

# HVAC Integration

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ARUP

# Façade decisions are key to HVAC loads

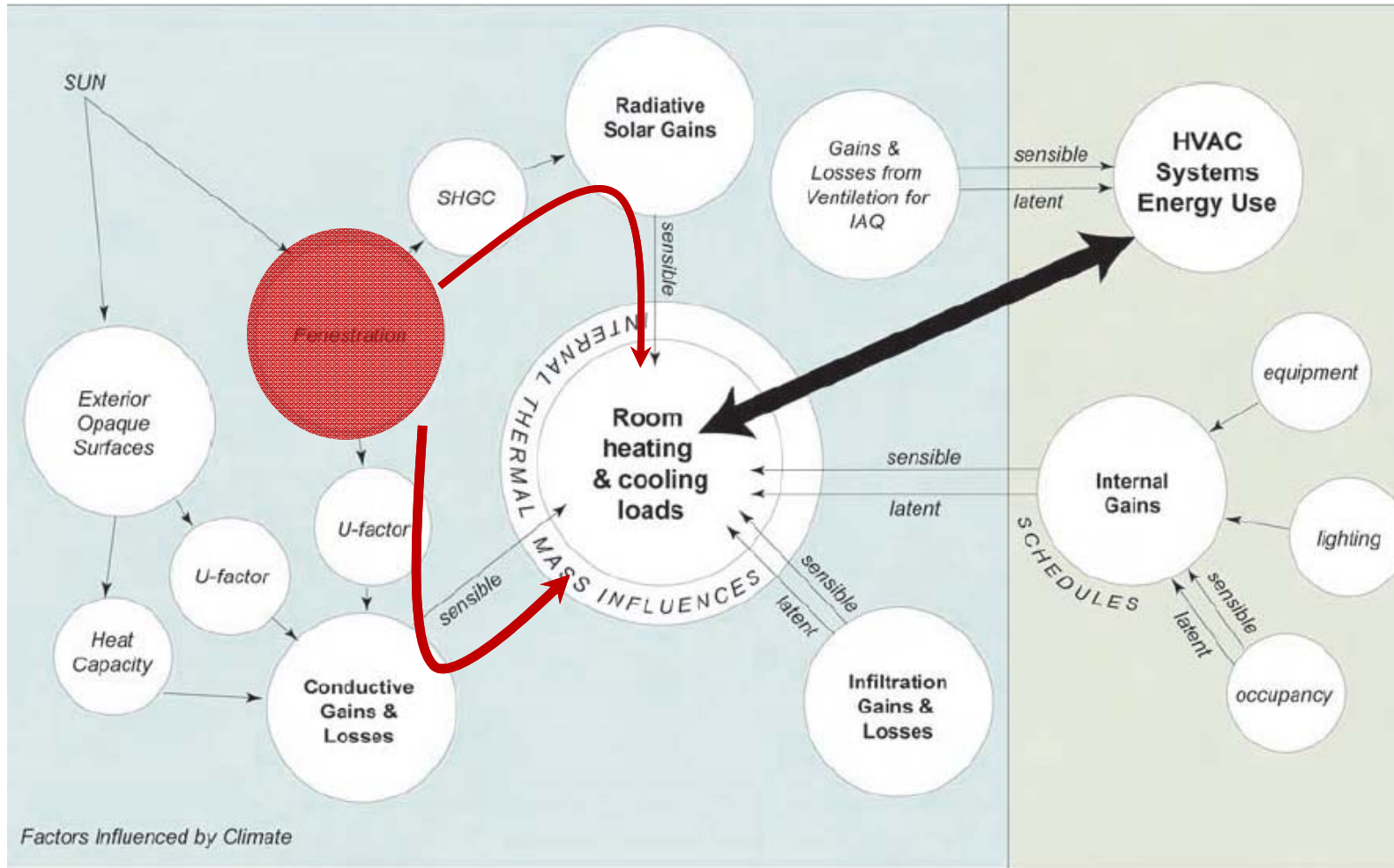
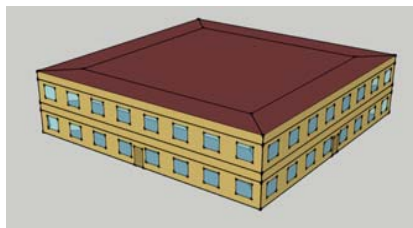
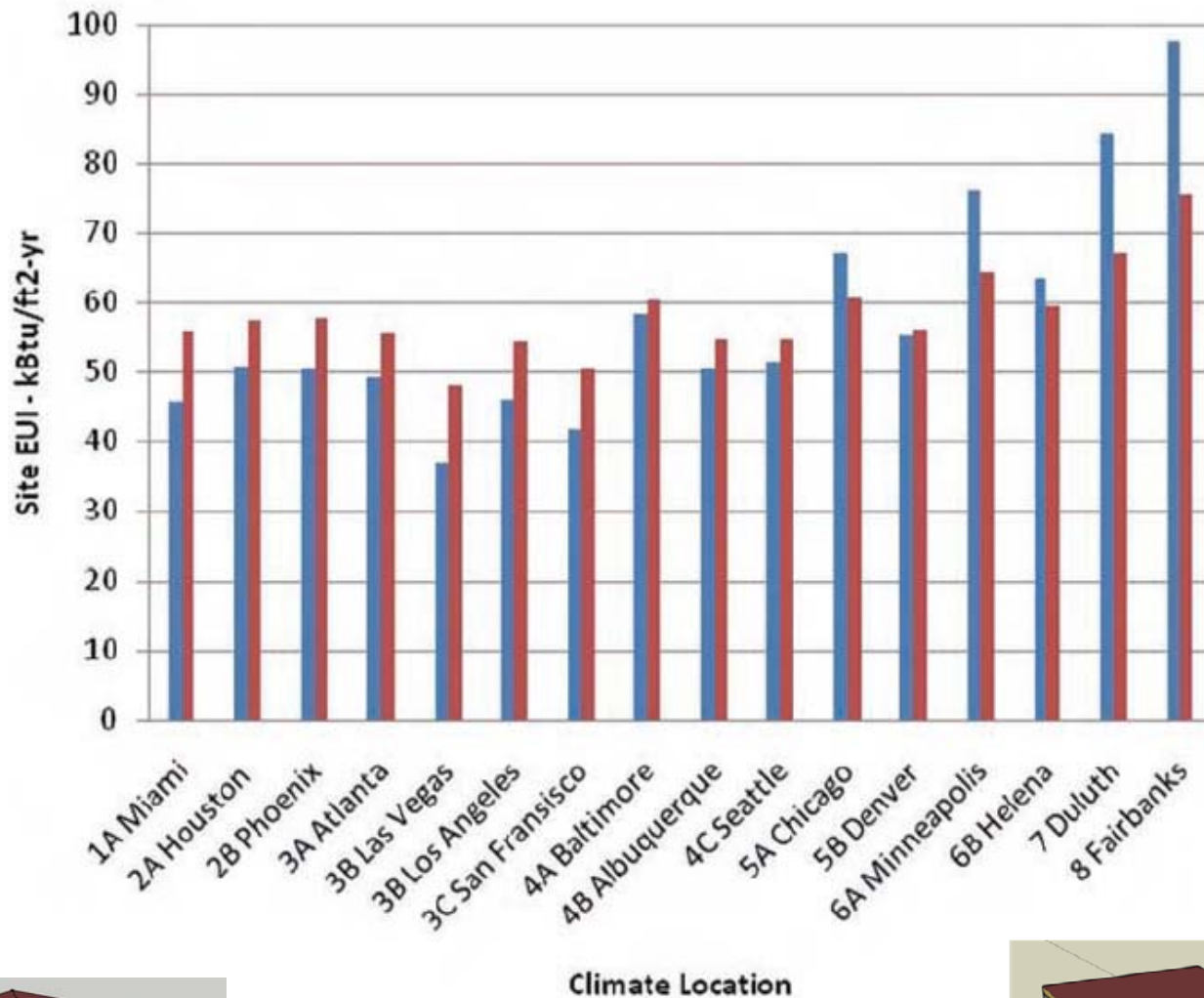
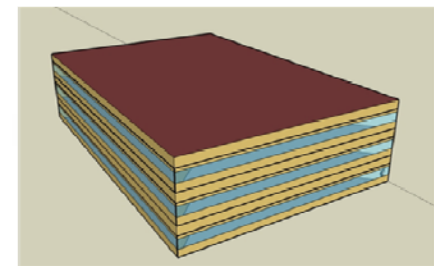


Figure 3-2 Heating and Cooling Influence



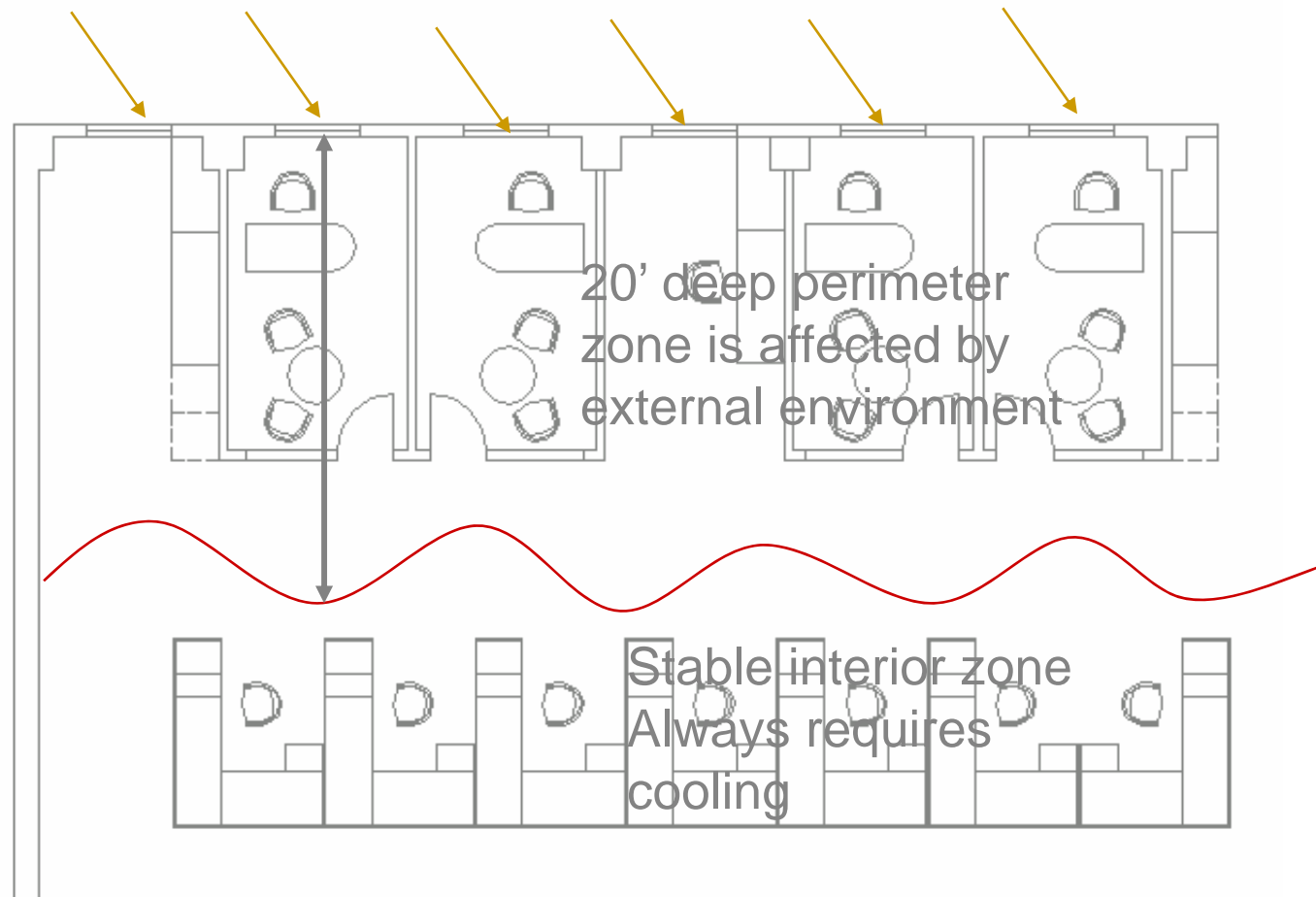
■ 20,000 ft<sup>2</sup> - Two Story    ■ 53,600 ft<sup>2</sup> - Three Story



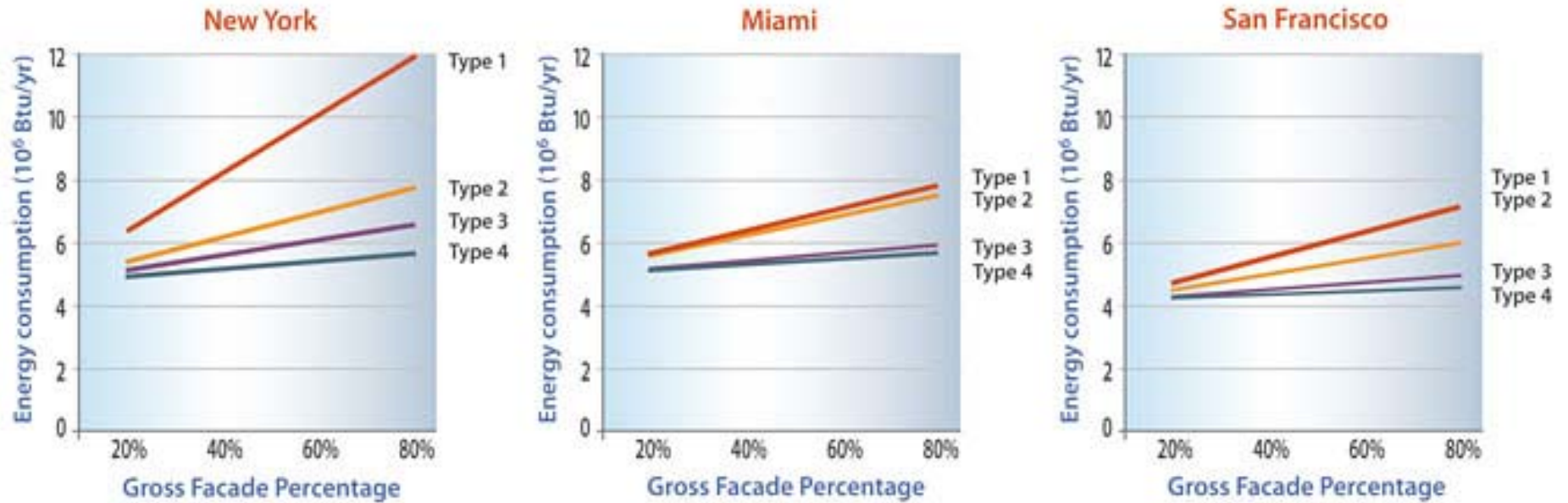
**Figure 3-11 Site EUI for Office Buildings**

Data source: Thornton et al. 2009, 2010

# Effect of façade on interior



# Climate impacts of glazing alone



Single Glaze

1

Double Glaze  
(No Low-E coating)

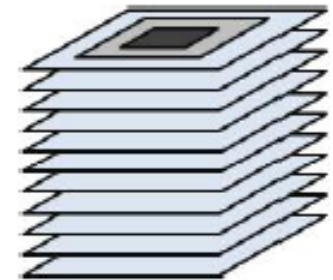
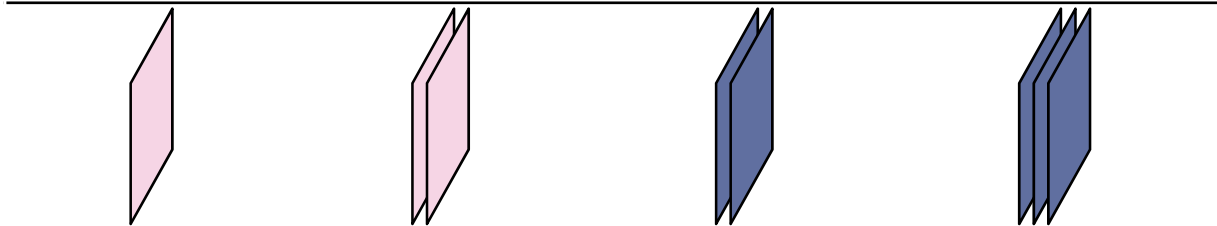
2

High Performance  
Double Glaze  
(Low-E Coating)

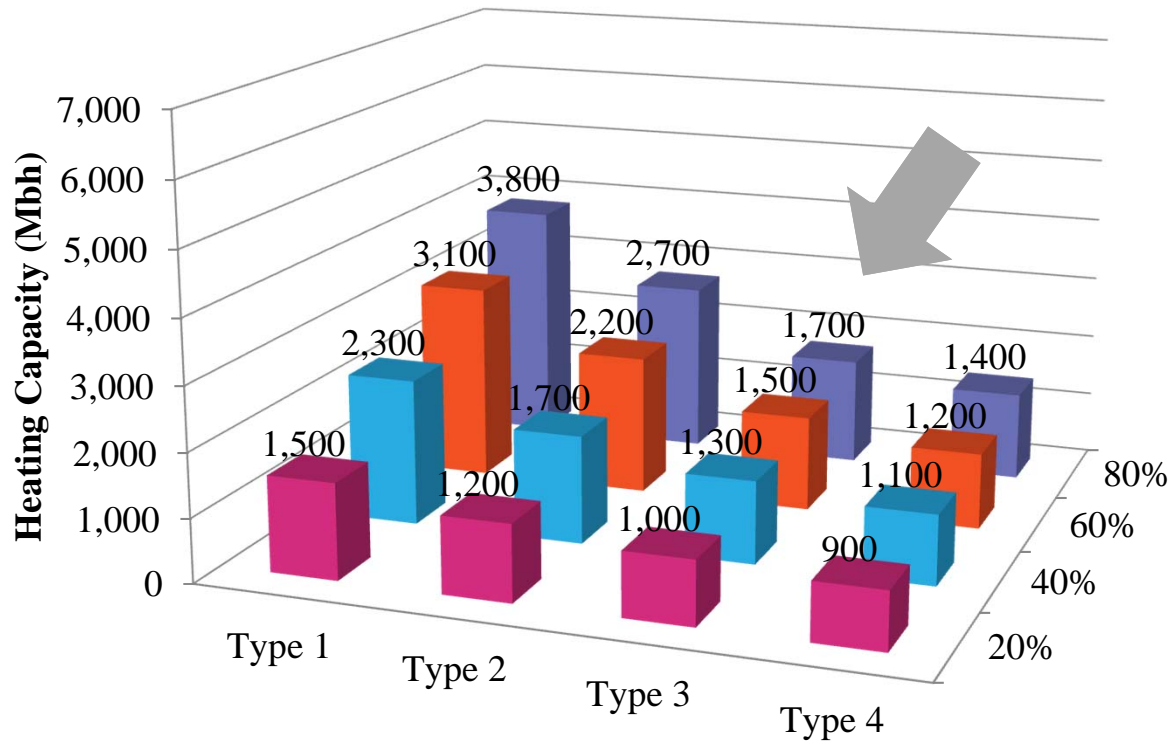
3

Triple Glaze  
(Low E-Coating)

4

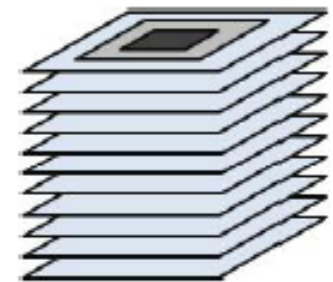
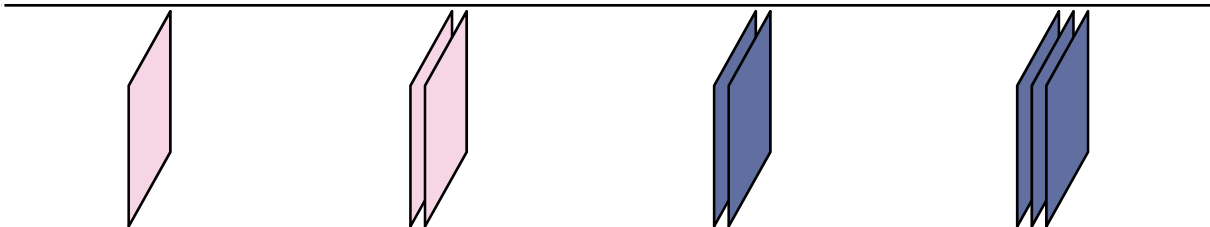


# San Francisco - Heating Capacity



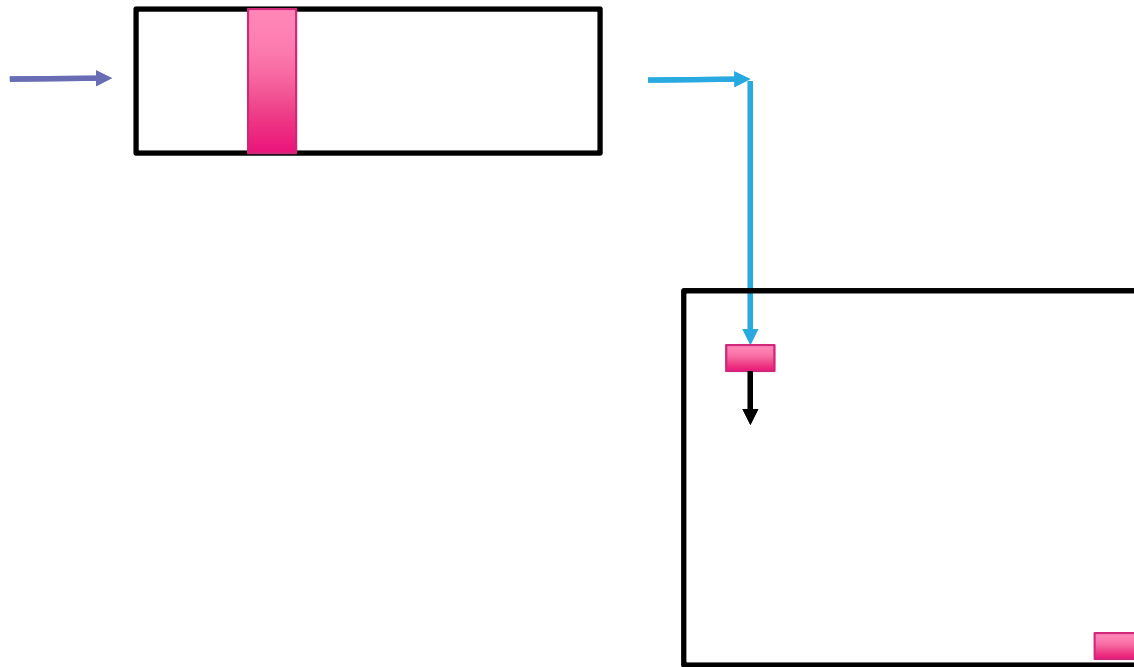
*Glass Facade Percentage*

- 1 Single Glaze
- 2 Double Glaze (No Low-E coating)
- 3 High Performance Double Glaze (Low-E Coating)
- 4 Triple Glaze (Low E-Coating)

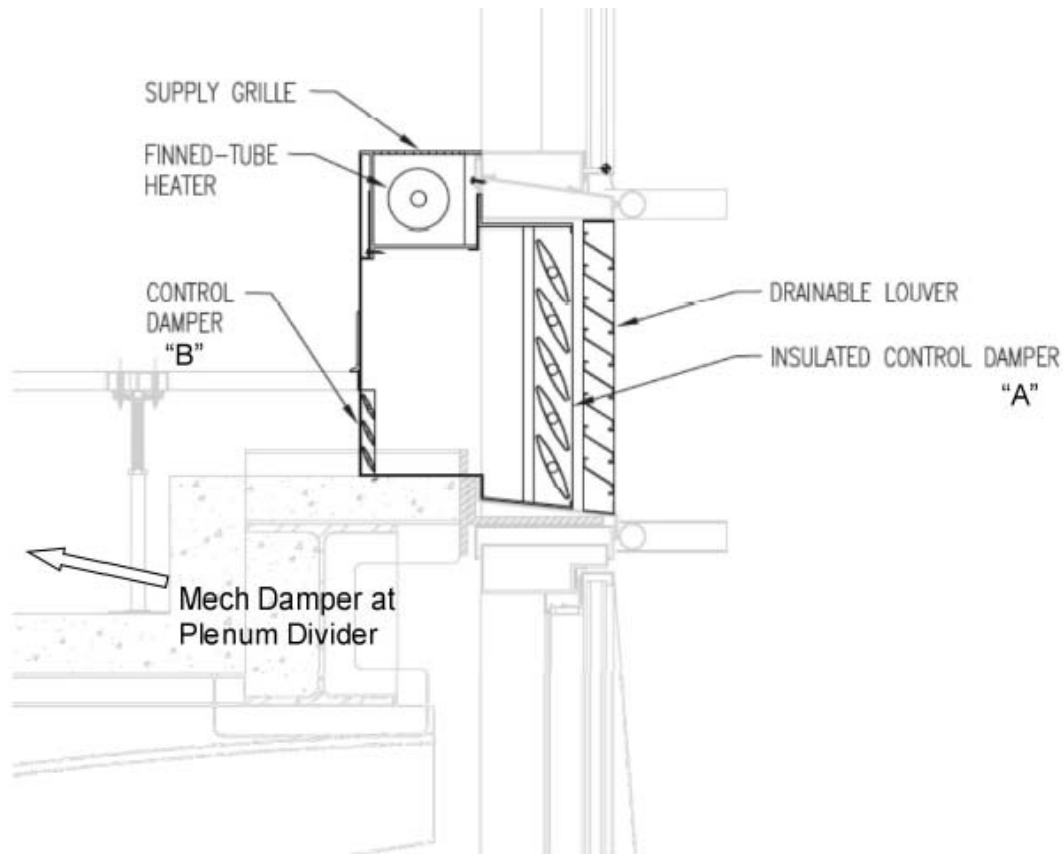


# Perimeter heating systems

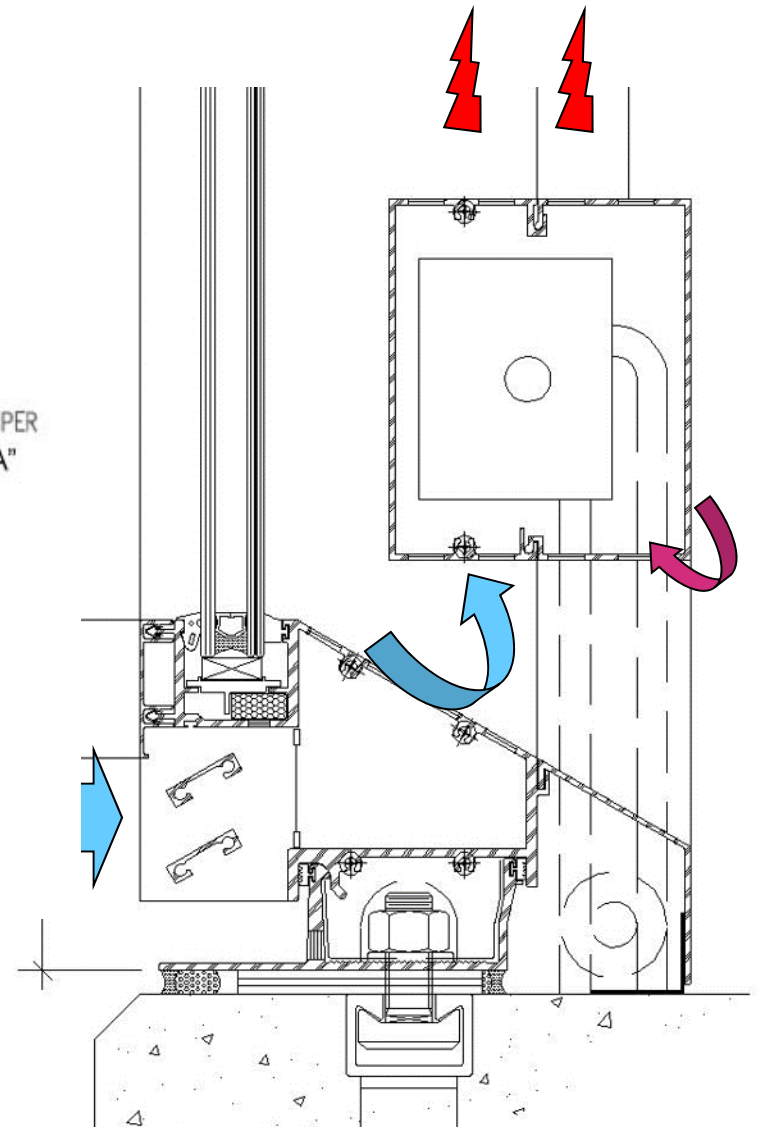
- Only three needs for heat:  
Outside air, perimeter heat loss, primary air boost



# SFPUC Building



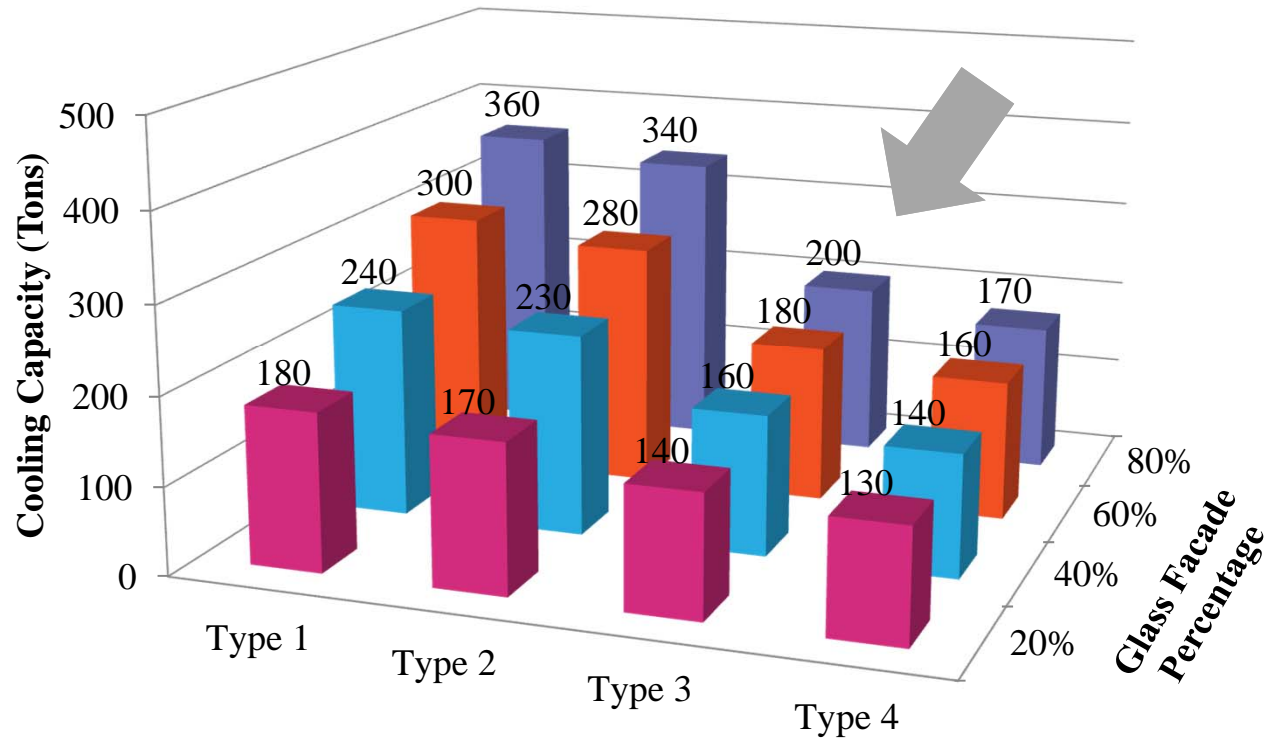
# SF Federal Building



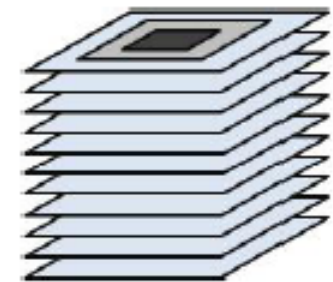
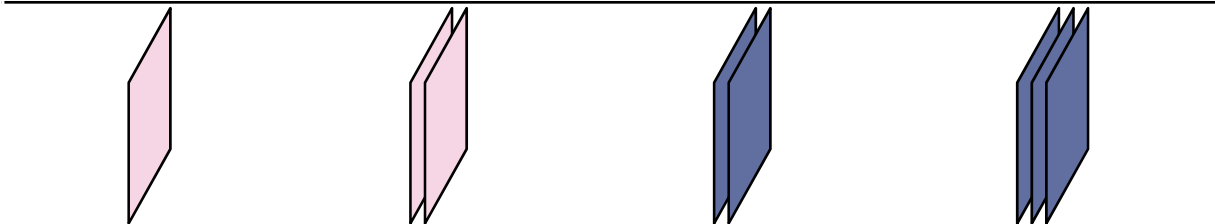




# San Francisco - Cooling Capacity

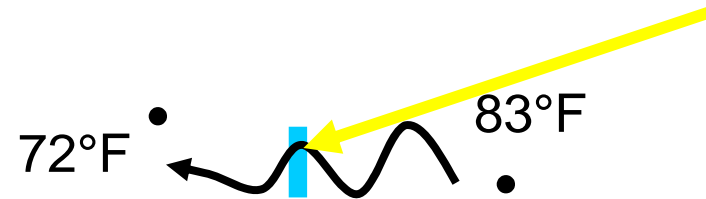
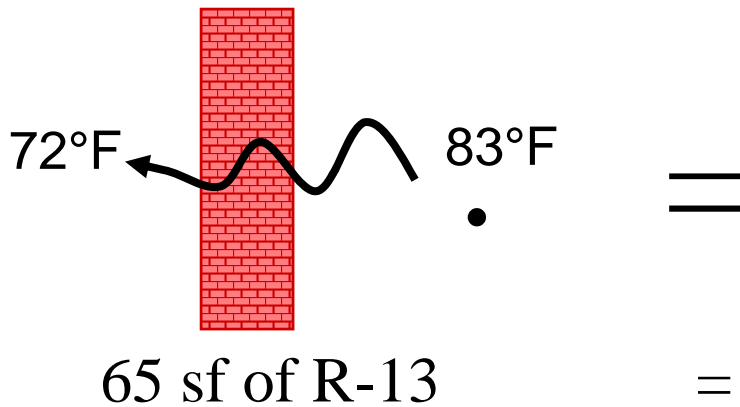
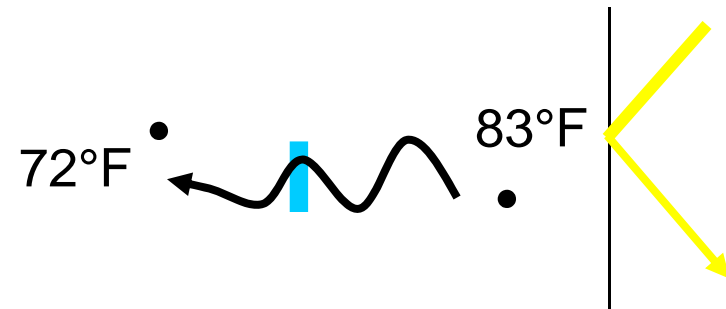
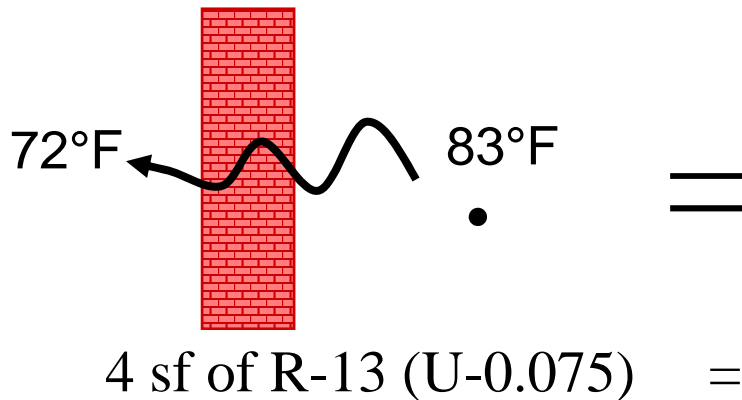


- 1 Single Glaze
- 2 Double Glaze (No Low-E coating)
- 3 High Performance Double Glaze (Low-E Coating)
- 4 Triple Glaze (Low E-Coating)



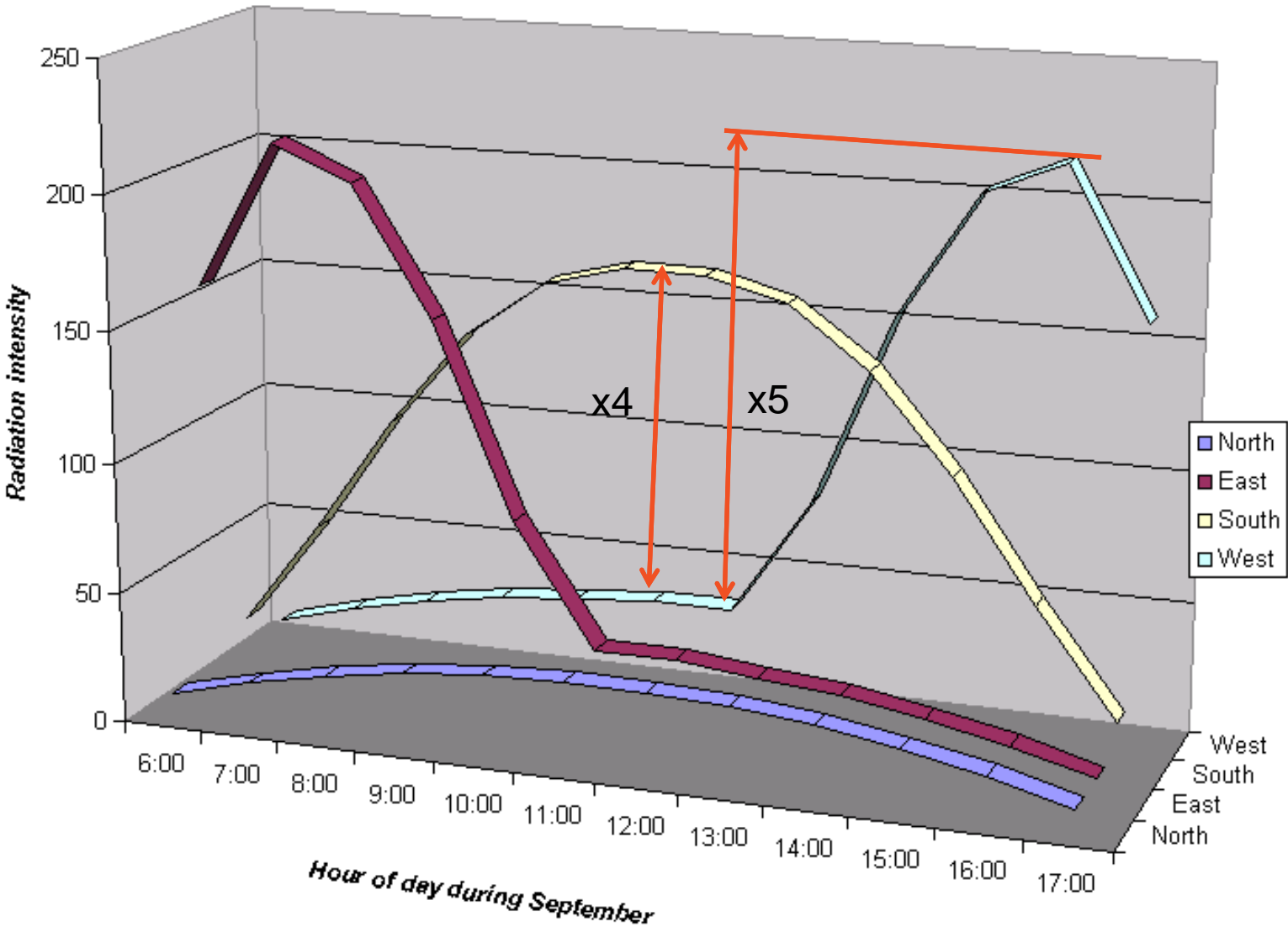
# Why window wall ratio matters so much

Conduction Heat Transfer =  $U \cdot \text{area} \cdot \Delta T$  (11F)

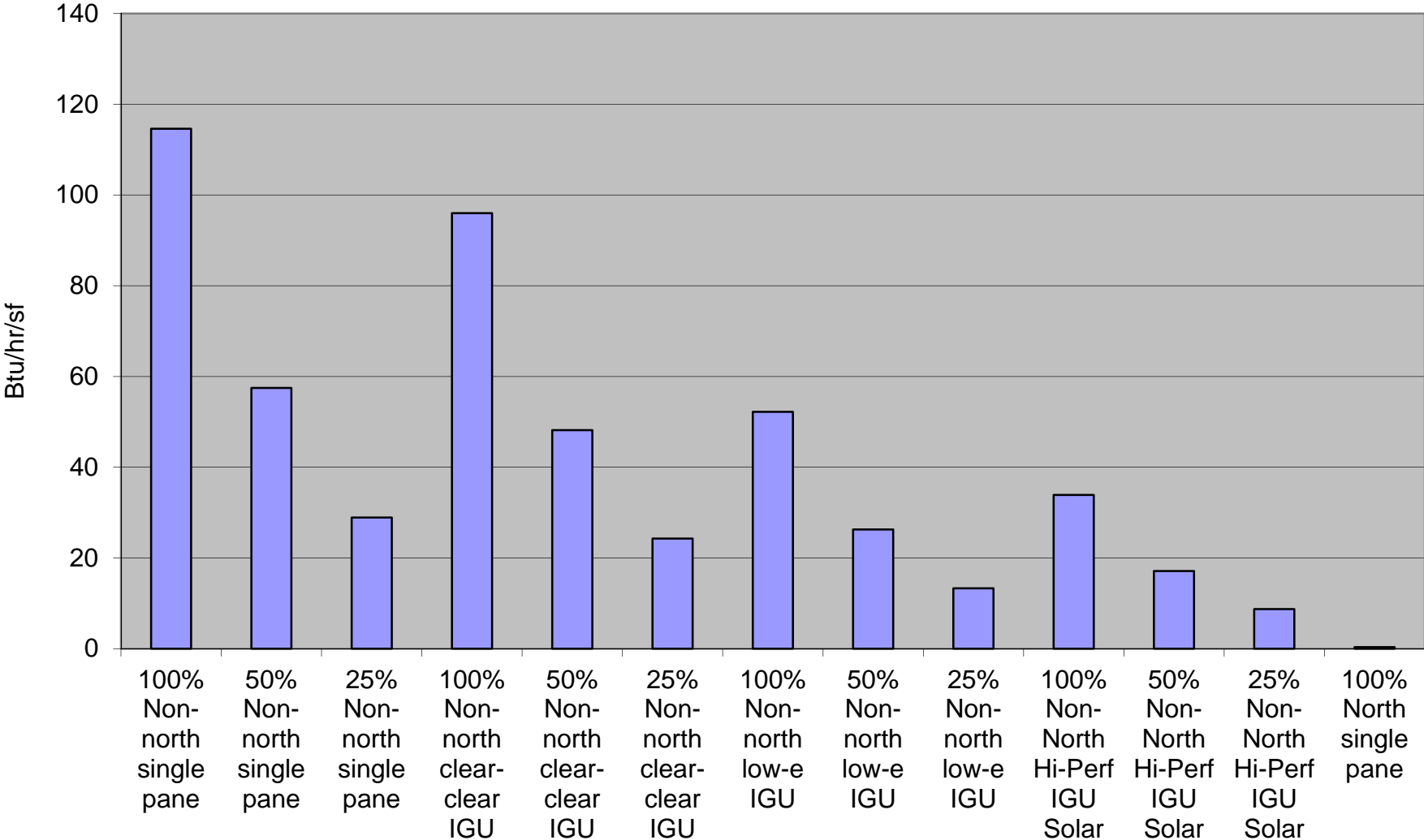


Solar heat gain = Btu/hr/sf solar x SHGC

Comparison of solar radiation by orientation

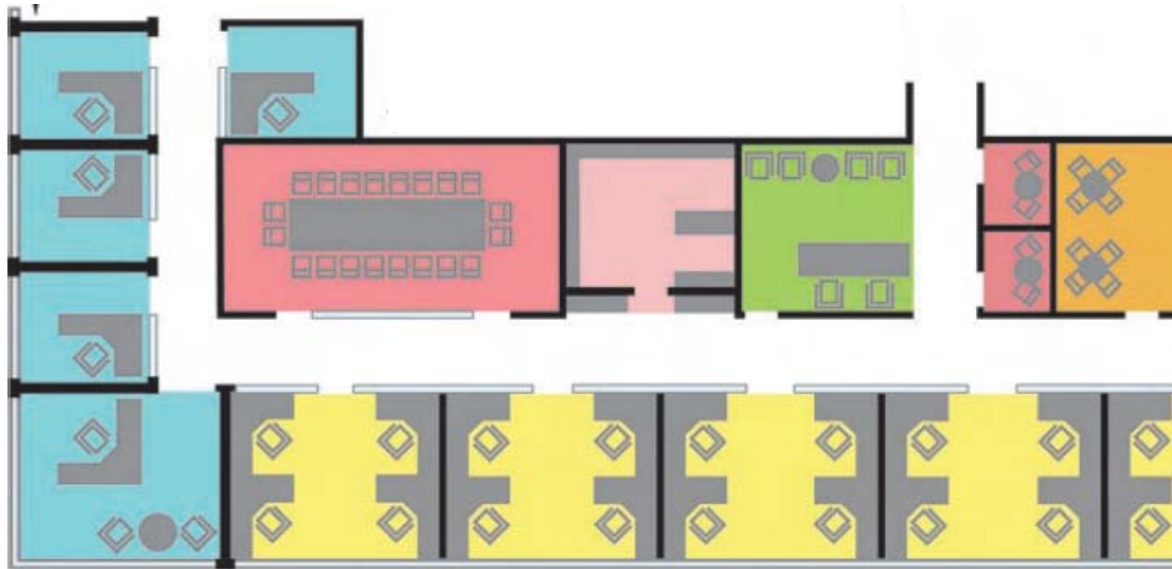


Comparison of External Heat Gain by glass type  
 for one 500 sf wall (50' x 10' high) prorated onto a 1000 sf perimeter room zone

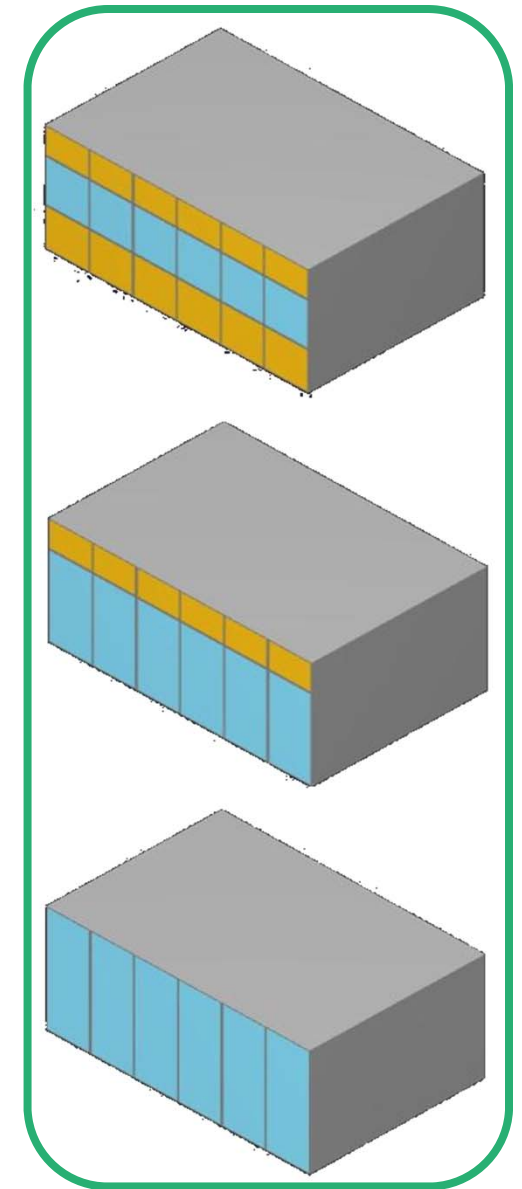
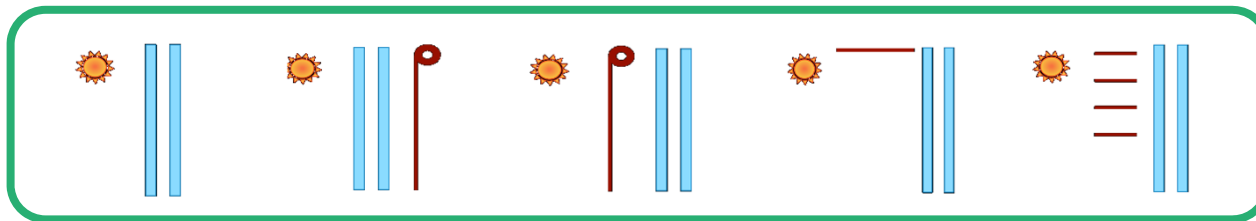
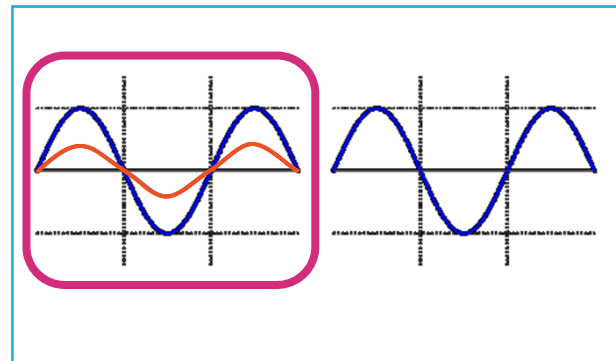
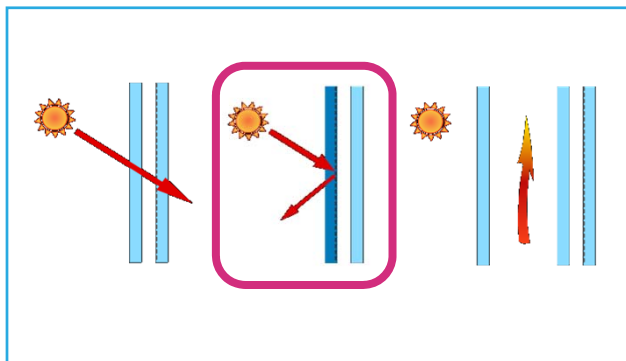
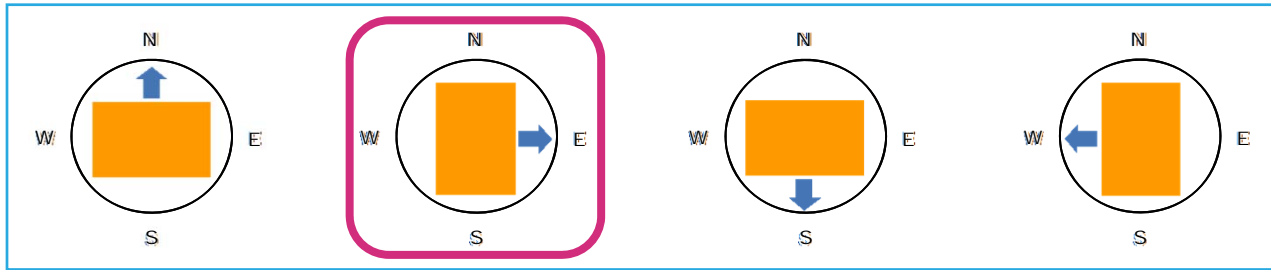


## Concept Design: Zoning

- Natural ventilation potential
- Glazing/ operable windows
- Perimeter occupant comfort
- Heat loss/ gain versus HVAC loads
- Potential for shade



# Key drivers for HVAC design in perimeter zones



## Are we close to being Title 24 code compliant?

- SHGC 0.25 X 40% WWR + 0 SHGC X (1-40%) = 0.1  
prescriptive code compliance
- SHGC 0.37 x ?% WWR + 0 SHGC X (1-WWR) = 0.1  
→ WWR = 0.27  
match to prescriptive façade energy budget, but if pursuing performance method, base building would match any WWR lower than 40%.
- SHGC ? X 100% WWR = 0.1 → SHGC = 0.1

# Façade effects on energy savings

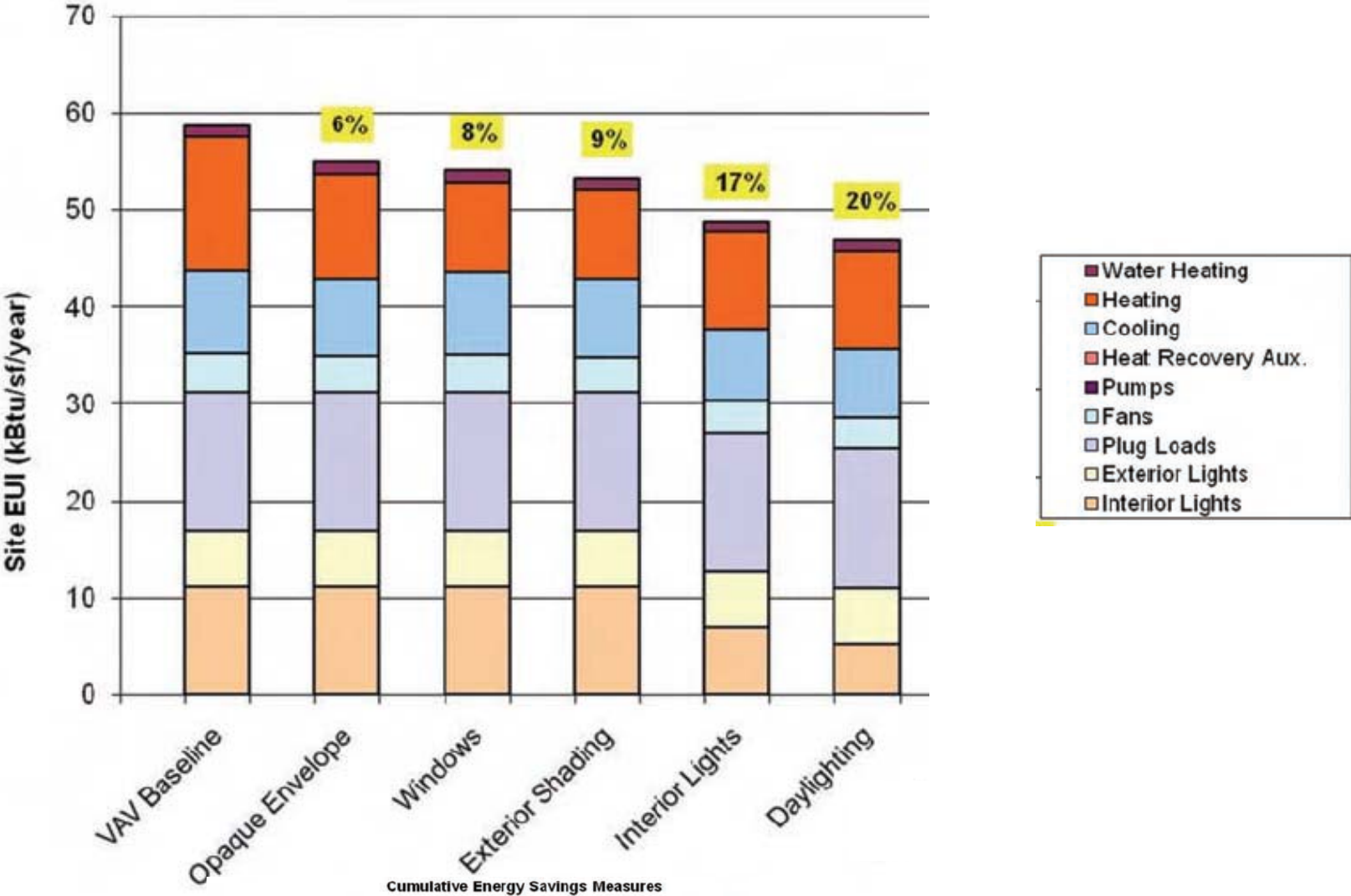
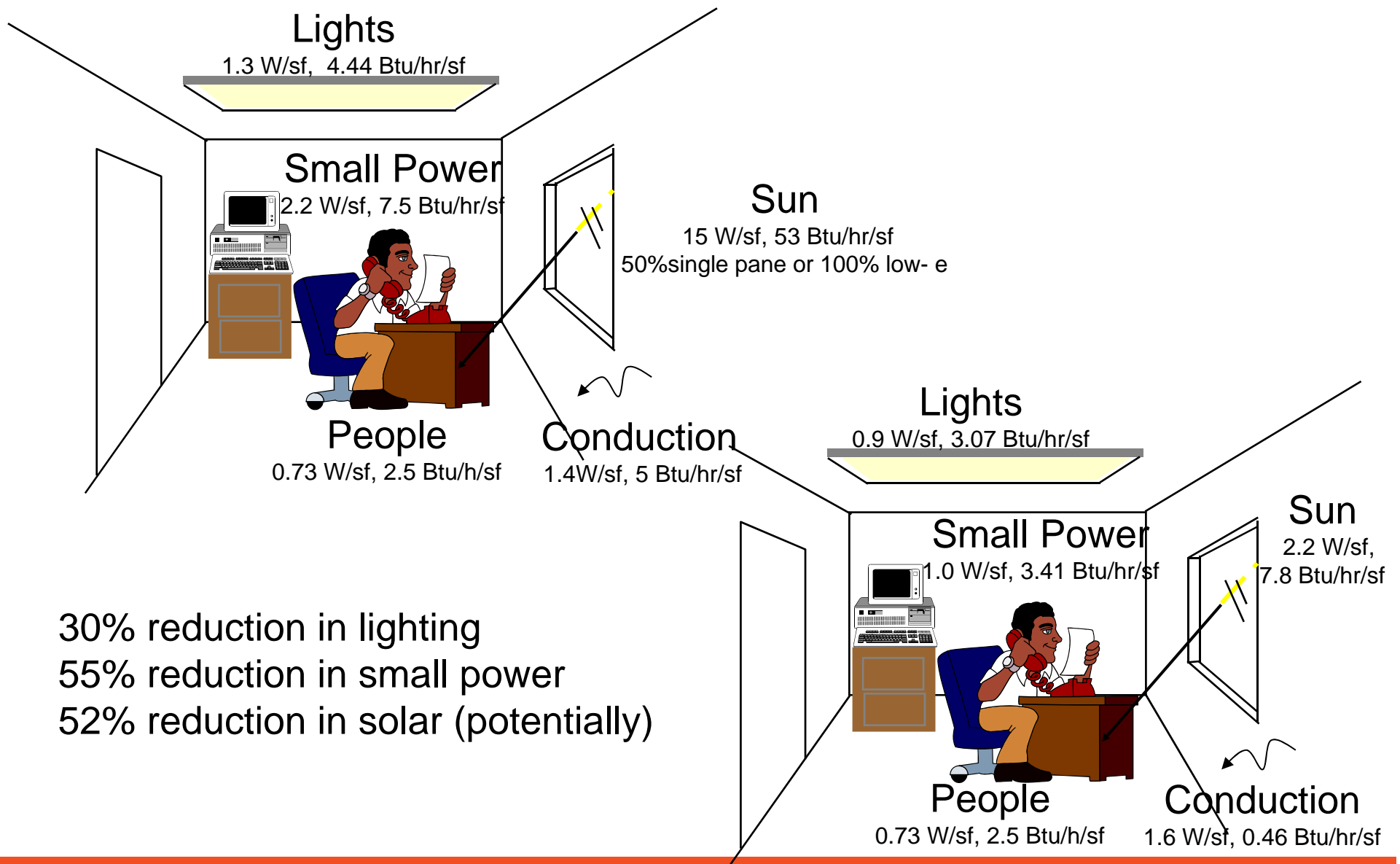


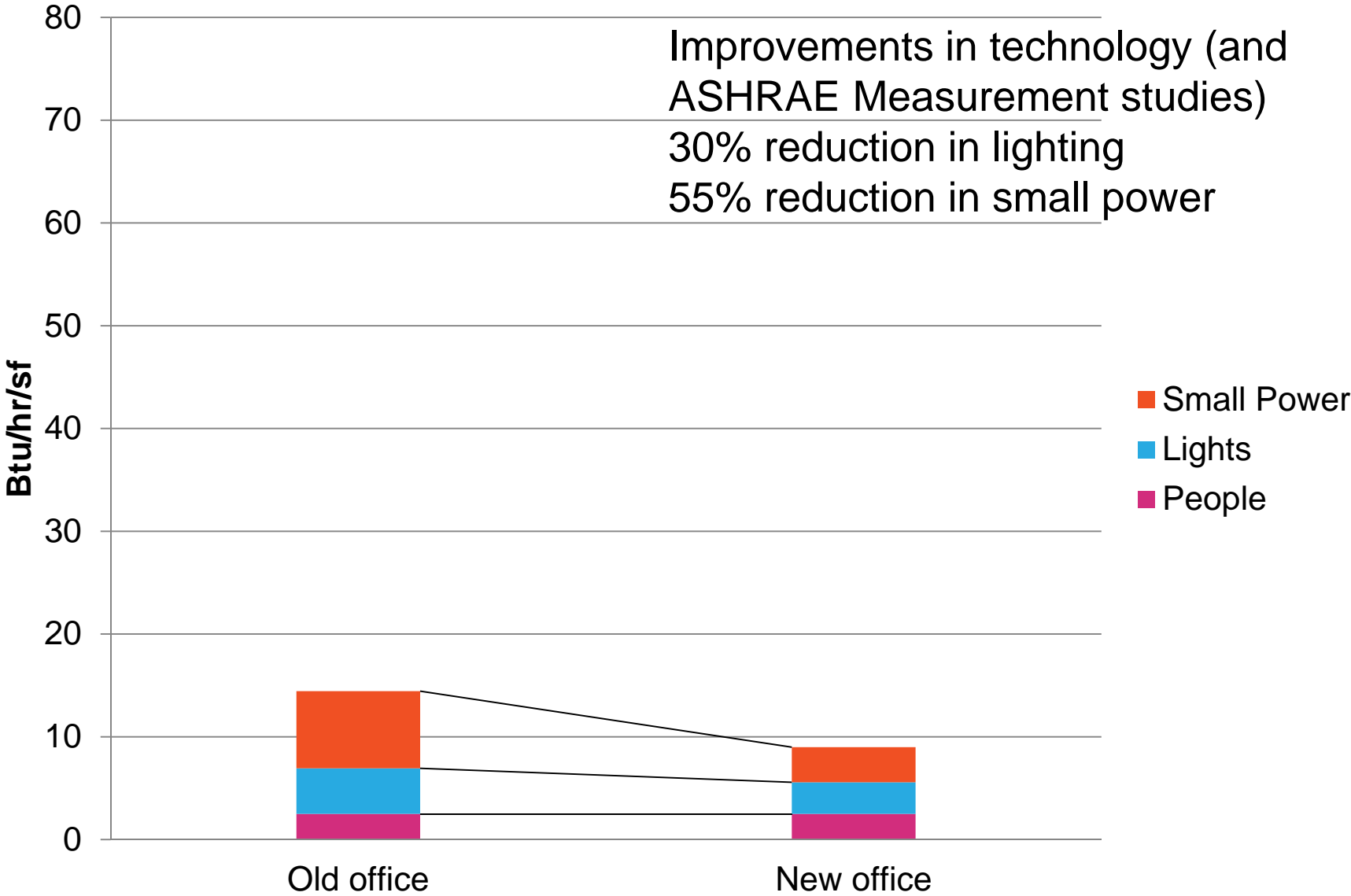
Figure 3-15 Relative Impact of Energy Savings Strategies

# Old paradigm vs new designs (update for new)

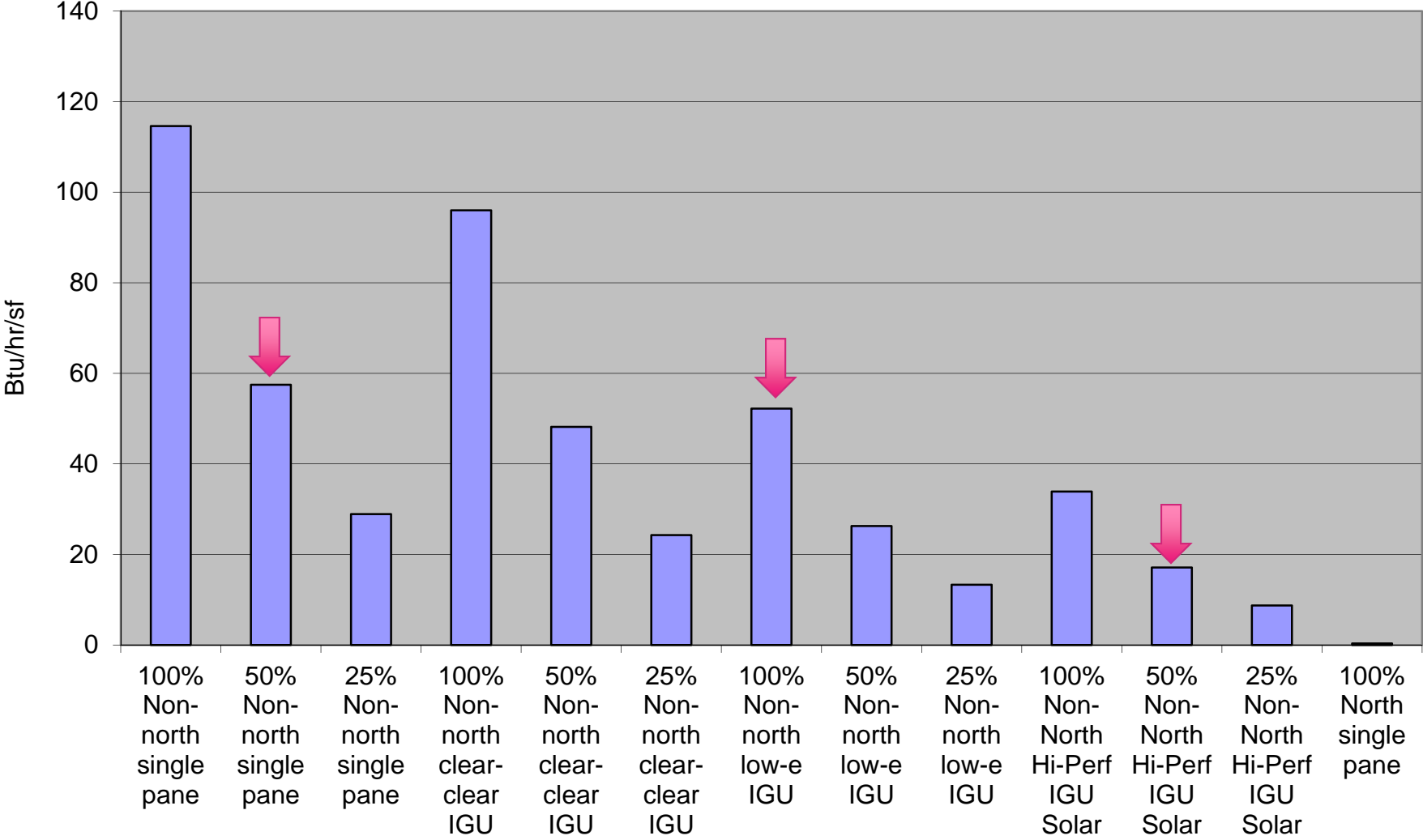


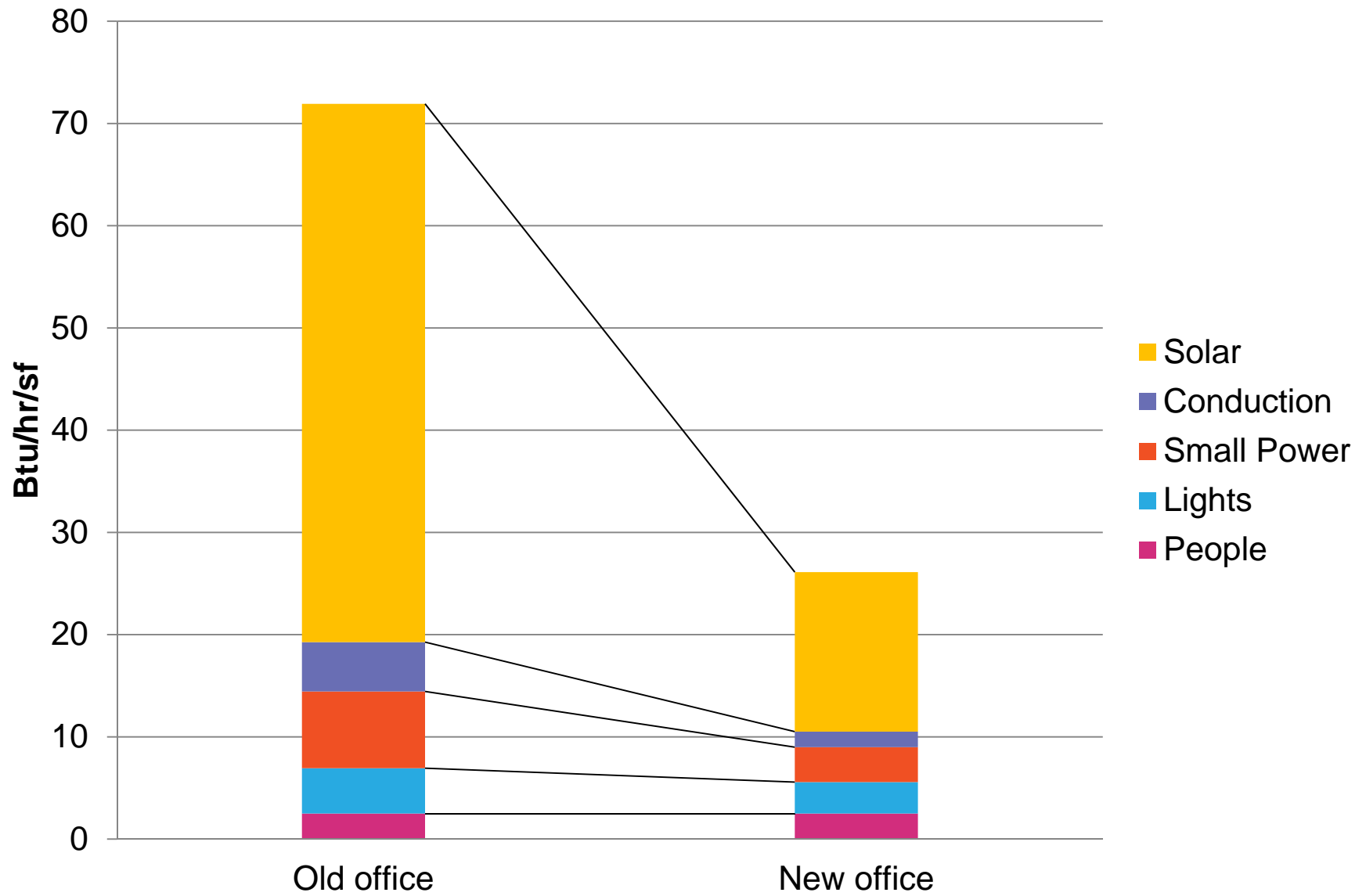
30% reduction in lighting  
 55% reduction in small power  
 52% reduction in solar (potentially)

Improvements in technology (and  
ASHRAE Measurement studies)  
30% reduction in lighting  
55% reduction in small power

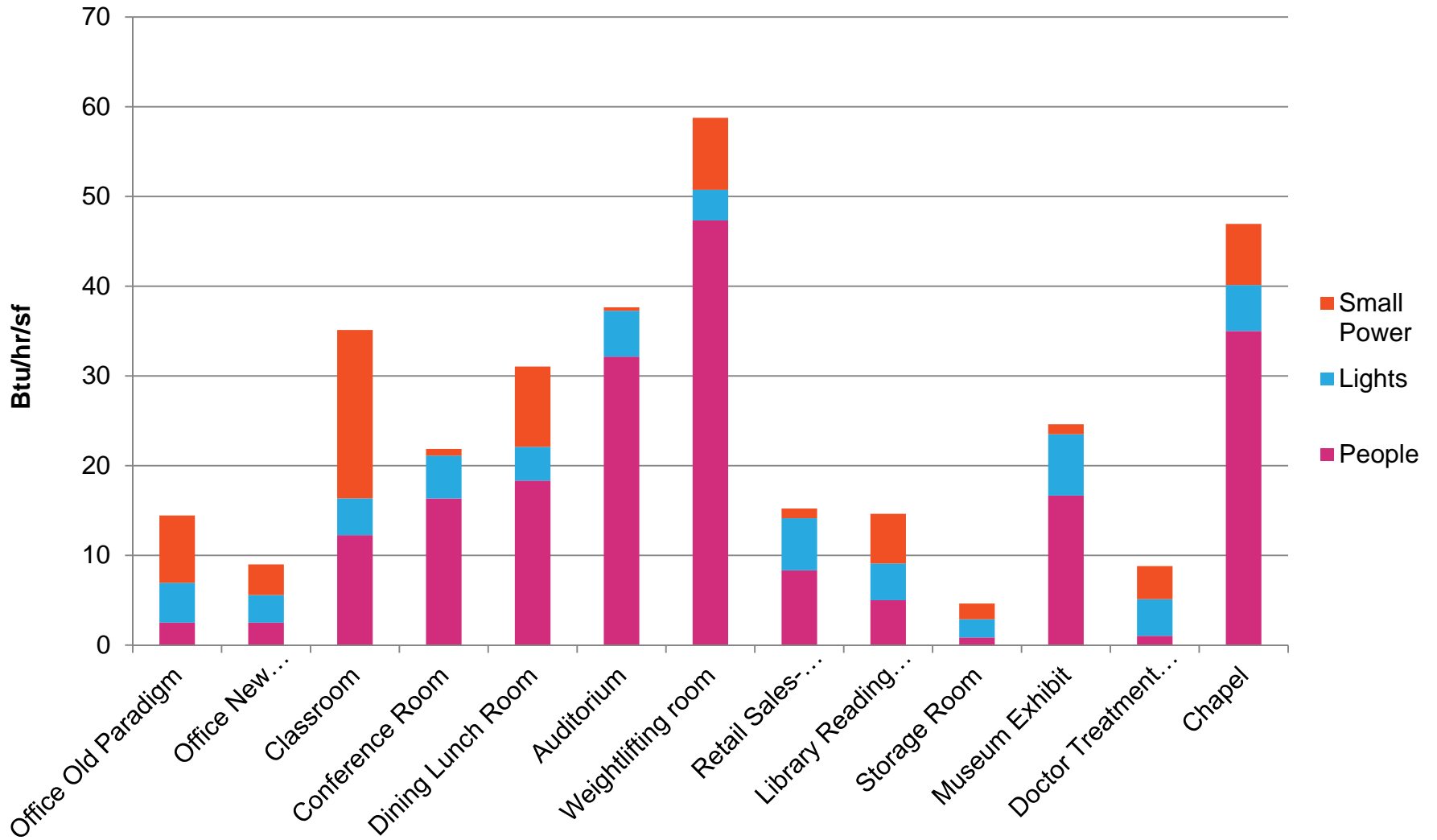


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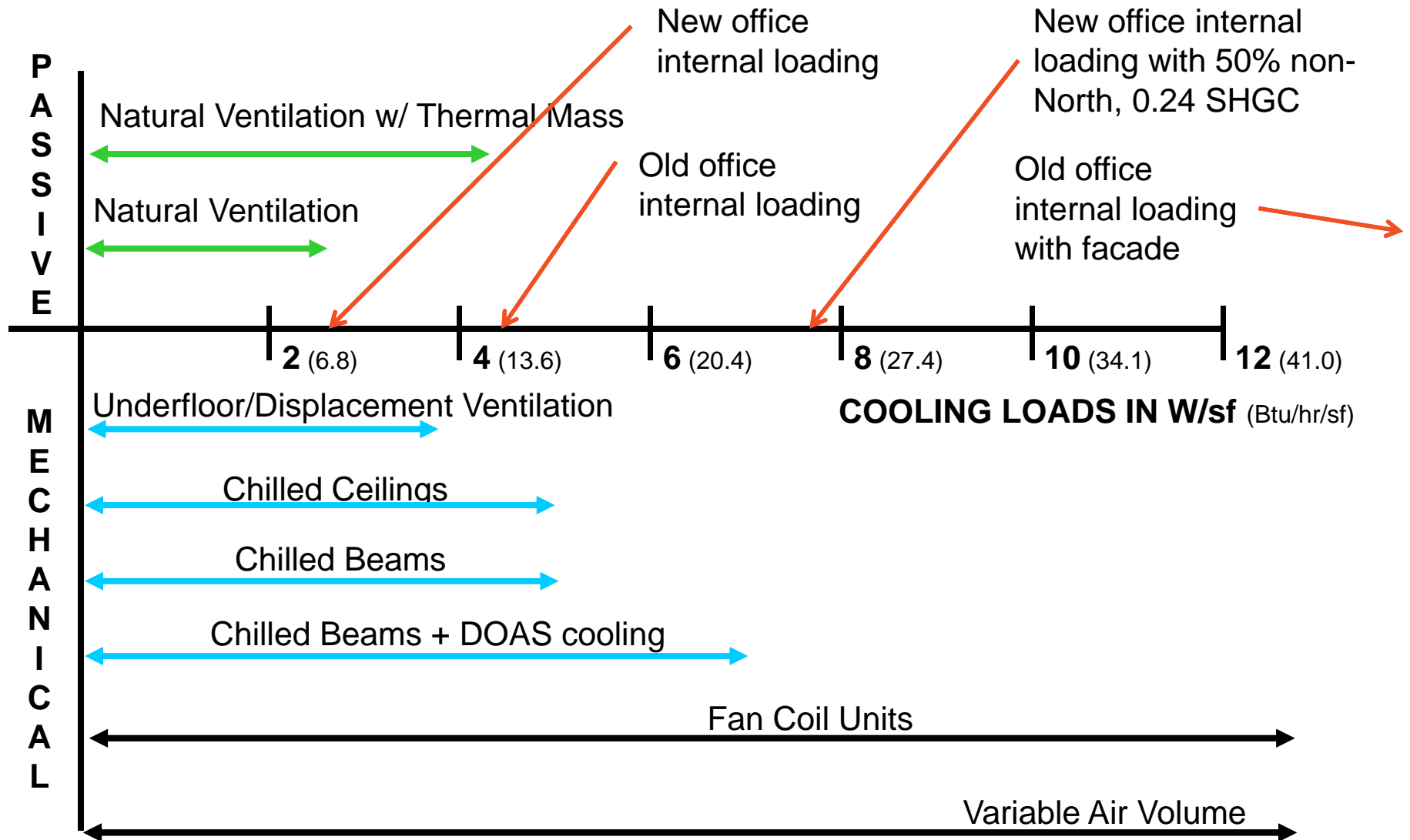


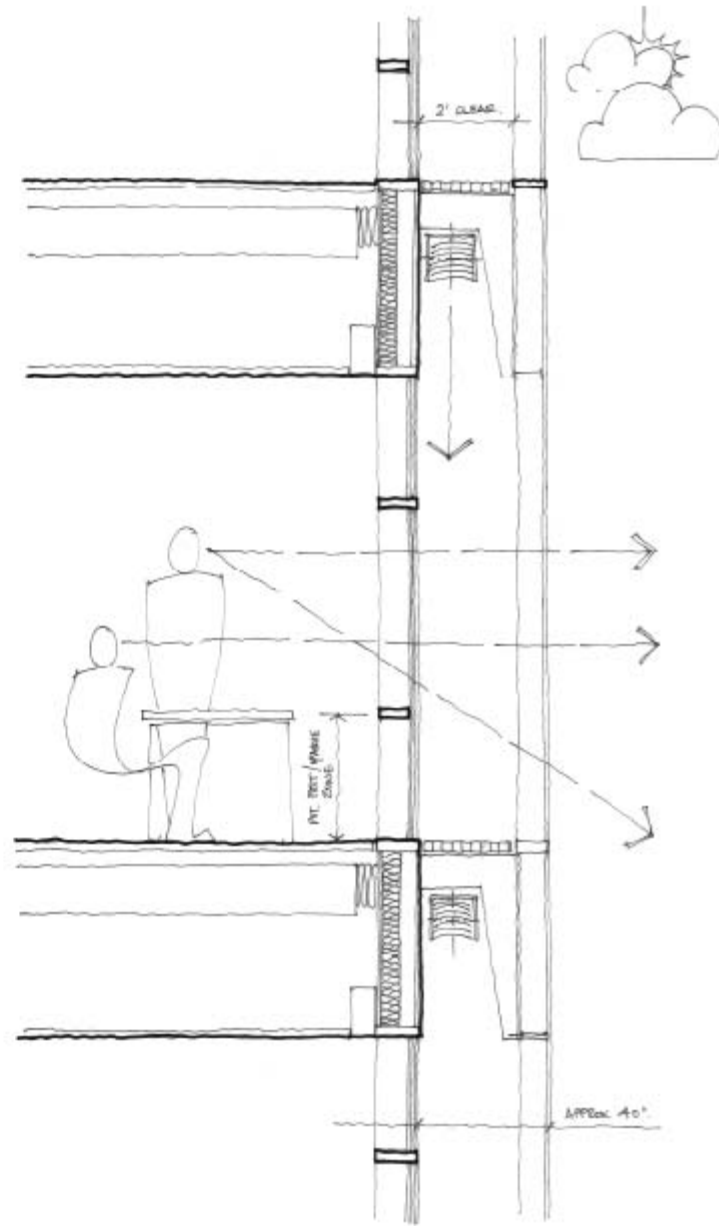
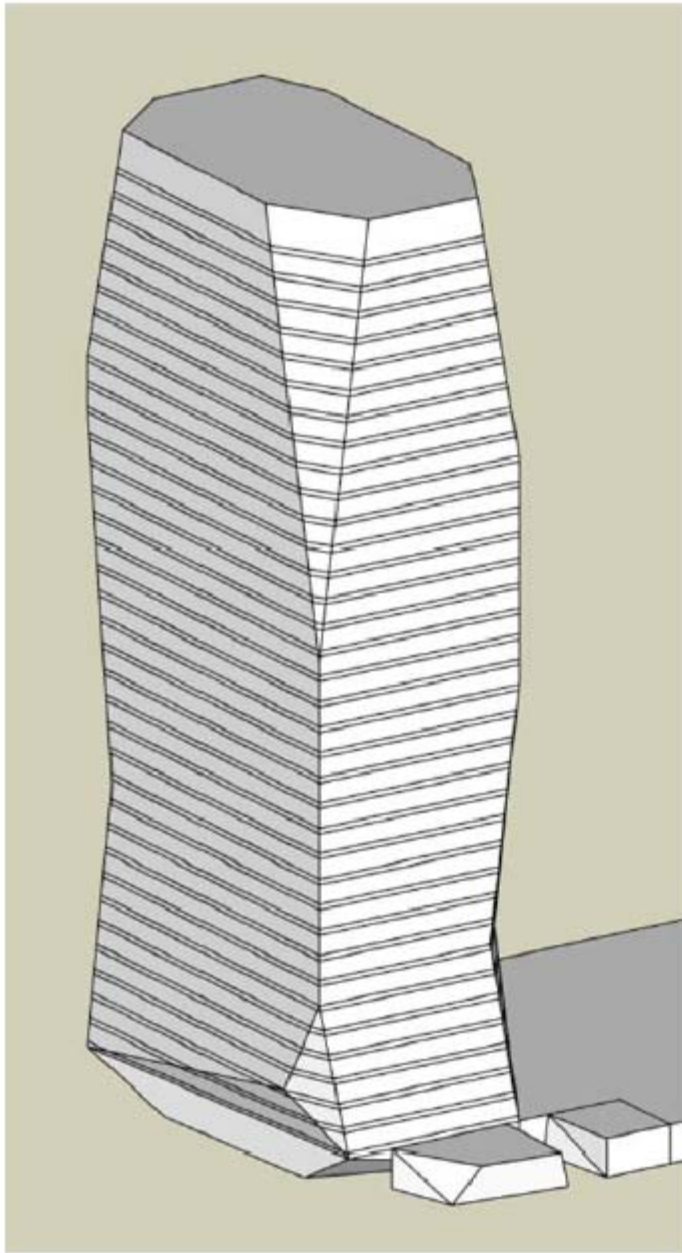


### Comparison of Internal Heat Gains by space type for 1000 sf room



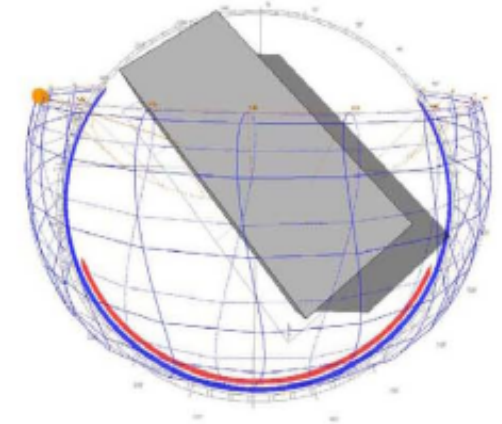
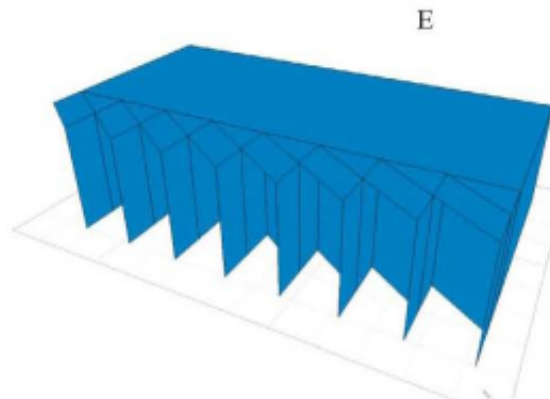
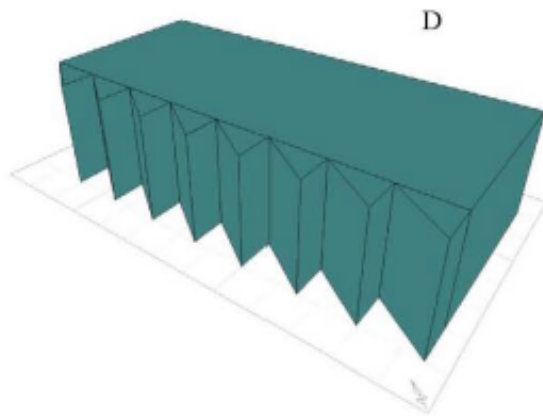
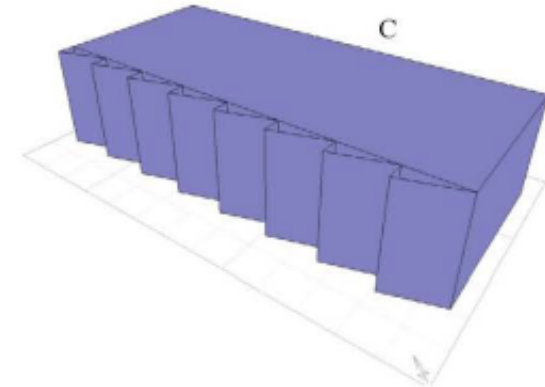
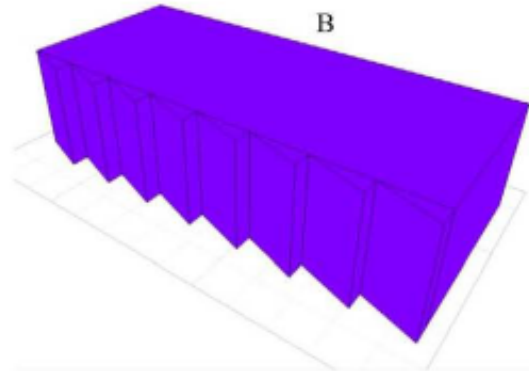
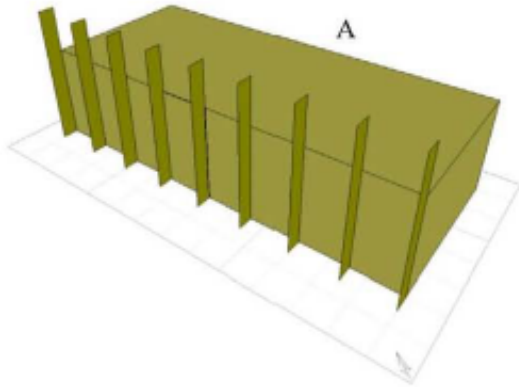
# Heat absorption limitations of systems



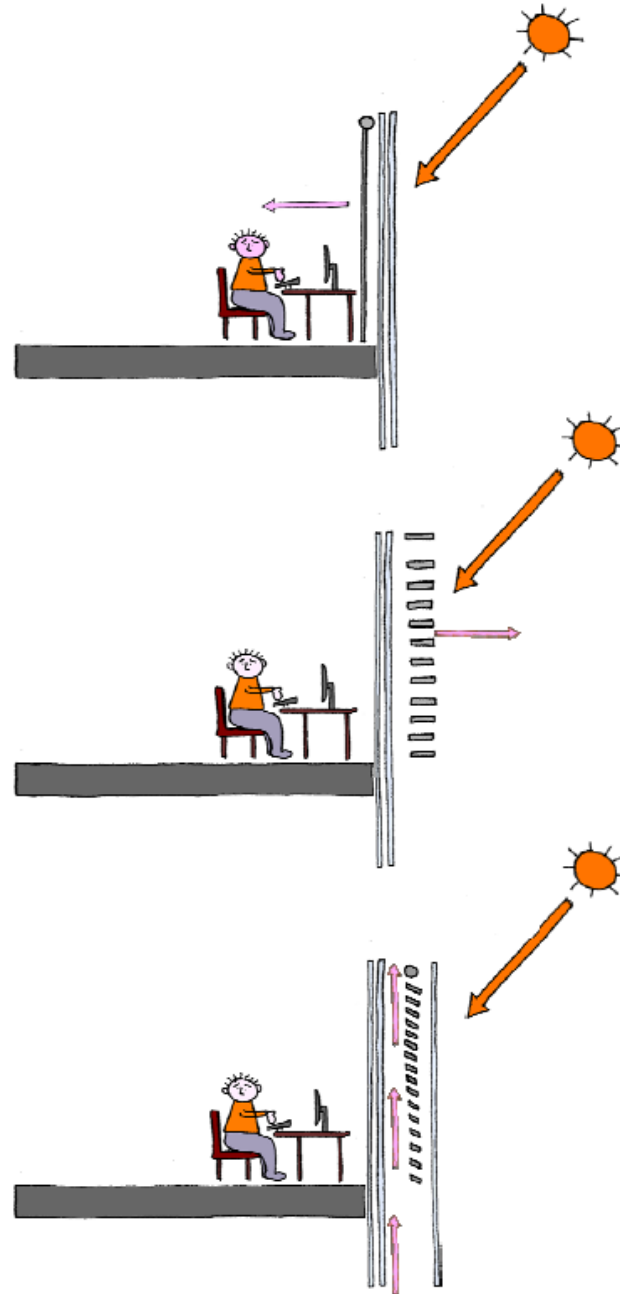
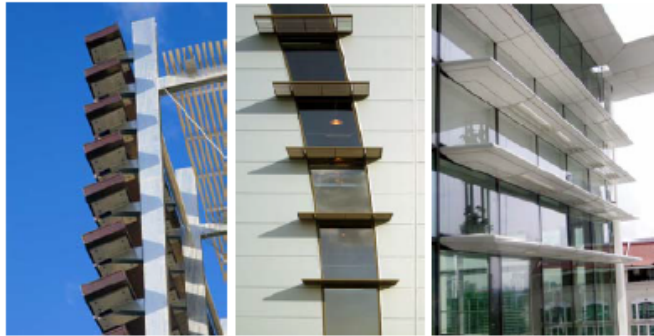


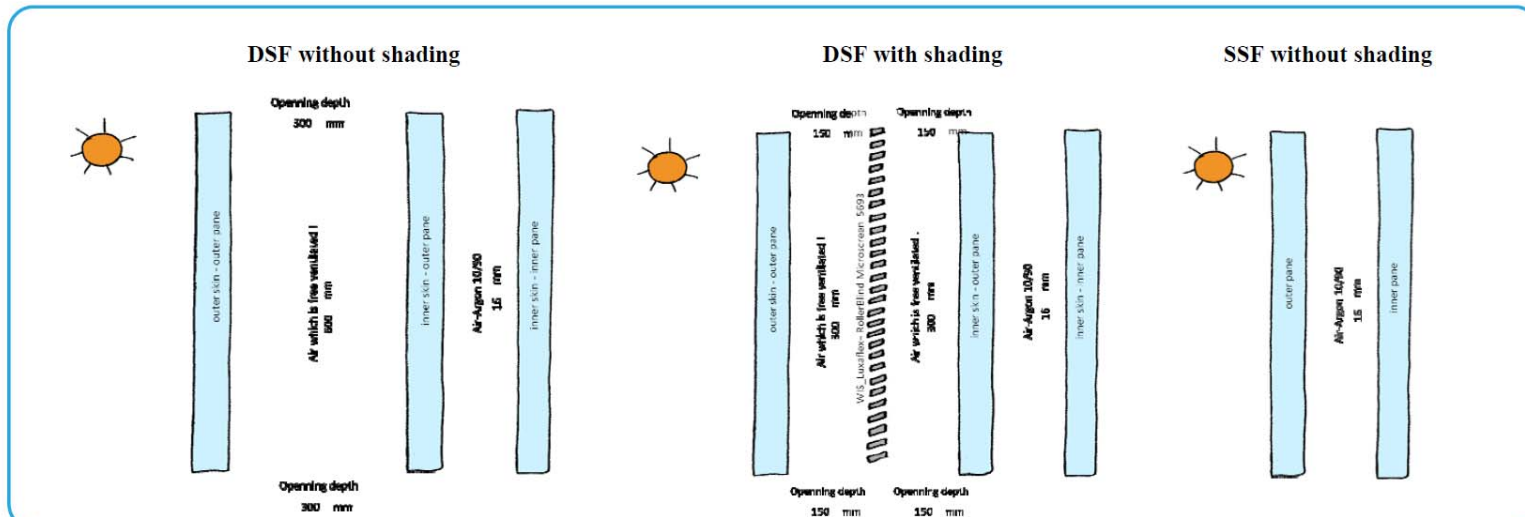
Improvement upon west facade

Option	Improvements over basecase	% reduction in transmitted solar energy	Transmitted solar energy [W/m <sup>2</sup> ]
A	Shaded with vertical fins (500mm deep, every 1500mm)	8.3	134
B	Inclined north by 18°	12.3	128
C	Inclined south by 18°	9.3	132
D	Inclined north by 34°	22.9	113
E	Inclined north by 34° + 1m overhangs + 1m vertical fins	26.0	108



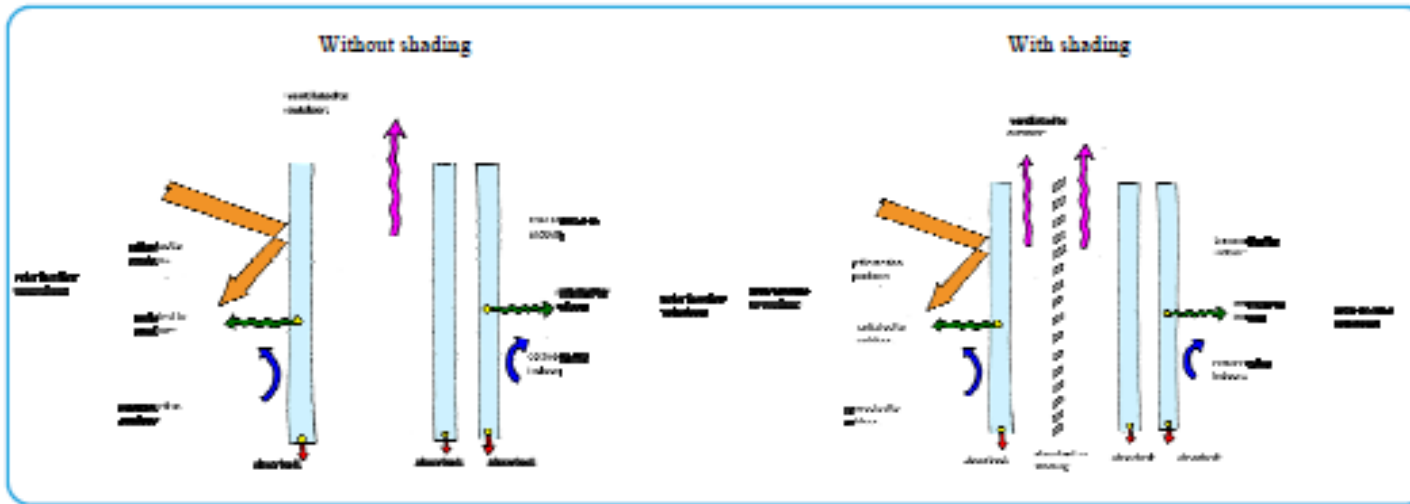
Even with heavy shading and adjustments to the facade inclination angle, the west facade is still receiving too much solar energy. Alternatives to a SSF approach may need to be considered.





Properties of Double Skin (DSF) and Single Skin Façade (SSF) cases

Case	Outer skin	Ventilated/External cavity	Inner skin		
	Pane type		Shading	Outer pane	Inner pane
DSF 0	Clear laminated with fritting	No	Solar control + low-E	Clear	No
DSF 1a	Clear laminated	No	Solar control + low-E	Clear	No
DSF 1b	Clear laminated	Roller blind	Solar control + low-E	Clear	No
DSF 2a	Clear laminated with fritting and XIR	No	Solar control + low-E	Clear	No
DSF 2b	Clear laminated with fritting and XIR	Roller blind	Solar control + low-E	Clear	No
DSF 3a	Clear laminated with fritting and XIR	No	Low-E	Clear	No
DSF 3b	Clear laminated with fritting and XIR	Roller blind	Low-E	Clear	No
DSF 4a	Clear laminated	No	Low-E	Clear	No
DSF 4b	Clear laminated	Roller blind	Low-E	Clear	No
SSF 1a	N/A	No	Solar control + low-E	Clear	No
SSF 1b	N/A	No	Solar control + low-E +fritting	Clear	No
SSF 1c	N/A	No	Solar control + low-E	Clear	Roller blind
SSF 2a	N/A	No	Low-E	Clear	No
SSF 2b	N/A	No	Low-E +fritting	Clear	No
SSF 2c	N/A	Horizontal louvres	Low-E	Clear	No



Solar Performance of the Assessed Cases

Case	U-value [W/m <sup>2</sup> K]	g-value	Light Transmittance	Solar Gain: [%]		Inner Pane Temperature [°C]	
				Primary	Secondary	Summer	Winter
DSF 0	0.95	0.16	0.280	11.3	5.1	28.5	17.7
DSF 1a	0.95	0.24	0.420	18.6	5.5	28.8	17.7
DSF 1b	0.92	0.05	--	2.7	2.8	27.2	17.8
DSF 2a	0.95	0.11	0.241	6.7	3.9	27.6	17.7
DSF 2b	0.92	0.03	--	1.3	1.9	26.6	17.7
DSF 3a	1.01	0.19	0.378	14.7	4.1	27.8	17.5
DSF 3b	0.98	0.05	--	2.8	2.0	26.2	17.7
DSF 4a	1.04	0.42	0.660	37.4	4.7	28.3	17.5
DSF 4b	0.98	0.05	--	5.9	2.9	27.2	17.6
SSF 1a	1.11	0.29	0.495	23.1	5.4	27.7	17.3
SSF 1b	1.19	0.21	0.322	15.3	5.6	28.0	17.1
SSF 1c	1.04	0.21	--	3.6	16.9	33.7	17.7
SSF 2a	1.19	0.56	0.777	50.6	5.8	28.5	17.1
SSF 2b	1.19	0.40	0.509	32.3	7.3	29.0	17.1
SSF 2c	0.98	0.15	--	7.2	--	28.6	17.6

# Drivers of Façade Optimization

1. Presenting the public “face” of the building
2. Protecting the indoors from wind and rain
3. Sealing the building envelope to contain conditioned space
4. Creating a security barrier
5. Creating a healthy and comfortable environment for occupants (thermal, acoustic, visual, and IAQ)
6. Mitigating solar heat to be removed by a comfort-conditioning system
7. Tempering the influence of cold and hot temperatures outdoors
8. Controlling noise break-in from the outdoors
9. Manipulating or enhancing daylight for useful purpose
10. Providing views to the outdoors to improve occupant satisfaction
11. Moving air in and out of the building (operable elements or louvers)
12. Maximizing usable/leasable square footage indoors

ASHRAE 50% AEDG for Small and Medium Office buildings

# Questions?

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