

announcements 5/22/08

Assignment 5: Solar Heating - Direct Gain

DUE NEXT WEEK

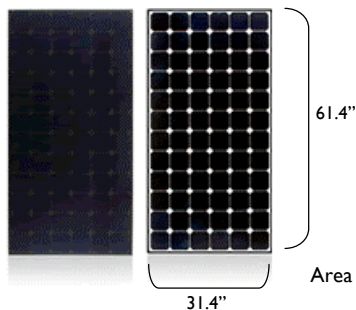
Available on the course website later tonight.

Graduate Section: I will email your assigned location for this exercise;

Quiz 5 Next Tuesday

Sizing a Solar PV System

I. Estimating Size (number of panels and their output, kW)



SUNPOWER
210 Solar Panel

Area = 61.4" x 31.4" = 1929 in² = **13.392 ft²**

DC Rating (output) = **210 Watts**

Energy "density" = 210 Watts/ 13.392 ft² = **15.68 W/ ft²**

Determine the number of panels you're willing or able to place on your roof and the resulting output (kW), the panel orientation (azimuth) and their tilt (altitude).

Sizing a Solar PV System (cont.)

2. Estimating Need * 2030 Challenge Targets - National Averages

- Use **Target Table** from www.architecture2030.org to find the average **Site Energy Use** for your building type;
- Use the **50% target** for Site **EUI** Targets (Energy Use Intensity);
- Use Average Percent Electric for your building type to estimate electricity demand;
- Convert from kBTU to kWh: 1 kBTU = .293 kWh



2030 CHALLENGE Targets: National Averages

Primary Space/Building Type ²	Available In Target Filter ³	Average Source EUI ⁴ (kBtu/Sq.Ft./Yr)	Average Percent Electric	Average Site EUI ⁴ (kBtu/Sq.Ft./Yr)	2030 Challenge Site EUI Targets (kBtu/Sq.Ft./Yr)				
					50% Target	60% Target	70% Target	80% Target	90% Target
Administrative/Professional & Government Office	✓								
Bank	✓								
Clinic/other outpatient health		219	76%	84.2	42.1	33.7	26.3	16.8	8.4
College/university (campus-level)		280	63%	120	60	30	24	16	6
Convenience store (with or without gas station)		753	90%	241.4	120.7	96.6	72.4	48.3	24.1
Distribution/shipping center		90	61%	44.2	22.1	17.7	13.3	8.5	4.4
Fast food		1306	64%	534.3	267.2	213.7	160.3	106.9	53.4
Fire station/police station		157	56%	77.9	39.0	31.2	23.4	15.6	7.8

Sizing a Solar PV System (cont.)

3. Estimating Output * PV Watts Calculator

- Go to http://rredc.nrel.gov/solar/codes_algs/PVWATTS/ and use **Version 1** to calculate the electrical output of your PV system for your location;
- Enter the **DC Rating (kW)** of the system you've sized and modify the **Array Tilt** and **Array Azimuth** to match your project's parameter then **calculate**;
- Repeat this process as necessary, changing the DC Rating (kW), tilt or azimuth, until you've either maximized your output or met your building's energy needs.



Building Envelope Integrated PV

Lausanne, Switzerland

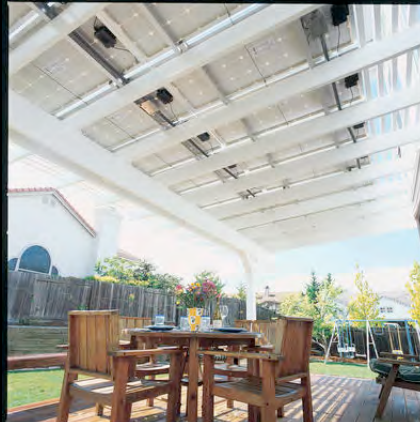


Barcelona, Spain



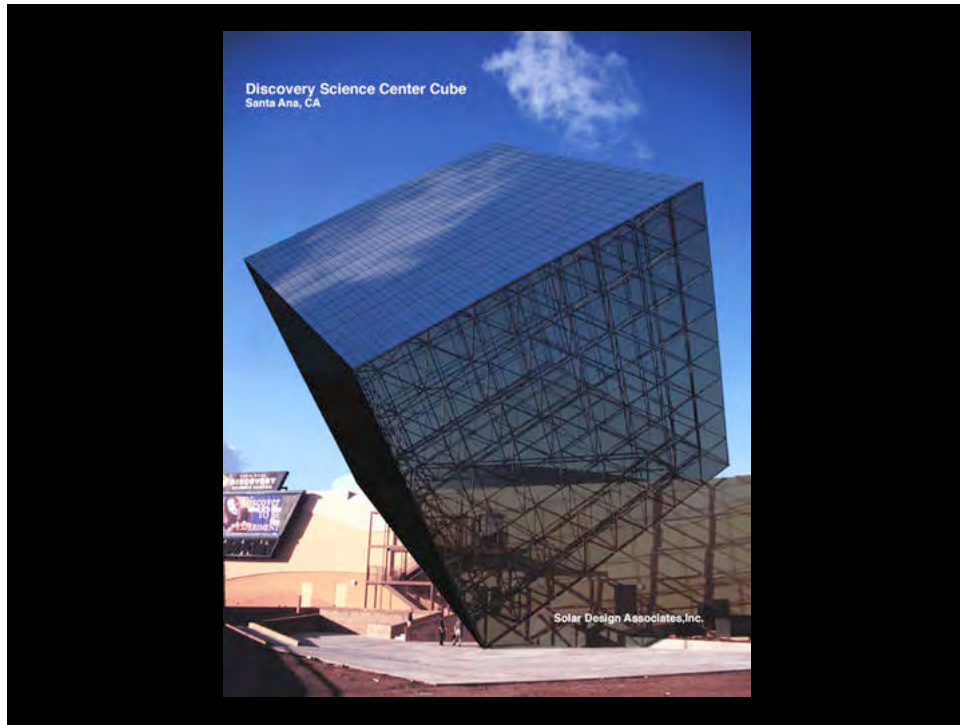
Building Integrated PV • Monocrystal PV

Integrated into an awning, this systems provides shade while generating electricity



Photovoltaic Sun Shades







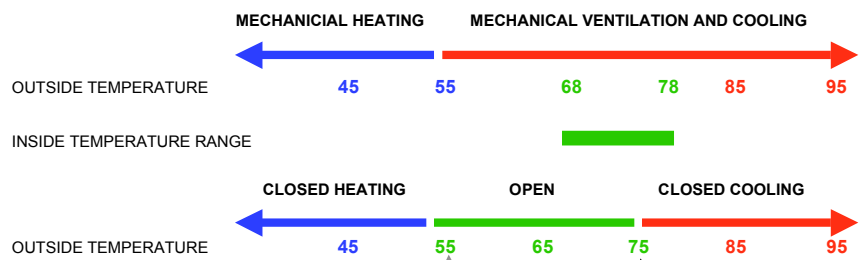
Palmetto House

Florida Keys

Jersey Devil



Passive Cooling & Architectural Sailing



Balance Point Temperature

“Change-over” Temperature*

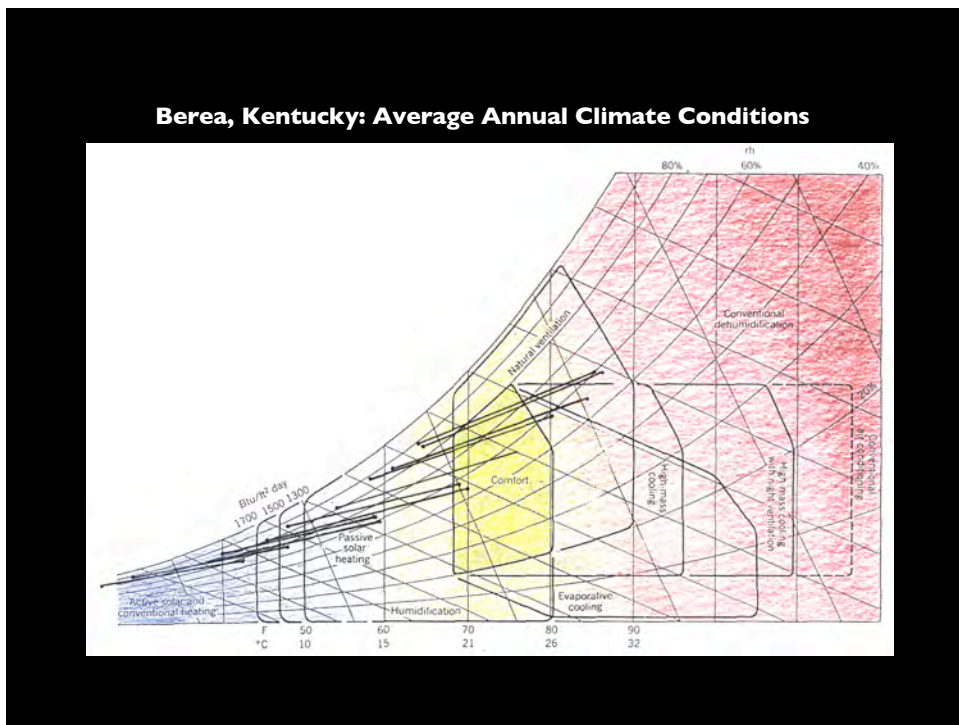
**natural ventilation rule-of-thumb assumes interior temperatures are typically 3°F higher than outside air temperatures when natural ventilation is effective, due to people, lights and equipment.*

Closed Heating Mode Strategies

- | | |
|------------------|----------------------|
| MECHANICAL | ARCHITECTURAL |
| • Active Solar | • Thermal Mass: Heat |
| • Furnace/Boiler | • Direct Gain: Sun |

Closed Cooling Mode Strategies

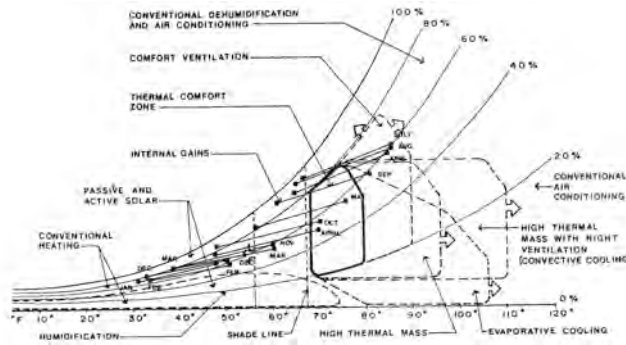
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|--------------------------|----------------|
| ARCHITECTURAL | MECHANICAL |
| • Thermal Mass: “Coolth” | • Ceiling Fans |
| • Evaporation: Water | • Chillers |



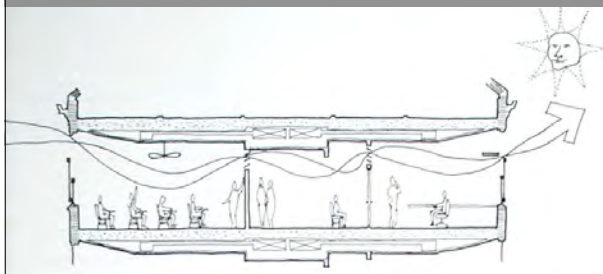
Climate Analysis & Architectural Strategies Knoxville, Tennessee

Temperate Climate

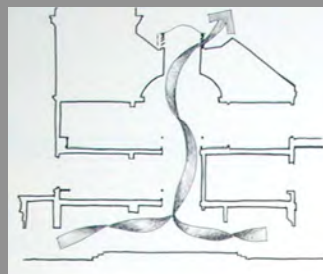
- Keep the heat in and cold temperatures out in the winter.
- Use natural ventilation for summer cooling
- Let the winter sun in.
- Protect from the summer sun.
- Protect from the cold winter winds.
- Avoid creating additional humidity during the summer.



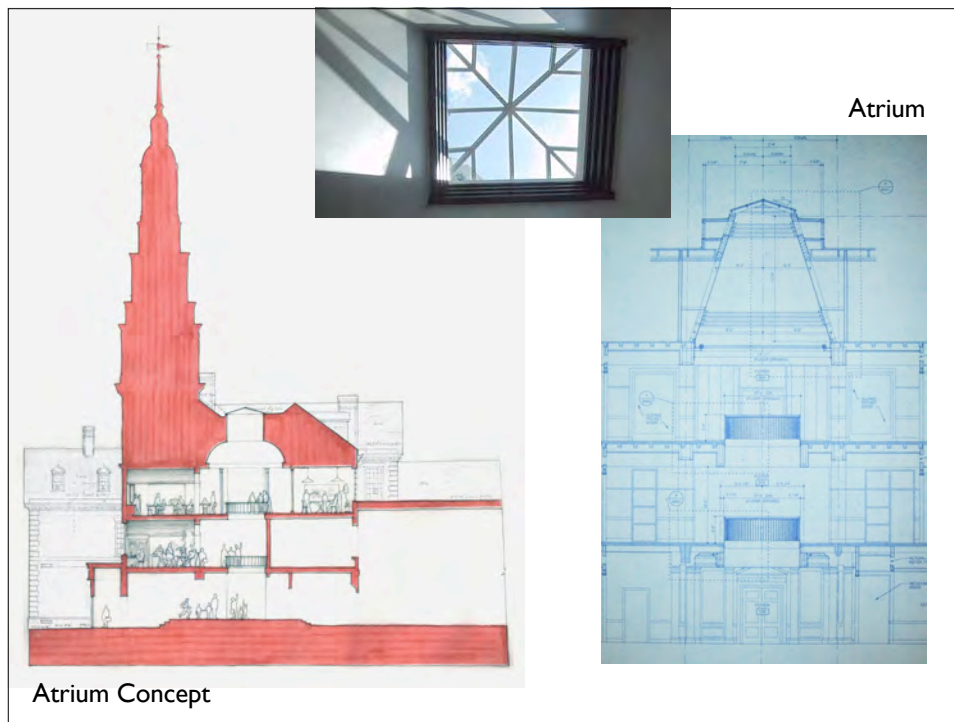
Cross Ventilation




Stack Ventilation



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





WINDOWS OPEN

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


TO REGULATE INDOOR CONDITIONS

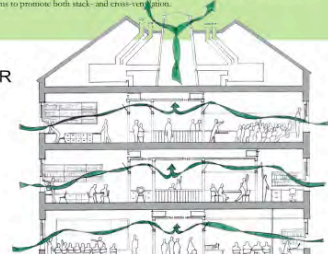
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- ¥ WINDOWS can be OPEN or CLOSED
- ¥ CEILING FANS can be ON or OFF
- ¥ BLINDS can be OPEN or CLOSED
- ¥ TRANSOMS and DOORS between rooms can be OPEN to promote ventilation

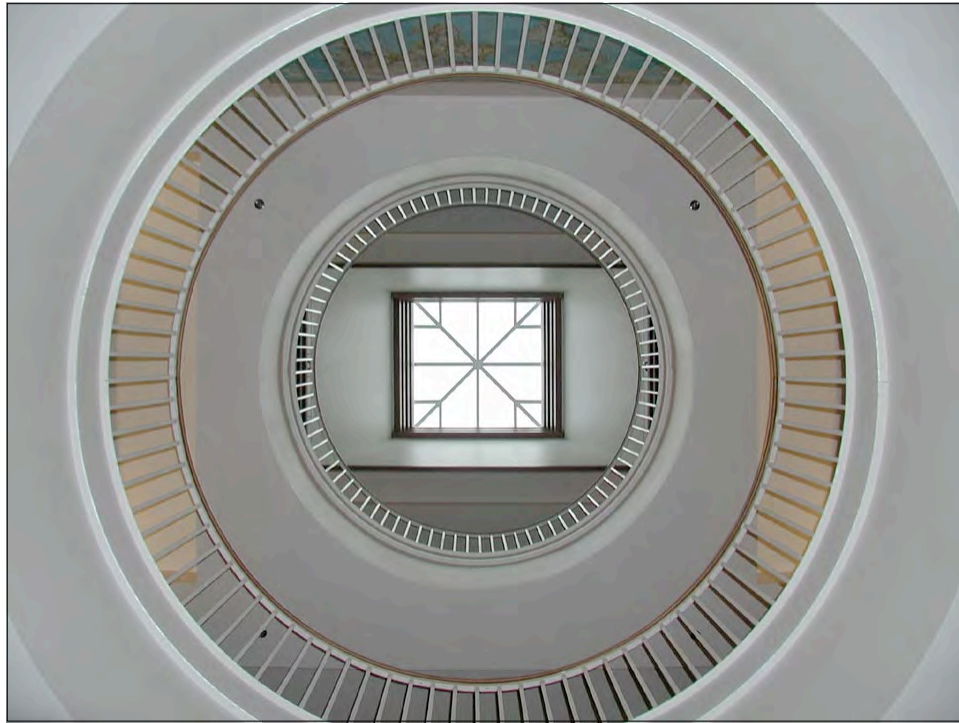
Anytime conditions outdoors are comfortable, windows can be opened and the building can "breathe" on its own without mechanical heating or cooling. When this occurs, temperature and humidity sensors located outside the building will send information to the mechanical system indicating that heating or 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









Passive Cooling

- *Shading*
- **Cross Ventilation**
- **Stack Ventilation**
- *Night Ventilation of Thermal Mass*

Step 1: Climate Analysis and Architectural Strategies

Step 2: Determine Cooling Load

Step 3: Use rule-of-thumb charts to predict the effectiveness of window openings

Passive Cooling

- **Cross Ventilation**
- **Stack Ventilation**
- *Night Ventilation of Thermal Mass*

Step 1: Climate Analysis and Architectural Strategies

Step 2: Determine Cooling Load

Step 3: Use rule-of-thumb charts to predict the effectiveness of window openings

PART A

Step 2: Determine Cooling Load

PEOPLE • LIGHTS • **EQUIPMENT**

ENVELOPE • INFILTRATION

F.3 ESTIMATING SUMMER HEAT GAINS MEEB 10th, pg. 1610

TABLE F.3 Approximate Summer Heat Gains from Occupants, Equipment, Lighting, and Envelope

Function	Area per Person ^a		Sensible Heat Gain (Btu/h ft ² of Floor Area)			Sensible Heat Gain (W/m ² of Floor Area)		
	ft ²	m ²	People ^b	Equipment ^c	Total	People ^b	Equipment ^c	Total
Office, U.S. ^c	180-100	16.7-9.3	1.3-2.3	0.4-1.1	1.7-3.4	4.1-7.3	1.2-3.4	5.3-10.7
Office, Europe ^d			1-1.6	2.2-4.2	3.2-5.8	3-5	7-13.1	10-18.1
School: elementary, U.S.	100-20	9.3-1.9	2.3-11.5	0-0.6	2.3-12.1	7.3-36.3	0-2.0	7.3-38.3
Schools, Europe ^d			3.8-8.0	0-0.6	3.8-8.6	12-25.2	0-2.0	12.0-27.2
School: secondary, college	150-100	13.9-9.3	1.7-2.6	0-0.6	1.7-3.2	5.4-8.2	0-2.0	5.4-10.2
Health care								
Sleeping (hospital)	240	22.3	0.9	0.6 ^e	1.5	2.8	2.0 ^f	4.8
In-patient (clinic)	120	11.1	1.9	Varies	1.9+	6.0	Varies	6.0+
Assembly: fixed seats	15	1.4	14.0	—	14.0	44.2	—	44.2
standing space, concentrated use	15-7	1.4-0.7	21.0-45.0	0-0.5	21.0-45.5	66.3-142.0	0-1.6	66.3-143.6
Restaurant ^g								
Fast food: dining area	15	1.4	17	3.4	20.4	53.6	10.7	64.3
Kitchen, refrigeration				17.1	17.1		54.0	54.0
Sit-down: dining area	25	2.3	10.2	5.1	15.3	32.2	16.1	48.3
Kitchen, refrigeration				7.2	7.2		22.7	22.7
Mercantile: street floor	50-30	4.7-2.8	6.3-10.5	3.4	9.7-13.9	19.9-33.1	10.7	30.6-43.8
Other sales floors	60-50	5.6-4.7	5.3-6.3	3.4	8.7-9.7	16.7-19.9	10.7	27.4-30.6
Shopping center, Europe ^d			3.2	0.3-1.3	3.5-4.5	10	1.0-4.0	11.0-14.0
Warehouse	1000-300	92.9-27.9	0.4-1.2	—	0.4-1.2	1.3-3.8	—	1.3-3.8
Hotels, nursing homes	300-200	27.9-18.6	0.8-1.2	3.4	4.2-4.6	2.5-3.8	10.7	13.2-14.5
Apartments ^h	300-200	27.9-18.6	0.8-1.2	See note g	See note g	2.5-3.8	See note g	See note g

PART B **Step 2: Determine Cooling Load**
 PEOPLE • **LIGHTS** • EQUIPMENT
 ENVELOPE • INFILTRATION

MEEB 10th, pg. 1610

Part B. Internal Heat Sources—Electric Lighting

Function	Sensible Heat Gain ^b (Btu/h ft ² of Floor Area)			Sensible Heat Gain ^b (W/m ² of Floor Area)		
	DF<1	1<DF<4 ^b	DF>4 ^b	DF<1	1<DF<4 ^b	DF>4 ^b
Office	5.1	2.0	0.5	16.1	6.3	1.6
School, elementary	6.3–6.8	2.5–2.7	0.6–0.7	19.9–21.5	7.9–8.5	1.9–2.2
School, secondary, college	6.3–6.8	2.5–2.7	0.6–0.7	19.9–21.5	7.9–8.5	1.9–2.2
Health care						
Sleeping (hospital)	6.8	2.7	0.7	21.5	8.5	2.2
In-patient (clinic)	6.8	2.7	0.7	21.5	8.5	2.2
Assembly	3.8	1.5	0.4	12.0	4.7	1.3
Restaurants ^c	6.3	2.5	0.6	19.9	7.9	1.9
Mercantile	5.1–6.8	2.0–2.7	0.5–0.7	16.1–21.5	6.3–8.5	1.6–2.2
Warehouse	2.4	1.0	0.2	7.6	3.2	0.6
Hotels, nursing homes	6.8	2.7	0.7	21.5	8.5	2.2
Apartments ^d	Up to 6.8	Up to 2.7	Up to 0.7	Up to 21.5	Up to 8.5	Up to 2.2

PART C **Step 2: Determine Cooling Load**
 PEOPLE • LIGHTS • EQUIPMENT
ENVELOPE • INFILTRATION

MEEB 10th, pg. 1610

Part C. Heat Gain through Envelope¹

	(Btu/h ft ² of Floor Area)		(W/m ² of Floor Area)	
	Outdoor Design Temperature		Outdoor Design Temperature	
	90°F	100°F	32°C	38°C
i. Gains through externally shaded windows ² :				
Find ratio, $\frac{\text{total window area}}{\text{total floor area}}$, then multiply by	16	21	50	66
ii. Gains through opaque walls:				
Find ratio, $\frac{\text{total opaque wall area}}{\text{total floor area}} \times (U_{\text{wall}})$, then multiply by	15	25	8	14
iii. Gains through roofs:				
Find ratio, $\frac{\text{total opaque roof area}}{\text{total floor area}} \times (U_{\text{roof}})$, then multiply by	35	45	19	25

PART D **Step 2: Determine Cooling Load**
OPEN vs. CLOSED
mode

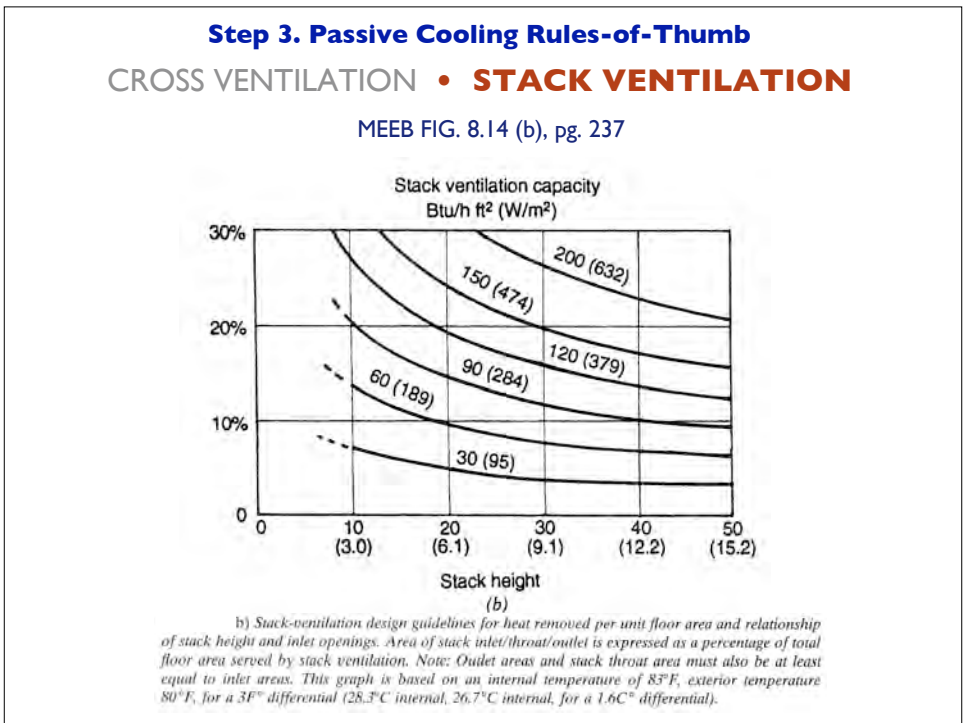
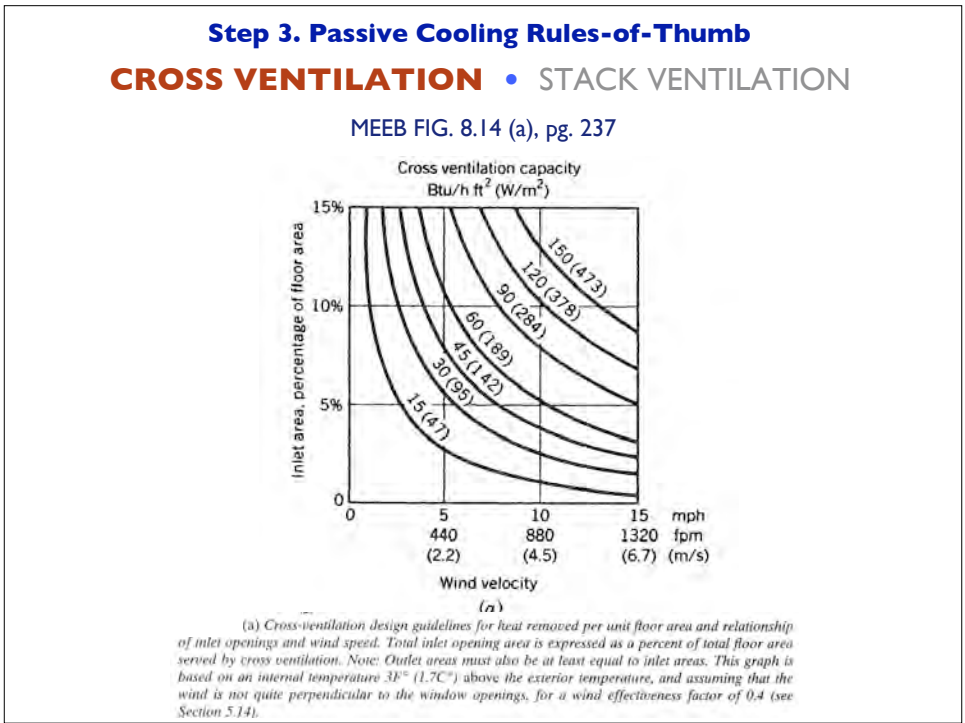
MEEB 10th, pg. 1611

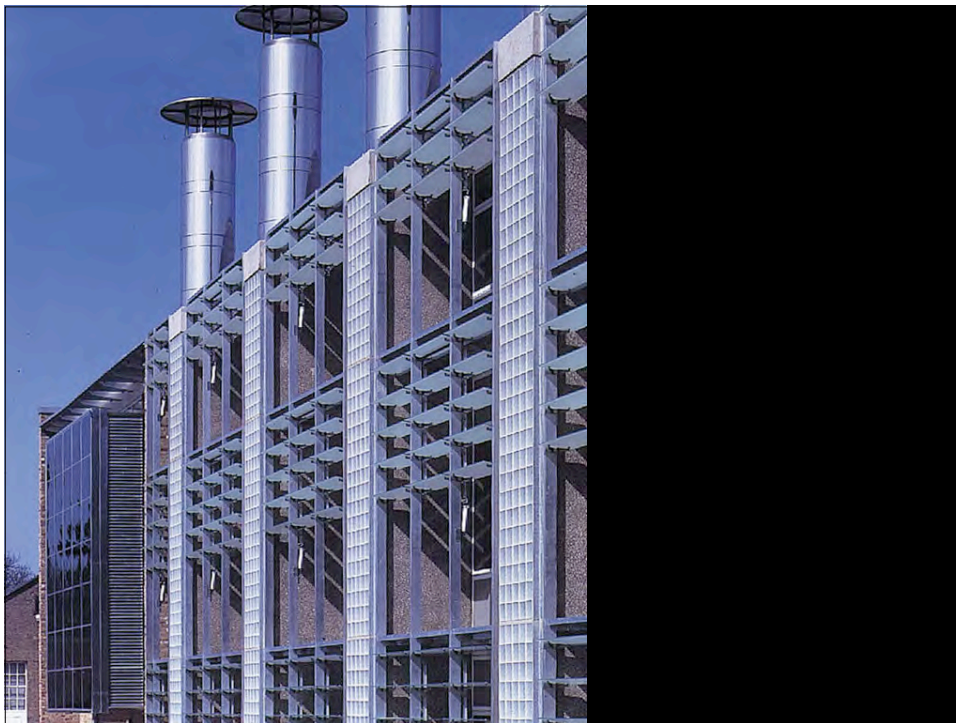
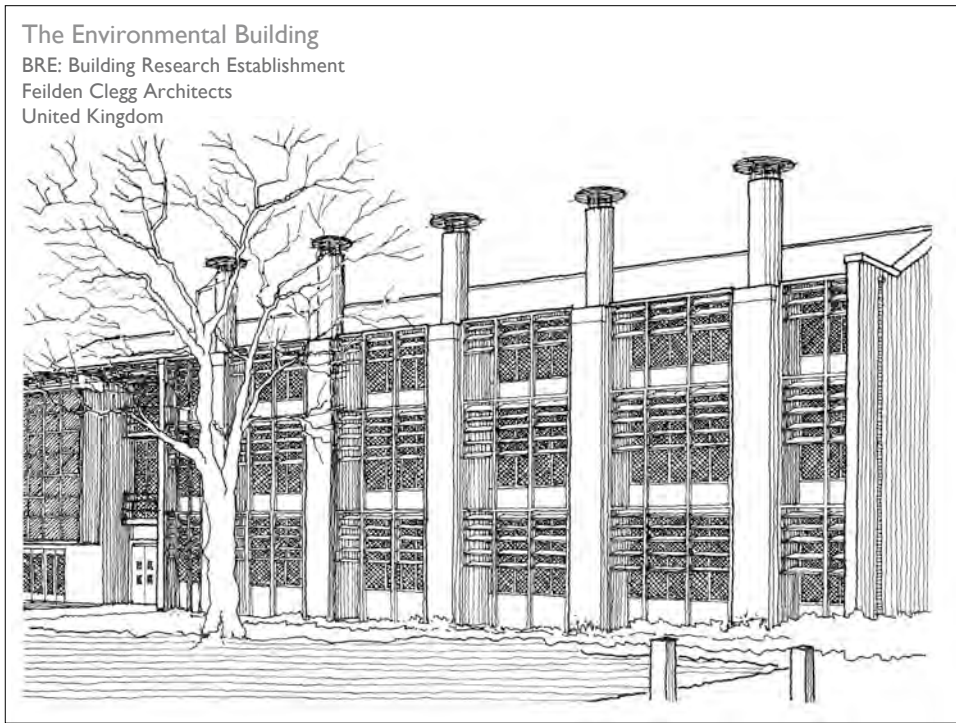
Part D. Summary Gains	
I. Passive cooling systems for (thermally) "open" buildings	
Cross-ventilation	
Stack ventilation	
Nighttime or "open" hours of thermal mass/night ventilation	
Total gains: Add Parts A, B, and C to obtain cooling load, in Btu/h ft² (W/m²), of floor area.	
II. Passive cooling systems for (thermally) "closed" buildings	
Roof ponds	
Evaporative cooling	
Daytime or "closed" hours of thermal mass/night ventilation	
Total gains: Add Parts A, B, C, and E to obtain cooling load, in Btu/h ft² (W/m²), of floor area.	

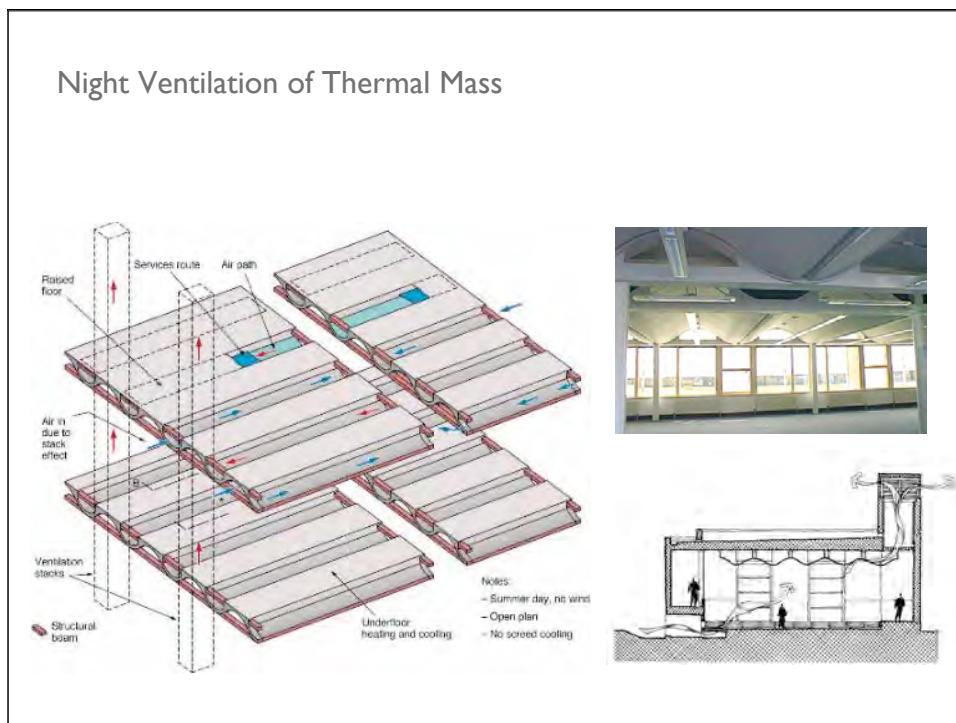
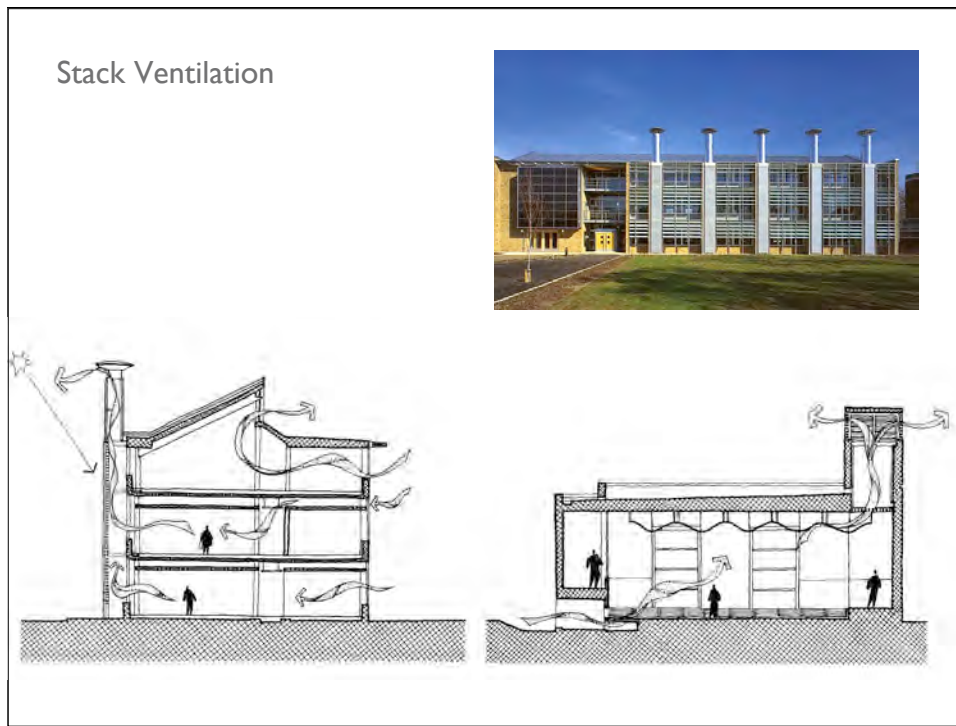
PART E **Step 2: Determine Cooling Load**
 PEOPLE • LIGHTS • EQUIPMENT
 ENVELOPE • **INFILTRATION**
CLOSED mode

MEEB 10th, pg. 1611

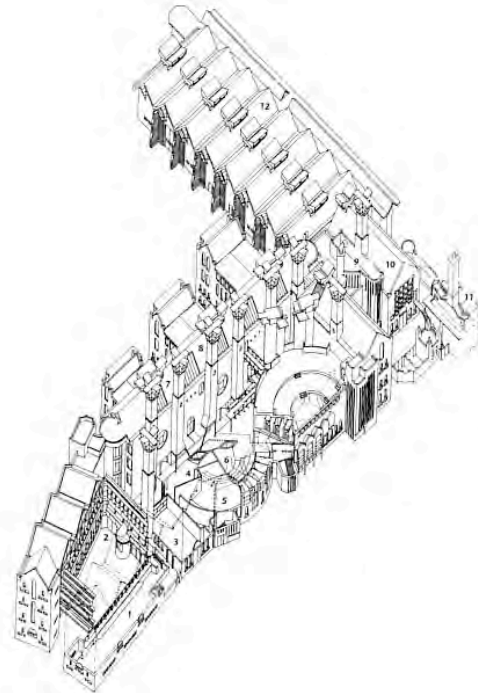
	Outdoor Design Temperature		Outdoor Design Temperature	
	90°F	100°F	32°C	38°C
Infiltration:				
Find ratio, $\frac{\text{total window + opaque wall area}}{\text{total floor area}}$, then multiply by	1.0	1.9	3.2	6.0
Ventilation:				
Find known $\frac{\text{total cfm of outdoor air}}{\text{total floor area, ft}^2}$, then multiply by	16	27	—	—
Find known $\frac{\text{total L/s of outdoor air}}{\text{total floor area, m}^2}$, then multiply by	—	—	9.9	16.8



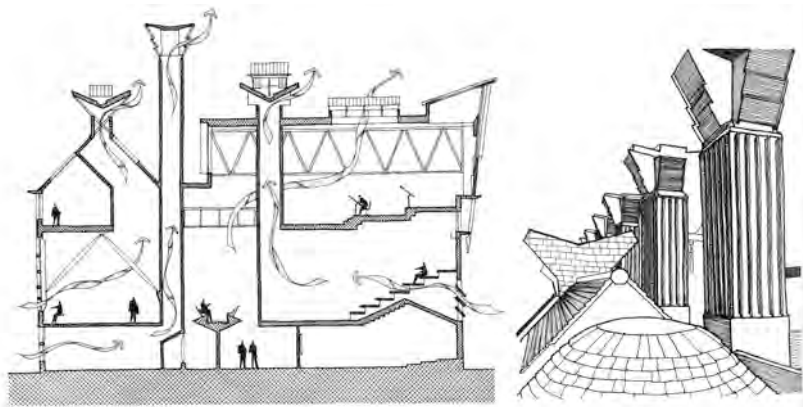




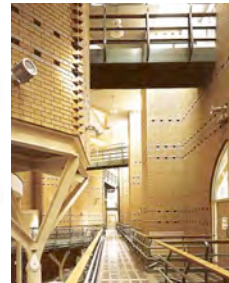
School of Engineering and Manufacture
Queens Building, de Montfort University
Short Ford & Associates Architects
United Kingdom



Stack Ventilation



Night Ventilation of Thermal Mass



Zion National Park
Visitor Center
NPS/Denver Service Center
Utah, United States



