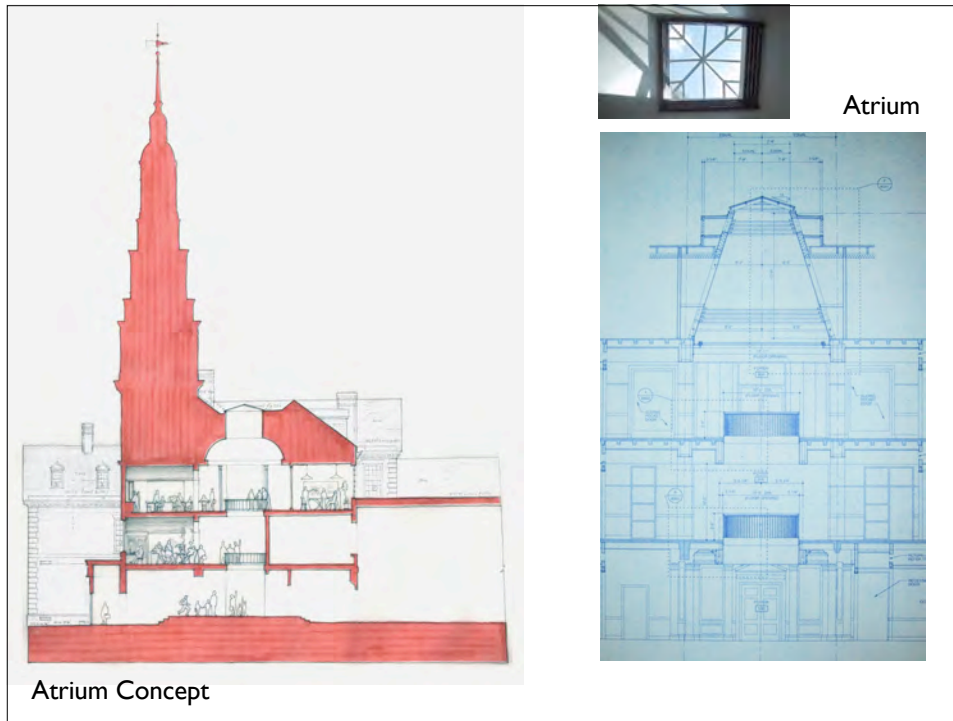










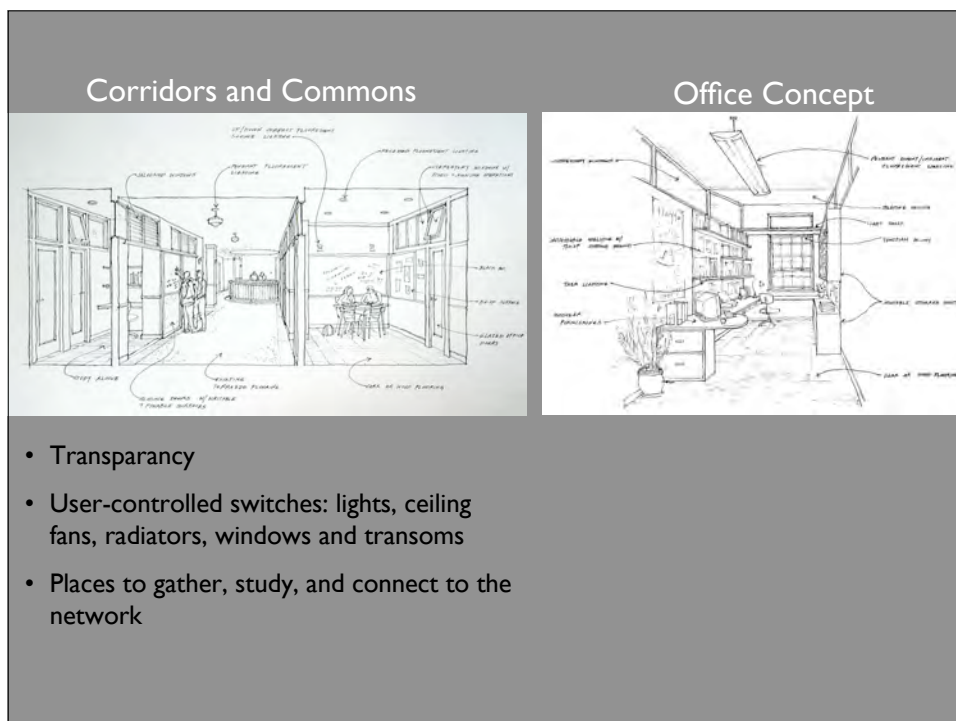
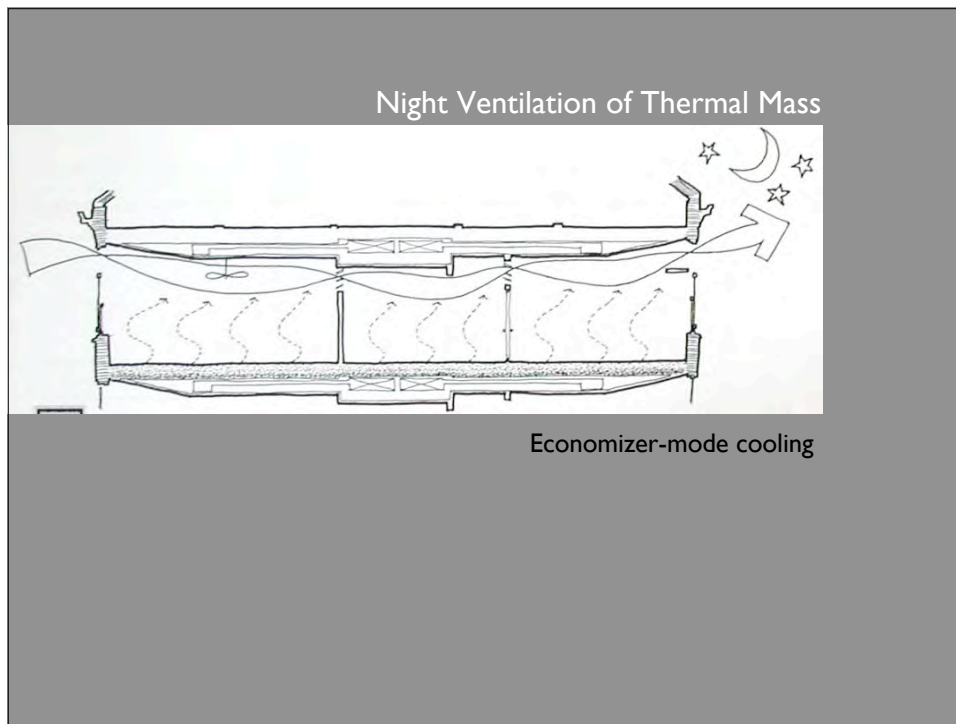


Cross Ventilation

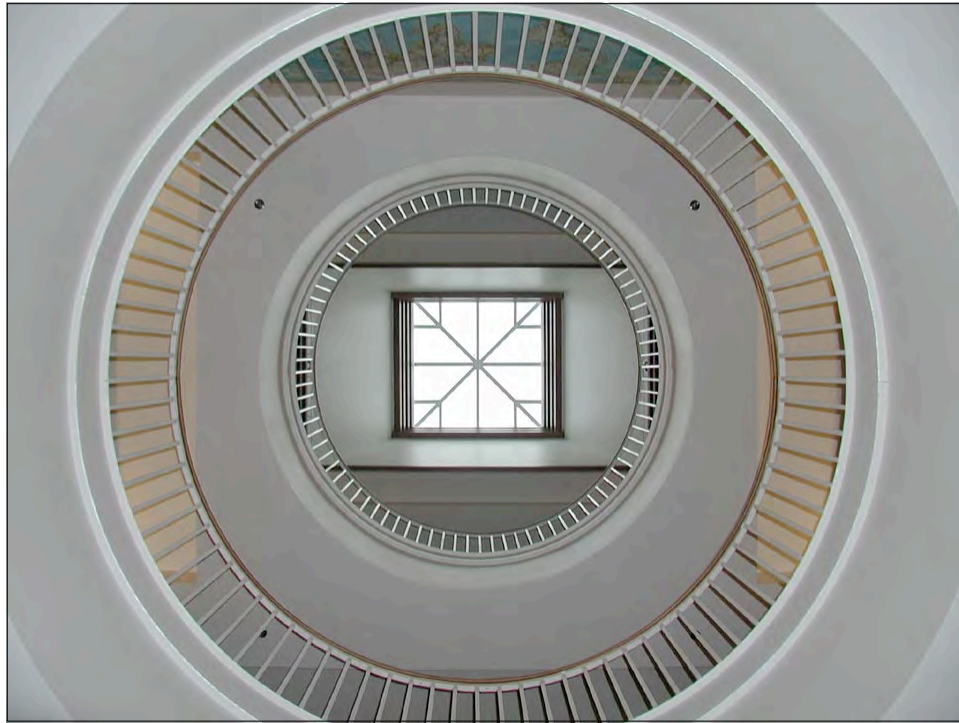
Stack Ventilation

- Double-hung windows
- Transom windows between perimeter rooms and corridors
- Integrated passive and mechanical systems


The image shows two diagrams illustrating ventilation concepts. The left diagram, labeled 'Cross Ventilation', shows a section of a building with a sun icon and arrows indicating air flow from one side to the other. The right diagram, labeled 'Stack Ventilation', shows a section of a building with a curved arrow indicating air rising and exiting through a high opening.







Door Cards  
Side I



## WINDOWS OPEN

WHEN MECHANICAL HEATING OR COOLING SYSTEM IS OFF  
RED INDICATOR LIGHT IS ON


all year

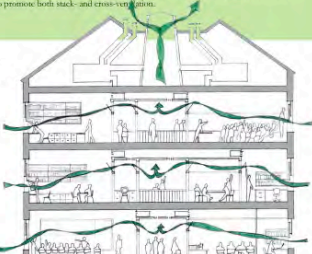
**TO REGULATE INDOOR CONDITIONS**

- ¥ WINDOWS can be OPEN or CLOSED
- ¥ CEILING FANS can be ON or OFF
- ¥ BLINDS can be OPEN or CLOSED
- ¥ TRANSOMS and DOORS between rooms can be OPEN to promote ventilation


Anytime conditions outdoors are comfortable, windows can be opened and the building can "all" on its own without mechanical heating or cooling. When this occurs, temperature and humidity sensors located outside the building will send information to the mechanical system indicating that heating or cooling systems can be turned off. When the heating or cooling system shuts down, a red light on the wall plate near each room's thermostat will turn on, indicating the building is in "open mode," and louvers at the top of the central atrium will open to the outside to promote "stack ventilation" throughout the building. Occupants of each room can regulate room conditions by opening windows, switching on ceiling fans, turning off electric lights, and opening doors and transoms between rooms to promote both stack- and cross-ventilation.

**RED INDICATOR LIGHT IS ON**





Door Cards  
Side 2



## WINDOWS CLOSED

WHEN MECHANICAL HEATING OR COOLING SYSTEM IS ON  
RED INDICATOR LIGHT IS OFF

TO REGULATE INDOOR CONDITIONS

summer

- ✘ LOWER and SHUT BLINDS for shade
- ✘ Use CEILING FANS for additional cooling

SUMMER: During hot and humid periods, all windows should be kept closed and sunshading blinds lowered. The mechanical system will provide cooled, filtered, fresh air throughout the building and exhaust stale air. The building is thermally zoned in four quadrants. The temperature of cooled air is controlled by a survey thermostat in each room within a zone and regulated to avoid over-cooling. Ceiling fans can provide additional "effective" cooling.

Thermostats regulate ONLY the radiators and are not operational for cooling.



winter

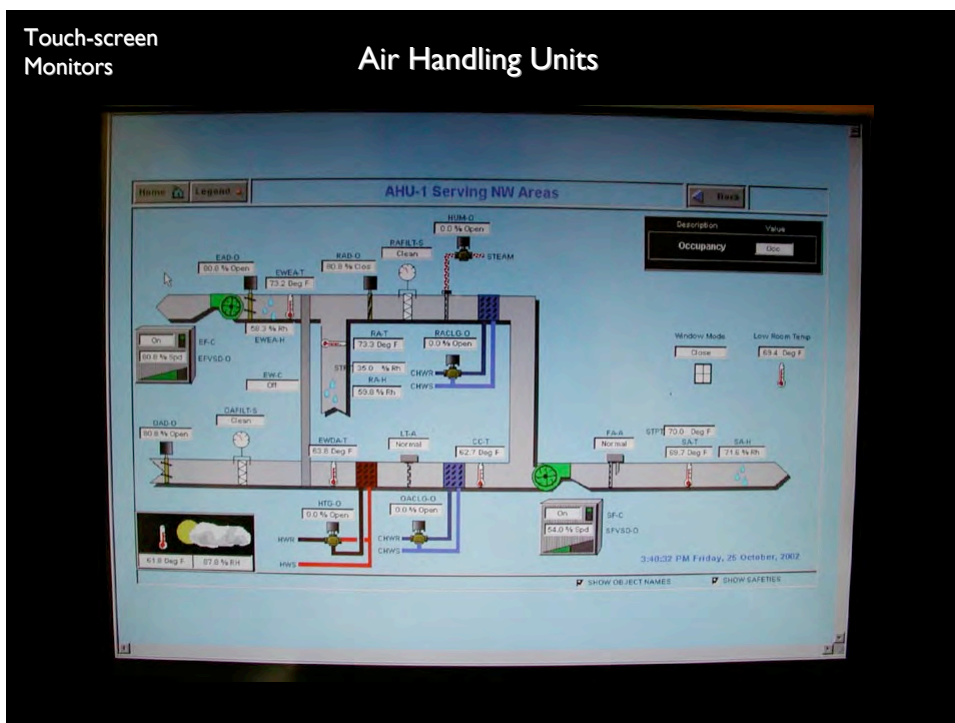
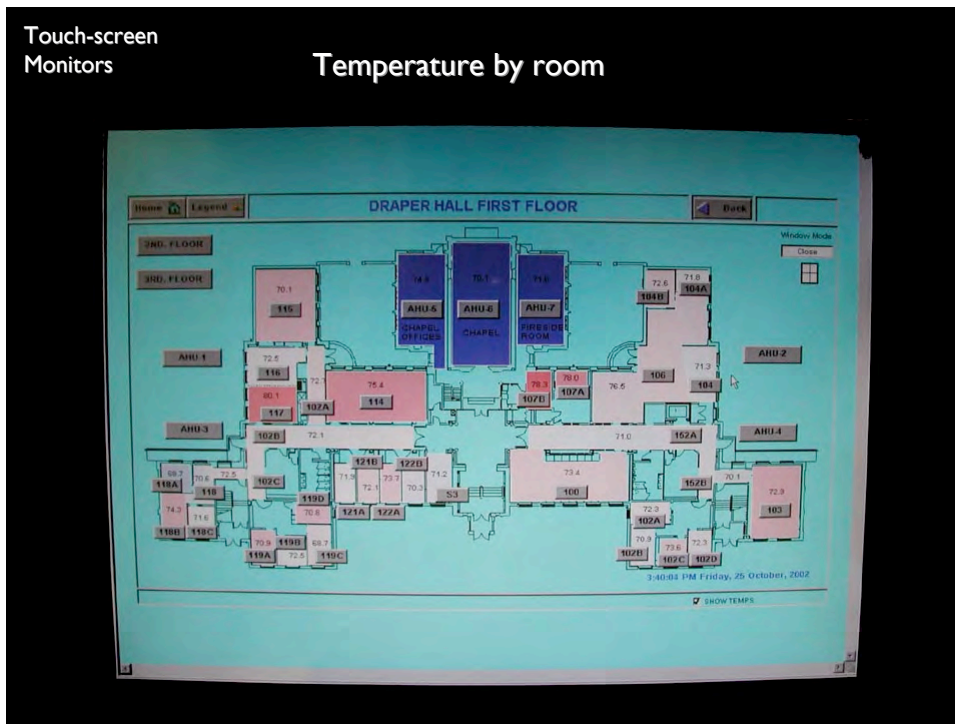
- ✘ OPEN BLINDS for sunlight and warmth
- ✘ Use THERMOSTATS to regulate warmth

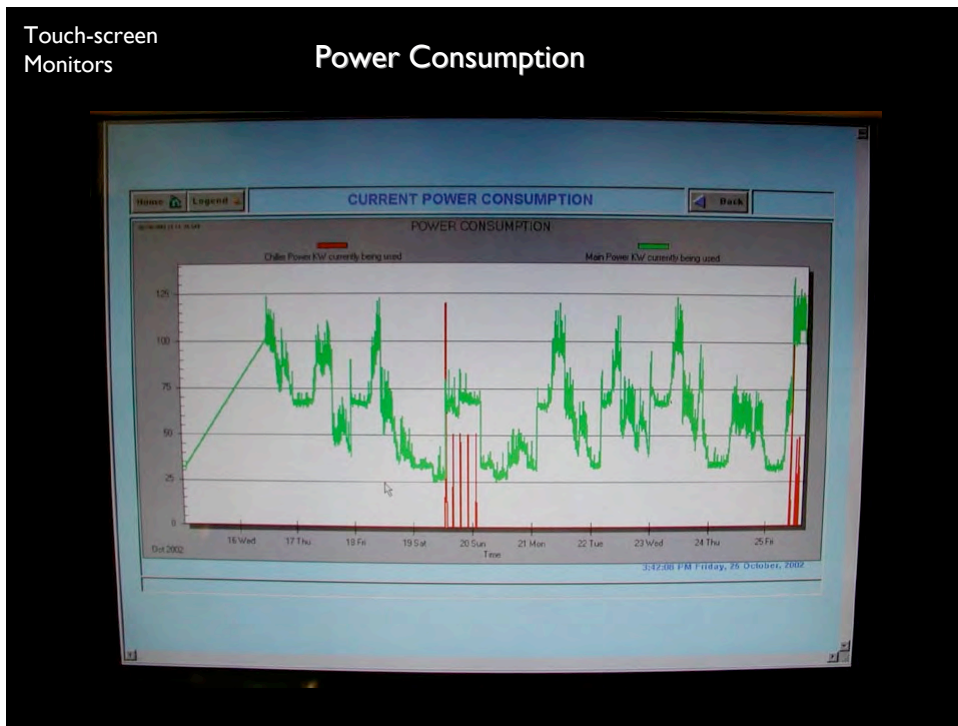
WINTER: During cold periods, all windows should be kept closed and sunshading blinds opened to capture available sunlight and warmth. The mechanical system will provide warmed, filtered and humidified fresh air throughout the building, and exhaust stale air after extracting most of its heat energy using a heat recovery system.

Thermostats regulate the radiators only; use the thermostats to fine-tune the room temperature when in the system is in heating mode.

RED INDICATOR LIGHT IS OFF





## Fundamental Criteria for Passive Solar Design

### 1. Insulation

- Keep the Heat In and Cold Out

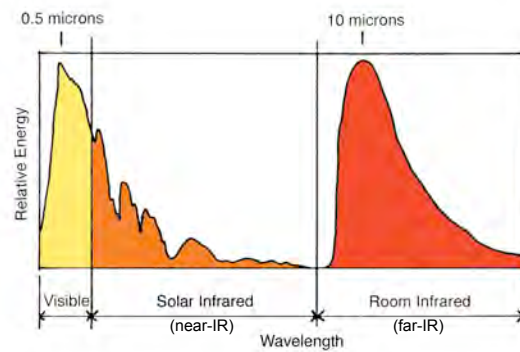
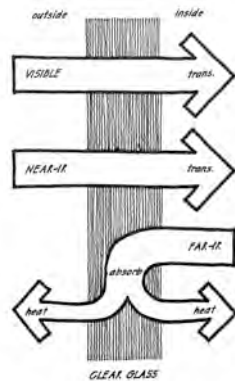
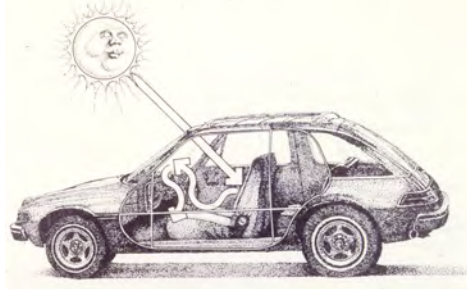
### 2. Glass

- Window Area and Solar Access

### 3. Mass

- Heat Capacity and Quantity of Materials
- Location and Distribution of Materials

**2. Glass**  
**Greenhouse Effect**



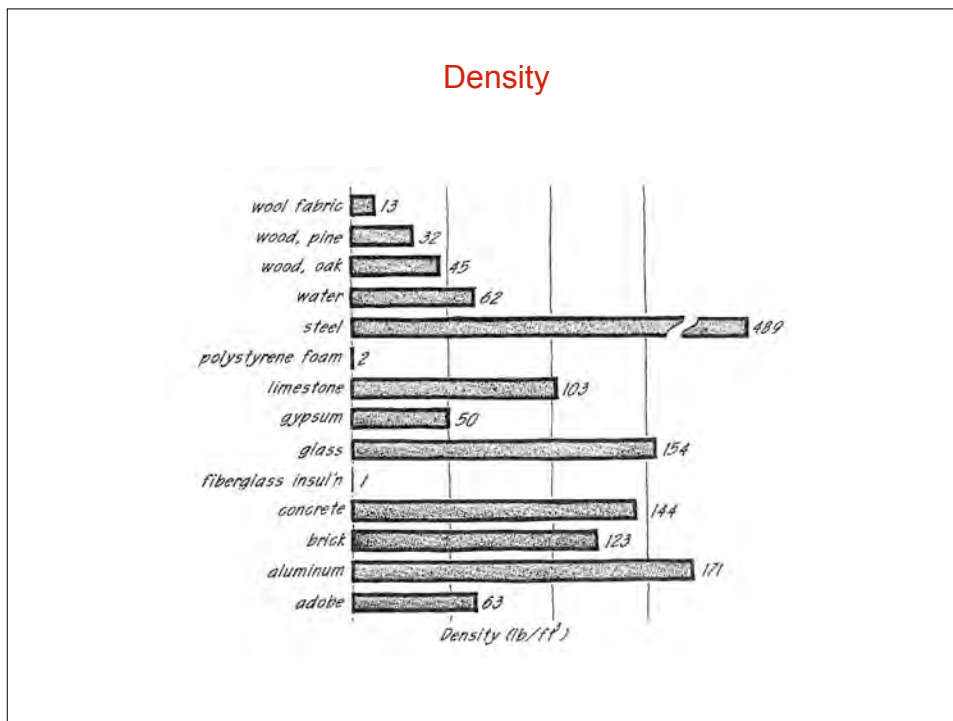
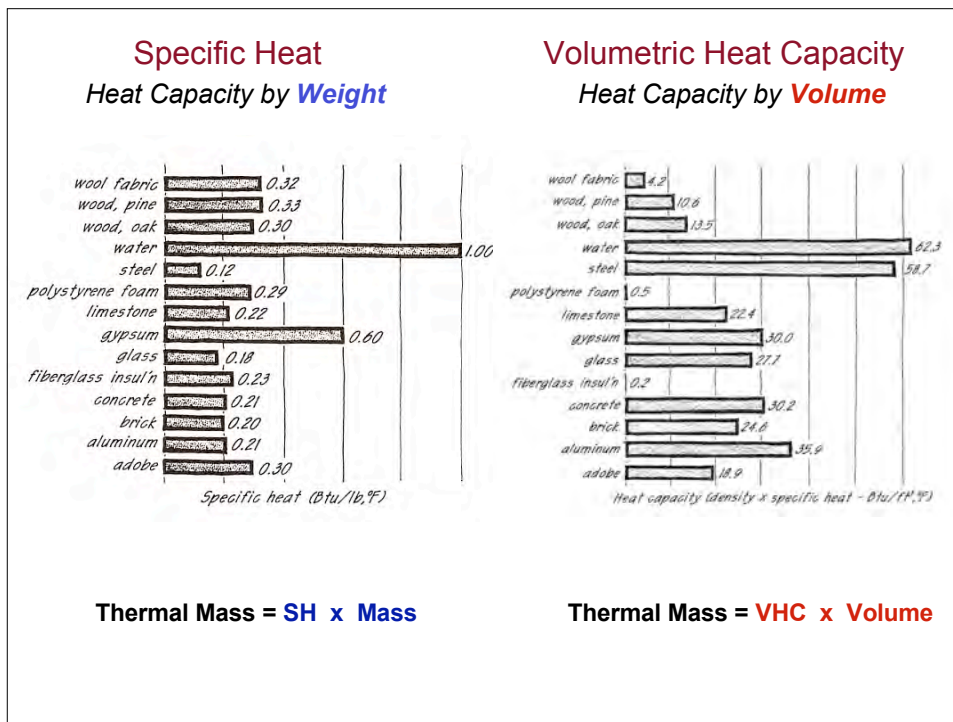
**3. Mass**  
**Thermal Mass:**

**HEAT CAPACITY**

*The capacity of a material to store heat for a given temperature change*



Specific Heat  
and  
Volumetric Heat Capacity



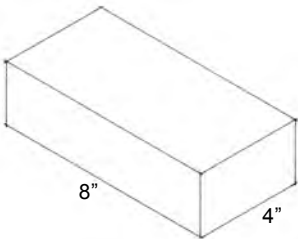
### Heat Capacity

*The capacity of a material to store heat for a given temperature change*

Material	Specific Heat BTU/lb °F	Density lb/ft <sup>3</sup>	VHC BTU/ft <sup>3</sup> °F
Water	1.00	62.0	62.0
Concrete	0.20	120.0	24.0
Wood	0.50	27.0	13.5
Air	0.24	.075	.018
Steel	0.12	489	58.7

### Heat Capacity

*The capacity of a material to store heat for a given temperature change*



Volume = 72 in<sup>3</sup>  
= .0417 ft<sup>3</sup>

Weight = 5 lbs

**Mass**

$$\text{Thermal Mass} = \text{SH} \times \text{Density} \times \text{Volume}$$

VHC

TM = VHC x Volume

TM = 24 BTU/ft<sup>3</sup> °F x .0417 ft<sup>3</sup> = **1.0 BTU / °F**

TM = Specific Heat x Mass

TM = .20 BTU/ lb °F x 5 lbs = **1.0 BTU / °F**

**Q = TM x dT**

